White Paper 1G-
Evaluation of Floristic Quality in NYS Lakes

Section 1: Species Richness and C Value Background

Aquatic ecologists generally view native plants more favorably than exotic plants, and a high diversity of plants more favorably than monocultures, particularly when the monoculture consists of invasive, exotic plants like Eurasian watermilfoil. However, in the absence of metrics developed for assessing the quality of aquatic plant communities, differences between lakes and over time within lakes, at least as it relates to the value of the aquatic plant community, might be difficult to quantify.

Floristic quality indices (FQI) or assessments (FQA) can be used to assess an area's ecological integrity based on its plant species composition (Wilhelm and Masters, 1995), based on the relative frequency of plants typical of undisturbed (pristine) environments. There are two components to FQIs- species richness (discussed at length in White Paper 1D) and coefficients of conservatism (discussed at length in White Paper 1F). The findings from these White Papers can be summarized as follows:

Species Richness (White Paper 1D) findings relevant for FQI computations:

- Species richness calculations are highly dependent on the ability of surveyors to collect enough plant material from each specimen to distinguish individual species, even if the actual identification of all species cannot be ascertained.
- There is a strong relationship between observed species richness (oSR) and the number of survey sites, as seen in plots showing cumulative species richness approaching an asymptotic value after many survey sites. This relationship can be estimated from logarithmic or power regressions of estimated cumulative species richness values derived from bootstrap analyses, requiring "granular" survey site data.
- Comparisons between lakes and over time require the computation of a standardized survey site density, leading to the development of a projected species richness, or pSR, derived from these cumulative species richness regressions.
- A standardized survey site density of 1 site per littoral hectare, consistent with the original NYSDEC survey requirements, is recommended for all lakes. For those lakes using this standardized survey site density to determine the number of survey sites, pSR can be calculated in the absence of granular survey site data. For lakes with either fewer or more survey sites, pSR values can be extrapolated from (for fewer sites) or projected from (for more sites) these regressions.
- Truncated surveys can be used to accurately estimate pSR, using regressions from as few as 15 sites for small lakes (those with fewer than 100 hectares of littoral area) and 25 sites for larger lakes.
- Although species richness increases with littoral area (due to increased space for plant growth), pSR values at discrete numbers of survey sites (5 sites, 15 sites, 30 sites) do not appear to be correlated to littoral area. Therefore, differences in pSR relative to expected pSR can be used to define pSR-based metris
- Metrics drawn from the NYS Biosurvey can be used to define species richness values associated with "good" (and "poor") lakes as a function of lake area, but more accurate metrics require more granular survey site data and additional surveyed lakes. No single

species richness (SR) threshold between good and bad lakes can be established due to steady increases in SR with littoral area, although the aforementioned evaluation of pSR relative to expected pSR at 5, 15 and/or 30 sites can be used in the interim to generate initial pSR scores. The best way to define the relationship between SR and littoral area is to identify reference lakes with standardized site density. The NYS BioSurvey data may be only alternative in the existing NYS lakes aquatic plant dataset, but even with the NYS BioSurvey the wide range in SR relative to lake area is likely due to differences in survey site density. This creates a challenge in developing mFQI thresholds, as discussed at length in Section 5 below.

Coefficients of Conservatism (White Paper 1F) findings relevant for FQI computations:

- Coefficients of conservatism, or C values, have been developed for all aquatic plants in New York (referred to in White Paper 1F as C_{ny}), but the application of these values to FQI computations suffer from several issues, including challenges in accurately identifying aquatic plants, particularly those retrieved from sites not observable by surveyors, merging of many species into single genera in historical surveys, regional differences in C values, and especially the designation of all exotic plants to a C value of 0 regardless of invasiveness.
- White Paper 1F proposes a modified C value system (C_m) that addresses many of these issues, by maintaining the same range as C_{ny} (0 to 10 for C_{ny}, -5 to 5 for C_m) but assigning various negative C_m values to exotic species based on invasiveness, assigning protected plants the highest C_m values, assigning nuisance native plants a C_m value =1, and assigning all other plants as C_m = 3). These proposed C_m values are well correlated with C_{ny} values, but result in aquatic plant community assessments that appear to more accurately characterize lake conditions.
- Metrics can be derived from mean C_m values using the Florida aquatic plant community designations, resulting in assessments that show significant variability between lakes and from year to year in many lakes
- These assessments further improve when mean C_m values, derived from evaluating the entire plant community, are corrected for plant frequency or plant abundance. Both frequency and abundance can be evaluated relatively (essentially a ranking of most to least frequent or abundant) or absolutely (evaluating frequency or abundance for all survey sites, not just comparing plants to each other), using formulae outlined in White Paper 1F.
- Although relative frequency or abundance corrections can be evaluated on the same scale as uncorrected mean C_m values, relative corrections cannot be easily applied to projected mean C_m values. Therefore, mean C_m values are best corrected for absolute frequency and abundance.
- The Florida aquatic plant community designations can be used to develop metrics for frequency-corrected mean C_m values, and the resulting assessments appear to closely match independent evaluations of aquatic plant communities. Abundance-corrected mean C_m

values may be even more accurate in characterizing these plant communities, but metric development will likely require additional analyses.

Based on the findings from White Papers 1D and 1F, FQI equations should be derived from projected species richness values (pSR) and either frequency- or abundance-corrected mean C_m values derived from a standardized survey site density of 1 site per littoral hectare, although FQIs derived from uncorrected mean C_m values will also be discussed.

Section 2- Floristic Quality Indices (FQI) Background

Floristic quality indices (FQIs) were developed by Wilhelm in the 1970s in the Chicago area, and expanded in the late 1990s in Wisconsin (Nichols, 1999). Although developed primarily for evaluating wetlands, floristic quality evaluations can extend to ponded waters, although clear criteria for interpreting the data generated from these assessments have not been established. An FQI can do the following:

- identify high quality lakes warranting protection;
- identify susceptible waterbodies (by finding many nearby low FQI lakes);
- serve as one measure of biological quality for the purposes of assessing support of designated uses
- establish a simple, reproduceable, standardized, quantitative, expert-based way to evaluate plant control efficacy, plant community trends, and overall ecological quality;
- allow state permit reviewers, managers, or lake communities to identify a trigger point for management (once an FQI falls below an "acceptable" level, active management may be needed, particularly for "nuisance" versus "invasive" conditions)

The two components of an FQI are a count of the number of unique species (i.e. species richness, or quantity) and the ecological integrity (quality) of the individual species that comprise the aquatic plant community. The former is discussed at length in White Paper 1D, and the latter is discussed in White Paper 1F.

FQI calculations use simple equations to generate an aquatic plant community value that can serve several purposes. These equations, however, can be modified to address some of the shortcomings associated with the FQI values, particularly related to C values and the need to assign appropriate values to plants given limitations in observation, collection, and identification of plants in these surveys. The concept of a modified C value system, and the assignment of C_m values to all plants, is discussed at length in White Paper 1F. C values can also corrected to account for plant frequency and abundance, using the tools outlined in White Paper 1C, and both species richness and C values, and the use of mean C_m values and species richness values can be projected to a standardized survey site density, also using the tools outlined in White Paper 1C (and summarized in White Papers 1D and 1F). These modifications and corrections to the simple FQI equations (Equation 1.1 and 1.2) cited above are discussed further in the rest of this White Paper.

Section 3- mFQI in New York State Lakes- Uncorrected Values

Section 3.1- Background

FQI can be calculated in several ways, usually distinguished by how invasive species are handled. These are discussed briefly in White Paper 1C, Section 2. As discussed in that White Paper, Equation 3.1.1 below represents the most commonly used equation for calculating FQI.

Equation 3.1.1: $FQI = \bar{C} \; x \; \sqrt{N}$, and $\bar{C} = \Sigma C / N$; where
N = number of unique plant species in a lake (=observed species richness, or oSR), and
C = coefficient of conservatism for each unique species

However, as discussed at length in White Papers 1C, 1D and 1F, both the N and C values in Equation 3.1.1 should be modified to address several issues raised in these White Papers. Specifically, and as discussed in Section 1 above, the New York-derived coefficients of conservatism (C values, or C_{ny}) were generated from a wealth of biological information, but encounter some problems when used to characterized plants collected in aquatic plant surveys. A modified C value system, or C_m values, can be effectively used to characterize many aquatic plants, and may be more appropriate for evaluating aquatic plant surveys conducted in most lakes. Therefore, for these surveys and for Equation 3.1.1, the mean C value ($\bar{C}$) should be generated from modified C_m values assigned to each major class (protected, beneficial native, nuisance native, and invasive) of aquatic plants.

The observed species richness (oSR) in Equation 3.1.1 should be replaced by a projected species richness (pSR) calculated from a standardized survey site density. In these White Papers, it is recommended that the standardized survey site density be anchored at 1 site per littoral hectare, consistent with the original NYSDEC aquatic plant monitoring requirements, a site density that is realistically achievable in most aquatic plant surveys, and a survey site density in which species richness (and as discussed below, mean C values) is relatively stable. However, for lakes without granular survey site data (an indication of the relative abundance or frequency of plants at each site surveyed, rather than summary information), pSR cannot be calculated, so oSR values can be used, However, the oSR data is only useful for lakes with similar survey site densities and most likely for comparison of individual lakes over time or within programs using comparable methodology allowing for comparison of species richness values across lakes. Where possible, comparisons of oSR data are provided in this White Paper.

For those lakes with the information (granular survey site data) needed to generate the more accurate pSR data, at a standardized survey site density, Equation 3.1.1 can be rewritten as follows:

Equation 3.1.2: $mFQI = \bar{C}_m \; x \; \sqrt{N}$, and $\bar{C} = \Sigma C / N$; where
mFQI = modified FQI
N = number of unique plant species in a lake projected to a survey site density of 1 site per littoral hectare (=projected species richness, or pSR), and
C_m = modified coefficient of conservatism for each unique species

As discussed in White Paper 1F and summarized in Section 1 above, the PIRTRAM data indicate that C_m values should be corrected for plant frequency or plant abundance. White Paper 1F shows C_m corrections using absolute frequency or abundance, rather than relative frequency or abundance, since these absolute corrections are easily applied to projected survey data. This would lead to updated mFQI values, as seen in Equation 3.1.3 and 3.1.4:

Equation 3.1.3: $mFQI_{uf} = \bar{C}_{m\_uf} \times \sqrt{N}$, and $\bar{C} = \Sigma C / N$; where
$mFQI_{uf}$ = modified FQI corrected for absolute plant frequency
N = number of unique plant species in a lake projected to a survey site density of 1 site per littoral hectare (=projected species richness, or pSR), and
C_{m_uf} = modified coefficient of conservatism for each unique species corrected for relative plant frequency

Equation 3.1.4: $mFQI_{ua} = \bar{C}_{m\_ua} \times \sqrt{N}$, and $\bar{C} = \Sigma C / N$; where
$mFQI_{ua}$ = modified FQI corrected for absolute plant abundance
N = number of unique plant species in a lake projected to a survey site density of 1 site per littoral hectare (=projected species richness, or pSR), and
C_{m_ua} = modified coefficient of conservatism for each unique species corrected for absolute plant frequency

Section 3.2- Monitoring Programs Used to Evaluate FQI

Traditional FQI, calculated using equation 3.1.1 above, requires a count of species richness and sufficiently detailed identification of aquatic plants in a lake to assign C values for each identified plant (species or genus). As discussed above and at length in White Paper 1D, projected species richness (pSR) is a more accurate metric for describing aquatic plant communities than is observed species richness (oSR), although both oSR and pSR will generally increase as the number of survey sites increase. White Paper 1D proposes the use of a standardized survey site density of 1 site per littoral hectare, consistent with on-time NYSDEC aquatic plant monitoring requirements, to compute pSR, allowing for comparisons across monitoring programs and lakes with differing survey site densities. This further requires the use of subsampling methods to project species richness to a specific survey site density. Such subsampling methods require the use of granular survey site data- presence and/or abundance of each plant at each surveyed site.

Of the four major monitoring programs discussed in White Paper 1A, the NYS BioSurvey of more than 300 lakes in the 1920s-30s, the PIRTRAM surveys of about 50 lakes in the 1990s-2010s, and the AWI surveys of about 85 lakes in the 2010s identified plants to species level, allowing for a computation of traditional FQI values based on C values AND observed species richness. However, in the absence of granular survey site data for either program, projected species richness cannot be calculated for each survey site density (except, of course, for calculating oSR values for all sites). In addition, the ALSC data only identified plants to genera level, precluding the use of floristic quality indices to evaluate aquatic plant communities in the ALSC lakes. Therefore, only the PIRTRAM dataset, with granular survey site data, can be used to generate pSR estimates at a standardized survey site density of 1 site per littoral hectare, resulting in pSR values for use in Equations 3.1.2 through 3.1.4. These data are summarized in Appendix 3.2

Section 3.3- mFQI Values in NYS Lakes- Uncorrected Values

Table 3.3.1 shows the modified FQI with mean C_m values uncorrected for frequency or abundance, along with the two primary components of this mFQI- species richness projected (pSR) to a standardized survey site density of 1 site per littoral hectare, and mean C_m values projected to the same survey site density.

mFQI values summarized in Figure 3.3.1 ranged from -2.8 in Blydenburgh Lake (dominated by *Hydrilla verticillata*) to 12.2 in Chautauqua Lake in 2017 (a very large lake with very high species richness) and 12.0 in Morehouse Lake (a small lake with no invasives). As expected, mFQI values decrease as invasive species are introduced to an aquatic plant community- most of the lakes in Table 3.3.1 with very high projected species richness (pSR) do not necessarily exhibit the highest mFQI values due to the presence of AIS.

Figure 3.3.1- Uncorrected mFQI (and Component) Values in NYS Lakes

Year Lake	Year	Std. Density	pSR	pCm_ 1/ha	mFQI_ Uncorr
Ballston Lake	2006	48	9.3	1.2	3.5
Big Fresh Pond	2006	13	8.5	2.6	7.7
Blydenburgh Lake	2012	40	4.3	-1.4	-2.8
Blydenburgh Lake	2014	40	3.3	-0.3	-0.6
Cazenovia Lake	2010	225	30.9	1.7	9.3
Cazenovia Lake	2011	225	30.8	1.9	10.5
Cazenovia Lake	2012	225	29.5	1.8	10.0
Cazenovia Lake	2013	225	35.4	1.8	10.5
Cazenovia Lake	2014	225	31.0	1.7	9.2
Cazenovia Lake	2015	225	35.4	1.8	10.5
Cazenovia Lake	2016	225	33.4	1.7	9.7
Cazenovia Lake	2017	225	31.2	1.7	9.3
Cazenovia Lake	2018	225	31.9	1.6	9.3
Cazenovia Lake	2019	225	31.4	1.7	9.4
Cazenovia Lake	2020	225	32.2	1.7	9.8
Cazenovia Lake	2021	225	30.4	1.9	10.6
Chautauqua Lake	2015	2060	31.6	1.9	10.9
Chautauqua Lake	2017	2060	28.4	2.3	12.2
Chautauqua Lake	2019	2060	30.9	1.9	10.3
Chautauqua Lake	2021	2060	37.8	1.9	11.5
Collins Lake	2007	5	8.3	0.5	1.4
Creamery Pond	2008	4	3.3	0.0	0.0
Creamery Pond	2010	4	6.9	0.3	0.8
Creamery Pond	2012	4	5.3	0.6	1.4
Hards Pond	2011	12	7.1	2.3	6.1
Java Lake	2008	21	6.1	1.7	4.2
Java Lake	2009	21	6.8	2.0	5.2
Java Lake	2010	21	5.2	1.1	2.6
Kinderhook Lake	2006	109	9.2	-0.6	-1.8
Kinderhook Lake	2007	109	8.5	-0.5	-1.6
Lake Luzerne	2009	24	19.4	2.3	10.2
Lake Luzerne	2010	24	21.6	2.3	10.7
Lake Rippowam	2008	4	2.4	-1.4	-2.2
Lake Rippowam	2016	4	2.7	-1.2	-1.9
Lake Rippowam	2018	4	2.2	-1.3	-1.9
Lake Rippowam	2020	4	2.4	-1.4	-2.2

The vast majority of lakes evaluated in Table 3.3.1 exhibited positive mFQI values, even though many of them were dominated (at least in the frequency or abundance of plants) by invasive species. This suggests that uncorrected mFQI values are less accurate than frequency- or abundance-corrected mFQI values in characterizing lakes, since it is presumed that dominance by invasive species is a characteristic of poor floristic quality.

Several lakes summarized in Table 3.3.1 were sampled over multiple years. Some of these lakes- Cazenovia Lake, Creamery Pond, Chautauqua Lake, Saratoga Lake, Snyders Lake- were managed for invasive or native plants over the period in which surveys were conducted, while other lakes- Java Lake, Lake Rippowam, Lake Waccabuc, and Oscaleta Lake- were not managed over this period. Table 3.3.2 shows the normalized standard deviation in the mFQI values in managed and unmanaged lakes. These data include lakes with high and low mFQI values. There appears to be little connection between normalized standard deviations in mFQI values and whether the lakes were managed or unmanaged, at least relative to the differences in lake size. While the highest deviation occurred in managed lakes, the relatively variability in mFQI in Creamery Pond and Snyders Lake reflects a relatively small absolute variability in these values (both Creamery Pond and Snyders Lake exhibit low mFQI values- hence relatively high percentage changes from year to year). Since it is presumed that active management may significantly affect floristic quality, these data further suggest that uncorrected mFQI is not a strong indication of floristic quality, particularly changes in floristic quality. This is also apparent in an in-depth evaluation of Cazenovia Lake, which exhibited an average mFQI of 9.6 in managed years, and an mFQI of 10.0 in unmanaged lakes, a difference (less than 5%) that is likely smaller than the normal variability from year to year.

Figure 3.3.1 (cont)- Uncorrected mFQI (and Component) Values in NYS Lakes

Year Lake	Year	Std. Density	pSR	pCm_ 1/ha	mFQI_ Uncorr
Lake Waccabuc	2008	20	8.6	1.3	3.9
Lake Waccabuc	2010	20	10.2	1.4	4.6
Lake Waccabuc	2013	20	10.0	1.4	4.4
Lake Waccabuc	2014	20	10.2	1.7	5.5
Lake Waccabuc	2015	20	10.7	1.6	5.3
Lake Waccabuc	2016	20	10.6	1.6	5.1
Lake Waccabuc	2017	20	9.1	1.7	5.0
Lake Waccabuc	2019	20	9.7	1.4	4.4
Lake Waccabuc	2021	20	10.7	1.3	4.1
Lamoka Lake	2006	160	28.0	2.1	10.9
Lamoka Lake	2009	160	26.6	2.3	11.9
Morehouse Lake	2010	35	15.5	3.1	12.0
Oscaleta Lake	2008	8	7.8	1.3	3.6
Oscaleta Lake	2016	8	8.3	1.5	4.2
Oscaleta Lake	2018	8	8.1	1.2	3.4
Oscaleta Lake	2020	8	7.3	1.0	2.8
Quaker Lake	2010	64	8.3	2.1	6.1
Saratoga Lake	2010	657	24.4	2.3	11.4
Saratoga Lake	2011	657	24.3	2.1	10.1
Saratoga Lake	2012	657	25.9	2.1	10.7
Snyders Lake	2002	15	5.8	0.5	1.3
Snyders Lake	2005	15	7.0	1.0	2.6
Snyders Lake	2008	15	8.9	0.8	2.5
Snyders Lake	2011	15	9.2	1.2	3.5
Waneta Lake	2006	170	15.0	1.4	5.3

Table 3.3.2- Variability in Uncorrected mFQI in Managed and Unmanaged Lakes

Lake	Category	N	Mean mFQI	StDev mFQI	Normal. StDev
Cazenovia Lake	managed	12	9.8	0.6	6%
Chautauqua Lake	managed	4	11.2	0.8	7%
Creamery Pond	managed	3	0.8	0.7	96%
Java Lake	unmanaged	3	4.0	1.3	33%
Lake Rippowam	unmanaged	4	-2.1	0.2	-9%
Lake Waccabuc	unmanaged	9	4.7	0.6	12%
Oscaleta Lake	unmanaged	4	3.5	0.6	17%
Saratoga Lake	managed	3	10.7	0.6	6%
Snyders Lake	managed	4	2.5	0.9	37%

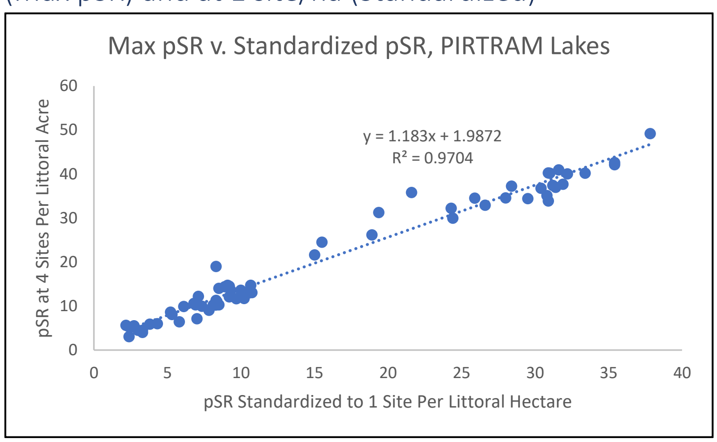
Changes in mFQI values in these lakes will also be discussed below in the evaluation of frequency- and abundance-corrected mFQI values.

Section 3.4- Potential Metrics for Evaluating Uncorrected FQI Values in NYS Lakes

No good metrics exist for interpreting uncorrected FQI values in New York state lakes. For example, coefficients of conservatism (C_{ny} or C_m) values provide information about the value of the individual plants (or the collective value of plants) within the aquatic plant community, but do not provide information about the number of species (the population of aquatic plants). Likewise, while species richness provides a summary of the number of unique plant species, these counts do not provide information about the value of those plants. Floristic quality indices- as calculated using Equation 3.1.1 above- include both C values and species richness values, but existing metrics have not been developed for lakes or rivers, most likely due to the limitations in FQI calculations (and associated C value and species richness components) in aquatic plant surveys.

While there are no universally accepted metrics developed for the use of floristic quality indices in aquatic ecosystems, Swink and Wilhelm (1994) indicated that an FQI of 1-19 in wetlands indicates low vegetative quality; 19-35 indicates high vegetative quality and above 35 indicates "Natural Area" quality. It is presumed that the components of FQI- species richness and mean coefficients of conservatism, in the Swink-Wilhelm thresholds represent the computed values for all plants found within a studied ecosystem, and it is further presumed that evaluated wetlands can be "fully" surveyed. In other words, these thresholds likely represent the maximum species richness and associated mean C values for the maximum species list for these wetlands. If these wetland-based metrics are applied to lakes and rivers in the New York state lakes evaluated in these White Papers, they need to be transformed for consistency with the recommendations in these White Papers. Specifically, the maximum species richness needs to be converted into a projected species richness standardized at a survey site density of 1 site per littoral hectare. The mean C values, presumably generated from C_{ny} (or equivalent) values for each of these individual plant species, need to be converted to equivalent modified C (C_m) values, and further modified to represent mean C_m values at the same standardized survey site density of 1 site per littoral hectare (further modifications to account for frequency- and abundance corrections, per White Paper 1F, are discussed below).

Figure 3.4.1- Comparison of Projected SR at 4 sites/ac (Max pSR) and at 1 site/ha (Standardized)



Fortunately, each of these processes are outlined in White Papers 1D and 1F and are summarized below.

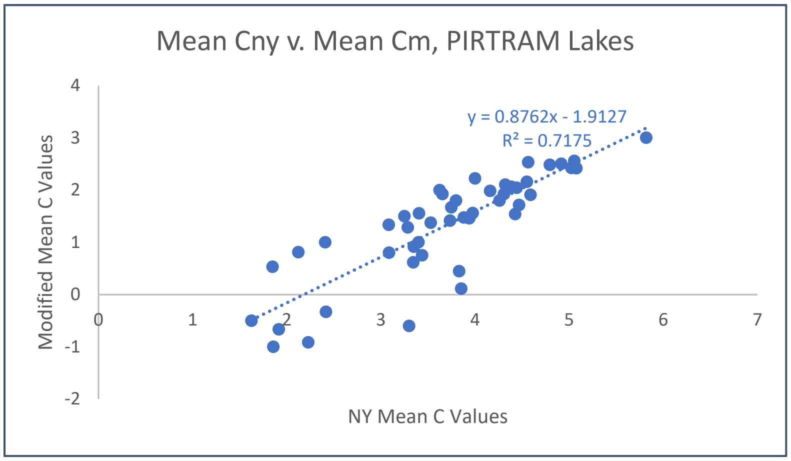
- *Step 1:* As discussed in White Paper 1D, the maximum species richness in a lake cannot be accurately estimated since the vast majority of the littoral zone, particularly those areas too deep to observe from the lake surface, can be accurately assessed. However, as discussed in White Paper 1D, a *practical* maximum species richness, as evaluated in a point-intercept rake toss survey, can be estimated using a survey site density of 4 sites per littoral acre, the "tightest" density achievable while minimizing the risk of overlapping survey sites. It should also be noted, as seen in White Paper 1D, that cumulative species richness values reach an asymptotic maximum at survey site densities well below this practical maximum site density.

  To convert maximum species richness to projected species richness at 1 site per littoral hectare, use the regression equation summarized in Figure 3.4.2:

  Equation 3.4.1: $pSR_{max} = 1.183pSR_{std} + 1.9872; R^2 = 0.9704$;
  SR_{max} = maximum projected species richness at 4 sites per littoral acre,
  pSR_{std} = projected species richness at the standardized 1 site per littoral hectare.

  Projected species richness (pSR) values reported in White Paper 1D are reported at this standardized survey site density. The relationship between SR_{max} and SR_{std} is shown for PIRTRAM lakes in Figure 3.4.1.

Figure 3.4.2- Comparison of Mean C_{ny} and Mean C_m



- *Step 2:* The mean coefficients of conservatism (C values) used in Swink and Wilhelm's calculations are generated using the same C = 1 to 10 scale (with invasives = 0) used to generate C_{ny}e same C = 1 to 10 scale (with invasives = 0) used to generate C_{ny} values discussed in White Paper 1F. As discussed at length in White Paper 1F, it is recommended that a modified C value system (C_m) be used to characterize aquatic plants, and by extension to develop mean C values used for FQI equations.

  Figure 3.4.2 shows the relationship between mean C values using the New York system (C_{ny}) and the proposed modified C value system (C_m) discussed in White Paper 1F.

To convert mean C_{ny} values to mean C_m values, use the regression equation in Figure 3.4.2:

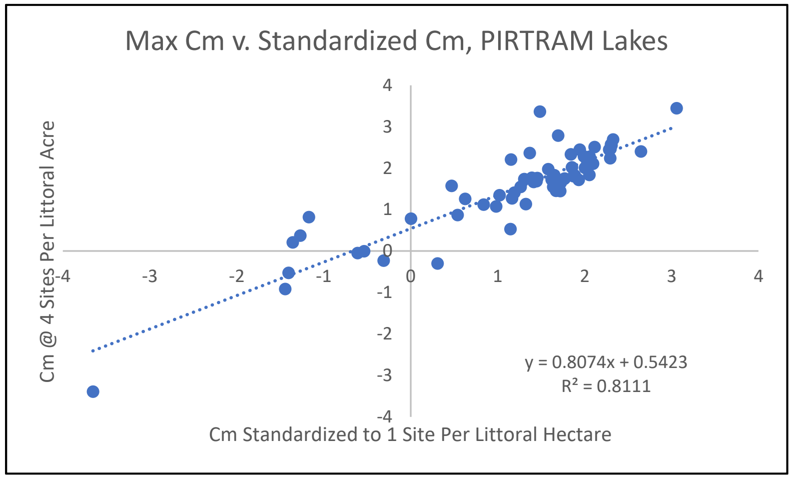
Equation 3.4.2: $\quad Mean\ C_m = 0.8733Mean\ C_{ny} - 1.9051;\ R^2 = 0.715;$

Mean C_m = mean C values using modified C value system

Mean C_{ny} = mean C values using the traditional New York C value system

- *Step 3*: As with species richness, it is assumed that the mean C values used in the wetlands FQI equations represents the mean C value associated with the maximum number of plant species reported in the surveyed area. However, in White Paper 1F, mean C_m values represent the mean of the coefficients of conservatism for "only" the individual plants found at the standardized survey site density.

Figure 3.4.3- Comparison of Mean C_{ny} and Mean C_m



To convert maximum mean C_m values (the mean C_m associated with the maximum species richness plant list) to projected C_m values at 1 site per littoral hectare (the standardized survey site density), use the regression equation summarized in Figure 3.4.3.:

Equation 3.4.3: $\quad pC_{m\_max} = 0.8074pC_{m\_std} - 0.5423;\ R^2 = 0.8111;$

pC_{m_max} = maximum projected mean C_m at 4 sites per littoral acre,

pSR_{m_std} = projected C_m at the standardized 1 site per littoral hectare.

Each of these factors must be applied to Equation 3.1.2 as it pertains to the Swink-Wilhelm thresholds to determine the most appropriate distinctions between low vegetative quality, high vegetative quality, and natural areas. However, the relationships between the FQI components requiring conversions are best described by regressions in the form y = mx+ b, indicating that the corrections- pSR_{std} , C_m , and C_{m_std} – are not simple substitutions. In fact, the corrected FQI thresholds correspond to ranges rather than single values.

This is apparent in Tables 3.4.1 and 3.4.2, which display changes to the Swink-Wilhelm thresholds due to corrections in mean C and species richness values over the range of species richness values encountered in NYS lakes. Table 3.4.1 shows that when these corrections- equations 3.4.1 through 3.4.3- are applied to the Swink-Wilhelm FQI threshold between "high vegetative quality" and "natural area" (= 35) shows that the maximum species richness (Max pSR in Table 3.4.1) increases as the maximum mean C value decreases (Max Cny in Table 3.4.1), using the Cny system. When the standardized pSR is substituted for the maximum pSR, the Swink-Wilhelm threshold (SW FQI1B in Table 3.4.1) varies from 25.0 at low species richness to 31.7 at high species richness.

When the maximum mean C values in the NY system is converted first to the mean modified C value (Corr Cm in Table 3.4.1) and then to the standardized mean Cm value (Std Cm in Table 3.4.1), the resulting Swink-Wilhelm threshold changes to a range of 17.8 (at low species richness) to 15.1 (at high species richness). It should be noted that at low species richness (max SR = 5-15), the corrected mean C_m values cannot be high enough to achieve a "natural area" designation- in other words, more than 15 unique species must be present to characterize an aquatic ecosystem as a "natural area". Likewise, for those aquatic systems with lower mean C_m values, very high species richness is required to meet the "natural area" designation.

Table 3.4.1- Stepwise Conversion of Max Cny and pSR to Standardized Cm and pSR and Impact to Swink-Wilhelm "Natural Area" FQI Thresholds

SW FQI1A	Max Cny	Max pSR	Std pSR	SW FQI1B	Corr Cm	SW FQI1C	Std Cm	SW FQI1D
35	>10	5	2.5	25.0	>5	18.8	>5	16.0
35	>10	10	6.8	28.8	>5	20.2	>5	17.7
35	9.0	15	11.0	30.0	>5	19.9	>5	17.8
35	7.8	20	15.2	30.5	4.9	19.2	4.5	17.6
35	7.0	25	19.5	30.9	4.2	18.6	3.9	17.4
35	6.4	30	23.7	31.1	3.7	17.9	3.5	17.1
35	5.9	35	27.9	31.3	3.3	17.2	3.2	16.8
35	5.5	40	32.1	31.4	2.9	16.6	2.9	16.5
35	5.2	45	36.4	31.5	2.7	16.0	2.7	16.2
35	4.9	50	40.6	31.5	2.4	15.4	2.5	15.9
35	4.7	55	44.8	31.6	2.2	14.8	2.3	15.6
35	4.5	60	49.0	31.6	2.0	14.3	2.2	15.3
35	4.3	65	53.3	31.7	1.9	13.8	2.1	15.1

Table 3.4.2- Stepwise Conversion of Max Cny and pSR to Standardized Cm and pSR and Impact to Swink-Wilhelm FQI Thresholds

SW FQI1A	Max Cny	Max pSR	Std pSR	SW FQI1B	Corr Cm	SW FQI1C	Std Cm	SW FQI1D
19	8.5	5	2.5	13.6	>5	8.8	5.0	8.0
19	6.0	10	6.8	15.6	3.3	8.7	3.2	8.4
19	4.9	15	11.0	16.3	2.4	7.9	2.5	8.2
19	4.2	20	15.2	16.6	1.8	7.0	2.0	7.8
19	3.8	25	19.5	16.8	1.4	6.2	1.7	7.4
19	3.5	30	23.7	16.9	1.1	5.5	1.5	7.1
19	3.2	35	27.9	17.0	0.9	4.8	1.3	6.7
19	3.0	40	32.1	17.0	0.7	4.1	1.1	6.4

This suggests that the determination whether the mFQI for an aquatic system fits the definition of a "natural area" waterbody depends on the species richness, which in turn (as seen in White Paper 1D) is a function of the size of the littoral area. **However, across a fairly wide range of species richness values (and therefore littoral area sizes), the modified Swink-Wilhelm threshold for a "natural" waterbody generally falls in the range of an mFQI of 16 to 18 for most waterbodies.**

Table 3.4.2 shows a similar conversion of the Swink-Wilhelm threshold of 19 for "high vegetative quality" to a comparable threshold for both mean C_m values and species richness projected at a standardized survey site density of 1 site per littoral hectare. When species richness is as low as 5 unique species, mean C values (whether using the New York or proposed modified C value system) cannot be high enough to support a "high vegetative quality" designation. As with Table 3.3.2.1, these thresholds vary somewhat with species richness and littoral area, but for most waterbodies, **the modified Swink-Wilhelm threshold for "high vegetative quality" generally falls in the range of an mFQI of 7 to 8.**

Section 3.5- Combining Potential FQI Metrics With C Values Metrics- Uncorrected Mean C_m

Section 3.3.2 outlines a process in which existing wetlands metrics, devised by Swink and Wilhelm to define "low vegetative quality", "high vegetative quality" and "natural areas", can be modified to identify comparable thresholds for lakes using projected species richness (discussed at length in White Paper 1D) and modified mean C_m values (discussed at length in White Paper 1F), with both FQI components computed at a standardized survey site density of 1 site per littoral hectare.

However, the Swink-Wilhelm thresholds is not well aligned with criteria used in other assessments or in state aquatic life characterizations that use terms such as "poor", "fair" and "good". It is likely that the Swink-Wilhelm thresholds cited above for "natural areas" (corresponding to FQI values > 35) would likely correspond to reference conditions (indicative of minimal impact to ecological function), which might also be comparable to the Florida aquatic plant community designation of "Outstanding". Likewise, although "fair vegetative quality" could be broadly to defined to include "fair", "poor" and "very poor" floristic quality, these labels are more precisely defined for mean C_m values discussed in White Paper 1F.

Table 3.5.1- Mean C_m Values Associated with Aquatic Plant Community Designations

	Outstanding	Excellent	Fair	Poor	Very Poor
Mean C_m	> 4.0	2.6-4.0	1.4-2.6	0.0-1.4	-0.8 – 0.0

Table 7.1.2 in White Paper 1F is reproduced below as Table 3.5.1, and shows the mean C_m values that fit the criteria of "outstanding", "good", "fair", "poor" and "very poor" aquatic plant designations in Florida (these criteria are presented in Table 7.1.1 in White Paper 1F). These metrics provide an incomplete picture of floristic quality, identifying the make up of the individual plants within a plant community, without requiring an appropriate number of aquatic plants (species richness) within that community. The metrics in White Paper 1F (related to the quality of the aquatic plants) and those discussed above (related to both the quantity and quality of the aquatic plants) can be combined into a single metric, as discussed below. It should be noted that none of these proposed

metrics account for plant frequency or abundance; frequency- and abundance-corrections to these proposed metrics are discussed later in this White Paper.

Table 3.5.2 shows a proposed combined metric for defining aquatic plant community designations using mean C_m values (Table 3.5.1) and the modified Swink-Wilhelm FQI thresholds outlined in Tables 3.3.2.1 and 3.3.2.2. Each of these proposed combined metrics must be met for a waterbody to meet the aquatic plant community designation. For example, a lake with a mean C_m between 2.6 and 4.0 and an mFQI between 6 and 16 would be characterized as having a "Good" aquatic plant community designation, while a lake meeting only one of these criteria would be defined as "Fair to Good" (or simply "Fair-Good"). Combining these criteria would select for those waterbodies with both aquatic plant community composition (the mean C_m value) and community populations (the species richness component of the mFQI value). There were several small modifications to the mean C_m criteria outlined in Table 3.4.1 and the mFQI thresholds in Table 3.4.1 and 3.4.2 that were needed to develop the criteria cited in Table 3.5.2. These include the following:

Table 3.5.2- Mean C_m Values and Uncorrected mFQI Values For Each Aquatic Plant Community Designation

	Outstanding	Good	Fair	Poor
Mean C_m	> 4.0	> 2.6	> 0	< 0
mFQI	> 16-18	> 6-8	> 0	< 0

- "poor" and "very poor" were collapsed into a single "poor" category. As discussed in White Paper 1F, there is probably little practical distinction between these categories. However, the actual mFQI values could be used to determine if, for example, natural or managed changes to an aquatic plant community resulted in improvements in floristic quality, even if the aquatic plant designation for the waterbody continued to be "poor". Either "very poor" or "poor" conditions will likely be an antecedent for management or regulatory action.
- "low vegetative quality" and "fair" were generally equated. Although neither term was explicitly defined, it is presumed that low vegetation quality is consistent with "fair" conditions. However, the Swink-Wilhelm thresholds do not include categories for plant communities dominated by invasive species, so a subset of "low vegetative quality"- corresponding to the lowest mFQI values, could be considered to be "poor".
- since the lower end of the range for "low vegetative quality" was further segregated to include "fair" and "poor", the lower threshold for "fair" was reduced to 0. This would define

Table 3.5.3- Combined mFQI Assessment Using Uncorrected C_m

Year Lake	Year	Std. Density	pSR	pCm_ 1/ha	mFQI_ Uncorr	FQI_Cm Combined Uncorr Assess.	pSR5_15 Score
Ballston Lake	2006	48	9.3	1.2	3.5	Fair	Fair
Big Fresh Pond	2006	13	8.5	2.6	7.7	Good	Fair
Blydenburgh Lake	2012	40	4.3	-1.4	-2.8	Poor	Poor-Fair
Blydenburgh Lake	2014	40	3.3	-0.3	-0.6	Poor	Poor-Fair
Cazenovia Lake	2010	225	30.9	1.7	9.3	Fair-Good	Good
Cazenovia Lake	2011	225	30.8	1.9	10.5	Fair-Good	Good
Cazenovia Lake	2012	225	29.5	1.8	10.0	Fair-Good	Good
Cazenovia Lake	2013	225	35.4	1.8	10.5	Fair-Good	Good
Cazenovia Lake	2014	225	31.0	1.7	9.2	Fair-Good	Good
Cazenovia Lake	2015	225	35.4	1.8	10.5	Fair-Good	Good
Cazenovia Lake	2016	225	33.4	1.7	9.7	Fair-Good	Good
Cazenovia Lake	2017	225	31.2	1.7	9.3	Fair-Good	Good
Cazenovia Lake	2018	225	31.9	1.6	9.3	Fair-Good	Good
Cazenovia Lake	2019	225	31.4	1.7	9.4	Fair-Good	Good
Cazenovia Lake	2020	225	32.2	1.7	9.8	Fair-Good	Good
Cazenovia Lake	2021	225	30.4	1.9	10.6	Fair-Good	Good
Chautauqua Lake	2015	2060	31.6	1.9	10.9	Fair-Good	Good
Chautauqua Lake	2017	2060	28.4	2.3	12.2	Fair-Good	Fair
Chautauqua Lake	2019	2060	30.9	1.9	10.3	Fair-Good	Good
Chautauqua Lake	2021	2060	37.8	1.9	11.5	Fair-Good	Good
Collins Lake	2007	5	8.3	0.5	1.4	Fair	Good
Creamery Pond	2008	4	3.3	0.0	0.0	Fair	Poor-Fair
Creamery Pond	2010	4	6.9	0.3	0.8	Fair	Fair
Creamery Pond	2012	4	5.3	0.6	1.4	Fair	Fair
Hards Pond	2011	12	7.1	2.3	6.1	Fair-Good	Fair
Java Lake	2008	21	6.1	1.7	4.2	Fair	Fair
Java Lake	2009	21	6.8	2.0	5.2	Fair	Fair
Java Lake	2010	21	5.2	1.1	2.6	Fair	Fair
Kinderhook Lake	2006	109	9.2	-0.6	-1.8	Poor	Fair
Kinderhook Lake	2007	109	8.5	-0.5	-1.6	Poor	Fair
Lake Luzerne	2009	24	19.4	2.3	10.2	Fair-Good	Good
Lake Luzerne	2010	24	21.6	2.3	10.7	Fair-Good	Good
Lake Rippowam	2008	4	2.4	-1.4	-2.2	Poor	Poor
Lake Rippowam	2016	4	2.7	-1.2	-1.9	Poor	Fair
Lake Rippowam	2018	4	2.2	-1.3	-1.9	Poor	Fair
Lake Rippowam	2020	4	2.4	-1.4	-2.2	Poor	Poor-Fair
Lake Ronkonkoma	2010	21	3.8	1.5	2.9	Fair	Poor
Lake Ronkonkoma	2014	21	3.0	-3.7	-6.3	Poor	Poor

all plant communities with invasive species- those with negative mFQI values, to be below zero. This seems to be intuitively satisfying.

- the terms "natural area" (in the Swink-Wilhelm designations), "excellent" and "outstanding" (in the Florida aquatic plant community designations) were considered to be equivalent, and referred to in Table 3.5.2 as "Outstanding". While "natural area" and "outstanding" are more likely to be indicative of reference or minimally impacted conditions, as a practical matter, there are few reference waterbodies for aquatic plants (unimpacted by shoreline development, acidification, or invasive species) in New York state, resulting in few waterbodies meeting fitting any of these descriptions.

Table 3.5.3 (cont)- Combined mFQI Assessment Using Uncorrected C_m

Year Lake	Year	Std. Density	pSR	pCm_ 1/ha	mFQI_ Uncorr	FQI_Cm Combined Uncorr Assess.	pSR5_15 Score
Lake Waccabuc	2008	20	8.6	1.3	3.9	Fair	Fair
Lake Waccabuc	2010	20	10.2	1.4	4.6	Fair	Fair
Lake Waccabuc	2013	20	10.0	1.4	4.4	Fair	Fair
Lake Waccabuc	2014	20	10.2	1.7	5.5	Fair	Fair
Lake Waccabuc	2015	20	10.7	1.6	5.3	Fair	Fair
Lake Waccabuc	2016	20	10.6	1.6	5.1	Fair	Fair
Lake Waccabuc	2017	20	9.1	1.7	5.0	Fair	Fair
Lake Waccabuc	2019	20	9.7	1.4	4.4	Fair	Fair
Lake Waccabuc	2021	20	10.7	1.3	4.1	Fair	Fair
Lamoka Lake	2006	160	28.0	2.1	10.9	Fair-Good	Good
Lamoka Lake	2009	160	26.6	2.3	11.9	Fair-Good	Good
Morehouse Lake	2010	35	15.5	3.1	12.0	Good	Fair-Good
Oscaleta Lake	2008	8	7.8	1.3	3.6	Fair	Fair
Oscaleta Lake	2016	8	8.3	1.5	4.2	Fair	Fair
Oscaleta Lake	2018	8	8.1	1.2	3.4	Fair	Fair
Oscaleta Lake	2020	8	7.3	1.0	2.8	Fair	Fair
Quaker Lake	2010	64	8.3	2.1	6.1	Fair-Good	Fair
Saratoga Lake	2010	657	24.4	2.3	11.4	Fair-Good	Good
Saratoga Lake	2011	657	24.3	2.1	10.1	Fair-Good	Fair
Saratoga Lake	2012	657	25.9	2.1	10.7	Fair-Good	Fair-Good
Snyders Lake	2002	15	5.8	0.5	1.3	Fair	Fair
Snyders Lake	2005	15	7.0	1.0	2.6	Fair	Fair
Snyders Lake	2008	15	8.9	0.8	2.5	Fair	Fair
Snyders Lake	2011	15	9.2	1.2	3.5	Fair	Fair
Waneta Lake	2006	170	15.0	1.4	5.3	Fair	Good
Waneta Lake	2009	170	18.9	2.0	8.7	Fair-Good	Fair

However, if additional high quality waterbodies are eventually subject to these same evaluations, there may eventually be sufficient data to establish mFQ (and C_m) values for each of these categories.

- "high vegetative quality" and "good" were considered to be equivalent, likely consistent with commonplace definitions for each term.

Table 3.5.3 summarizes the modified FQI (mFQI)- mean C_m combined assessment, using modifications to the Swink-Wilhelm FQI thresholds and the Florida aquatic plant community designations. This table also includes the component values for uncorrected projected mean C_m and the projected species richness, both estimated at a standardized survey site density of 1 site per littoral hectare, and the pSR scores at 5 and 15 sites summarized in Sections 6 and 7 in White Paper 1D. The mFQI assessments for each lake year correspond to the aquatic plant community thresholds provided in Table 3.5.2. A summary of the percentage of lakes in each of the aquatic plant community designations shown in Table 3.5.3 is provided in Table 3.5.4.

Table 3.5.4- % PIRTRAM Lake Years in Aquatic Plant Designations Using Uncorrected Mean C_m and mFQI

Outstd.	Good-Outstd.	Good	Fair-Good	Fair	Poor-Fair	Poor
0%	0%	3%	40%	42%	0%	14%

"Outsd" = outstanding

These summaries show that no PIRTRAM waterbodies can be defined as "Outstanding". While few lake years could be characterized as "good" using the combined mFQI criteria, the pSR criteria from White Paper 1D (Sections 6 and 7) show more “good” lakes. This is consistent with the observation that nearly all PIRTRAM lakes (lake years) correspond to or anticipate management actions, which would not be consistent with “outstanding” or even “good” conditions (indicating lower quality of plant species), but that overall species richness can be relatively high in many of these lakes. The majority of the lake years correspond to “fair” mFQI conditions, and those with very high species richness likely correspond to either selective management of plants or management in relatively small geographic areas. However, since many of these lakes were managed, and nearly all of these lakes possess invasive species (see White Paper 1E), a higher percentage of “poor” lakes would be expected, consistent with the higher percentage of “fair” and especially “poor” lakes when only considering the mean C_m value thresholds outlined in White paper 1F, Table 7.3.4. While that table indicates a low percentage of high quality (Good to Outstanding) lakes when considering only mean C_m values, consistent with the data summarized in Table 3.5.4 above, Table 7.3.4 indicates that more than 40% of the PIRTRAM lakes (lake years) would be characterized as “poor” when looking only at the mean C_m values. **It should be noted that the higher species richness (pSR5_15 score in the last column in Table 3.5.3) in many of these lakes suggest that, if management can effectively remove or at least reduce the frequency and density of poor quality (AIS or nuisance native) plants, many of these other plants could expand and thereby increase mFQI scores.** However, extensive sustained and selectively control of AIS continues to be difficult to achieve, owing to the persistence of these highly invasive species.

Since the pSR5_15 scores represent only interim measures of relative species richness, and since these scores appear to be more favorable than those associated with the combined mFQI metrics in Table 3.5.3 (and later in this White Paper), these pSR scores will only be reintroduced when all lake plant metrics are summarized (in Table 5.4.3).

This discrepancy indicates that setting the bottom of the “fair” threshold at an mFQI of 0 may drive too many “poor” quality lakes into the “fair” category, even though setting this threshold at a point where a dominance by invasive species is an intuitively clean boundary between “fair” and “poor”. In other words, many lakes with many invasive plant species may be incorrectly characterized as “fair” (rather than “poor”) since these lakes possess more native plants. In addition, these data suggest that even the modifications to the Swink-Wilhelm FQI thresholds for wetlands may be too likely to characterize some “poor” quality lakes as “fair”.

Table 3.5.5- % Lakes (Lake Years) in Aquatic Plant Designations Using Uncorrected Mean C_m and mFQI For Each NYS Monitoring Program

Program	Outstd.	Good-Outstd.	Good	Fair-Good	Fair	Poor-Fair	Poor
PIRTRAM	0%	0%	3%	40%	42%	0%	14%
NYS BioSurvey	0%	6%	43%	49%	0%	0%	0%
AWI	0%	0%	14%	73%	13%	0%	0%

"Outsd" = outstanding

Another way to evaluate these criteria is to compare the PIRTRAM lakes to those surveyed through other monitoring programs. Table 3.5.5 shows the aquatic plant community designations for lakes in the NYS BioSurvey and AWI program using the combined FQI criteria summarized in Table 3.5.2 (compared to those assessments for PIRTRAM lakes summarized in Table 3.5.4). Note that neither the NYS BioSurvey nor the AWI lakes data can be evaluated for projected species richness or uncorrected mean C_m values at the standardized survey site density of 1 site per littoral hectare, due to the lack of consistent granular survey site data for these programs. It is likely that these lakes were surveyed at a lower survey site density than 1 site per littoral hectare, so the projected species richness in these lakes is even higher, and therefore mFQI values are higher. However, Table 3.5.5 shows that a very high percentage of the NYS BioSurvey and AWI lakes would be characterized as better than "fair"- all of the NYS BioSurvey and most of the AWI lakes- although it is likely that lakes surveyed in these programs exhibited some impacts to aquatic plant communities (due to shoreline development, water quality issues, or the presence of AIS). Therefore, it is likely that the mFQI thresholds outlined in Table 3.5.2, using mFQI values uncorrected for plant abundance, overestimate the aquatic plant community designations in New York state lakes.

AS DISCUSSED IN WHITE PAPER 1F, AQUATIC PLANT COMMUNITY ASSESSMENTS CAN BE DERIVED USING (ONLY) MODIFIED COEFFICIENTS OF CONSERVATISM (MEAN C_M VALUES). CONTINUING EVALUATION OF FLORISTIC QUALITY ASSESSMENTS BASED ON MEAN C_M VALUES ONLY AND ON FQI VALUES THAT ENCOMPASS BOTH MEAN C_M VALUES (AQUATIC PLANT VALUE) AND SPECIES RICHNESS (AQUATIC PLANT POPULATIONS) WILL HELP TO DETERMINE WHICH APPROACH IS MORE ACCURATE.

Finally, as discussed at length in White Paper 1F, aquatic plant assessments, as related to the generation of mean C_m values, improve when these values are corrected for plant frequency and/or plant abundance. These are discussed in Section 4 below.

Section 4- mFQI in New York State Lakes- Frequency-Corrected Values

Section 4.1- Background

As reported in Section 3 and White Paper 1F, modified FQI (mFQI) values appear to be more accurate when the mean modified coefficients of conservatism (mean C_m) are corrected to absolute plant frequency; this accounts for an imbalance between the frequency of native or invasive plants relative to uncorrected assessments. Equation 3.1.3 shows the mFQI equation corrected for absolute frequency; as discussed at length in White Paper 1F, this correction applies to mean C_m values rather than species richness values.

Section 4.2- Monitoring Programs Used to Evaluate Frequency-Corrected mFQI

As discussed in Section 3.2, modified FQI values involve projecting species richness and coefficients of conservatism, using subsampling and bootstrapping methods, to estimate these values at a standardized survey site density of 1 site per littoral hectare (as well as the use of modified C_m values). These methods require regressions of granular survey site data to estimate cumulative species richness and mean C_m values at all intervals of survey site densities. Section 3.2 indicates that only the PIRTRAM dataset- among the New York state aquatic plant survey programs discussed in White Paper 1A- possesses granular survey site data required to conduct these analyses.

Section 4 (and White Paper 1F) indicate that these modified FQI (mFQI) values appear to be more accurate when corrected for absolute plant frequency, using Equation 3.1.3

Table 4.3.1- Frequency-Corrected mFQI (and Component) Values in NYS Lakes

Year Lake	Year	Std. Density	pSR	Corr pCm_uf	mFQI_uf
Ballston Lake	2006	48	9.3	-0.14	-0.4
Big Fresh Pond	2006	13	8.5	0.84	2.4
Blydenburgh Lake	2012	40	4.3	-0.17	-0.4
Blydenburgh Lake	2014	40	3.3	-1.06	-1.9
Cazenovia Lake	2010	225	30.9	0.39	2.1
Cazenovia Lake	2011	225	30.8		
Cazenovia Lake	2012	225	29.5		
Cazenovia Lake	2013	225	35.4	0.36	2.1
Cazenovia Lake	2014	225	31.0		
Cazenovia Lake	2015	225	35.4		
Cazenovia Lake	2016	225	33.4	0.33	1.9
Cazenovia Lake	2017	225	31.2		
Cazenovia Lake	2018	225	31.9		
Cazenovia Lake	2019	225	31.4	0.38	2.1
Cazenovia Lake	2020	225	32.2		
Cazenovia Lake	2021	225	30.4		
Chautauqua Lake	2015	2060	31.6		
Chautauqua Lake	2017	2060	28.4		
Chautauqua Lake	2019	2060	30.9		
Chautauqua Lake	2021	2060	37.8		
Collins Lake	2007	5	8.3	-0.05	-0.1
Creamery Pond	2008	4	3.3	-0.13	-0.2
Creamery Pond	2010	4	6.9	0.18	0.5
Creamery Pond	2012	4	5.3	0.18	0.4
Hards Pond	2011	12	7.1	0.79	2.1
Java Lake	2008	21	6.1		
Java Lake	2009	21	6.8		
Java Lake	2010	21	5.2	0.20	0.5
Kinderhook Lake	2006	109	9.2		
Kinderhook Lake	2007	109	8.5	-0.67	-2.0
Lake Luzerne	2009	24	19.4		
Lake Luzerne	2010	24	21.6	0.39	1.8
Lake Rippowam	2008	4	2.4		
Lake Rippowam	2016	4	2.7		
Lake Rippowam	2018	4	2.2		
Lake Rippowam	2020	4	2.4		
Lake Ronkonkoma	2010	21	3.8	-0.75	-1.5
Lake Ronkonkoma	2014	21	3.0	-1.60	-2.8

Table 4.3.1 (cont)- Frequency-Corrected mFQI (and Component) Values in NYS Lakes

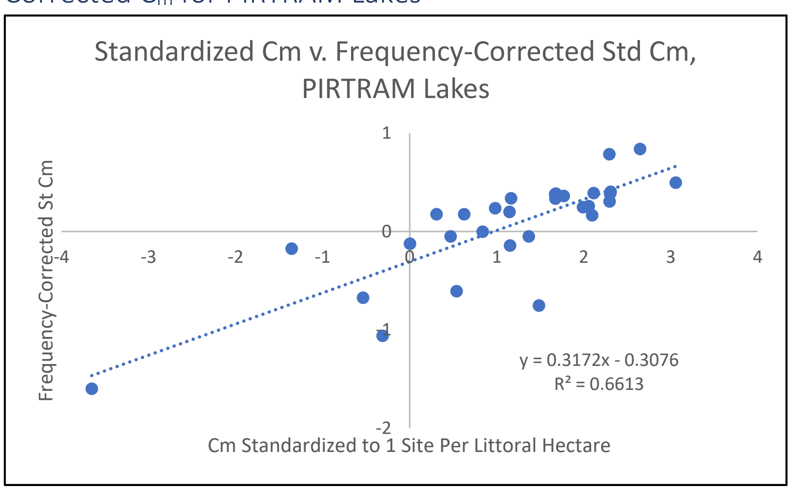
Year Lake	Year	Std. Density	pSR	Corr pCm_uf	mFQI_uf
Lake Waccabuc	2008	20	8.4		
Lake Waccabuc	2010	20	10.2		
Lake Waccabuc	2013	20	10.0		
Lake Waccabuc	2014	20	10.2		
Lake Waccabuc	2015	20	10.7		
Lake Waccabuc	2016	20	10.6		
Lake Waccabuc	2017	20	9.1		
Lake Waccabuc	2019	20	9.7		
Lake Waccabuc	2021	20	10.7		
Lamoka Lake	2006	160	28.0	0.26	1.4
Lamoka Lake	2009	160	26.6	0.40	2.1
Morehouse Lake	2010	35	15.5	0.50	2.0
Oscaleta Lake	2008	8	7.8		
Oscaleta Lake	2016	8	8.3		
Oscaleta Lake	2018	8	8.1		
Oscaleta Lake	2020	8	7.3		
Quaker Lake	2010	64	8.3	0.39	1.1
Saratoga Lake	2010	657	24.4	0.31	1.5
Saratoga Lake	2011	657	24.3		
Saratoga Lake	2012	657	25.9	0.17	0.8
Snyders Lake	2002	15	5.8	-0.61	-1.5
Snyders Lake	2005	15	7.0	0.24	0.6
Snyders Lake	2008	15	8.9	0.00	0.0
Snyders Lake	2011	15	9.2	0.34	1.0
Waneta Lake	2006	170	15.0	-0.05	-0.2
Waneta Lake	2009	170	18.9	0.25	1.1

in this White Paper. As with the use of uncorrected mFQI data discussed in Section 3 above, only the PIRTRAM dataset is used to generate frequency-corrected mFQI values and assessments derived from those values.

Section 4.3- mFQI Values in NYS Lakes- mFQI Corrected for Absolute Frequency

Table 4.3.1 shows the modified FQI with mean C_m values corrected for absolute plant frequency, along with the two primary components- pSR (projected species richness at 1 site per littoral hectare) and mean C_{m_uf} (mean modified coefficient of conservatism corrected for absolute frequency at a survey site density of 1 site per littoral hectare). As discussed at length in White Paper 1F, the analyses summarized in Table 4.3.1 include only a subset of the PIRTRAM lake-years, although all PIRTRAM lakes are represented and lakes surveyed in multiple years include analyses of frequency-corrected FQI for representative years for these lakes.

Figure 4.3.1- Comparison of Uncorrected and Frequency-Corrected C_m for PIRTRAM Lakes



The frequency-corrected mFQI (mFQI_pCm_uf) values ranged from 2.4 in Big Fresh Pond and 2.1 in several lakes (Cazenovia Lake, Hards Lake, and Lamoka Lake) to about -2 in several lakes (Lake Ronkonkoma, Blydenburgh Lake, and Kinderhook Lake. These values and range of values are about as expected given the uncorrected FQI values and the relative abundance of invasive species (low in the lakes with the highest mFQI values, high in the lakes with the lowest mFQI values). As seen in Figure 4.3.1, the correlation between uncorrected and frequency-corrected mFQI values was fairly high (R^2 = 0.66).

In addition, in lakes with multiple years of data, the range of frequency-corrected mFQI values was comparable to the range in uncorrected mFQI values. For example, mFQI values changed little in multiple years of surveying in Cazenovia Lake, whether these values were uncorrected or corrected for plant frequency. The difference between uncorrected mFQI values in response to management in Cazenovia Lake was less than 5%, as discussed in Section 3.3 above. Likewise, the differences in frequency-corrected mFQI in managed and unmanaged years in Cazenovia Lake, as seen in Table 4.3.1, were also less than 5%, well within normal variability. However, as seen below, these relatively small changes in overall mFQI values from year to year at times resulted in changes in aquatic plant community designations for these lakes, most likely consistent with observations on the ground in these lakes.

Section 4.4- Potential Metrics for Evaluating Frequency-Corrected FQI Values in NYS Lakes

Section 3.4 outlined a process for converting the Swink-Wilhelm wetland FQI thresholds to equivalent lake thresholds using the modified uncorrected C value system and projected C_m and species richness values (as components of a modified FQI) to a standardized survey site density of 1 site per littoral hectare.

Table 4.4.1- Frequency-Corrected Mean C_m Values Associated with Aquatic Plant Community Designations (from WP1F, Table 7.2.1)

	Outstanding	Excellent	Fair	Poor	Very Poor
Mean C_m (C_{m_uf})	> 2.4	0.8-2.4	0.3-0.8	0.1-0.3	-0.3 – 0.1 (< 0.1)

While in theory uncorrected mFQI values could be similarly converted to frequency-corrected mFQI values using the same process (through a relationship between uncorrected mean C_m and frequency-corrected mean C_m values per Figure 4.3.1), since these values fall within the same broad range, these machinations may not be necessary. The mFQI equations displayed above (as mFQI equations 3.1.2 and 3.1.3) differ primarily in the application of mean C_m values- these values are

Table 4.4.2- Frequency-Corrected Mean C_m Values and FQI Values Associated with Aquatic Plant Community Designations

	Outstanding	Good	Fair	Poor
Mean C_m	> 2.4	> 0.8	> 0	< 0
mFQI	> 6-7	> 2	> 0	< 0

Table 4.4.3- % PIRTRAM Lake Years in Aquatic Plant Designations using Uncorrected and Frequency Corrected Mean C_m and mFQI

Category	Outstd.	Good-Outstd.	Good	Fair-Good	Fair	Poor-Fair	Poor
Uncorrected	0%	0%	3%	40%	42%	0%	14%
Frequency-corrected	0%	0%	3%	17%	43%	0%	37%

Table 4.4.4- Assessments of Un- and Frequency-Corrected mFQI and Mean C_m Values in NYS Lakes

Year Lake	Year	mFQI_mean C Assess Uncorr	mFQI_mean C Assess Freq Corr
Ballston Lake	2006	Fair	Poor
Big Fresh Pond	2006	Good	Good
Blydenburgh Lake	2012	Poor	Poor
Blydenburgh Lake	2014	Poor	Poor
Cazenovia Lake	2010	Fair-Good	Fair-Good
Cazenovia Lake	2011	Fair-Good	
Cazenovia Lake	2012	Fair-Good	
Cazenovia Lake	2013	Fair-Good	Fair-Good
Cazenovia Lake	2014	Fair-Good	
Cazenovia Lake	2015	Fair-Good	
Cazenovia Lake	2016	Fair-Good	Fair
Cazenovia Lake	2017	Fair-Good	
Cazenovia Lake	2018	Fair-Good	
Cazenovia Lake	2019	Fair-Good	Fair-Good
Cazenovia Lake	2020	Fair-Good	
Cazenovia Lake	2021	Fair-Good	
Chautauqua Lake	2015	Fair-Good	
Chautauqua Lake	2017	Fair-Good	
Chautauqua Lake	2019	Fair-Good	
Chautauqua Lake	2021	Fair-Good	
Collins Lake	2007	Fair	Poor
Creamery Pond	2008	Fair	Poor
Creamery Pond	2010	Fair	Fair
Creamery Pond	2012	Fair	Fair
Hards Pond	2011	Fair-Good	Fair-Good
Java Lake	2008	Fair	
Java Lake	2009	Fair	
Java Lake	2010	Fair	Fair
Kinderhook Lake	2006	Poor	
Kinderhook Lake	2007	Poor	Poor
Lake Luzerne	2009	Fair-Good	
Lake Luzerne	2010	Fair-Good	Fair
Lake Rippowam	2008	Poor	
Lake Rippowam	2016	Poor	
Lake Rippowam	2018	Poor	
Lake Rippowam	2020	Poor	
Lake Ronkonkoma	2010	Fair	Poor
Lake Ronkonkoma	2014	Poor	Poor

uncorrected in equation 3.1.2 and corrected for absolute frequency in equation 3.1.3. An easier way to generate mFQI thresholds is to update Table 3.5.2 with the frequency-corrected mean C_m thresholds for each aquatic plant community designation (using Table 4.4.1 reproduced from Table 7.2.1 in White Paper 1F) and mFQI values that reflect the change in mean C_m values.

The updated criteria used to characterize these aquatic plant communities are provided in Table 4.4.2. As with Table 3.5.2, the aquatic plant community designations from Florida and the Swink-Wilhelm FQI thresholds were compressed into four categories- "outstanding" for the highest quality (reference) aquatic plant communities, "good" for high quality communities, "fair" for those lower quality aquatic plant communities dominated by native plants, and "poor" for those plant communities primarily comprised of invasive plants. When these designations, and associated mFQI and frequency-corrected mean C_m values, are applied to the data summarized in Table 4.3.1, a higher percentage of lakes (lake years) were characterized as having less favorable quality, at least relative to those assessments conducted using uncorrected mean C_m values. Specifically, a high percentage of lakes characterized as "fair to good" when evaluating mFQI and mean C_m uncorrected for plant frequency were instead categorized as (only) "fair" when these calculations were corrected for absolute plant frequency. Likewise, it appears that many of the "fair" lakes were recategorized as "poor". As discussed in White Paper 1F, this shift toward less favorable assessments appears to be consistent with the perceived quality of the aquatic plant communities in these lakes, since most were managed for nuisance or invasive species. The summary assessment (aquatic plant community designations) for the uncorrected and frequency-corrected aquatic plant survey data for these lakes is provided in Table 4.4.3, and the assessments for the individual lake years is provided in Table 4.4.4.

Table 4.4.4 (cont)- Assessments of Un- and Frequency-Corrected mFQI and Mean C_m Values in NYS Lakes

Year Lake	Year	mFQI_mean C Assess Uncorr	mFQI_mean C Assess Freq Corr
Lake Waccabuc	2008	Fair	
Lake Waccabuc	2010	Fair	
Lake Waccabuc	2013	Fair	
Lake Waccabuc	2014	Fair	
Lake Waccabuc	2015	Fair	
Lake Waccabuc	2016	Fair	
Lake Waccabuc	2017	Fair	
Lake Waccabuc	2019	Fair	
Lake Waccabuc	2021	Fair	
Lamoka Lake	2006	Fair-Good	Fair
Lamoka Lake	2009	Fair-Good	Fair-Good
Morehouse Lake	2010	Good	Fair
Oscaleta Lake	2008	Fair	
Oscaleta Lake	2016	Fair	
Oscaleta Lake	2018	Fair	
Oscaleta Lake	2020	Fair	
Quaker Lake	2010	Fair-Good	Fair
Saratoga Lake	2010	Fair-Good	Fair
Saratoga Lake	2011	Fair-Good	
Saratoga Lake	2012	Fair-Good	Fair
Snyders Lake	2002	Fair	Poor
Snyders Lake	2005	Fair	Fair
Snyders Lake	2008	Fair	Poor
Snyders Lake	2011	Fair	Fair
Waneta Lake	2006	Fair	Poor
Waneta Lake	2009	Fair-Good	Fair

These data show a wider range in assessments across the range of surveyed lakes, including slightly greater variability in aquatic plant assessments from year to year in some lakes surveyed in multiple years. There were several lakes in which aquatic plant community designations changed when mean C_m (and therefore mFQI) values were corrected for absolute plant frequency. Every lake for which assessments changed- Ballston Lake, Cazenovia Lake in 2016, Collins Lake, Creamery Pond and Snyders Lake in 2008, Lake Luzerne and Lake Ronkonkoma in 2010, Lamoka Lake in 2006, Quaker Lake in 2010, Saratoga Lake in 2010 and 2012, Snyders Lake in 2002 and 2008, and Waneta Lake in 2006 and 2009, exhibited a degradation in aquatic plant designations. Without exception, and as discussed in White Paper 1F, this is due to a relatively high frequency of nuisance and/or invasive plants in each lake. This intuitively appears to be consistent with the expectation that these lakes (lake years) exhibit less favorable aquatic plant community assessments due to the higher frequency of these less valuable plants. This is yet another indication that aquatic plant community assessments are more accurate as aquatic plant frequency is incorporated into these assessments.

Section 5- mFQI in New York State Lakes- Abundance-Corrected Values

Section 5.1- Background

Section 4.1 referenced the information in White Papers 1D and 1F indicating that modified FQI (mFQI) values appear to be more accurate when the mean modified coefficients of conservatism (mean C_m) are corrected to absolute plant frequency. These corrections are likely to improve even more when these mean C_m values are corrected for absolute plant abundance, since the latter is more likely to reflect the complete extent of aquatic plant communities in lakes, as discussed at length in White Paper 1F. Equation 3.1.4 shows the mFQI equation corrected for absolute abundance; as discussed at length in White Paper 1F, this correction applies to mean C_m values rather than species richness values. However, since both species richness and coefficients of conservatism are components of mFQI, abundance corrections to mean C_m directly affect mFQI values.

Section 5 of this White Paper is dedicated to defining and evaluating mFQI values that are corrected for absolute abundance, with the latter defined in White Paper 1F. While mFQI values uncorrected for aquatic plant frequency or abundance can be compared directly to FQI thresholds cited in Section 3, comparison of these thresholds to frequency- or abundance-corrected mFQI values require some data manipulation. Since abundance-corrected mFQI values exist on a different scale than uncorrected values, and since there is no clear relationship between aquatic plant abundance and floristic quality, assessments of abundance-corrected FQI values require evaluating optimal levels of abundance-corrected mean C_m values, as discussed at length in White Paper 1F. These discussions outline the challenges in defining optimal abundance-corrected mean C_m values due to some uncertainties in "optimal" levels of aquatic plant abundance. Tables 7.3.1 and 7.3.2 provide estimates for the aquatic plant abundance and makeup of the aquatic plant community, respectively, associated with each of the aquatic plant community designations used to assess aquatic plants in White Paper 1F. There remain some (potentially significant) uncertainties in determining whether these estimates accurately reflect the aquatic plant community dynamics and especially abundance levels needed to support these designations, but as discussed in White Paper 1F, these estimates should continue to be modified as additional data and independent assessment tools are considered. It should also be noted that, as discussed below, the resulting abundance-corrected mFQI assessments, using these plant community and abundance estimates, appear to be well aligned to expected assessments for these lakes.

Section 5.2- Monitoring Programs Used to Evaluate Abundance-Corrected mFQI

The information about relevant NYS aquatic plant monitoring programs for evaluating frequency-corrected mFQI values discussed in Section 4.2 also apply to evaluation of abundance-corrected mFQI values. As discussed in Section 4.2, only the PIRTRAM dataset- among the New York state aquatic plant survey programs discussed in White Paper 1A- possesses granular survey site data required to conduct these evaluations.

White Paper 1F indicates that these modified FQI (mFQI) values appear to be more accurate when corrected for absolute plant abundance, using Equation 3.1.4 in this White Paper, recognizing that clear metrics have not been established for linking these modified FQI values to specific aquatic plant designations. White Paper 1F also provides some suggested metrics, based on reasonable expectation of relative abundance for each category of aquatic plant (protected, benign native, nuisance native and invasive) for each potential aquatic plant community designation. As with the use of uncorrected mFQI data discussed in Section 3 above, and with frequency-corrected mFQI data discussed in Section 4 above, only the PIRTRAM dataset is used to generate abundance-corrected mFQI values and assessments derived from those values. None of the other White Paper 1A monitoring programs- the NYS BioSurveys, ALSC, and AWI programs- offer consistent granular survey site data needed to generate assessments for projected modified FQI values and associated projected species richness and mean C_m values (and especially those mFQI values corrected for plant frequency or abundance).

Table 5.3.1- Abundance-Corrected mFQI (and Component) Values in NYS Lakes

Year Lake	Year	Std. Density	pSR	pCm_ua 1/ha	mFQI _ua
Ballston Lake	2006	48	9.3	-10.6	-32.2
Big Fresh Pond	2006	13	8.5	8.7	25.5
Blydenburgh Lake	2012	40	4.3	-86.6	-179.5
Blydenburgh Lake	2014	40	3.3	-60.6	-110.0
Cazenovia Lake	2010	225	30.9	1.9	10.7
Cazenovia Lake	2011	225	30.8	0.9	5.1
Cazenovia Lake	2012	225	29.5	1.7	9.1
Cazenovia Lake	2013	225	35.4	-1.3	-7.5
Cazenovia Lake	2014	225	31.0	0.5	2.6
Cazenovia Lake	2015	225	35.4	-1.3	-7.5
Cazenovia Lake	2016	225	33.4	-3.4	-19.8
Cazenovia Lake	2017	225	31.2	1.9	10.4
Cazenovia Lake	2018	225	31.9	-0.1	-0.7
Cazenovia Lake	2019	225	31.4	2.0	11.3
Cazenovia Lake	2020	225	32.2	0.6	3.3
Cazenovia Lake	2021	225	30.4	1.7	9.4
Chautauqua Lake	2015	2060	31.6	0.1	0.5
Chautauqua Lake	2017	2060	28.4	0.5	2.9
Chautauqua Lake	2019	2060	30.9	0.4	2.1
Chautauqua Lake	2021	2060	37.8	0.1	0.3
Collins Lake	2007	5	8.3	1.8	5.3
Creamery Pond	2008	4	3.3	-45.1	-82.0
Creamery Pond	2010	4	6.9	-27.9	-73.2
Creamery Pond	2012	4	5.3	-24.4	-56.2
Hards Pond	2011	12	7.1	4.5	11.9
Java Lake	2008	21	6.1	3.9	9.7
Java Lake	2009	21	6.8	4.6	11.9
Java Lake	2010	21	5.2	3.1	7.1
Kinderhook Lake	2006	109	9.2	-4.6	-14.1
Kinderhook Lake	2007	109	8.5	-7.8	-22.9
Lake Luzerne	2009	24	19.4	0.8	3.5
Lake Luzerne	2010	24	21.6	1.6	7.4
Lake Rippowam	2008	4	2.4	-0.7	-1.0
Lake Rippowam	2016	4	2.7	-0.6	-1.0
Lake Rippowam	2018	4	2.2	4.7	7.0
Lake Rippowam	2020	4	2.4	-6.3	-9.8
Lake Ronkonkoma	2010	21	3.8	-68.2	-133.0
Lake Ronkonkoma	2014	21	3.0	-25.6	-44.4

Table 5.3.1 (cont)- Abundance-Corrected mFQI (and Component) Values in NYS Lakes

Year Lake	Year	Std. Density	pSR	pCm_ua 1/ha	mFQI _ua
Lake Waccabuc	2008	20	8.4	-0.4	-1.2
Lake Waccabuc	2010	20	10.2	0.2	0.6
Lake Waccabuc	2013	20	10.0	0.2	0.6
Lake Waccabuc	2014	20	10.2	0.4	1.1
Lake Waccabuc	2015	20	10.7	0.4	1.2
Lake Waccabuc	2016	20	10.6	0.1	0.3
Lake Waccabuc	2017	20	9.1	0.5	1.7
Lake Waccabuc	2019	20	9.7	0.5	1.7
Lake Waccabuc	2021	20	10.7	-0.1	-0.4
Lamoka Lake	2006	160	28.0		
Lamoka Lake	2009	160	26.6		
Morehouse Lake	2010	35	15.5	5.2	20.3
Oscaleta Lake	2008	8	7.8	0.9	2.5
Oscaleta Lake	2016	8	8.3	3.0	8.7
Oscaleta Lake	2018	8	8.1	7.6	21.7
Oscaleta Lake	2020	8	7.3	10.9	29.5
Quaker Lake	2010	64	8.3	-1.5	-4.2
Saratoga Lake	2010	657	24.4	7.3	35.8
Saratoga Lake	2011	657	24.3	2.9	14.3
Saratoga Lake	2012	657	25.9	2.9	14.6
Snyders Lake	2002	15	5.8	-11.9	-28.6
Snyders Lake	2005	15	7.0	-3.3	-8.8
Snyders Lake	2008	15	8.9	-5.8	-17.2
Snyders Lake	2011	15	9.2	5.4	16.3
Waneta Lake	2006	170	15.0		
Waneta Lake	2009	170	18.9		

Section 5.3- mFQI Values in NYS Lakes- mFQI Corrected for Absolute Abundance

Table 5.3.1 shows the modified FQI with mean C_m values corrected for absolute plant abundance, along with the two primary components- pSR (projected species richness at a survey site density of 1 site per littoral hectare) and mean C_m (mean modified coefficient of conservatism, also projected to a standardized survey site density of 1 site per littoral hectare). As discussed at length in White Paper 1F, both the expected mean C_m values and relative abundance of each aquatic plant category are evaluated for each aquatic plant community designation. As with frequency-corrections, abundance corrections were not generated for all lake years- for example, not all surveyed years for Chautauqua Lake, Creamery Pond, Snyders Lake, and some other lakes cited in Table 5.3.1, and absolute abundance data are not available for Lamoka Lake and Waneta Lake. However, the lake years evaluated in Table 5.3.1 are a representative cross-section for all surveyed years in each PIRTRAM lake.

The abundance-corrected mFQI values (mFQI_ua in Table 5.3.1) range from less than -25 in several lakes (Ballston Lake, Blydenburgh Lake, Creamery Pond, Lake Ronkonkoma, Snyders Lake) dominated by invasive species to greater than +25 in several lakes (Big Fresh Pond, Oscaleta Lake, Saratoga Lake) dominated by native plant species. The abundance-corrected mFQI values were lower than -100 for Blydenburgh Lake, which exhibited very high abundance of several invasive species. The variability in abundance-corrected mFQI values in some frequently-surveyed lakes was much greater than the variability in frequency-corrected or uncorrected mFQI values in the same lakes. This greater availability allows for a broader range of metrics used to assess floristic quality in these lakes (and therefore a greater likelihood that the differences in metrics for each aquatic plant community designation exceeds the normal variability within each category).

Three lakes can be evaluated to demonstrate this point:

a. While the uncorrected mFQI and frequency-corrected mFQI values in **Cazenovia Lake** changed little from year to year (Table 3.5.3 and 4.5.3), the range of abundance-corrected mFQI values in the lake spanned from -20 in 2016 (when invasive species were close to a majority of all plants) to +11 in 2010 and 2019 (when the abundance of invasive species was less than 8% of the overall aquatic plant community).

   The lowest mFQI values in Cazenovia Lake occurred in 2013, 2015, 2016 and 2018. All of these values corresponded to years in which Cazenovia Lake was not managed for invasive species (by application of aquatic herbicides)- and corresponded to the year before management activities were conducted. Recognizing that the timing of aquatic plant management actions in this lake was influenced by some factors unrelated to the need for management- available funds, permitting considerations, etc.- these data suggest that the need for management was closely aligned to a dip in abundance-corrected mFQI values.

b. Similarly, in **Snyders Lake**, abundance-corrected mFQI values ranged from -29 in 2002 (when the abundance of invasive plants exceeded 98% of all plants in the lake) to +16 in 2011 (when invasive plants were less than 4% of the overall aquatic plant community by abundance). In the latter year, overall plant abundance was not particularly high, leading to overall mFQI levels that were not indicative of “good” floristic quality, but the differences between these years demonstrate the impact of invasive species and need for modified C_m values, and the need for correcting these values for abundance (as seen in Table 3.5.3, the assessments in these two years were comparable when mFQI values were not corrected for either frequency or abundance).

   The lack of annual abundance-corrected mFQI data for Snyders Lake precludes an evaluation of the connection between the timing of management actions and changes in mFQI. However, the lowest mFQI values occurred in 2002 (pre-spot herbicide treatment), 2005 (post-treatment) and 2008 (post-treatment), and the highest mFQI was reported in 2011, several years after treatment. However, though not reported in Table 5.3.1, the lowest abundance-corrected mFQI values were around the time of the 1998 whole lake herbicide treatment, when the lake was a near monoculture of *Myriophyllum spicatum*. This suggests that, unlike Cazenovia Lake, the relationship between aquatic plant management and mFQI was not particularly clean in Snyders Lake, although Snyders Lake had very little aquatic plant diversity, and a high abundance of invasive species, until the lake stabilized several years after the mid-2000s management actions.

c. In **Lake Rippowam**, mFQI values ranged from -10 in 2020 (when invasive species comprised more than 25% of the aquatic plant community, with much of the rest comprised of nuisance species) to 7 in 2018 (when invasive species were less than 6% of all plants by abundance). As seen in Table 3.5.3, the aquatic plant community assessments uncorrected for frequency and abundance for Lake Rippowam were comparable in all surveyed years. Lake Rippowam was not managed for excessive aquatic plants during any of the surveyed years.

Several other lakes cited in Table 5.3.1 exhibited ranges between negative mFQI and positive mFQI values, representing shifts from invasive- to native-plant dominance. As with the “study” lakes cited above, the relationship between abundance-corrected mFQI was not clear in all lakes, although it appears that abundance-corrected mFQI levels were more likely to be positively influenced by management actions in lakes with some invasive species and high diversity than in lakes with low diversity and extensive invasive species growth. In the latter lakes, it appears that management actions can drastically alter mFQI through extensive control of (the only and therefore targeted invasive) plants in lake, with lake and mFQI recovery dependent on highly lake-specific factors. This is discussed further in Section 6 below.

Section 5.4- Potential Metrics for Evaluating Abundance-Corrected FQI Values in NYS Lakes

Table 5.4.1- Abundance-Corrected Mean C_m Values Associated with Modified Aquatic Plant Community Designations

	Good	Fair	Poor
Mean C_m (C_{m_ua})	> 8	> 0	< 0

As discussed at length in White Paper 1F, the Swink-Wilhelm wetland FQI thresholds can be modified using the modified C value (mean C_m) system and granular survey site absolute abundance data to identify abundance-corrected mean C_m values. These were presented in Table 7.3.3 in White Paper 1F and are reproduced here as Table 5.4.1, showing the abundance-corrected mean C_m thresholds associated with specific aquatic plant community designations. In Section 4.4 above, it was noted that modified FQI (mFQI) thresholds to characterize the floristic condition of the aquatic plant community should consider measures of both the quality of the (individual and collective) aquatic plants- the mean C_m value corrected for absolute or unbounded plant abundance (mean C_{m_ua}) - and the quantity of the aquatic plants- the species richness, consistent with FQI calculations that include both components. Both measures, and the resulting mFQI calculation, should also be defined at a standardized survey site density of 1 site per littoral hectare, as discussed at length in White Papers 1D and 1F.

Table 5.4.2- Abundance-Corrected Mean C_m Values and FQI Values Associated with Aquatic Plant Community Designations

	Good	Fair	Poor
Mean C_{m_ua}	> 8	> 0	< 0
mFQI	> 32	> 0	< 0

The resulting mean C_{m_ua} and mFQI thresholds for "good", "fair", and "poor" aquatic plant communities are provided in Table 5.4.2. White Paper 1F outlines the extensive base of assumptions about plant community distributions and expected abundance levels for each aquatic plant type (protected, native, nuisance and invasive) and the merging of multiple aquatic plant community designation (Florida criteria) and vegetative quality (Swink-Wilhelm thresholds) categories and numeric boundaries required to generate Tables 5.4.1 and 5.4.2. Further research and FQI evaluation of more lakes, particularly those with more favorable floristic quality than seen in PIRTRAM lakes, may result in further modifications to these tables and perhaps additional aquatic plant community designations for New York state lakes. For now, the floristic assessments discussed below reflect these "interim" designations.

Table 5.4.3 shows the uncorrected, frequency-corrected and abundance-corrected mFQI assessments for the PIRTRAM lakes (lake years), using the mFQI and mean C_m criteria outlined in Table 3.5.2, Table 4.4.2 and Table 5.4.2, respectively. This Table also includes the pSR score at 5 and 15 sites for each lake year, drawn from White Paper 1D and reproduced from Table 3.5.3 in this White Paper.

Table 5.4.3 - Assessments for Uncorrected, Frequency- and Abundance-Corrected mFQI and Mean C_m Values

Year Lake	Year	mFQI_mC Assess Uncorr	mFQI_mC Assess Freq Corr	mFQI_mC Assess Abund Corr	pSR5_15 Score
Ballston Lake	2006	Fair	Poor	Poor	Fair
Big Fresh Pond	2006	Good	Good	Fair-Good	Fair
Blydenburgh Lake	2012	Poor	Poor	Poor	Poor-Fair
Blydenburgh Lake	2014	Poor	Poor	Poor	Poor-Fair
Cazenovia Lake	2010	Fair-Good	Fair-Good	Fair	Good
Cazenovia Lake	2011	Fair-Good		Fair	Good
Cazenovia Lake	2012	Fair-Good		Fair	Good
Cazenovia Lake	2013	Fair-Good	Fair-Good	Poor	Good
Cazenovia Lake	2014	Fair-Good		Fair	Good
Cazenovia Lake	2015	Fair-Good		Poor	Good
Cazenovia Lake	2016	Fair-Good	Fair	Poor	Good
Cazenovia Lake	2017	Fair-Good		Fair	Good
Cazenovia Lake	2018	Fair-Good		Poor	Good
Cazenovia Lake	2019	Fair-Good	Fair-Good	Fair	Good
Cazenovia Lake	2020	Fair-Good		Fair	Good
Cazenovia Lake	2021	Fair-Good		Fair	Good
Chautauqua Lake	2015	Fair-Good		Fair	Good
Chautauqua Lake	2017	Fair-Good		Fair	Fair
Chautauqua Lake	2019	Fair-Good		Fair	Good
Chautauqua Lake	2021	Fair-Good		Fair	Good
Collins Lake	2007	Fair	Poor	Fair	Good
Creamery Pond	2008	Fair	Poor	Poor	Poor-Fair
Creamery Pond	2010	Fair	Fair	Poor	Fair
Creamery Pond	2012	Fair	Fair	Poor	Fair
Hards Pond	2011	Fair-Good	Fair-Good	Fair	Fair
Java Lake	2008	Fair		Fair	Fair
Java Lake	2009	Fair		Fair	Fair
Java Lake	2010	Fair	Fair	Fair	Fair
Kinderhook Lake	2006	Poor		Poor	Fair
Kinderhook Lake	2007	Poor	Poor	Poor	Fair
Lake Luzerne	2009	Fair-Good		Fair	Good
Lake Luzerne	2010	Fair-Good	Fair	Fair	Good
Lake Rippowam	2008	Poor		Poor	Poor
Lake Rippowam	2016	Poor		Poor	Fair
Lake Rippowam	2018	Poor		Fair	Fair
Lake Rippowam	2020	Poor		Poor	Poor-Fair
Lake Ronkonkoma	2010	Fair	Poor	Poor	Poor
Lake Ronkonkoma	2014	Poor	Poor	Poor	Poor

The pSR scores are generally more favorable than those scores generated from the modified FQI criteria, particularly when those criteria represent modifications to the mean C values for the frequency and abundance of aquatic plants. The majority of the discrepancies between the pSR-based scores and any of the mFQI scores in Table 5.4.3 are due to relatively high species richness but high frequency and/or abundance of AIS or nuisance plants. Examples of this include lakes with a mix of native and invasive plants, such as Cazenovia Lake in most years, Lake Luzerne, and Waneta Lake in 2006, as well as lakes with lower species richness but very high quantities of invasive plants, such as Creamery Pond, Kinderhook Lake, and Snyders Lake in some years. **These data indicate that the interim pSR scoring criteria outlined in White Paper 1D (comparing pSR values at 5 and 15 sites to the expected range of pSR values of existing, non-reference lakes) generates scores that are inconsistent with those generated from the mFQI criteria cited above, particularly when those criteria represent corrections to mean C values due to plant frequency or abundance. Since these corrections are recommended as a**

means to more accurately assess floristic quality, the interim pSR scoring system should be used only discretely, or at least as only a supplemental metric, in evaluating aquatic plant communities.

As discussed above, the potential assessments for uncorrected and frequency-corrected mFQI range from "poor" to "outstanding", since no assumptions are needed to evaluate optimal quantities of plants in these assessments (or in the foundational FQI equations used for these assessments). However, since some assumptions about optimal plant abundance is needed to generate abundance-corrected mFQI values, assessments range only from "poor" to "good". This results in some challenges in comparing uncorrected and frequency-corrected aquatic plant assessments to those corrected for abundance.

Table 5.4.3 (cont) - Assessments for Uncorrected, Frequency- and Abundance-Corrected mFQI Values

Year Lake	Year	mFQI_mC Assess Uncorr	mFQI_mC Assess Freq Corr	mFQI_mC Assess Abund Corr	pSR5_15 Score
Lake Waccabuc	2008	Fair		Poor	Fair
Lake Waccabuc	2010	Fair		Fair	Fair
Lake Waccabuc	2013	Fair		Fair	Fair
Lake Waccabuc	2014	Fair		Fair	Fair
Lake Waccabuc	2015	Fair		Fair	Fair
Lake Waccabuc	2016	Fair		Fair	Fair
Lake Waccabuc	2017	Fair		Fair	Fair
Lake Waccabuc	2019	Fair		Fair	Fair
Lake Waccabuc	2021	Fair		Poor	Fair
Lamoka Lake	2006	Fair-Good	Fair		Good
Lamoka Lake	2009	Fair-Good	Fair-Good		Good
Morehouse Lake	2010	Good	Fair	Fair	Fair-Good
Oscaleta Lake	2008	Fair		Fair	Fair
Oscaleta Lake	2016	Fair		Fair	Fair
Oscaleta Lake	2018	Fair		Fair	Fair
Oscaleta Lake	2020	Fair		Fair-Good	Fair
Quaker Lake	2010	Fair-Good	Fair	Poor	Fair
Saratoga Lake	2010	Fair-Good	Fair	Fair-Good	Good
Saratoga Lake	2011	Fair-Good		Fair	Fair
Saratoga Lake	2012	Fair-Good	Fair	Fair	Fair-Good
Snyders Lake	2002	Fair	Poor	Poor	Fair
Snyders Lake	2005	Fair	Fair	Poor	Fair
Snyders Lake	2008	Fair	Poor	Poor	Fair
Snyders Lake	2011	Fair	Fair	Fair	Fair
Waneta Lake	2006	Fair	Poor		Good
Waneta Lake	2009	Fair-Good	Fair		Fair

That said, it appears that overall aquatic plant assessments were less favorable when corrected for plant abundance than uncorrected or, at least in some lakes, when corrected for plant frequency. In fact, there are no lakes (lake years) presented in Table 5.4.3 that demonstrated improved aquatic plant community assessments as mFQI values were corrected for either plant frequency or plant abundance, although it is likely that other high quality lakes- those with a high abundance of native (protected, or at least non-nuisance) plants would exhibit a high floristic quality even after abundance corrections. Most of the lakes in Table 5.4.3 exhibiting less favorable aquatic plant community assessments as frequency or abundance corrections were applied were subject to aquatic plant management actions or some other significant event altering aquatic plant community dynamics.

White Paper 1G-
Evaluation of Floristic Quality in NYS Lakes

As discussed in White Paper 1F, the aquatic plant community designation of “fair” in these assessments may be overly broad, encompassing both some lakes that could easily be characterized as having “good” quality plant plant communities, as well as those having “poor” quality plant communities. Some of this is a consequence of the decision to anchor the boundary between “fair” and “poor” at a mean C_m value and therefore mFQI value of 0. While equating the boundary between positive and negative mean C_m and mFQI values with a distinction between “fair” and “poor” makes intuitive sense- lakes dominated by invasives are “poor”, while those dominated by natives are “fair”- there may be some lakes with positive mean C_m and mFQI values that are more accurately described as “poor”. Likewise, the boundary between “good” and “fair” might be too stringent, since it is possible that a higher percentage of lakes in Table 5.4.3 could be more accurately characterized as “good” due to high species richness and a relatively high percentage of favorable native plants. The process for defining these boundaries was outlined in White Paper 1F and in this White Paper, and should be reevaluated as more aquatic plant surveys, particularly those from “known” high quality lakes, are reviewed.

Table 5.4.4 shows the percentage of all lake years summarized in Table 5.4.3 that meet the combined mFQI and mean C_m criteria outlined in Table 3.5.4, Table 4.4.4 and Table 5.4.4 for uncorrected mFQI, frequency-corrected mFQI and abundance-corrected mFQI values, respectively. As discussed above, the assessment categories “outstanding” (and “good-outstanding”) were not defined for abundance-corrected mFQI and mean C_m values for reasons described in White Paper 1F. However, Table 5.4.4 shows that about 95% of the PIRTRAM lake years were characterized as having “fair” or “poor” floristic quality when corrected for absolute abundance, compared to 80% of these lakes (lake years) when corrected for absolute frequency, and 56% when uncorrected. At the other end of the spectrum, more than 40% of the lakes were “fair-good” or better, compared to 20% of the frequency-corrected lakes, and only 5% of the abundance-corrected lakes.

It is not known which of these assessments, or those using only mean C_m values (White Paper 1F, Table 7.3.4), more accurately characterize the floristic quality of these lakes. Since most of the lakes included in Table 5.4.3 were either managed for excessive plant growth or were candidates for management, it is expected that most of these lakes would exhibit less favorable aquatic plant community assessments. This suggests, again, that uncorrected assessments- resulting in a high percentage of “fair to good” lakes- are probably not sufficiently accurate. Additional data from other surveyed lakes would help to determine if assessments using frequency- or abundance-corrections more accurately characterize lakes.

Table 5.4.4- % PIRTRAM Lake Years in Aquatic Plant Designations using Uncorrected and Corrected Mean C_m and mFQI Values

Category	Outstd.	Good-Outstd.	Good	Fair-Good	Fair	Poor-Fair	Poor
Uncorrected	0%	0%	3%	40%	42%	0%	14%
Frequency-corrected	0%	0%	3%	17%	43%	0%	37%
Abundance-corrected	Not applicable		0%	5%	57%	0%	38%

However, as discussed in Section 6, the individual modified FQI (mFQI) values, rather than the categorical assessments, may be useful in evaluating changes in individual lakes.

Section 6- Evaluating mFQI (Corrected and Uncorrected) for Individual lakes

Section 6.1- Introduction

The FQI data and FQI scoring systems discussed in Sections 1 through 5 of this White Paper outline a recommended process for defining modified floristic quality indices (mFQI values) to lakes and comparing these values to assessment scores associated with multiple criteria related to wetland FQI values and mean modified coefficients of conservatism (mean C_m). However, while mFQI scores are highly valuable in characterizing one component of aquatic life in lakes, and for determining whether aquatic plant management actions may be warranted, they may have limited utility in evaluating the impact of these management actions and expected annual variability in floristic quality.

These dichotomies are somewhat akin to trophic state classifications. The use of trophic state classifications- “eutrophic”, “mesotrophic” and “oligotrophic” (as well as transitional states between these larger trophic categories) are highly valuable for state lake managers to characterize lake conditions, assess waterbodies and even identify long-term goals for management actions. For example, many state lake management actions on the lake, nearshore, or watershed level are directed to moving lakes from “eutrophic” to “mesotrophic”, or from “mesotrophic” to “oligotrophic”, particularly since these changes in trophic state represent improvement in water quality conditions, enhanced usage for potable water or recreation, public perception, and a reduction in impacts associated with excessive nutrient levels, algae growth and decreased water clarity. However, large scale changes in trophic state, if possible, usually occur over a very long timescale (years to decades), and may not accurately characterize meaningful progress along this continuum. Successful management actions- significant septic reduction, agricultural BMP implementation, curtailing lawn fertilization, etc.- may result in improvements within trophic states (making a lake less “eutrophic”) without actually changing the trophic state, at least within a relatively short timeline.

Likewise, a lake with significantly improving floristic quality could still be characterized as “poor” or “fair” even after implementation of successful actions leading to increases in species richness, improvement in the balance of native to invasive plants (thereby increasing mean C_m values), or optimizing bottom cover. Therefore, changes in the actual mFQI values may be more appropriate for evaluating short-term changes in floristic quality associated with management actions, and long-term changes in floristic conditions attributable to sustainable change and other factors. Timeline mFQI data for lakes surveyed over multiple years can also be used to evaluate the criteria used to establish mFQI/mean C_m scores and further evaluate factors (management, AIS presence and extent, etc.) used to define floristic quality.

Appendix 6.1.2 provides a graphical display of the various FQI calculations, using the modified C_m and New York C_{ny} value system, and corrected for both normalized and unbounded frequency and abundance data, for all PIRTRAM lakes with at least four years of plant survey data. This dataset represents small and large lake littoral areas, lakes located throughout the state, those with high and low nutrient levels, and lakes that have been managed and those without management (as cited in Appendix 6.1.1). These Appendices also includes a summary of the plant survey and management history, and the annual combined mFQI and mean C_m assessments for each lake.

It should be noted that some of the individual summaries in Section 6.2 include time series analyses of modified FQI (mFQI) data comprised of observed species richness (oSR) and mean C_m values calculated at the actual number of survey sites (rather than both values being projected to a standardized survey site density of 1 site per littoral hectare). These projections could not be achieved for these lakes due to a lack of granular survey site data. As discussed in White Papers 1D and 1F, the relationship between oSR and projected species richness (pSR) is fairly strong in most lakes, although the number of survey sites used to generate oSR differ from lake to lake. Likewise, observed mean C_m values are similar to projected mean C_m values, since mean C_m does not necessarily exhibit a steady increase as survey sites are added. However, while the number of survey sites in these lakes is fairly stable, allowing for the use of these modified oSR and mFQI data for intra-lake (time series) comparison, any comparisons between lakes using oSR and observed mean C_m values is not recommended due to these inconsistencies in surveying from lake to lake.

Section 6.2- Individual Lake Summaries

1. **Adirondack Lake**. As discussed in White Paper 1A, Adirondack Lake was not surveyed using traditional PIRTRAM methods, and therefore neither projected nor corrected species richness or mean C_m values can be calculated for the lake using the methods outlined in White Paper 1D, White Paper 1F, and in Sections 3-5 in this White Paper. However, some adjusted values can be calculated and assessed.

   Floristic quality was presumed to have degraded sometime after the 2007 grass carp stocking, generally around 2010, and especially in response to the (in retrospect) unneeded 2012 stocking. Species richness, uncorrected (modified and New York) FQI, and particularly mFQI data corrected for frequency (and to a lesser extent abundance) reflect this degradation in floristic quality. Uncorrected mFQI criteria (mFQI and mean C_m values) generally become less favorable over time, as do those mFQI and mean C_m values corrected for plant frequency ($mFQI_{uf}$). Abundance-corrected mFQI and mean C_m values are consistently cited as “fair”, despite the lack of invasive species- this likely reflects less favorable floristic quality due to significant plant removal by grass carp. These data suggest that lakes without AIS in some lakes are not well characterized by these FQI measures (for example, a higher boundary between “fair” and “poor” assessments would likely characterize this lake as “poor”. However, at least prior to the lake being denuded by carp overgrazing, somewhat more favorable FQI scores may have been appropriate. These data also suggest that grass carp stocking, at least in Adirondack Lake, might not be a *defacto* measure of poor floristic quality, although the multiple stockings likely led to a degradation in floristic quality around 2008-2010. **The data presented in Appendix 6.1.2 suggest that**

all measures of floristic quality- species richness, mean C_m values, and mFQI- can be used to characterize changes in Adirondack Lake in response to grass carp stocking, although the combined (mFQI and mean C_m) scoring criteria might not accurately characterize the lake. Specifically, the Appendix 6.1 plots suggest that a "poor" assessment might be warranted, requiring a higher boundary between "fair" and "poor" in Tables 3.5.4, 4.4.4 and 5.4.4.

2. **Cayuga Lake**. An evaluation of the Cayuga Lake south shelf dataset might be impacted by large variations in the number of sampling sites during the study years. In addition, no granular survey site data are available, so the mFQI values and assessments discussed below represent observed, not projected, values (and therefore direct comparisons to criteria cited in this White Paper should be considered only cautiously). Although the south shelf had some very small scale direct and indirect treatments, it is presumed that this (part of the) lake is best characterized as "untreated". The species richness and uncorrected FQI values show little difference from 2012 to 2019 (Appendix 6.1), but the FQI measures corrected for frequency or abundance show stability or a decline from 2012 to the mid-2010s, then steadily improve through 2019. This appears to be due primarily to first an increase in *Nitellopsis obtusa* and then a decrease in abundance (and to a lesser extent frequency) in all invasive plants. These modified FQI values, whether corrected for plant frequency or plant abundance, generally follow the FQI scores cited in Appendix 6.1.2, with overall floristic quality characterized as "poor", with some minor improvements after the mid-2010s, due primarily to the high density of invasive plants throughout the survey period.

   Although some measures of aquatic plant community health, such as species richness or uncorrected FQI values, indicate favorable conditions, it is likely that less favorable "scores", as seen using these FQI scoring measures, are probably a stronger indication of floristic quality on the south shelf of Cayuga Lake. These data suggest that **modified FQI values corrected for plant abundance (mFQI_na and mFQI_ua), and to a lesser extent for plant frequency mFQI_nf and mFQI_uf) appear to be the best measure of floristic quality in Cayuga Lake.**

3. **Cazenovia Lake**. The lake was treated periodically over the last decade, with the staggered schedule at least in part the result of the need to raise funds and to allow some refugia zones. Partial lake or staggered treatments might compromise the ability to evaluate FQIs in response to treatments, since post-treatment and pre-treatment years may overlap. The species richness and uncorrected FQIs do not show clear differences between treated and untreated years, and the relationship between observed species richness (oSR) and projected species richness (pSR) is fairly stable, consistent with a strong consistency in sampling effort (number of surveyed sites) in all years.

   However, dominance by AIS appears to decrease in response to treatment, with some recovery of AIS (and resulting decrease in mFQI) in the following year(s)), leading to an increase in corrected (for frequency and especially abundance) mFQI values in the treatment year. This is particularly apparent with the significant increase in abundance-corrected mFQI values in the year of treatment (noting that the treatments occur several months before surveys are conducted, presumably allowing time for the targeted plants to be controlled), and a significant decrease in mFQI in the year after treatment. **This indicates that the plant abundance FQI measures appear to be the best measure of floristic quality in Cazenovia Lake.**

4. **Chautauqua Lake**. Even more so than Cayuga Lake or Cazenovia Lake, the evaluation of FQIs in Chautauqua Lake may be compromised by significant annual differences in the number and perhaps location of sampling sites, and by the relationship between treatment zones and sampling sites. This may explain why all FQI measures- uncorrected or corrected for frequency or abundance- vary significantly from year to year. In addition, granular survey site data are only available for 2015, 2017, 2019 and 2021, so the balance of the data and assessments shown in Appendix 6.1 represent unprojected values and should be evaluated against this criteria with some caution.

   Species richness and uncorrected FQI values are similar and vary closely with each other from 2003 to the present (Appendix 6.1), indicating similarities in uncorrected mean C_m values. The lowest FQI (corrected or uncorrected) was generally found in 2012 and 2013, due to the highest quantity of invasive species, and increased by most FQI measures in each year since from 2013 to 2021. Differences in mFQI scores generally ranged from fair to poor, usually dependent on the extent of invasive weed growth. Projected mFQI values shown in the Appendix 6.1.2 plots, derived from granular survey site data and projected to a standardized survey site density of 1 site per littoral hectare, were probably similar to unprojected values when differences in (projected versus observed) species richness were considered. Unfortunately, the lowest observed mFQI values could not be evaluated as projected mFQI values due to the lack of granular survey site data- the abundance-corrected mFQI assessments in 2015, 2017, 2019, and 2021 (not shown above) were all considered to be “fair”, consistent with the assessments in these years generated from unprojected data. Moreover, these plots suggest that observed and projected mFQI values were similar. These data **suggest that mFQI based on abundance data appear to be the best measures of floristic quality in Chautauqua Lake.**

5. **Creamery Pond**. Floristic quality has likely been persistently degraded in Creamery Pond due to shallow water, the eutrophic conditions and presence of high quantities of both invasive (*Hydrilla verticillata*) and poor-quality native (*Ceratophyllum demersum* and *Wolffia sp.)* plants. Unfortunately, surveys were only conducted after *Hydrilla* was reported in 2008. In general, species richness and uncorrected mFQI values were closely aligned. Uncorrected mFQI calculations show a steady increase in floristic quality (and species richness) in response to the herbicide treatments and grass carp stocking, but highly variable mFQIs over this period when corrected for frequency or abundance (Appendix 6.1.2). The very high abundance-corrected mFQI values in 2009 were due to very high densities of nuisance native plants, a “finding” that appears to be inconsistent with observations of

excessive plant growth (although the mFQI scoring system discussed in Section 5 above would likely characterize the projected mFQI and mean C_m values for the lake as "fair-good", an assessment that is probably closer to reality). There are clear distinctions in corrected FQI between Poor and Fair years using the modified C value/FQI system. **The data in Appendix 6.1.1 and 6.1.2 suggests that the modified C value system corrected for abundance data (mFQI_na and mFQI_ua) represents the best measures of floristic quality in Creamery Pond, notwithstanding the likely (somewhat) inaccurate assessment in 2009.**

6. **Donahue Pond**. Only summary data are available for this lake (no granular survey site data), so mFQI, mean C_m and species richness values are unprojected and only peripherally addressed using the criteria outlined in this White Paper. As with several other lakes, uncorrected FQI values show less annual variability in floristic quality than mFQI measurements corrected for frequency or abundance (Appendix 6.1). Abundance data generally show a steady decrease in floristic quality, despite herbicide treatments in most of these years, with very low mFQI values in 2010 corresponding to more than 80% of the plant community comprised of *Cabomba caroliniana* (no more than 35% in any other year). Appendix 6.1.2 suggests that **abundance data most closely match the FQI Criteria scores and are therefore likely the best measures of floristic quality in Donahue Pond.**

7. **Glen Lake**. Only summary data are available for this lake (no granular survey site data), so mFQI, mean C_m and species richness values are unprojected and only peripherally addressed using the criteria outlined in this White Paper. The lake was treated with herbicides in 2009 and 2010, and uncorrected FQI values increased slightly over this period, consistent with an increase in species richness (higher than in other similarly sized lakes). Changes in uncorrected mFQI were not closely tied to management. However, modified FQIs corrected with frequency and abundance data, perhaps lagged by a year or two, were consistent with changes in floristic quality due to management actions (resulting in AIS presence but not dominance), as seen in Appendix 6.1.2. **These data suggest that the modified C value system corrected for abundance data represents the best measures of floristic quality in Glen Lake, although frequency data may also generate results that accurately characterize the lake.**

8. **Lake Rippowam**. Granular survey site data show relatively stable projected species richness and (low) uncorrected mFQI- the latter due to the presence of *Myriophyllum spicatum*. This plant comprised only 6% of the aquatic plant community (by abundance) in 2010, but at least 19% of the aquatic plant community in other years (the impact of plant frequency was not evaluated in this lake, although Eurasian watermilfoil was the most frequently reported plant in the lake. However, due to low species richness in all years, combined modified mFQI and mean C_m assessments were relatively unfavorable, even in years when AIS were a small part of the aquatic plant community. The abundance-corrected assessment in 2018 was more favorable than the frequency-corrected assessments, due to the high abundance of nuisance native plants- this is discussed further below. **The plots in**

Appendix 6.1.2 suggest that mFQI and mean C_m corrected for abundance likely most accurately characterize aquatic plant communities in Lake Rippowam, although no frequency-corrected data are available for comparison.

9. **Lake Ronkonkoma**. This lake was a candidate for herbicide treatment or grass carp stocking due to high levels of *Hydrilla verticillata,* and risk of spread out of the lake due to the public boat launch site. However, pre-infestation surveys identified few plants in the lake (suggesting that the loss of habitat associated with *Hydrilla* control might compromise the lake fishery). In addition, local (county) approvals for herbicide use were onerous, and grass carp stocking was not strongly supported by local and state agencies. Appendix 6.1.2 shows a mostly steady relationship between observed and projected species richness, and observed and projected uncorrected and frequency-corrected mFQI. This appendix also shows a steady decrease in uncorrected mFQI due to the rapid increase in *Hydrilla* after introduction in the late 2000s, with small temporary increases in mFQI still indicative of poor conditions. The change in floristic quality was even more apparent when evaluating FQIs corrected for plant frequency or abundance. FQI Scores were consistently low, and the differences between observed and predicted abundance-corrected mFQI were likely normal variability in lakes with very poor floristic quality. **Therefore, any of the FQI measures could be successfully used to characterize floristic quality in Lake Ronkonkoma, although the modified FQIs corrected for frequency or abundance likely represent the best measure of floristic quality in the lake**.

10. **Lake Waccabuc**. Although this lake was surveyed nearly every year from 2008 to 2021, mFQI and mean C_m evaluations were limited to representative years in this range. Small patches of *Egeria densa* were hand harvested in the lake, but the vast majority of the lake was unmanaged during this time. This is reflected in very stable species richness and uncorrected mFQI values with varied only slightly over the decade of surveys. However, corrected FQI values- modified abundance data- exhibited strong variability from year to year (Appendix 6.1). The lowest abundance-corrected mFQI occurred in 2008 and 2021, when *Myriophyllum spicatum* comprised more than 25% of the aquatic plant community (by abundance, 2008) or was mixed with many nuisance native plants (2021); Eurasian watermilfoil was consistently the most frequently observed plant in the lake). **The data in Appendix 6.1.2 suggests that either frequency- or abundance-corrections to mFQI and mean C_m may adequately characterize the floristic quality of Lake Waccabuc.**

11. **Lamoka Lake**. Abundance data are not available for this lake. Unprojected assessments were conducted for all survey years, but projected assessments, using criteria outlined in White Paper 1G above, were limited to 2010 and 2014. Lamoka Lake has been periodically treated with herbicides, though not during the survey period included in PIRTRAM and not as often as Waneta Lake. The uncorrected modified FQIs for the lake increased over time, and the differences between observed and projected species richness were also fairly small and consistent over this survey period, most likely due to consistency in survey site density. mFQI values corrected for plant frequency increased significantly over this period, and

increased in the final survey year despite slight decrease in species richness. This suggests that overall floristic quality in the lake improved over this period. **The data in Appendix 6.1.2 indicate that FQI values corrected for frequency data appear to most accurately characterize floristic quality in Lamoka Lake, although the lack of abundance data precludes evaluating FQIs corrected for plant abundance.**

12. **Monroe Mills Pond**. This lake was treated in each of the survey years, with little variability in species richness and inconsistent variability in uncorrected FQI over this period- note that all species richness, mean C_m and mFQI values are unprojected due to the lack of granular survey site data. mFQI values corrected for frequency and abundance were higher in 2009 and 2010, consistent with the lack of any invasive species among the four most frequently reported or abundant plants in the lake in those two years. As a result, the combined mFQI and mean C_m assessment scores presented in Appendix 6.1.2 indicate mostly favorable conditions, particularly in 2009 and 2010. The Appendix 6.1.2 data suggests that the **modified FQIs corrected for frequency and abundance (mFQI_uf and mFQI_ua, respectively) appear to be the most accurate measures of floristic quality**.

13. **Oscaleta Lake**. Granular survey site data show relatively stable projected species richness, with decreases in uncorrected mFQI consistent with slight decreases in species richness. The data in Appendix 6.1.2 show increasing abundance-corrected mFQI- due to the relative decrease in *Myriophyllum spicatum*, although Eurasian watermilfoil was the most frequently reported plant in the lake. However, due to moderate species richness in all years, the combined modified mFQI and mean C_m assessments ranged from fair to good, particularly when abundance-corrected data were used. The most favorable assessments occurred when the abundance of Eurasian watermilfoil was lowest, although the more favorable abundance-corrected assessments in 2020 corresponded to a high abundance of nuisance native plants (nearly 70% of all plants). **The plots in Appendix 6.1.2 suggest that mFQI and mean C_m corrected for abundance likely most accurately characterize aquatic plant communities in Oscaleta Lake, although no frequency-corrected data are available for comparison.**

14. **Snyders Lake**. A 1997 herbicide treatment to address essentially a monoculture of *Myriophyllum spicatum* led to a short-term barren lake bottom, with *Najas minor* the pioneering re-colonizer. A slow recovery occurred after a large partial lake contact herbicide treatment in 2003 was instituted primarily to address localized heavy *N. minor* beds. Species richness and uncorrected FQIs varied between treatments and steadily increased from 2004 to 2009, eventually decreasing slightly. These changes were apparent when evaluating all FQI permutations, including those corrected for frequency or abundance (Appendix 6.1.2), although both of those metrics improved after 2002 rather than 2004, with some variability from year to year. There appeared to be little difference between observed and projected FQI measures in most years, and assessments were comparable using either data set. Most of the surveyed years with positive mFQI corresponded to aquatic plant communities

dominated by (small amounts of) native plants. **Any of the FQI measures could be successfully used to characterize floristic quality in Snyders Lake.**

15. **Waneta Lake**. Abundance data are not available for this lake. Waneta Lake was treated with herbicides during some of the PIRTRAM survey years, providing an opportunity to evaluate treatment impacts. The modified FQIs for the lake increased from 2002 to 2009, but frequency-corrected mFQIs decreased for the first part of this period. The differences between observed and projected species richness and mFQI were small and fairly consistent over this period, most likely due to consistency in survey site density. The 2008 herbicide treatment may have resulted in an increase in species richness and mFQI values, although these differences may have been lagged a year and improved mFQI and species richness may have already been underway at that time. **The data in Appendix 6.1.2 indicate that mFQI values corrected for frequency (mFQI_uf) data appear to most accurately characterize floristic quality in Waneta Lake.**

A summary of the long-term plant survey data for these 15 lakes indicate that **the modified FQI system corrected with abundance data should be used to characterize floristic quality in New York state lakes, although for these lakes, particularly those with only frequency data, mFQIs corrected for plant frequency also appear to accurately evaluate floristic quality. This is consistent with the findings in Sections 2 through 5 of this White Paper. These data do not show a clear improvement when mFQI values are corrected for absolute frequency or abundance, at least for most lakes, so it is recommended that mFQI values be corrected for relative plant abundance, with corrections for relative plant frequency acceptable when plant abundance data are not available.**

Nearly all of the multi-year lakes summarized in Appendix 6.1 and Appendix 6.1.2 exhibited either stable or degrading aquatic plant community assessments as mFQI and mean C_m were corrected for plant frequency and abundance. However, a few of these lakes exhibited an improvement in these assessments when mFQI and mean C_m were corrected for plant abundance. These “exceptions” reflect a quirk in the mFQI calculations from Equation 3.1.4. This equation appropriately characterizes lakes with high quantities of beneficial aquatic plants (C_m = 3 or 5) as having high floristic quality, and lakes with high quantities of invasive plants (C_m < 0) as having poor floristic quality. However, lakes with a very high abundance of nuisance native plants (C_m = 1) can exhibit high mean C_m and mFQI values when these values are corrected for plant abundance, especially when other plants are found in much lower quantities.

Table 6.2.1- % Abundance in Nuisance Plants in Surveyed Lakes with Assessment Outliers

Lake	Year	Frequency-Corrected Assessment	Abundance-Corrected Assessment	% Abundance Nuisance Plants
Collins Lake	2007	Poor	Fair	54%
Creamery Pond	2009	Fair	Good	68%
Lake Rippowam	2018	Poor	Fair	94%
Oscaleta Lake	2020	Fair	Fair-Good	68%

Table 6.2.1 shows four lakes for which abundance-corrected assessments were more favorable than frequency-corrected

Table 6.2.2- Abundance-Corrected Mean C_m Values and FQI Values Associated with Aquatic Plant Community Designations

	Good	Fair	Poor
Mean C_{m_ua}	> 8	> 0	< 0
mFQI	> 32	> 0	< 0
% Abund. Nuisance	NA	<50%	>50%

assessments for which the abundance of nuisance plants was very high. All of these lakes are very small (littoral areas < 8 hectares), but the four lake-years cited in Table 6.2.1 represent only the small portion of the small littoral area lakes for which abundance-corrected mFQIs are not well aligned with frequency-corrected mFQI values. However, the four lake years in Table 6.2.1 can be compared to the rest of the lakes cited in Table 5.4.3, for which the average % abundance of nuisance plants was 27% (with most values below 20%). **These data suggest that Table 5.4.2 could be updated to include an additional criterion associated with the abundance-corrected percentage of nuisance species (C_m = 1).** This wouldn't apply to "Good" lakes to avoid penalizing lakes with relatively low overall plant abundance but high species richness that might have a high percentage of nuisance plants, but instead could be an additional criteria to evaluate the difference between "fair" and "poor" lakes. This potential update is shown in Table 6.2.2. **However, since there are so few exceptions to the criteria outlined in Table 5.4.2, the updated Table 6.2.2 criteria are not recommended unless far more lakes are seen to exhibit much more favorable than expected abundance-corrected mFQI and mean C_m assessments.**

Section 7- Comparison of mFQI and Mean C_m Metrics

Note that the same discussion is (mostly) reproduced in White Paper 1F.

Section 7.1- Summary of Mean C_m metrics

White Paper 1F identifies potential metrics for characterizing the condition of the aquatic plant community in lakes using various combinations of coefficients of conservatism (specifically, mean C values developed from a proposed modified C value system, or mean C_m values). Each of the proposed metrics have some advantages over other potential metrics; for example, uncorrected mean C_m values can be generated from nearly every aquatic plant survey dataset, particularly those reported only with summary data (cumulative numbers of identified plant species), with a low to moderate level of accuracy. Those mean C_m values corrected for aquatic plant frequency and abundance, if generated from summary data (number or percentages of sites with each plant, particularly if subdivided by relative plant abundance categories), improve the accuracy of the assessments. However, given the high variability in survey site densities used in each aquatic plant survey program, a standardized survey site density of 1 site per littoral hectare was recommended for computing these mean C_m values. When granular survey site data- the occurrence and/or abundance of each plant at each site- were available, the accuracy of the mean C_m values projected to this standardized survey site density improved even more, with the most accurate assessments corresponding to frequency- and abundance-corrected mean C_m values. Representative mean C_m values can then be calculated for aquatic plant community designations- "outstanding" through "poor"- developed by botanists in the state of Florida.

A summary of the abundance-corrected mean C_m values is provided in Table 7.1.1. This table was modified slightly from Table 7.3.3 in White Paper 1F to reflect the decision to anchor the boundary between "fair" and "poor" at a mean C_{m_ua} value of 0, reflecting the expectation that lakes dominated by native plants (mean $C_m > 0$) exhibit fair or good aquatic plant conditions, while those dominated by invasive plants (mean $C_m < 0$) exhibit poor conditions (the possibility of some "poor" lakes with positive mean C_m values is discussed in White Paper 1F). The resulting aquatic plant community designations for the PIRTRAM lakes are identified in Table 7.1.2 (drawn from Table 7.3.4 in White Paper 1F), indicating the lakes using C_{m_ua} meeting the "good" (including "outstanding"), "fair" and "poor" criteria in Table 7.1.1 (the comparable assessments for uncorrected mean C_m values and frequency-corrected mean C_m values (C_{m_uf}) are also provided). These data indicate that, using abundance-corrected mean C_{m_ua} values, about 40% of all the PIRTRAM lakes would be characterized as "poor", about 50% would be characterized as "fair", and fewer than 10% would be characterized as "good". While it is recognized that the PIRTRAM dataset used in Table 7.1.2 would be expected to yield a high percentage of fair to poor lakes, since these lakes were mostly either subject to management actions or were acknowledged to "need" management of invasive species, it is not clear if these assessments accurately represent the floristic quality of these lakes. In White Paper 1F, it is noted that these assessments could improve if species richness and (by extension) floristic quality indices were added to the assessments. These are presented below.

Table 7.1.1- Abundance-Corrected Mean C_m Values Associated with Modified Aquatic Plant Community Designations

	Good	Fair	Poor
Mean C_m (C_{m_ua})	> 8	> 0	< 0

Table 7.1.2- % Lakes Meeting Various C_m Criteria

	C_m Evaluation using Criteria Above				
	Outst.	Exc.	Fair	Poor	V.Poor
% Lakes Using C_{m_ua}	5% (Good)		53%	42% (Poor)	
% Lakes Using C_{m_uf}	0%	6%	35%	12%	47%
% Lakes Using C_m	0%	10%	48%	24%	19%

Legend- Outst = Outstanding, Exc = Excellent; Cm = modified C value system

Section 7.2- Summary of mFQI (and Mean C_m) metrics

Sections 1 through 6 of this White Paper outlines a process by which modified floristic quality indices (mFQIs) are calculated from mean Cm values (using a modified C value system) and species richness values projected from a standardized survey site density of 1 site per littoral hectare. As discussed at length in Sections 4 through 6 of this White Paper, the resulting mFQI scores assigned to ranges of mFQI values appeared to improve (become more accurate in characterizing aquatic plant communities) as these mFQI values (and associated mean C_m values) were corrected for aquatic

Table 7.2.1- Abundance-Corrected Mean C_m Values and mFQI Values Associated with Aquatic Plant Community Designations

	Good	Fair	Poor
Mean C_{m_ua}	> 8	> 0	< 0
mFQI	> 32	> 0	< 0

Table 7.2.2- % Lake Years in Aquatic Plant Designations Using Projected SR (via mFQI) and Uncorrected and Corrected Mean C_m

Category	Outstd.	Good-Outstd.	Good	Fair-Good	Fair	Poor-Fair	Poor
Uncorrected	0%	0%	3%	40%	42%	0%	14%
Frequency-corrected	0%	0%	3%	17%	43%	0%	37%
Abundance-corrected	Not applicable		0%	5%	57%	0%	38%

plant frequency and for aquatic plant abundance. However, the accuracy of these assessments may improve even more when additional criteria are established for the quality of the aquatic plant community, requiring lakes with the most favorable plant communities designations to exhibit both a high species richness AND high quality plants within that community. White Paper 1D indicates that single species richness thresholds cannot be established without penalizing small lakes (which by nature have lower species richness), and even species richness thresholds anchored to littoral area sizes cannot be developed in the absence of reference conditions or other measures of what "should" be the species richness in each littoral size interval (and reference condition data have not been collected in New York state). Therefore, criteria associated with species richness will likely need to use mFQI as a surrogate measure.

Table 7.2.1, drawn from Table 5.4.2 in this White Paper, shows the mFQI and mean C_m thresholds for each of the aquatic plant community designations, indicating the differences between "good", "fair" and "poor" lakes. Both criteria need to be met for a lake to be included in each characterization. Table 7.2.2, drawn from Table 5.4.4 in this White Paper, shows the percentage of PIRTRAM lakes (lake years) meeting the Table 7.2.1 criteria (as well as the uncorrected and frequency-corrected mean C_m and mFQI values).

Section 7.3- Comparison of Mean C_m and Combined mFQI -Mean C_m) Metrics

Since there are no independent evaluations of aquatic plant communities for comparison with either the mean C_m only (Table 7.1.1) or the combined mean C_m – mFQI criteria (Table 7.2.1), it is not clear if one method is more likely to yield greater accuracy in aquatic plant community assessments. For the majority of the lakes evaluated by these methods, assessments were identical- for example, most lakes with poor or fair floristic quality were identified by either method as poor or fair, respectively. In fact, there were only three lake years- Big Fresh Pond in 2006, Oscaleta Lake in 2010, and Saratoga Lake in 2010- for which the two assessment methods summarized above yielded different aquatic plant community assessments. In addition, there were nine other lake years for which the frequency-corrected assessments were different than the abundance-corrected assessments using either the combined (mFQI and mean C_m) or mean C_m – only methods. These differing assessments are shown in Table 7.3.1, and each case is discussed below to evaluate if either method is more closely aligned to assessments drawn from conditions in the field (i.e. intuitively evaluated). It should be noted that none of the 120+ lake years exhibited wide variations in assessments based on these methods- for example, no lakes were identified as "good" using one method and "poor" using the other method.

Table 7.3.1- Comparison of mFQI and Mean C_m Assessment Methods

Lake	Year	Combined Freq Assess	Combined Abund Assess	Abund-Corr Mean Cm Assess
Big Fresh Pond	2006	Good	Fair-Good	Good
Cazenovia Lake	2010	Fair-Good	Fair	Fair
Cazenovia Lake	2013	Fair-Good	Poor	Poor
Cazenovia Lake	2019	Fair-Good	Fair	Fair
Collins Lake	2007	Poor	Fair	Fair
Creamery Pond	2010	Fair	Poor	Poor
Creamery Pond	2012	Fair	Poor	Poor
Hards Pond	2011	Fair-Good	Fair	Fair
Oscaleta Lake	2020		Fair-Good	Good
Quaker Lake	2010	Fair	Poor	Poor
Saratoga Lake	2010	Fair	Fair-Good	Good
Snyders Lake	2005	Fair	Poor	Poor

- *Big Fresh Pond 2006*. The combined mFQI-mean C_m evaluations identified the lake as "fair-good", indicating that the mFQI only assessment for the lake was "fair". However, the abundance-corrected mean C_m and frequency-corrected assessments both identified the lake as "good". This lake was dominated by native plant species, and the aquatic plant community was likely supportive of multiple ecosystem functions. The abundance-corrected mFQI value for the lake was about 26, just below the "good" threshold of 32, and indicative of a lake with fairly high floristic quality. **In this case, the combined criteria suggests that the lake falls between two clean characterizations, an assessment that appears to accurately represent aquatic plant community conditions in the lake.**
- *Cazenovia Lake 2010 and 2019*. In both years, the frequency-corrected combined assessment falls between "fair" and "good", while the abundance-corrected combined assessment is "fair". The difference between these assessments reflects very small differences between the frequency-corrected mFQI values in these two years (2.1 in both years) and the boundary between "fair" and "good" (= 2.0). It is likely that these very small differences are within the normal range of variability, and do not indicate a real difference between these assessments. **Therefore, either the combined mFQI-mean C_m metric or**

the single mean C_m metrics (resulting in identical assessments) accurately characterize Cazenovia Lake in these two years.

- *Cazenovia Lake 2013*. The frequency-corrected combined assessment in 2013 is nearly identical to the assessments cited above (mFQI = 2.1 in 2013 as well), although the abundance-corrected combined assessment was "poor", indicating both poor quality plants and a low mFQI. The difference between these assessments reflects a very high percentage by abundance of *Myriophyllum spicatum*l (nearly 40% of the aquatic plant community) driving the abundance-corrected mFQI and mean C_m values below zero, indicating poor floristic quality. **The combined mFQI-mean C_m metric appears to be accurate for this lake-year, although as with Cazenovia Lake in 2010 and 2013, both the combined and singular metrics offered the same assessment.**
- *Collins Lake 2007*. The difference between the frequency-corrected assessment ("poor") and abundance-corrected assessment ("fair") reflects the high frequency of two invasive species (*Potamogeton crispus* and *Najas minor*) but relatively high abundance of two native plants (*Nymphaea* sp. and *Potamogeton zosteriformis*). These assessments appear to accurately characterize floristic quality, and **either the combined or singular metrics correctly identify the abundance-corrected mFQI values as indicative of "fair" lakes.**
- *Creamery Pond 2010 and 2012*. The abundance-corrected mFQI values for this lake in both years are typical of "poor" quality lakes, while the frequency-corrected mFQI values tag the lake as "fair". The difference between these assessments indicate a high percent frequency of native plants (including *Wolffia* sp. and *Ceratophyllum demersum*) in many years, but a high abundance of invasive plants (particularly *Hydrilla verticillata*) at the same time. **These assessments appear to be accurate whether combined or singular abundance-corrected metrics are used**.
- *Hards Pond 2011*. Frequency-corrected assessments are slightly more favorable than abundance-corrected assessments in this lake in 2011, regardless of the abundance-corrected metric used. This reflects a very high frequency of beneficial native plants (*Elodea canadensis*) but slightly higher abundances of nuisance native plants (*Ceratophyllum demersum*). In addition, as with Cazenovia Lake, the frequency-corrected mFQI value of 2.1 is very close the boundary between "good" and "fair" (= 2.0), suggesting more "fair" than "good" conditions. **These assessments are likely accurate whether the combined mFQI-mean C_m metrics or the singular mean C_m metric is used.**
- *Oscaleta Lake 2020*. The abundance-corrected mFQI values in Oscaleta Lake in 2020 suggest that the lake could be characterized as having "fair" floristic quality, while the abundance-corrected mean C_m values are more indicative of "good" lakes. The latter was due to high levels of *Brasenia schreberi* and *Nymphaea*, two native plants, while the lower mFQI values were due to relatively low species richness. Given that both components of species richness (representing the quantity of plants) and the abundance-corrected mean C_m values (representing the abundance of the quality of plants), **these assessments are likely more accurate when the combined (abundance-corrected) mFQI-mean C_m metrics are used**.
- *Quaker Lake 2010.* The frequency-corrected assessments for the lake were more favorable ("fair") than the poor assessments corrected for plant abundance, whether the combined

mFQI-mean C_m or singular mean C_m metrics were used. This difference reflects the high abundance of *Myriophyllum spicatum* in the lake (more than 45% of all plants) even though a native plant (*Ceratophyllum demersum*) was the most frequently-occurring plant. **This suggests that either the combined (abundance-corrected) mFQI-mean C_m metrics or the singular mean C_m metrics are used.**

- *Saratoga Lake 2010.* There was some variability in aquatic plant community assessments in Saratoga Lake in 2010 depending on whether frequency-corrected assessments ("fair"), abundance-corrected assessments using combined criteria ("fair-good") or abundance-corrected mean C_m values only ("good"). The more favorable abundance-corrected mean C_m values reflect a low abundance of invasive plants (about 5%) and a slightly higher frequency of these plants (about 10%). However, species richness was fairly high, and the abundance-corrected mean C_m values (= 7.3) were only slightly below the "good" threshold outlined in Table 7.2.1. As such, **it appears that the combined abundance-corrected mFQI-mean C_m criteria accurately represent the floristic quality of these lakes**.
- *Snyders Lake 2005.* As with Quaker Lake in 2010, the frequency-corrected assessments for the lake were more favorable ("fair") than the poor assessments corrected for plant abundance, whether the combined mFQI-mean Cm or singular mean C_m metrics were used. The disparity between the frequency-corrected and abundance-corrected assessments is due to slight differences between frequency and abundance levels of native (narrow leafed pondweeds) and invasive plants (*Myriophyllum spicatum* and *Najas minor*). The frequency-corrected mFQI and mean C_m values that led to "fair" assessments were close to the "fair"-"poor" boundary, while the "poor" abundance-corrected mFQI and mean C_m values were also close to the "fair"-"poor" boundary. This suggests that the either **the combined abundance-corrected mFQI-mean C_m criteria or singular mean C_m criteria accurately represent the floristic quality of these lakes.**

In summary, there does not appear to be a significant difference in abundance-corrected assessments of aquatic plant community conditions whether using combined mFQI-mean C_m criteria or just the mean C_m criterion. Nearly all lakes characterized as "poor", "fair" or (rarely) "good" using one criteria would also be characterized the same way using the other criteria. In those few instances in which there is a discrepancy between these criteria, the summary above suggests that the **combined mFQI-mean C_m criteria most accurately characterize the floristic quality of these lakes, and therefore the combined criteria should be used.**

Section 8- Application of FQI Criteria

Section 8.1- Background

As discussed in Sections 1 through 7 of this White Paper, uncorrected modified FQI (mFQI) calculations, or modified FQI calculations corrected for absolute plant frequency ($mFQI_{\_uf}$) or absolute plant abundance ($mFQI_{ua}$) can be used to define Poor, Fair and Good (to Outstanding) floristic quality "scores", particularly when combined with abundance-corrected mean C_m values. These corrected mFQI and mean C_m values and their associated mFQI/mean C_m scores appear to be closely aligned to ecological thresholds distinguishing various levels of floristic quality, and these values and scores appear to be reflective of aquatic plant community changes associated with aquatic plant management actions. While any of the various mFQI and mean C_m values and scores can be used to adequately characterize floristic quality of lakes, these assessments are even more accurate when aligned to frequency-corrected and especially abundance-corrected mFQI and mean C_m values. Some of the potential application of these scores and associated values are described below.

Section 8.2- Biological assessment of lakes

The NYSDEC is charged with assessing waterbodies for their attainment of 'designated uses'- potable water, recreation, aquatic life, and others. These assessments rely on a combination of water quality data (*in situ* and post-treatment), management needed to attain a designated use, measured impacts, and other factors. These factors are outlined in a Consolidated Assessment and Listing Methodology (CALM) document produced by the NYSDEC Division of Water every few years; for example (https://www.dec.ny.gov/docs/water_pdf/asmtmeth17.pdf), with most NYSDEC historical criteria based on aquatic plant communities as one measure of "aquatic life". However, it should be noted that the 2021 CALM identifies "fishing", not "aquatic life" as a designated use.

In most recent iterations of the CALM, aquatic plant management necessary to support designated uses figured into assessments for Public Bathing (Contact Recreation), and the presence of AIS is used to characterize Habitat (which in CALM parlance is a waterbody "condition" rather than a designated use). However, floristic quality indicates could be used to characterize Habitat and Aquatic Life, particularly since the proposed FQI categories (Poor, Fair and Good, with Outstanding included for uncorrected or frequency-corrected assessments) are either directly aligned with Habitat assessment categories, or could be easily linked to previous Aquatic Life categories (Stressed, Threatened, and Fully Supported). Table 8.2 summarizes how the recommended mFQI scores summarized in Section 8 could translate into Aquatic Life or Habitat "conditions" used in some recent iterations of the NYSDEC CALM, or how they could translate into Aquatic Life use assessments, should these categories return to the NYSDEC assessment program. As discussed in Sections 1 through 7 of this White Paper, the aquatic life assessments improve as aquatic plant frequency and abundance data are included in the assessments that form the basis of Table 8.2.

Table 8.2- Matrix Comparing FQI Scores to Aquatic Life Assessments

FQI Score	Aquatic Life or Habitat "Condition" Assessment	Aquatic Life Use Assessment
Poor	Poor	Stressed
Fair	Fair	Threatened
Good	Good	Fully Supported
Outstanding		

It should be noted that some designated uses can be assigned an assessment of "impaired" when water quality standards are not achieved. In the absence of a water quality standard associated with aquatic plants, and in the absence of a designated “pollutant” triggering the use impairment associated with aquatic plants (i.e. a specific chemical pollutant rather that “biological pollution”), an assessment status of “impaired” may not be appropriate for regulatory aquatic life designations.

These FQI-derived assessments could supplement any other biological metrics adopted by the NYSDEC in future CALM derivations- for example, macroinvertebrates, phytoplankton, zooplankton, fish or HABs criteria used evaluate aquatic life.

Section 8.3- Evaluation of lake management actions.

Aquatic plant management actions are evaluated in many ways. Lake communities returning to a specific management action (herbicide, grass carp, etc.) and/or continuing with the use of a specific lake manager could use (m)FQI values or scores a measure of perceived success, particularly if associated criteria were supported by most lake residents. Other measures often used to evaluate lake management actions include changes in species richness (as discussed in White Paper 1D), the diminution or loss (or increase) of target plants or AIS and retention (or loss) of protected plants (as discussed in White Paper 1E), changes in mean coefficients of conservatism (White Paper 1F) and other factors not evaluated in these White Papers, including improved or degraded fishing, property values, recreational access or aesthetics; fish kills (or lack of); and other economic, ecological, or logistic factors. As discussed at length in this White Paper, floristic quality indices can be used to evaluate the impact of lake management actions, whether the change in FQI results in a shift into a different floristic quality category (an FQI score) or a large change within an existing category. In fact, changes in FQI values can be used to evaluate aquatic plant management efficacy. This is discussed for some lakes previously in this White Paper.

One way to do this would be to estimate the expected normal annual variability in corrected mFQI values from year to year in the absence of management or other significant events that would “artificially” alter the aquatic plant community, and then determine if the change in corrected mFQI associated with a new management action was greater than the normal annual variability. A positive change- an increase in corrected mFQI beyond normal variability- could be characterized as a successful lake management action. This would occur, for example, if this management action significantly decreased the frequency and/or abundance of targeted AIS species, since this should result in an increase in mFQI values, even if there is some (though not significant) collateral loss of positive native plant species. Very large improvements in corrected mFQI values can even result in a shift from a lower mFQI score (“Poor”, for example) to a higher mFQI score (“Fair” or “Good”). However, if management actions are targeted at native plants, particularly benign native plants, mFQI values might not be expected to increase. White Papers 1D (Species Richness), 1E (Individual Plants) and 1F (Coefficients of Conservatism) also outline processes by which and tools for evaluating the effectiveness of plant management actions- corrected mFQI values can supplement those outputs.

Note that this tool- the comparison of post-management corrected mFQI values to those collected prior to management- would require a lake community or manager to “anticipate” this management and collect sufficient years of plant survey data to evaluate normal variability. This baseline monitoring- timing, costs, effort- might represent an unrealistic expectation for lake communities, but the use of PIRTRAM methodologies and a modified C value system affords a greater opportunity for such monitoring by lake communities without access to plant surveying or identification expertise. The use of a standardized survey site density- either measured (observed) or projected using subsampling tools outlined in White Paper 1C- and the judicial use of truncated surveys also facilities annual comparisons when minimal resources are available. However, regional monitoring programs on large groups of unmanaged lakes for multiple years, such as the AWI surveys, might present an opportunity to define normal annual variability, but as noted above, this might require the use of projected species richness (pSR) values and the use of standardized survey site densities to account for expected differences in the number of surveyed sites among the surveyed lakes.

Section 8.4- Criteria for determining if plant management is appropriate.

Section 8.3 summarizes a process by which plant management actions (presumably those already garnering local support and required permits, and presumably already conducted) can be evaluated to determine if these actions successfully increase floristic quality, as defined by a statistically significant increase in corrected mFQI values (and mean C_m values), or even an upgrade from one mFQI – mean C_m score to another. This process, which requires multiple years of pre-management data (preferably on the lake considered for plant management), presumes that the decision to conduct this management falls outside the realm of evaluating corrected mFQI values. However, mFQI-mean C_m values could be used to supplement the information used to make the determination to manage the lake. An obvious example occurs when a lake exhibits a negative mFQI values (mFQI < 0 and mean $C_m < 0$). This would represent a lake dominated by invasive plants. Since AIS are often associated with ecological and human use impacts, a lake with mFQI < 0 is likely a strong candidate for management. However, lakes with suboptimal FQI values or especially suboptimal mFQI scores (“Poor” or even “Fair”) might be considered for management, particularly if this mFQI score can be linked to ecological or human use problems, or if the mFQI value has decreased over time.

Likewise, an existing optimal mFQI – mean C_m value and associated mFQI score could be the basis for rejecting the “need” for aquatic plant management. For example, lakes with “Good” floristic quality may presently support a variety of ecological and human use functions, and attempts to address small scale or localized aquatic plant beds with large scale management actions could degrade the mFQI score for the lake.

Section 8.5- Impacts of AIS introduction

It is presumed that the introduction of AIS leads to changes in aquatic plant communities that are likely to impact the floristic quality. For all of the PIRTRAM lakes cited in Appendix 6.2 (with the possible exception of Lake Ronkonkoma), there are no pre-AIS introduction surveys to compare to post-AIS introduction conditions, since all of the surveyed lakes either possessed or were free of AIS throughout the survey period. However, for other New York state lakes absent AIS, contemporary surveys could serve as a benchmark for comparison when AIS are eventually (presumably accidentally) introduced into the lake.

This could be done in stages. Uncorrected mFQI may decrease as AIS are introduced, since the decrease in C_m values will presumably offset the initial slight increase in projected species richness (pSR) associated with the addition of a “bad” plant. However, it is not known if small changes in mFQI will be apparent relative to normal variability observed in lakes surveyed over the long term. It is expected that as AIS densities and frequencies within the aquatic plant community increase, corrected mFQI values will decrease. Presumably at first modified FQI corrected for plant frequency (mFQI_uf) will decrease as AIS spread at low densities throughout the lake, then abundance-corrected values (mFQI_ua) will increase as these individual spreading events spawn plant beds- this phenomenon was observed in NYS lakes and was discussed in White Papers 1E and 1F. Unfortunately, this timeline did not occur over the period of any PIRTRAM surveys, but such a change in mFQI might be apparent as future pioneering introductions occur in presently uninfested lakes.

Section 8.6- Regional comparisons

mFQI calculations can be used to evaluate groups of lakes in a geographic region, particularly when evaluated against projected species richness (White Paper 1E and Section 2 of this White Paper) and clusters of lakes with a mix of lake sizes, trophic state, access, or AIS presence/dominance. These regional comparisons can also be extended to comparisons across US Ecological regions, or within the northeastern US, both of which would presumably cross state boundaries.

This is one reason why the modified FQI system is relevant and preferably to the traditional (New York) FQI system, since the nyFQI system uses C_{ny} values unique to NY, while C_m values in the modified FQI system could be defined for a state or larger region. In addition, since the C_{ny} values were established on a statewide level, regional differences within New York state may be under-emphasized. For example, fanwort and VLM are highly invasive in Long Island but much less invasive in low conductivity lakes in the Adirondacks and in the high elevation downstate region. While the C_m system (at present) also defines a single value for New York state, the use of “block” values- all benign native plants are defined to have a $C_m = 3$, all exotic plants are assumed to have a $C_m < 0$- reduces the impact of these multistate or substate regional differences. This can also be addressed in other ways, as described in Section 9.

Section 9- Recommendations to Improve FQI Evaluations

This White Paper summarizes floristic quality in large groups of New York state lakes, and provides several recommendations to improve the calculation and use of floristic quality. These include the following, discussed at length in Sections 1 through 6; some of these recommendations are also included in White Papers 1D and 1F.

1. As discussed in White Paper 1F, the modified FQI system, or mFQI, should adopt modified C values (C_m), rather than New York-specific C values (C_{ny}) to assign each native plant into one of three C_m categories (protected plants- C_m = 5; benign plants- C_m = 3; nuisance plants- C_m = 1), and each exotic plant into one of three different C_m categories (benign exotic plants- C_m = -1; regional or moderately invasive plants- C_m = -3; highly invasive plants- C_m = -5).
2. As discussed in White Papers 1D and 1F, mFQI calculations suffer from inconsistencies in the number of survey sites since species richness (one component of mFQI) increases as survey sites increase (mean C_m values, on the other hand, reach an asymptotic value after a relatively small number of survey sites, although these mean C_m values continue to vary slightly). These mFQI values, or more specifically the component species richness and C values, should be evaluated at a standardized survey site density of 1 site per littoral hectare, to compare lakes across programs or individual lakes over time. However, standardized values require granular survey site data showing the frequency and/or relative abundance of each plant at each site to generate regressions showing changes in mean C_m values at any survey site density. This is achieved by using subsampling methods outlined in White Paper 1C.
3. mFQI values should be corrected for unbounded or absolute plant abundance or, when abundance data are not available, for unbounded or absolute plant frequency
4. mFQI values can be translated into “scores” for ease of evaluation- ranging from “poor” to “outstanding” (or “good” for abundance-corrected values). All uncorrected or corrected mFQI values < 0 are consistently associated with “poor” floristic quality. Uncorrected mFQI values > 16 are usually associated with “outstanding” floristic quality and mFQI > 6 associated with "good", with the balance defined as having “fair” quality.
5. For mFQI corrected for plant frequency ($mFQI_{uf}$), these boundaries are set at $mFQI_{uf}$ > 6 for “Outstanding”, > 2 for “Good”, and >0 for “Fair”.
6. For mFQI corrected for plant abundance ($mFQI_{ua}$) , multiple criteria are needed to account for both mFQI and mean C_m values to minimize the likelihood of a lake with high $mFQI_{ua}$ but low mean C_m values, being incorrectly characterized. Due to the uncertainties in determining the optimal abundance for each category, “Outstanding” and “Good” were collapsed into a single “Good” category with an mFQI of 32 (and mean C_m of 8), with “Fair” and “Poor” boundaries for both mFQI and mean C_m continuing to be set at 0.
7. Abundance-corrected floristic quality “scores” appear to be most accurate when combining abundance-corrected mFQI values and abundance-corrected mean C_m values, and these abundance-corrected scores appear to be the most accurate means for characterizing floristic quality.

8. mFQI values and/or scores can be used to evaluate floristic quality as it relates to aquatic life assessments, plant management efficacy and need, impact of AIS introductions, and regional lake comparisons.

In addition to these general recommendations, several other actions can be taken to improve the use of FQIs:

1. As discussed in White Paper 1F, regional agreement on which plants should be included in each modified C value category, with a particular focus on the lakes that should be characterized as "nuisance native" (C_m = 1). The present list includes those native plants that are periodically the subject of plant management actions in New York state, and generally thrive in lakes with compromised water quality (due to an ability to grow prolifically in turbid water, organic sediments, and both shallow and deep water). While such a list can be generated from a combination of aquatic plant permit applications and feedback from local lake professionals, the "nuisance native" plant list may differ from state to state. Since it is likely that both a significant overlap in nuisance native plants exist across states and there are few nuisance native plants that are unique to a specific (northeastern US) state, a common list could be developed. This could be done in consultation with both state permit managers and regional lake professionals, such as those involved with the Northeast Aquatic Plant Management Society.
2. Regional support for and development of relative abundance scales for use in developing mFQI values corrected for plant abundance, as well as for metrics used in White Papers 1D (Species Richness), 1E (Individual Species) and 1F (Coefficients of Conservatism). This White Paper (Table 5.3) recommends the use of a $\log_5$ scale converting ordinal plant abundance scores (1, 2, 3, 4) with relative abundance values based on the relationship between rake toss categories and estimated biomass values in Chautauqua Lake, discussed at length in White Papers 1B and 1F. As discussed above, the use of the $\log_5$ scale represents an attempt to find a consistent measure that generally falls in the mid range of biomass values associated with each narrative rake toss "score" (trace, sparse, moderate and dense). However, additional analyses and evaluation of rake toss and biomass data on additional lakes may determine that other conversion scales may be more appropriate.
3. As discussed in White Paper 1F, there may be a need to evaluate whether additional plants should be included in the "most sensitive"/ "protected" category (C_m = 5). At present, the proposed C_m = 5 designation is limited to the few RTE plants defined in NYS, assigning "favored" status to those plants cited on the NYS Rare Plant list and thereby conferred special protection. One consequence of this is the finding that few lakes fit the definition of "outstanding", which is anchored to a high percentage of protected plants. However, other plants might have very high ecological value that warrants inclusion on the protected category list. This would ultimately increase FQI values, perhaps appropriately, but would results in more plants that require identification expertise, create a new non-regulatory category for plants not otherwise afforded special protection, and might cloud the distinction between C_m and C_{ny} values.
4. The proposed mFQI scoring system, based on mean C_m values, anchors the boundary between fair and poor floristic conditions at a value of 0, whether considering corrected or

uncorrected mFQI values. While this is intuitively satisfactory (generally defining the difference in these categories by whether the lake is dominated by native or invasive species), there may be some lakes with low but positive mFQI values that should instead by defined as poor rather than fair, consistent with the strictly numeric criteria outlined for mean C_m values in White Paper 1F (Tables 7.2.1 and 7.3.3). These differences should continue to be explored, with modifications to the boundaries between fair and poor lakes updated as needed.

5. Abundance-corrected mFQI scores require some assumptions about appropriate abundance levels (outlined in Table 7.3.1 in White Paper 1F) for each aquatic plant community designation (good, fair and poor). While the resulting mFQI scores appear to be consistent with field observations of these lakes, these scores and associated connection to appropriate abundance levels should continue to be evaluated
6. Even with the adoption of a C_m system that reduces the need to accurately identify all plants, including those assigned the $C_m = 3$ value, there remains a need to enhance aquatic plant identification skills to improve use of FQIs. This would inspire a higher confidence in C values, an accurate count of all plant species (species richness) and associated FQI values. This could be done with enhanced ID workshops focusing on RTEs, exotics, and the few regional nuisance native plant species (collectively representing less than 10% of all aquatic plants), but could also be done by supporting collaborations between plant ID experts and plant survey teams.
7. One method to evaluate "good" floristic quality is the use of reference waterbodies to define FQI values associated with lakes for which aquatic plant communities represent "unimpacted" conditions. Reference waterbody datasets largely do not exist in New York state, even with the NYS BioSurvey lakes (many of which were already ringed with residences and supporting significant recreational use). As per EPA guidance for developing numeric nutrient criteria (and as discussed in this White Paper), reference conditions could be establishing, using a representative statistic- typically the 75th percentile of FQI values, perhaps corrected for littoral area- to establish a threshold associated with "good" floristic quality for most of these lakes. The use of FQI values would be enhanced by conducting aquatic plant surveys on unimpacted lakes throughout the state and across a wide range of trophic states and littoral areas- most likely those lakes with minimal shoreline and watershed development, very limited access- and identifying reference conditions associated with these reference waterbody datasets.

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Appendix 6.1.1: Lake-Year Conditions for Each PIRTRAM Study Lake

Lake	Managed	AIS Dominant / Present
Adirondack Lake	2001, 2004, 2007, 2012 (s); 2013-2017 (r)	none all years
Artist Lake	none	present
Ballston Lake	none	dominant
Beaver Dam Lake	none	dominant
Beaver Lake	none	present
Big Fresh Pond	none	none
Blydenburgh Lake	none all years	dominant all years
Cayuga Lake-south shelf	Peripheral (h)	2013-2017 (d), 2012, 2018-2019 (p)
Cazenovia Lake	2009-2010, 2012, 2014, 2017, 2019, 2021 (h)	2008, 2011, 2013, 2015-2016, 2018 (d), other years (p)
Central Park Lake	none	dominant
Chautauqua Lake	2019, 2021 (h)	2003, 2007, 2012-13, 2016 (d), 2004, 2018 (i), 2008-2011, 2015, 2017, 2019 (p)
Collins Lake	2006 (h)	2006 (p), 2007 (d)
Cranberry Lake	2006, 2009 (h)	2006, 2009 (p)
Creamery Pond	2008 (h), 2011 (s)	2008, 2010-11, 2013 (d), 2009, 2012 (p)
Donahue Pond	2008-2012 (h)	2010, 2012 (d), 2007, 2011 (i), 2008-2009 (p)
Eagle Lake	none	dominant
Echo Lake	none	none
Galway Lake	none	present
Glen Lake	2009-2010 (h)	present all years
Great Patchogue Lake	none	dominant
Guymard Lake	none	dominant
Hards Pond	none	present
Java Lake	none	2008, 2010 (p)
Katonah Lake	2009-2010 (h)	dominant
Kinderhook Lake	none	dominant
Lake Luzerne	2010-2011 (h)	2009-2010 (i), 2011 (p)
Lake Oscaleta	none all years	2008, 2016 (i), 2018 (p)
Lake Rippowam	none all years	intermediate all years
Lake Ronkonkoma	none all years	dominant all years

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Lake	Managed	AIS Dominant / Present
Lake Waccabuc	none all years	2008, 2015-17 (d), all others (p)
Lamoka Lake	2008, 2009, 2012, 2014, 2020 (h)	2000-2009 (i?), 2016 (i), 2010-2015, 2017-2019 (p)
Little We Wah Lake	none	dominant
Long Pond	none	intermediate
Lower Yaphank Lake	none	dominant
Mohegan Lake	none	present
Monroe Mills Pond	all years (h)	present (all years)
Morehouse Lake	none	none
Quaker Lake	none	intermediate
Robinson Pond	all years (h)	2010 (d), 2008 (p)
Saratoga Lake	all years (h)	all years (p)
Snyders Lake	1997, 2003 (h); 1998-2000 (r), all others none	1997, 2000-05, 2007-08 (d), 2006 (i), all others (p)
Southards Pond	none	intermediate
Stissing Pond	none	present
Tuxedo Lake	none	present
Vly Creek Reservoir	none	dominant
Waneta Lake	2003, 2008, 2009, 2012, 2020 (h)	2000-2013 (i?), 2010-2019 (p)
We Wah Lake	none	present
White Lake	none	present

Legend:
(unless otherwise noted, it is assumed that all study years are part of the listed classification)

Managed: h = herbicide applications, s = grass carp stocking, r = recovering
AIS: d = dominant (among most abundant and frequent); i = intermediate (among most abundant or most frequent- but not both); p = present

Appendix 6.1.2: FQI Graphical Trends in Select Study Lakes

Data and graphics for each lake includes the following information:

Background:

Lake Name: Major New York state drainage basin, trophic status, size of littoral zone; range of survey sites during PIRTRAM survey years included in summary, years of sampling, sampling organization

Management and AIS summary: management action used and years in which action(s) were used; lake response if denuded (based on >75% decrease in plant abundance); listing and relative abundance of AIS found in lake

FQI Scores:

For all lakes scores cited are a combined mFQI and mean C_m score (using Tables 3.5.2, 4.4.2, and 5.4.2). For lakes with species richness and mean C_m values projected to a standardized survey site density (those with pSR data in the first plot), scores are calculated from projected values. For all other lakes, scores are calculated from observed values.

FQI Calculations:

Plot 1 (upper left): observed or projected Species Richness (# unique plants recorded during survey) by year. Projected Species Richness is provided for lakes with granular plant survey data- these values are projected to a standardized survey site density of 1 site per littoral hectare

Plot 2 (upper right): Uncorrected mFQI by year. mFQI in lakes (lake years) with pSR values in Plot 1 include projected pSR and mean C_m values, and observed values for lakes with oSR only. mFQI value calculated from Equation 3.1.2

Plot 3 (bottom left): mFQI corrected for (projected or observed) frequency (= $mFQI_{\_uf}$), derived from Equation 3.1.3

Plot 4 (bottom right): mFQI corrected for (projected or observed) abundance (= $mFQI_{\_ua}$), derived from Equation 3.1.4

Approximate time (year) of aquatic plant management techniques is shown using red arrows (herbicides) or green arrows (grass carp)

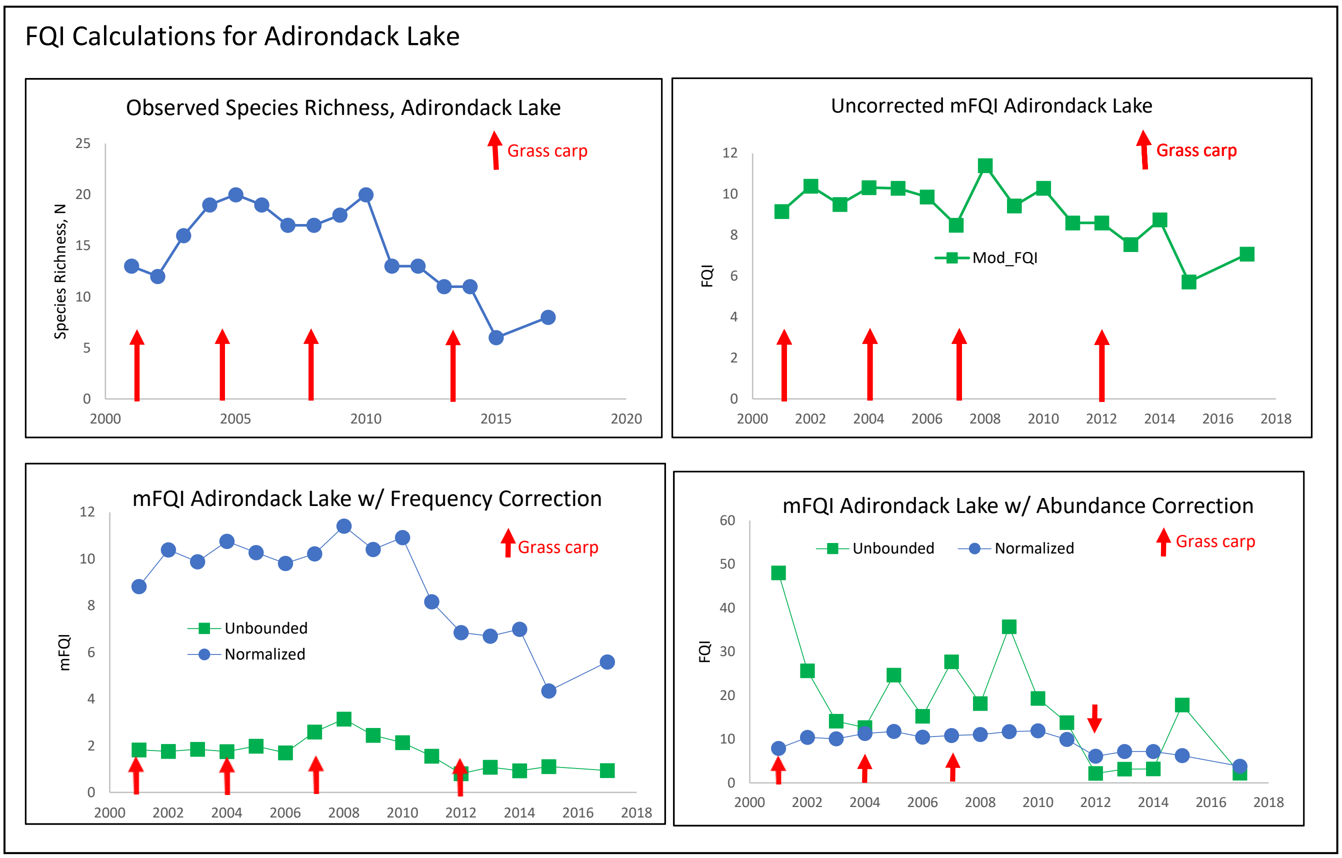
Adirondack Lake: Upper Hudson River basin, mesotrophic, 39ha littoral zone; 29-32 survey sites, 2001-2017 NYSDEC surveys

Management and AIS summary: stocked grass carp 2001, 2004, 2007, 2012; denuded after 2012; no (submergent or floating) AIS present

FQI Scores: note that these are estiimates since mFQI for this lake is derived from observed species richness and since neither frequency- nor abundance-corrections use the same methodology as recommended in White Papers 1D, 1F and 1G

	2017	2015	2014	2013	2012	2011	2010	2009
mFQI_Combined Criteria	Fair-Good	Fair	Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good
mFQIuf_Comb Criteria	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Good-Outs	Good-Outs
mFQIua_Comb Criteria	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Outstandir

	2008	2007	2006	2005	2004	2003	2002	2001
mFQI_Combined Criteria	Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Good	Fair-Good
mFQIuf_Comb Criteria	Good-Outs	Good-Outs	Fair-Good	Fair-Good	Good	Good	Good	Good
mFQIua_Comb Criteria	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Outstandir



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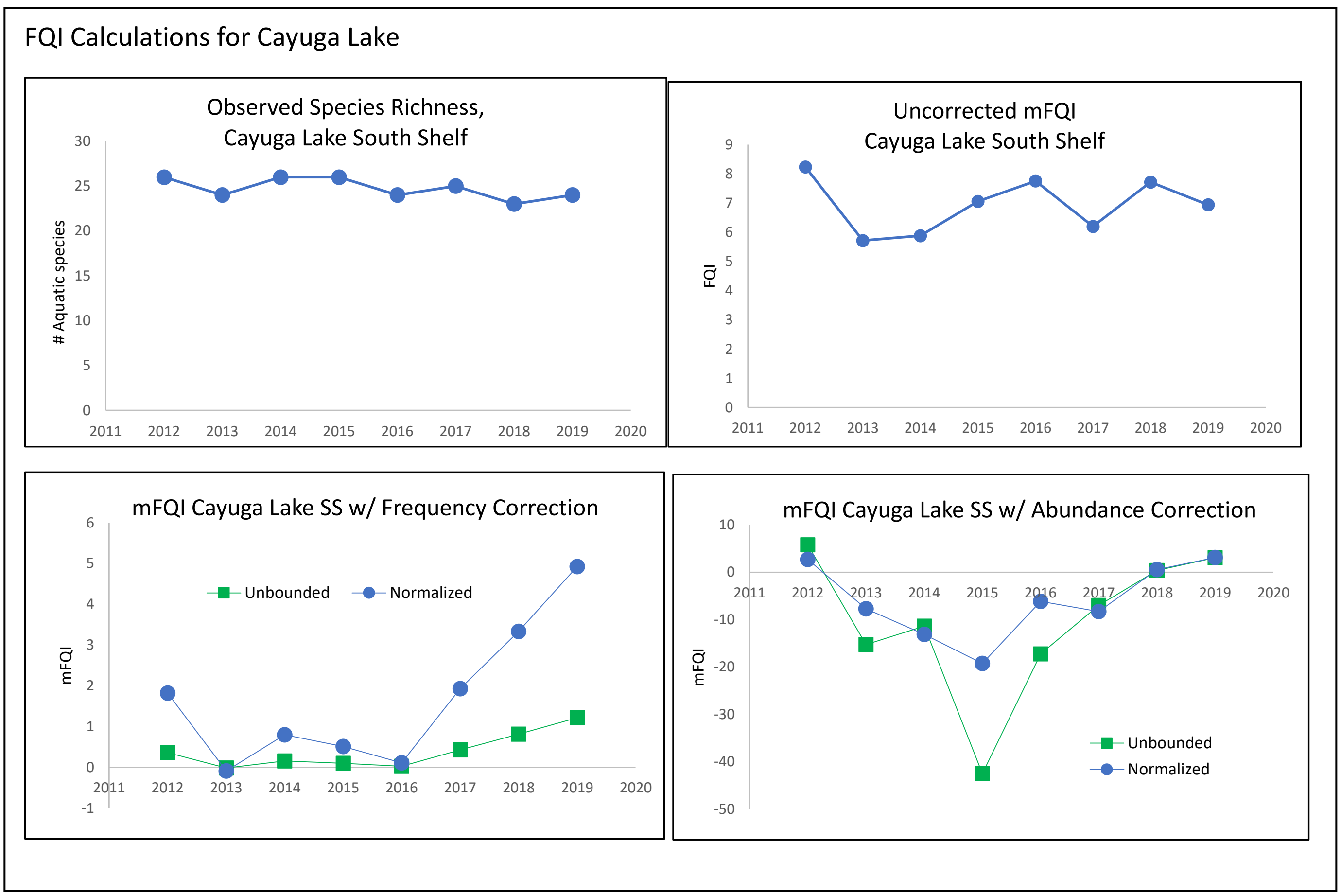
Cayuga Lake (south shelf): Oswego River basin, mesotrophic; 392ha littoral zone; 973-2115 survey sites, 2013-2019 Racine-Johnson Aquatic Ecologists survey

Management summary: herbicide treatments in inlets, spot control in lake; AIS (*Myriophyllum spicatum*, *Nitellopsis obtusa*) frequent or most abundant 2013-2017, present (with *Marsilea quadrifolia*, *Najas minor*, *Potamogeton crispus*) but neither most abundant nor frequent other years

FQI Scores: note that these are estimates since mFQI for this lake is derived from observed species richness and since neither frequency- nor abundance-corrections use the same methodology as recommended in White Papers 1D, 1F and 1G

	2012	2013	2014	2015	2016	2017	2018	2019
mFQI_Combined Criteria	Fair-Good	Fair	Fair	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good
mFQIuf_Comb Criteria	Fair	Poor	Fair	Fair	Fair	Fair	Fair	Fair-Good
mFQIua_Comb Criteria	Fair	Poor	Poor	Poor	Poor	Poor	Fair	Fair



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Cazenovia Lake: Oswego River basin, mesotrophic; 225ha littoral zone; 304 survey sites; 2008 Allied Biological, 2009-2019 Racine-Johnson Aquatic Ecologist surveys

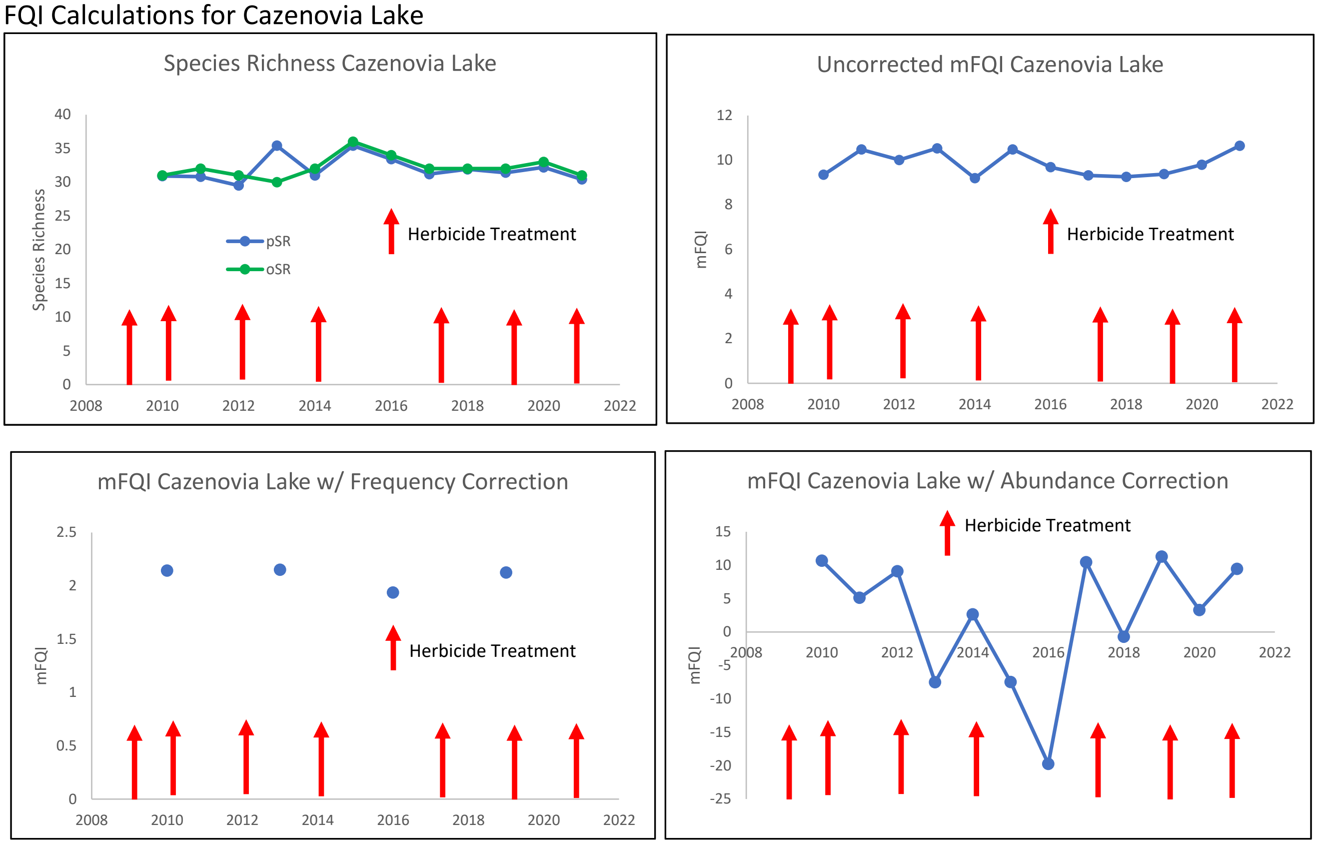
Management and AIS summary: herbicide (whole or large partial lake) treatments 2009, 2010, 2012, 2014, 2017, 2019, 2021; AIS (*Myriophyllum spicatum*) most frequent and abundant 2008, 2011, 2013, 2015-2016, 2018, 2020 (freq); AIS (including *Hydrocharis morsus-ranae*, *Nitellopsis obtusa*, and *Potamogeton crispus*) present but neither most frequent or abundant in other years.

FQI Scores: each of the mFQI scoring categories cited in White Papers 1D, 1F and 1G are not calculated for each year in which Cazenovia Lake was surveyed, but instead were calculated for representative years.

	2010	2011	2012	2013	2014	2015
mFQI_mean C Assess Uncorr	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good
mFQI_mean C Assess Freq Corr	Fair-Good			Fair-Good		
mFQI_mean C Assess Abund Corr	Fair	Fair	Fair	Poor	Fair	Poor

	2016	2017	2018	2019	2020	2021
mFQI_mean C Assess Uncorr	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good
mFQI_mean C Assess Freq Corr	Fair			Fair-Good		
mFQI_mean C Assess Abund Corr	Poor	Fair	Poor	Fair	Fair	Fair

FQI Calculations for Cazenovia Lake



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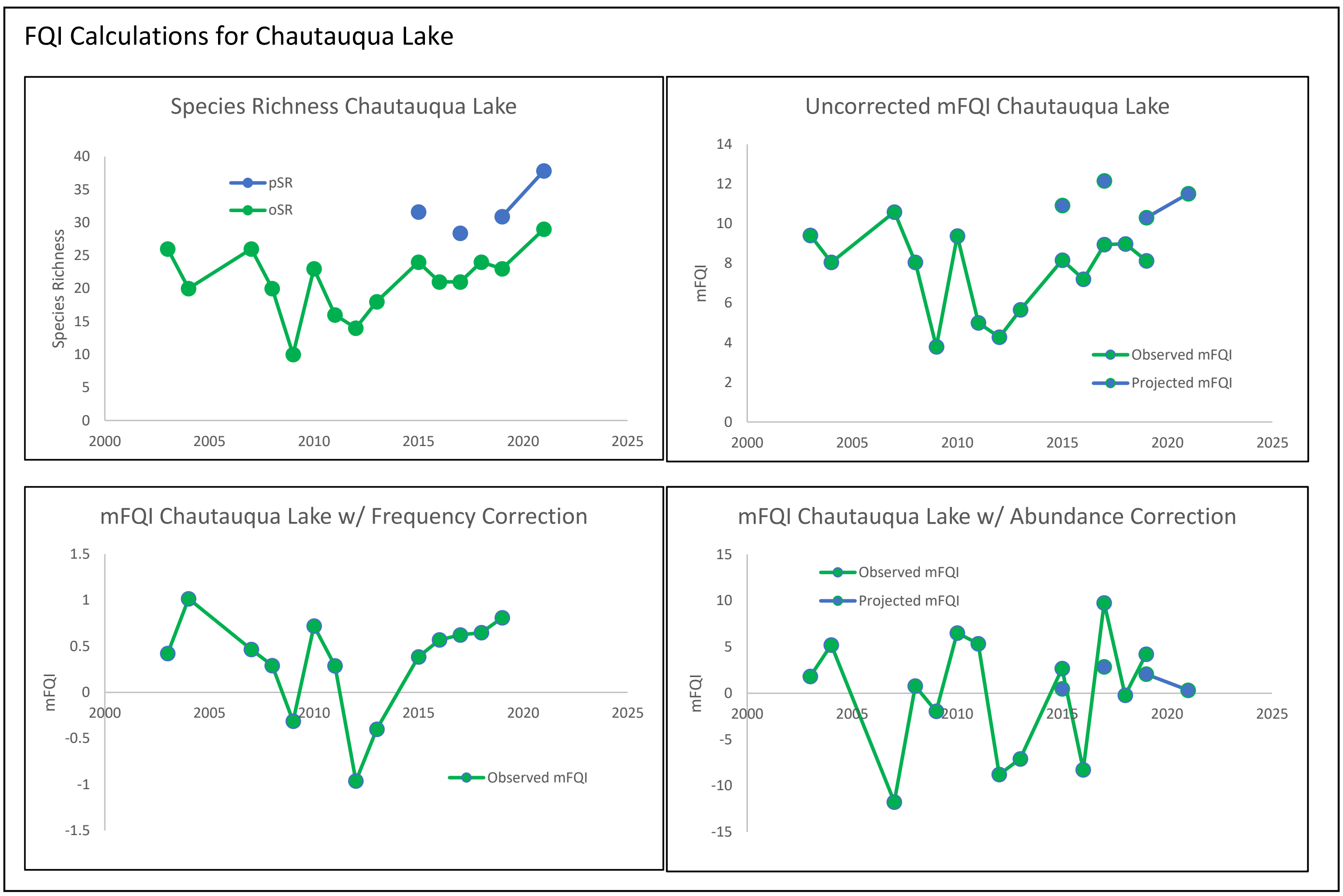
Chautauqua Lake: Allegany River basin, eutrophic, 2060ha littoral area, 115-722 survey sites; 2003-2021 (16 years) Racine-Johnson Aquatic Ecologists plant surveys

Management and AIS summary: mechanical harvesting; herbicides in 388 acres of the lake 2019, 2021; AIS (*Myriophyllum spicatum*) most frequent & abundant 2003, 2007, 2012, 2013, 2016; most frequent or abundant 2004, 2018; present (with *Najas minor*, *Nitellopsis obtusa*, and *Potamogeton crispus*) other years. *NOTE- it is not known which survey sites represented treated areas in 2019*

FQI Scores: note that these are estimates since mFQI for this lake is derived from observed species richness and and unprojected mean C_m- assessments for 2015, ’17, ’19 and ’21 are discussed below

	2007	2003	2004	2007	2008	2009	2010	2011
mFQI_Combined Criteria	Poor	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair	Fair-Good	Fair
mFQIuf_Comb Criteria	Poor	Fair	Fair-Good	Fair	Fair	Poor	Fair-Good	Fair
mFQIua_Comb Criteria	Poor	Fair	Fair	Poor	Fair	Poor	Fair	Fair

	2012	2013	2015	2016	2017	2018	2019
mFQI_Combined Criteria	Fair	Fair	Fair-Good	Fair-Good	Fair-Good	Fair-Good	Fair-Good
mFQIuf_Comb Criteria	Poor	Poor	Fair	Fair	Fair	Fair	Fair-Good
mFQIua_Comb Criteria	Poor	Poor	Fair	Poor	Fair	Poor	Fair



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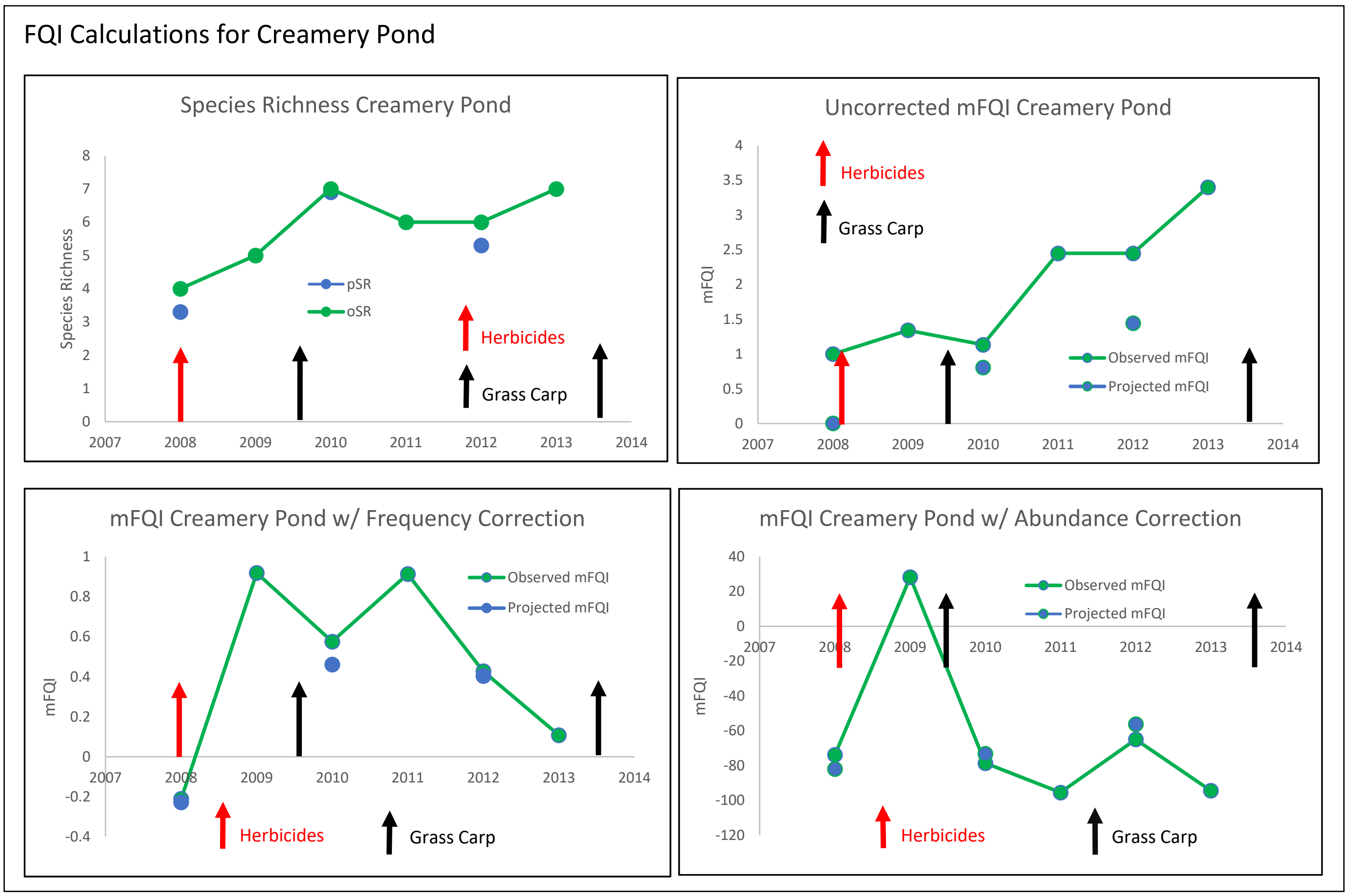
Creamery Pond: Lower Hudson River basin; eutrophic; 4 ha littoral zone; 20 survey sites; 2008-2016 NYSDEC survey (7 years)- 2016 survey not available

Management and AIS summary: herbicide treatment 2008 (post survey); grass carp stocking 2010, 2015; AIS (*Hydrilla verticillata*) most frequent and abundant 2008, 2010-11, 2013; present other years

FQI Scores: note that these are estimates since mFQI for this lake is derived from observed species richness and and unprojected mean C_m- assessments for 2008, '10 and '12 are discussed below

	2013	2012	2011	2010	2009	2008
mFQI_Combined Criteria	Fair	Fair	Fair	Fair	Fair	Fair
mFQIuf_Comb Criteria	Fair	Fair	Fair	Fair	Fair	Poor
mFQIua_Comb Criteria	Poor	Poor	Poor	Poor	Outstanding	Poor



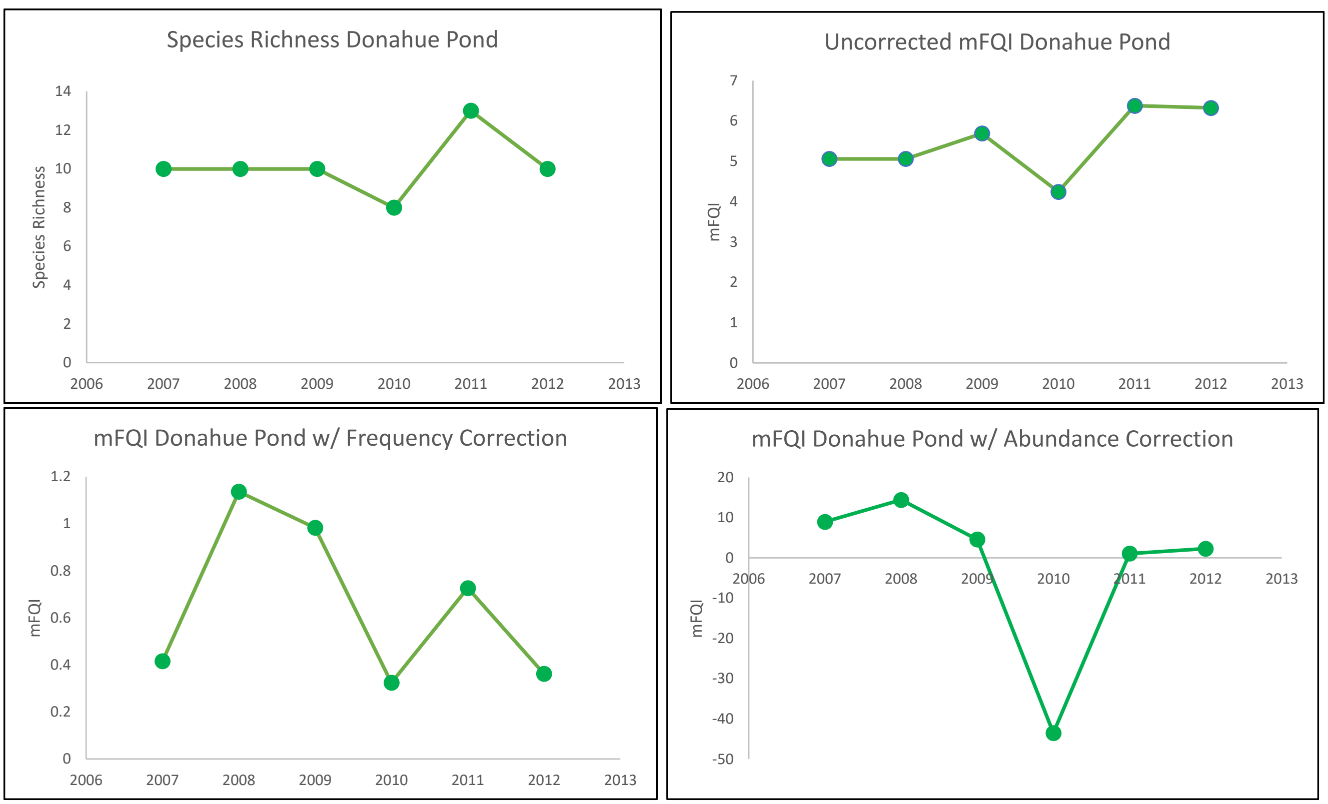
Donahue Pond: Long Island; eutrophic? (presumed based on location, but no WQ data)?; 17ha littoral zone, 60-76 survey sites; 2006-2012 (6 years) Allied Biological Inc./SOLitude plant surveys

Management and AIS summary: herbicide treatments 2008-12; AIS (*Cabomba caroliniana*) most frequent and abundant 2010, 2012; most frequent or abundant 2007, 2011; present other years.

FQI Scores: note that these are estimates since mFQI for this lake is derived from observed species richness and and unprojected mean C_m

	2007	2008	2009	2010	2011	2012
mFQI_Combined Criteria	Fair	Fair	Fair	Fair	Fair-Good	Fair-Good
mFQIuf_Comb Criteria	Fair	Fair-Good	Fair-Good	Fair	Fair-Good	Fair-Good
mFQIua_Comb Criteria	Fair	Fair	Fair	Poor	Fair	Fair

FQI Calculations for Donahue Pond

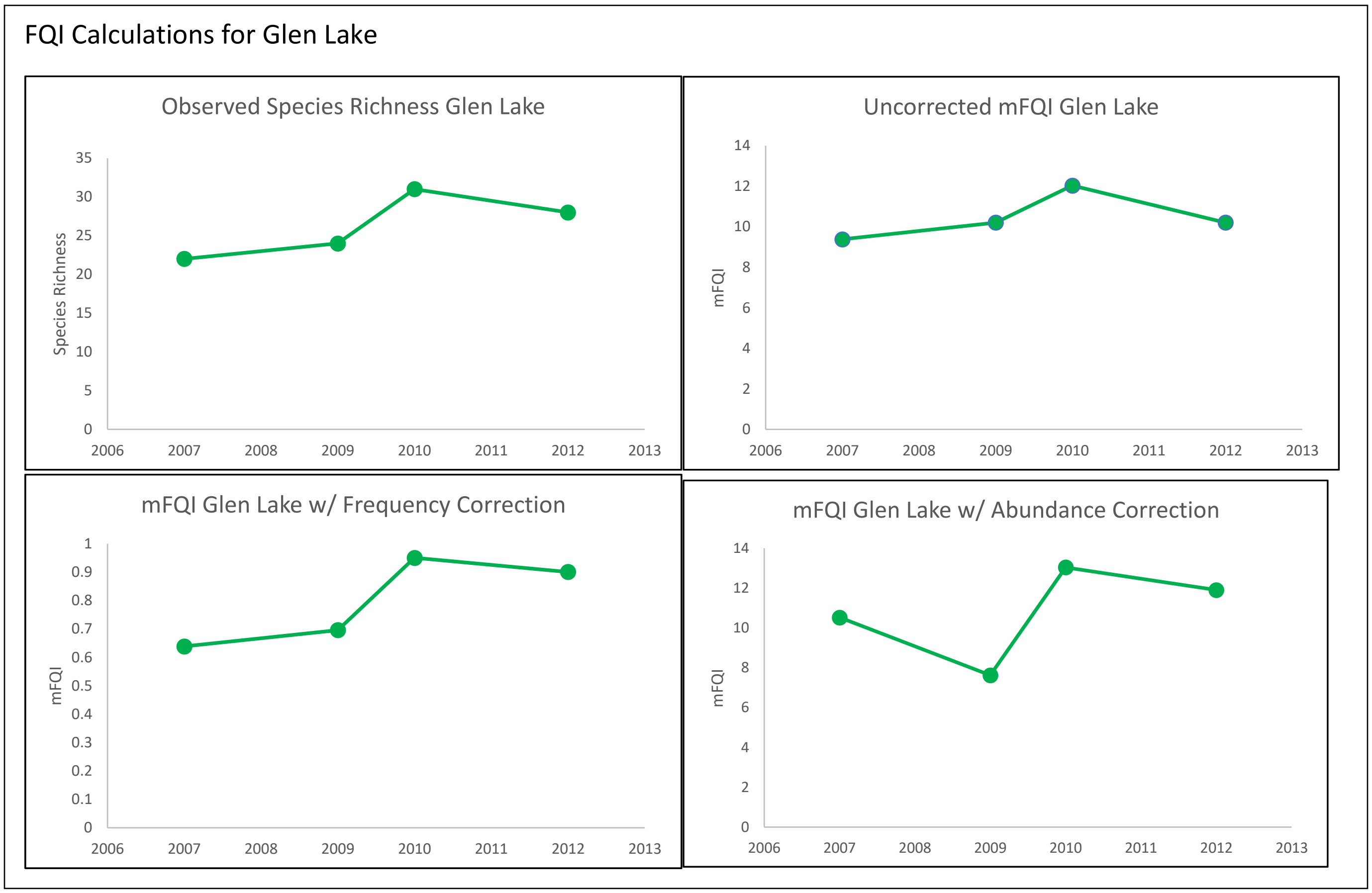


Glen Lake: Lake Champlain basin; mesoligotrophic; 78ha littoral zone; 175 plant survey sites; 2007-2012 (4 years) Allied Biological Inc. / SOLitude plant surveys

Management and AIS summary: herbicide treatments 2009-2010; AIS (*Myriophyllum spicatum*) most frequent or abundant 2007; present (with *Najas minor*, *Potamogeton crispus*) other years

FQI Scores: note that these are estimates since mFQI for this lake is derived from observed species richness and and unprojected mean C_m

	2012	2011	2010	2009	2008	2007
mFQI_Combined Criteria	Fair-Good	Fair-Good	Fair	Fair	Fair	Fair
mFQIuf_Comb Criteria	Fair-Good	Fair-Good	Fair	Fair-Good	Fair-Good	Fair
mFQIua_Comb Criteria	Fair	Fair	Poor	Fair	Fair	Fair



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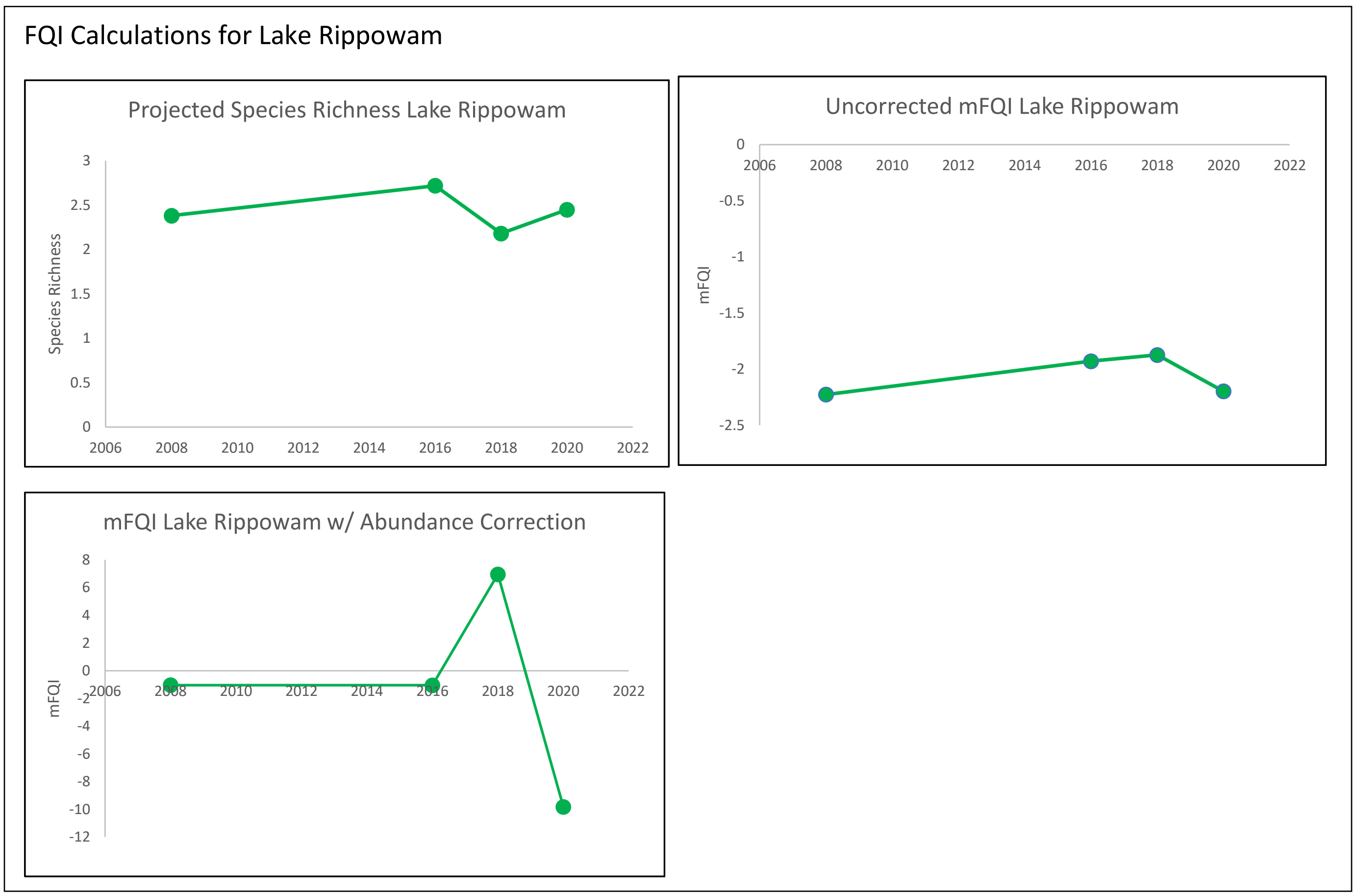
Lake Rippowam: Lower Hudson River basin; mesoeutrophic; 4ha littoral zone; 45-60 survey sites; 2006-2020 (4 years) Allied Biological Inc / SOLitude plant surveys

Management and AIS summary: no management history; AIS (*Myriophyllum spicatum)* most frequent and 2nd most abundant most years (but not 2010).

FQI Scores: each of the mFQI scoring categories cited in White Papers 1D, 1F and 1G are not calculated for each year in which Lake Rippowam was surveyed, but instead were calculated for representative years

	2008	2016	2018	2020
mFQI_Combined Criteria	Poor	Poor	Poor	Poor
mFQIuf_Comb Criteria				
mFQIua_Comb Criteria	Poor	Poor	Fair	Poor



Lake Ronkonkoma: Long Island; eutrophic; 21ha littoral zone; 23 plant survey sites; 2009-2014 NYSDEC Region 1 plant surveys

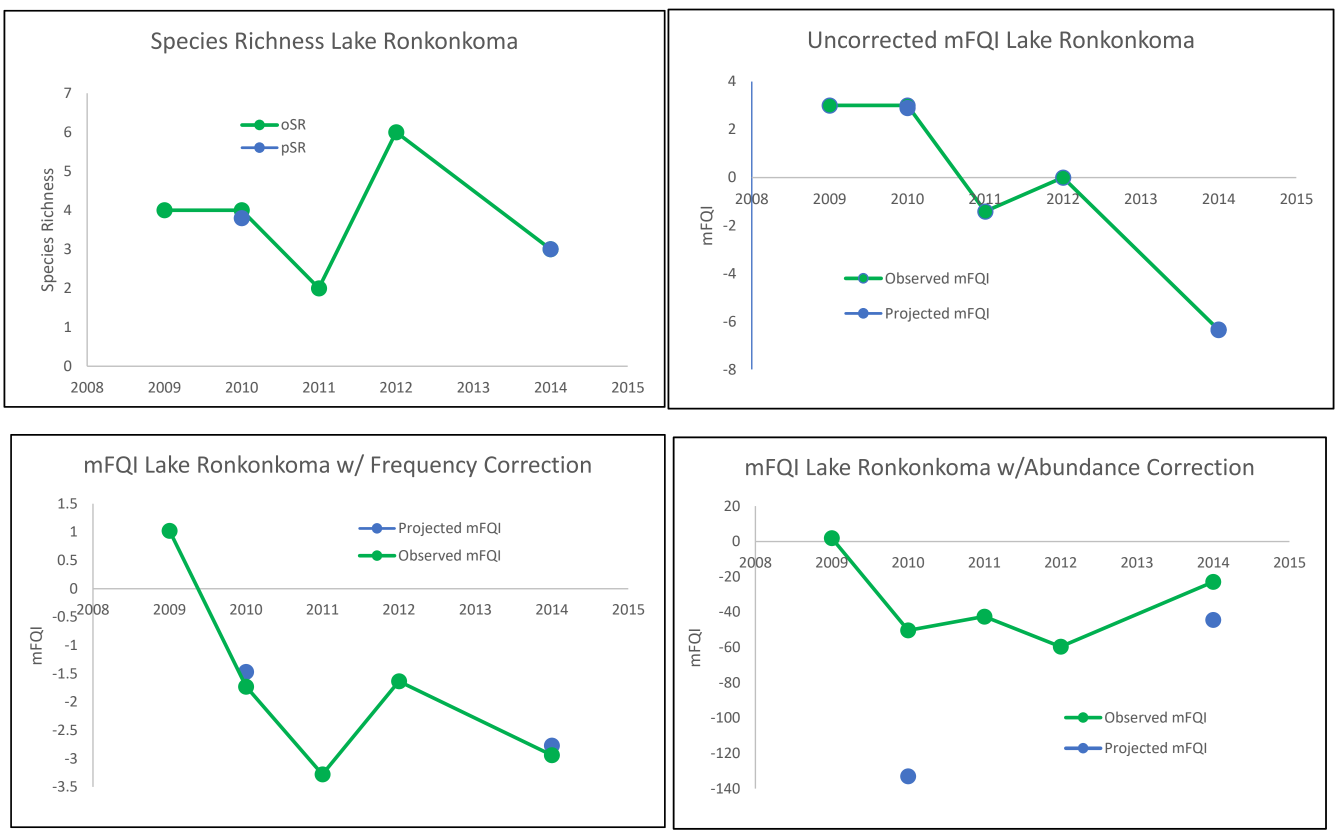
Management and AIS summary: no management history (at least up to 2014); AIS (*Hydrilla verticillata)* most frequent and abundant 2010-2014; present (with *Myriophyllum spicatum* and *Najas minor*) other years.

FQI Scores: note that these are estimates since mFQI for this lake is derived from observed species richness and and unprojected mean C_m- assessments for 2010 and 2014 are discussed below.

Unprojected Data	2014	2012	2011	2010	2009
mFQI_Combined Criteria	Poor	Poor	Poor	Fair	Fair
mFQIuf_Comb Criteria	Poor	Poor	Poor	Poor	Fair-Good
mFQIua_Comb Criteria	Poor	Poor	Poor	Poor	Fair

Projected Data	2010	2014
mFQI_Combined Criteria	Fair	Poor
mFQIuf_Comb Criteria	Poor	Poor
mFQIua_Comb Criteria	Poor	Poor

FQI Calculations for Lake Ronkonkoma



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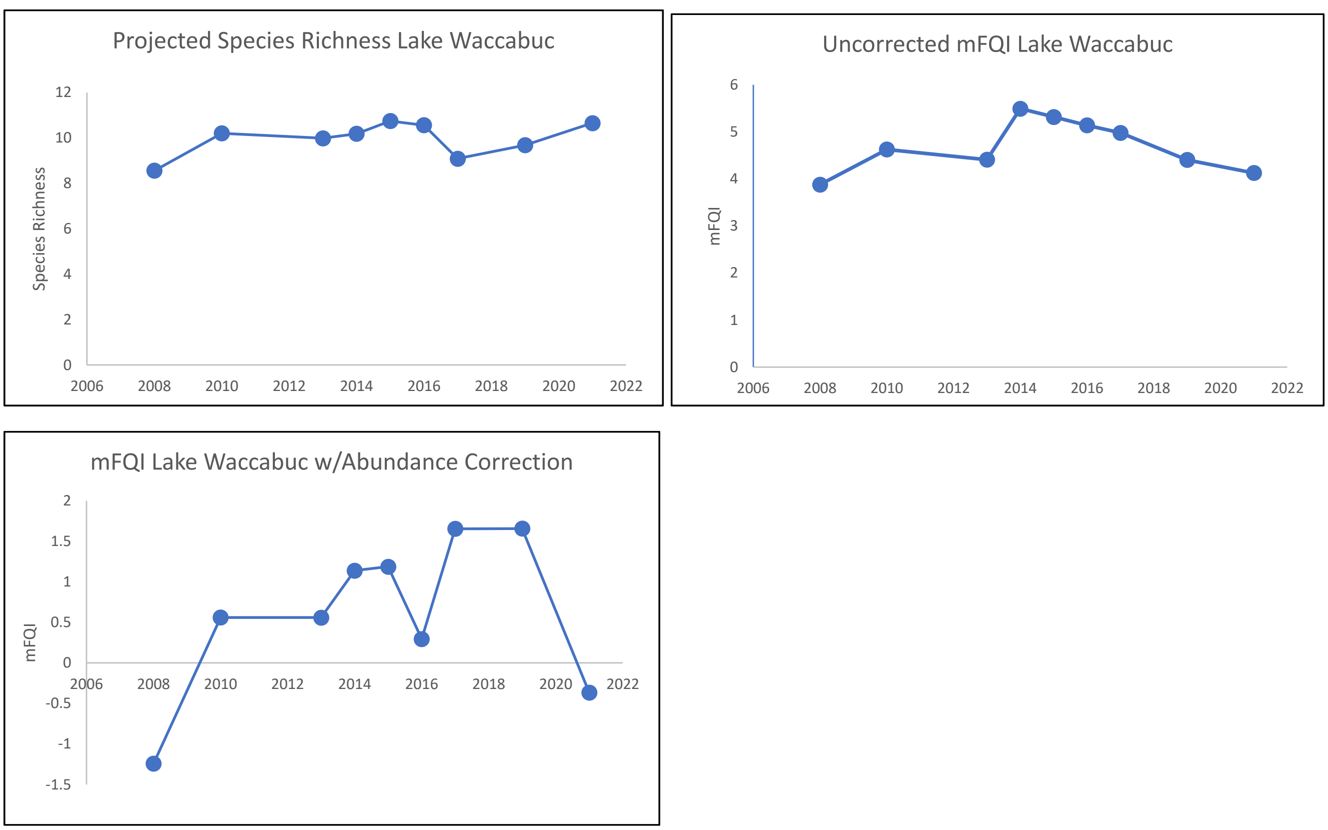
Lake Waccabuc: Lower Hudson River basin; mesoeutrophic; 19ha littoral zone; 120 survey sites; 2008-2021 (12 years) Allied Biological Inc / SOLitude plant surveys

Management FQI summary: no lakewide plant mgmt (hand pulling isolated *Egeria densa* beds); AIS (*Myriophyllum spicatum*) most frequent & abundant in 2008, 2014-2016; most frequent or most abundant in other years; other AIS (*Najas minor*, *Potamogeton crispus*, *Trapa natans*) present

FQI Scores: each of the mFQI scoring categories cited in White Papers 1D, 1F and 1G are not calculated for each year in which Lake Rippowam was surveyed, but instead were calculated for representative years

	2008	2010	2013	2014	2015	2016	2017	2019	2021
mFQI_Combined Criteria	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
mFQIuf_Comb Criteria									
mFQIua_Comb Criteria	Poor	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Poor

FQI Calculations for Lake Waccabuc



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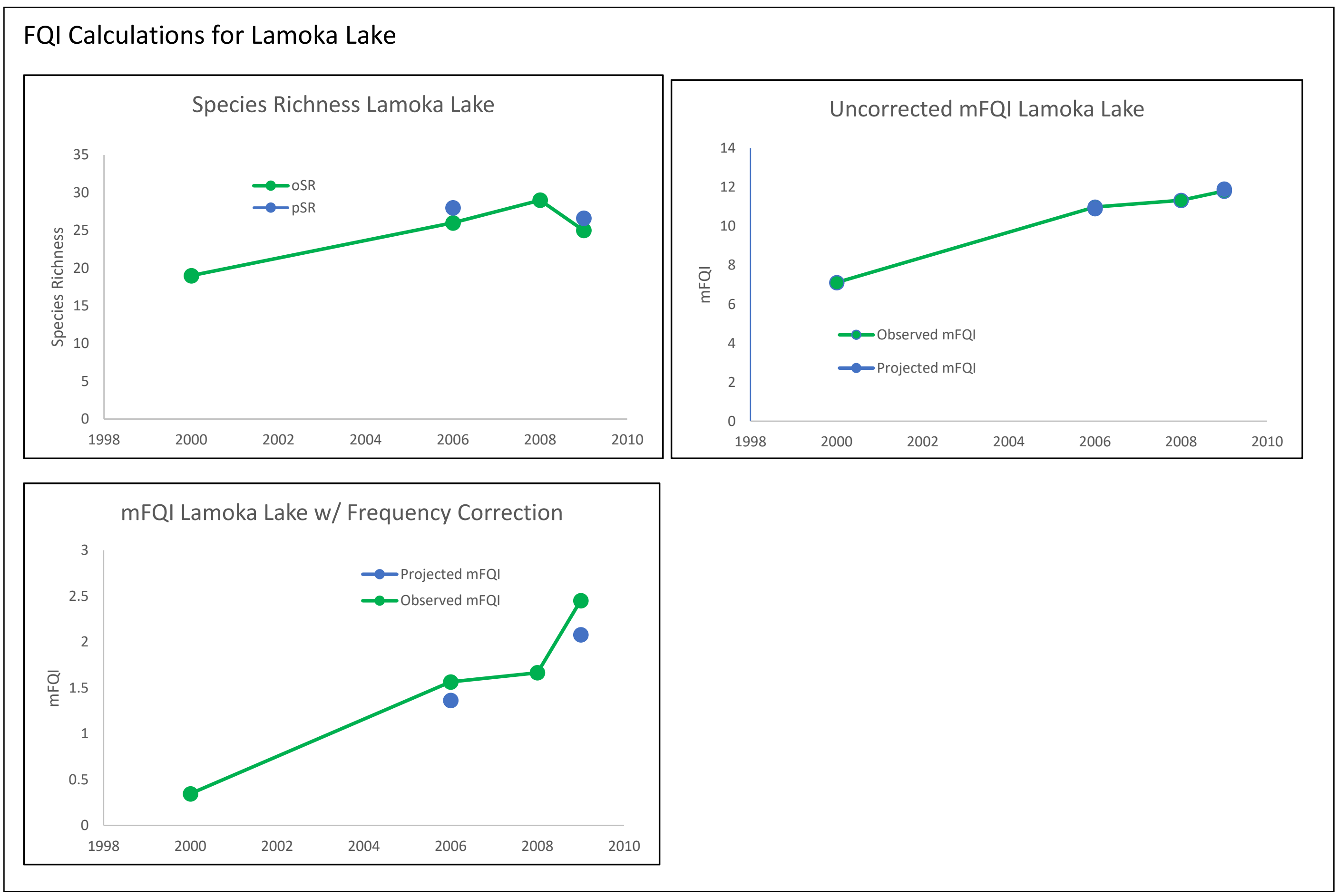
Lamoka Lake: Chemung River basin; eutrophic; 166ha littoral zone; 169 plant survey sites; 2000-2019 (12 years) Racine-Johnson Aquatic Ecologists (or other) plant surveys

Management and AIS summary: herbicide treatments 2003 (proposed), 2008, 2009, 2012, 2014, 2020 (proposed); AIS (*Myriophyllum spicatum*) present to most frequent in most years; other AIS (*Potamogeton crispus)* present (abundance data not available)

FQI Scores: each of the mFQI scoring categories cited in White Papers 1D, 1F and 1G are not calculated for each year in which Lamoka Lake was surveyed, but instead were calculated for representative years (all with only frequency data).

Unprojected Data	2000	2006	2008	2009
mFQI_Combined Criteria	Fair-Good	Fair-Good	Fair-Good	Fair-Good
mFQIuf_Comb Criteria	Fair	Fair-Good	Fair-Good	Good
mFQIua_Comb Criteria	Poor	Poor	Poor	Poor

Projected Data	2010	2014
mFQI_Combined Criteria	Fair-Good	Fair
mFQIuf_Comb Criteria	Fair-Good	Fair-Good
mFQIua_Comb Criteria		



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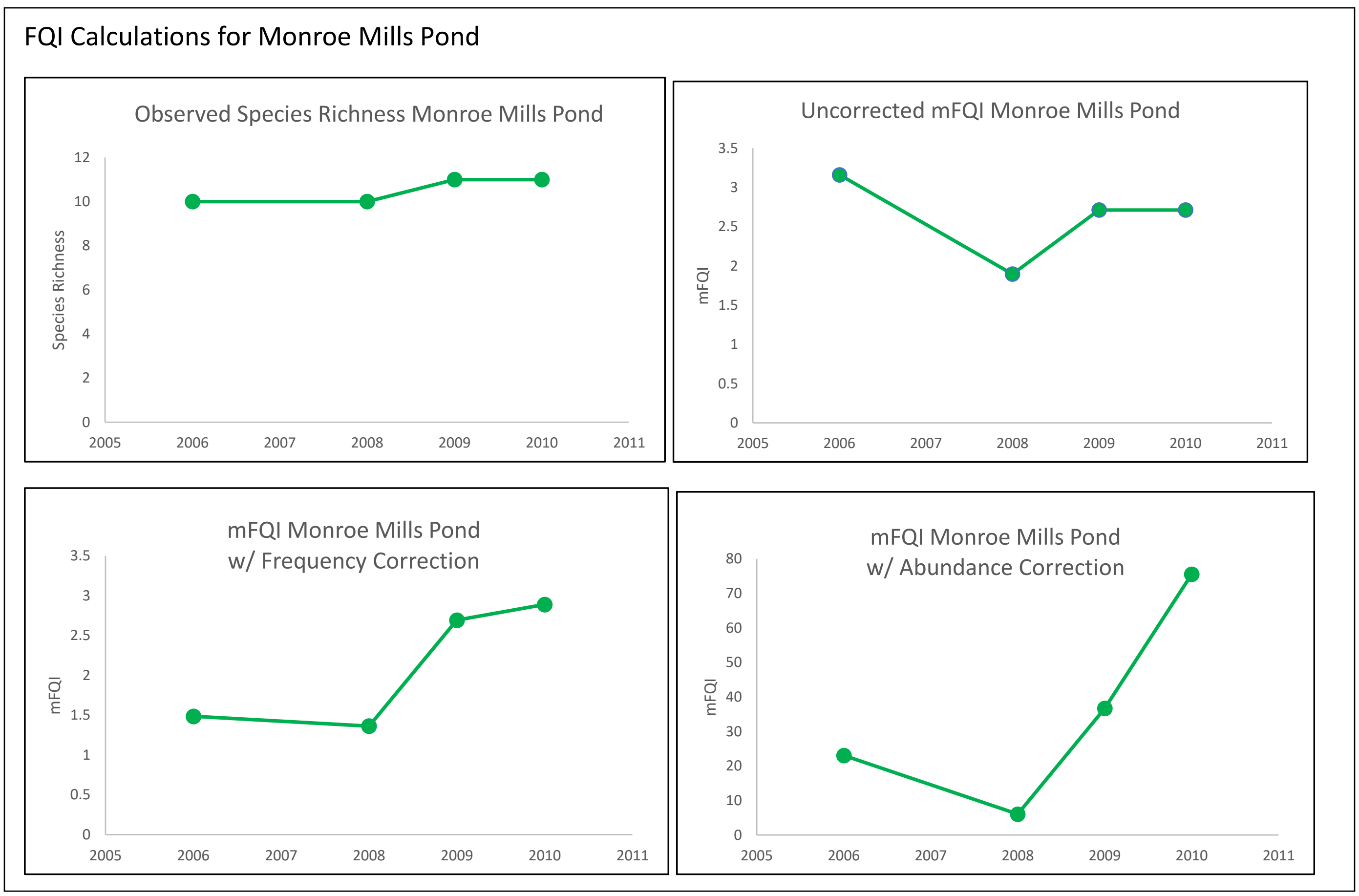
Monroe Mills Pond: Lower Hudson River basin; eutrophic?; (assumed) 35ha littoral zone; 58-66 plant survey sites; 2006-2010 (4 years) Allied Biological Inc / SOLitude plant surveys

Management and AIS summary: herbicide treatment all years; AIS (*Myriophyllum spicatum*, *Najas minor*, *Potamogeton crispus*, *Trapa natans*) present but neither most frequent nor most abundant

FQI Scores: note that these are estimates since mFQI for this lake is derived from observed species richness and and unprojected mean C_m

	2010	2009	2008	2006
mFQI_Combined Criteria	Fair	Fair	Fair	Fair
mFQIuf_Comb Criteria	Good	Good	Fair-Good	Fair-Good
mFQIua_Comb Criteria	Outstanding	Outstanding	Fair	Fair



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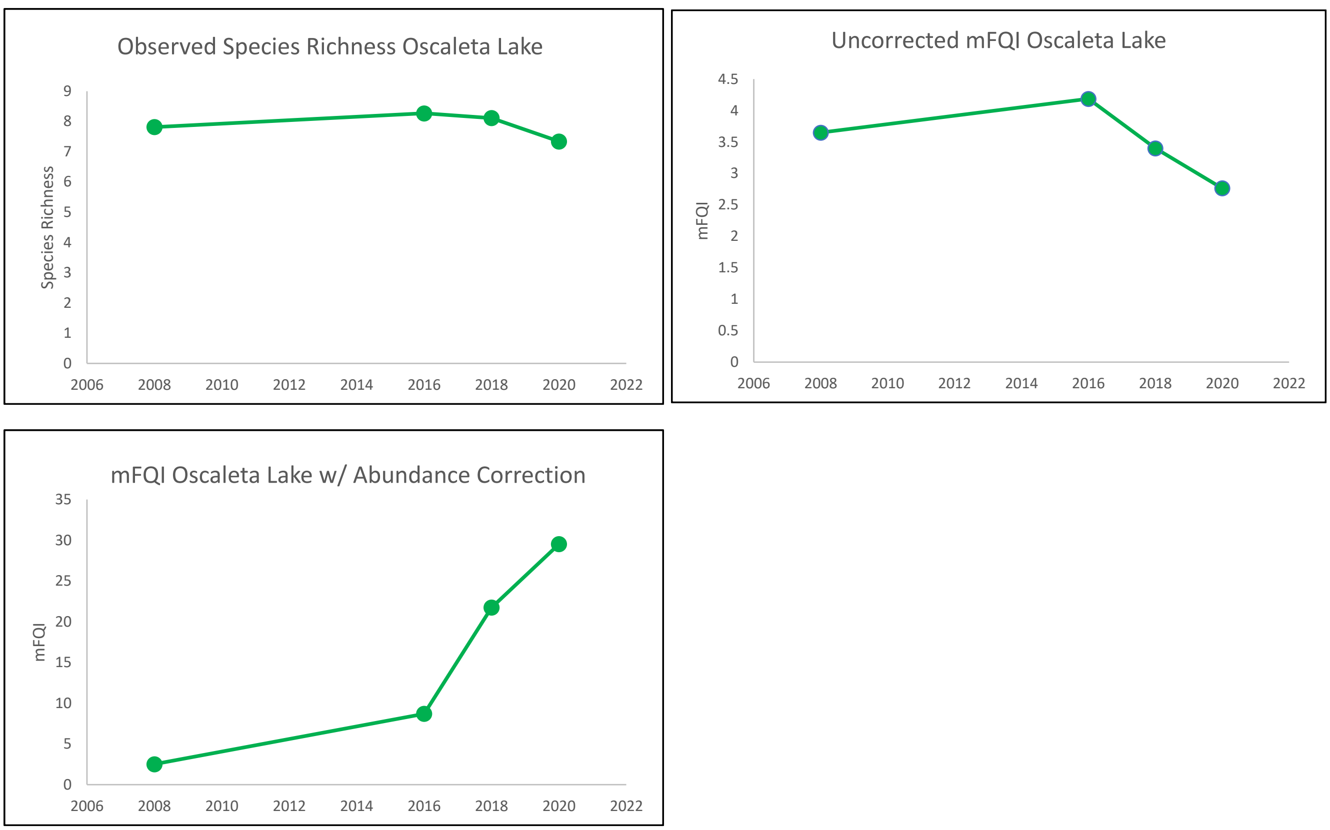
Oscaleta Lake: Lower Hudson River basin; mesoeutrophic; 8ha littoral zone; 60-89 survey sites; 2006-2020 (4 years) Allied Biological Inc / SOLitude plant surveys

Management and AIS summary: no management history; AIS (*Myriophyllum spicatum)* among two frequent and abundant plants most years.

FQI Scores: each of the mFQI scoring categories cited in White Papers 1D, 1F and 1G are not calculated for each year in which Oscaleta Lake was surveyed, but instead were calculated for representative years

	2008	2016	2018	2020
mFQI_Combined Criteria	Fair	Fair	Fair	Fair
mFQIuf_Comb Criteria				
mFQIua_Comb Criteria	Fair	Fair	Fair	Fair-Good

FQI Calculations for Oscaleta Lake



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Snyders Lake: Lower Hudson River basin; mesoeutrophic; 15ha littoral zone; 32-58 plant survey sites; 1997-2011 NYSDEC plant surveys

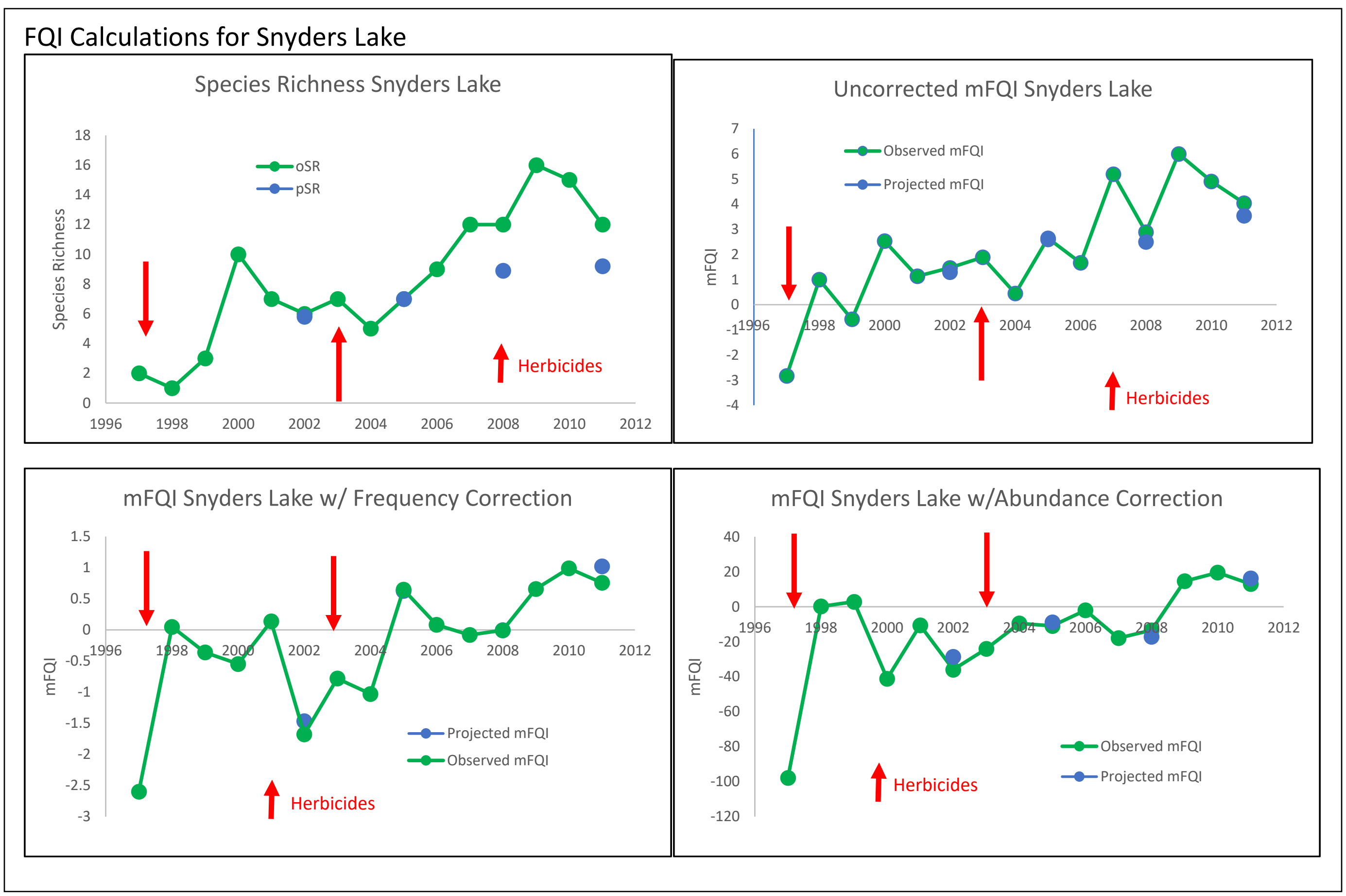
Management and AIS summary: herbicide treatments 1997, 2003 (large localized treatment); AIS (*Myriophyllum spicatum or Najas minor*) most frequent and abundant 1997, 2000-2005, 2007-2008, AIS most frequent or most abundant 2006; AIS (including *Potamogeton crispus*) present other yrs

FQI Scores: The mFQI scoring categories are a mix of unprojected and projected data

Unprojected Data	2004	2005	2006	2007	2008	2009	2010	2011
mFQI_Combined Criteria	Fair	Fair	Fair	Fair	Fair	Fair	Fair	Fair
mFQIuf_Comb Criteria	Poor	Fair	Fair	Poor	Poor	Fair-Good	Fair-Good	Fair-Good
mFQIua_Comb Criteria	Poor	Poor	Poor	Poor	Poor	Fair	Fair	Fair

Unprojected Data	1997	1998	1999	2000	2001	2002	2003
mFQI_Combined Criteria	Poor	Fair	Poor	Fair	Fair	Fair	Fair
mFQIuf_Comb Criteria	Poor	Fair-Good	Poor	Poor	Fair	Poor	Poor
mFQIua_Comb Criteria	Poor	Fair	Fair	Poor	Poor	Poor	Poor

Projected Data	2002	2005	2008	2011
mFQI_Combined Criteria	Fair	Fair	Fair	Fair
mFQIuf_Comb Criteria	Poor	Fair	Poor	Fair
mFQIua_Comb Criteria	Poor	Poor	Poor	Fair



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Evaluation of Floristic Quality in NYS Lakes

Waneta Lake: Chemung River basin; eutrophic; 170ha littoral zone; 102 plant survey sites; 2000-2019 (7 years) Racine-Johnson Aquatic Ecologists plant surveys

Management and AIS summary: herbicide treatments 2003 (proposed), 2008, 2009, 2012, 2014, 2020 (proposed); denuded 2004-2005; AIS (*Myriophyllum spicatum*) present to frequent; other AIS (*Najas minor*, *Potamogeton crispus*) present (abundance data not available).

FQI Scores: each of the mFQI scoring categories cited in White Papers 1D, 1F and 1G are not calculated for each year in which Waneta Lake was surveyed, but instead were calculated for representative years (all with only frequency data).

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FQI Calculations for Waneta Lake