RESULTS OF THE WISCALM BOTANIST REVIEW PANEL FOR AQUATIC MACROPHYTE IMPAIRMENT

CONTENTS

20, May 2013

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OVERVIEW

The 2014 assessment cycle of WisCALM calls for biological confirmation of phosphorus listings. Along with chlorophyll-*a*, aquatic macrophytes are proposed as a possible means of biological confirmation. An eight-member panel of botanists (see Table 1) met to discuss the state of the aquatic macrophyte community in fourteen proposed lakes (see Table 2). The group used both multivariate and multimetric methods to judge the plant communities of the assessment lakes. Both methods were used to complement each other; each method proved valuable for different reasons. The review panel sought to decipher the driving factors behind low scores for either method so both methods were thoroughly interrogated. The resulting decisions are as follows: 5 "Good" lakes, 1 "Good/Fair" lake, 3 "Fair" lakes, 4 "Fair/Poor" lakes, and 1 "Poor" lake (see Figure 1, in Results and Discussion section). During the decision-making process, the review panel relied on more information than was captured by either method. For example, species richness and species identity were important factors for decision-making although none of the metrics used directly addressed those factors. As a result, the panel proposed several new metrics to explore for impairment decisions during future WisCALM assessment cycles.

Participants	Affiliation
Martha Barton	WDNR Bureau of Science Services
Elizabeth Haber	WDNR Bureau of Science Services
Susan Knight	UW Extension Trout Lake Station
Ali Mikulyuk	WDNR Bureau of Science Services; UW Madison CFL
Michelle Nault	WDNR Bureau of Science Services
Paul Skawinski	Golden Sands RC&D; UW Stevens Point
Scott Van Egeren	WDNR Bureau of Water Quality
Kelly Wagner	WDNR Bureau of Science Services

Table 1: Review panel participants and affiliated agencies. Meeting held on 10 May 2013 in Stevens Point, WI.

Lake Name	County	WIBIC
Black Otter	Outagamie	315600
Bullhead	Manitowoc	68300
Carstens	Manitowoc	66800
English	Manitowoc	68100
Harpt	Manitowoc	84600
Hartlaub	Manitowoc	67200
Krohns	Manitowoc	94700
Little Green	Green Lake	162500
Long	Manitowoc	77500
Noquebay	Marinette	525900
Pigeon	Manitowoc	64000
Silver	Manitowoc	67400
Tichigan	Racine	763600
White	Waupaca	272900

Table 2: Listing of the 14 assessment lakes. A total of 31 lakes were originally proposed, fourteen of which had PI survey data available.

METHODS

MULTIVARIATE ANALYSIS

Plant communities in reference and assessment lakes were represented by a species-by-lakes dataframe with species abundance expressed as % littoral frequency of occurrence. Plant communities in reference lakes were first grouped into internally-consistent classes using a hierarchical agglomerative clustering procedure. Three reference clusters were obtained using this method. Reference clusters were characterized using quadratic discriminate analysis that allowed us to explain the biotic groupings using abiotic characteristics. The three reference clusters became the South group, North Muck group, and North Sand group. The latitude cutoff for the South group was <44.8 degrees. The substrate cutoff for the North groups was >40% sand. Assessment lakes were assigned to a cluster based on their values for the two best-performing variables in the discriminate function: latitude and percent of the substrate that was sand. Assessment lake plant communities were then substituted into the list of reference lakes communities one-by-one, and nonmetric multi-dimensional scaling was used to plot each group of lakes in two dimensions (x,y). Distances between lakes in the plot reflected underlying community difference as expressed by the Bray-Curtis dissimilarity measure. Finally, bivariate probability ellipses were constructed using the 95%, 99%, and 99.9% of the reference lakes x and y scores. Lakes were assessed as 'excellent or good', 'fair', or 'poor' based on their distance from the reference cluster in the plot (i.e. based on which ellipses, if any, contained them). Each assessment lake was assessed individually in order to avoid a disproportionate effect on the cluster analysis. This approach is outlined by Reynoldson et al. (1995; 1997).

MULTIMETRIC ANALYSIS

We used a combination of four metrics, plus two summary metrics (Nichols 1999; Nichols et al. 2000) to judge assessment lakes. The metrics were chosen because of their relationship to potential impairment stressors of lakes. A list of the metrics and definitions appears below:

- Littoral vegetation – This is the percent of the littoral area that is vegetated. It was calculated by dividing the number of sampling points where plants were found by the total number of sampling points within the littoral zone of the lake.
- Sensitive species – We defined a sensitive species as any species having a coefficient of conservatism of 8 and above. The result is the sum of the percent relative frequency of occurrence of all sensitive species found in the survey.
- Tolerant species – Five species were found to have a positive relationship with disturbance. These five species are: *Ceratophyllum demersum* (Coontail), *Heteranthera dubia* (Water star-grass), *Myriophyllum spicatum* (Eurasian watermilfoil), *Potamogeton crispus* (Curly-leaf pondweed), and *Stuckenia pectinata* (Sago pondweed). The result is the sum of the percent relative frequency of occurrence of all tolerant species found in the survey.
- Max depth of plants (m) – This is the maximum depth at which plants were found growing. Filamentous algae, aquatic moss, freshwater sponge, and liverworts were excluded from the max depth calculation.
- FQI – This metric was calculated according to Nichols 1999.
- AMCI – This metric was calculated according to Nichols et al. 2000.

Metric thresholds were calculated following guidance from the EPA's Lake and Reservoir Bioassessment and Biocriteria document using the reference approach (USEPA 1998). Tables 3-5 list the metrics assessed, along with the threshold values for each lake type designation.

South Lake Group

Metric	Impaired range	Intermediate range	Unimpaired range
Littoral vegetation low	0 – 0.398	0.399 – 0.797	0.798 – 0.897
Littoral vegetation high	0.949 – 1	0.898 – 0.948	0.798 – 0.897
Sensitive species	NA	NA	NA
Tolerant species	0.513 – 1	0.02 – 0.512	0 – 0.01
Max depth of plants (m)	0 – 2.25 m	2.26 – 4.4 m	≥ 4.5 m
FQI	0 – 8	8.1 – 16.1	≥ 16.2
AMCI	0 – 23.7	23.8 – 47.4	≥ 47.5

Table 3: Metric thresholds based on the Southern reference lake group. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

North Muck Lake Group

Metric	Impaired range	Intermediate range	Unimpaired range
Littoral vegetation low	0 – 0.226	0.227 – 0.452	0.453 – 0.888
Littoral vegetation high	0.945 – 1	0.899 – 0.944	0.453 – 0.888
Sensitive species	0 – 0.05	0.06 – 0.1	0.11 – 1
Tolerant species	0.569 – 1	0.138 – 0.568	0 – 0.137
Max depth of plants (m)	0 – 1 m	1.1 – 2.1 m	≥ 2.2 m
FQI	0 – 10.4	10.5 – 20.8	≥ 20.9
AMCI	0 – 27.4	27.5 – 54.9	≥ 55

Table 4: Metric thresholds based on the Northern Muck reference lake group. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition.

North Sand Lake Group

Metric	Impaired range	Intermediate range	Unimpaired range
Littoral vegetation low	0 – 0.215	0.216 – 0.431	0.432 – 0.582
Littoral vegetation high	0.795 – 1	0.583 – 0.794	0.432 – 0.582
Sensitive species	0 – 0.15	0.16 – 0.31	0.32 – 1
Tolerant species	NA	NA	NA
Max depth of plants (m)	0 – 0.8 m	0.9 – 1.7 m	≥ 1.8 m
FQI	0 – 12	12.1 – 24.2	≥ 24.3
AMCI	0 – 23.4	23.5 – 46.9	≥ 47

Table 5: Metric thresholds based on the Northern Sand reference lake group. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

RESULTS AND DISCUSSION

The results of the panel rankings can be seen in Figure 1. Five of the proposed lakes were deemed "Good" and therefore should be protected. The panel felt that one lake, Bullhead Lake in Manitowoc County, was not quite up to a "Good" level, but not quite "Fair" either. Three lakes were considered to be a solid "Fair", while four lakes straddled the line between "Fair" and "Poor". The lakes that lie between the "Poor/Fair" and "Fair/Good" lines should be considered Watch lakes. The panel graded one lake as "Poor" and recommends that lake to be listed as Impaired.

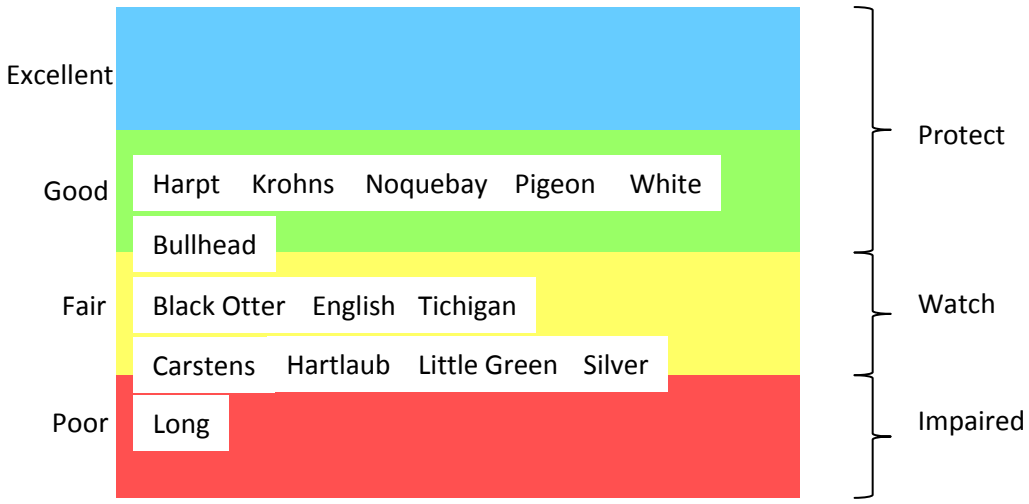

Figure 1: Ranking results based on the four categories of 303(d) listing.

Following is a lake-by-lake narrative of the review panel's justifications for their decisions. Figures 2-15 display the results of the multivariate analysis for each year of survey data. If the assessment lake lies within the green circle, the plant community of the assessment lake is not significantly different from those of the reference lakes. If the assessment lake lies between the green and orange circles, the plant community of the assessment lake is between 95% and 99% different from those of the reference lakes. If the assessment lake lies between the orange and red circles, the community of the assessment lakes is between 99% and 99.9% different from those of the reference lakes. If the assessment lake lies outside of the red circle, the plant community of the assessment lake is greater than 99.9% different from those of the reference lakes. Tables 6-19 display the metric values and scores for each lake. Lakes are listed alphabetically.

BLACK OTTER LAKE, OUTAGAMIE COUNTY WBIC 315600

Multivariate Assessment

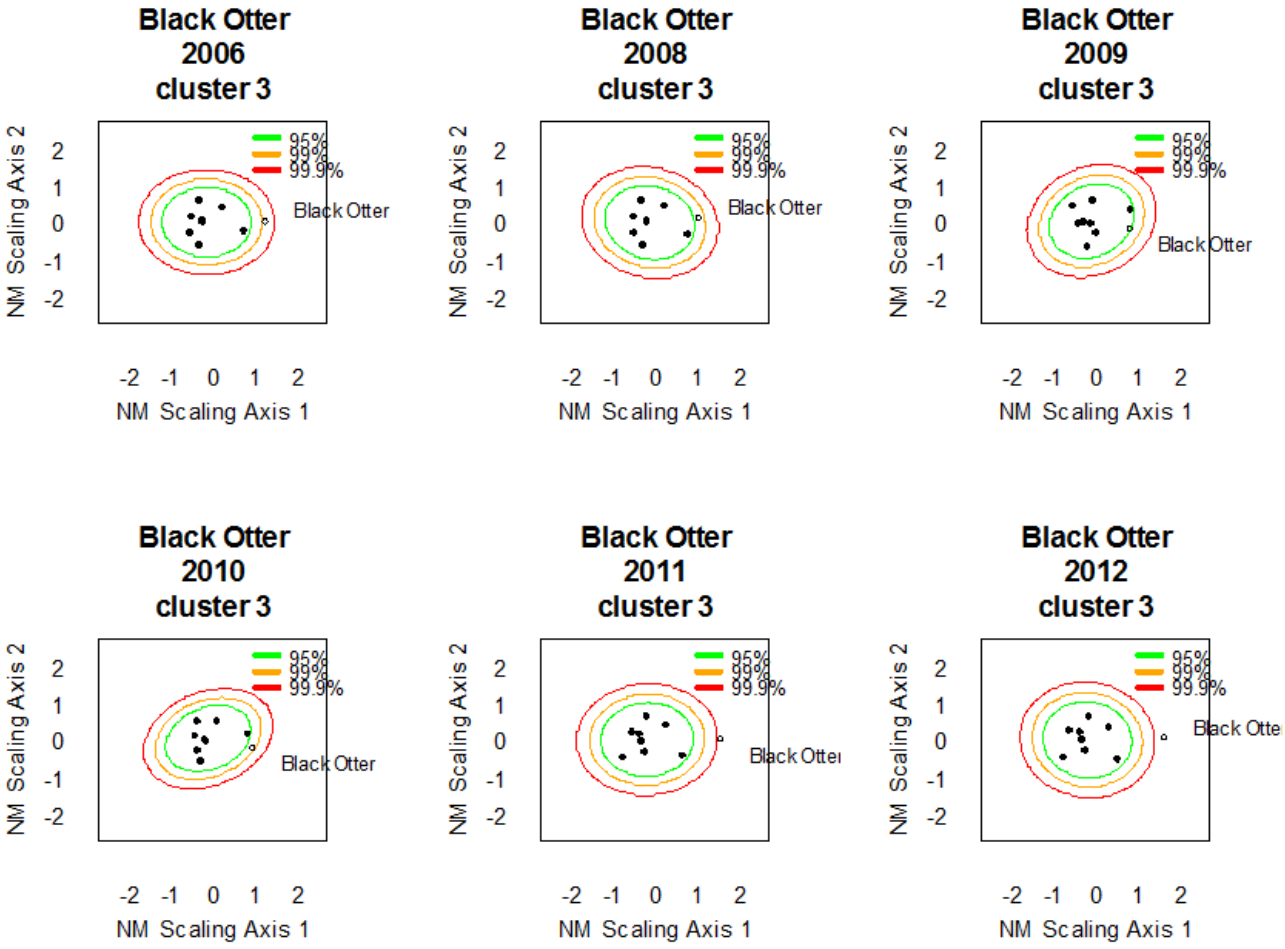

Figure 2: Results of the multivariate assessment of Black Otter Lake for 2006, 2008-2012. Reference lakes are plotted as filled circles. Black Otter Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2006	0.9962	0.012	0.606	3.4	15.98	40
2008	0.95	0	0.622	2.7	15.18	35
2009	0.9871	0	0.577	3.2	18.59	42
2010	0.8254	0	0.473	2.7	17.2	42
2011	0.9122	0	0.364	2.7	16.13	37
2012	0.9881	0	0.294	2.9	15	41

Table 6: Metric values for Black Otter Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

The multivariate and multi-metric analyses gave different results. The multivariate analysis trends toward impaired, while the metrics peak in 2009-2010 and then trend toward impaired. The lake is trending toward poor, but last 2 years of survey data are suspect due to surveyor effort. *Elodea canadensis* relative percent frequency of occurrence (rel % FOO) has skyrocketed due to management, but it is not one of our tolerant plant species. Curly-leaf pondweed rel % FOO has gone down to below 1%.

The panel voted twice on this lake. The first vote was split evenly between "Poor" and "Fair", with many of the members voting for "Poor" citing the increasing abundance of *Elodea canadensis* as the reason for their choice. The second vote saw three of the four panel members who previously voted "Poor" change to "Fair" due to the fact that the metrics of Black Otter Lake are similar to other lakes designated as "Fair". There is a need for more reliable survey data for this lake.

BULLHEAD LAKE, MANITOWOC COUNTY WBIC 68300

Multivariate Assessment

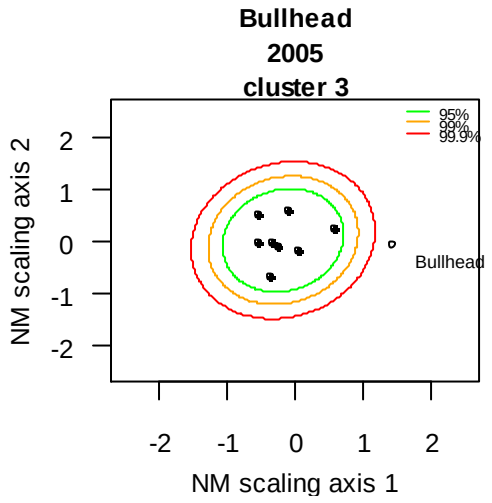

Figure 3: Results of the multivariate assessment of Bullhead Lake for 2005. Reference lakes are plotted as filled circles. Bullhead Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2005	0.8889	0.022	0.334	4.6	17.71	49

Table 7: Metric values for Bullhead Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

The multivariate and multi-metric analyses gave conflicting results. The multivariate analysis flagged Bullhead Lake as being very different from reference condition, while three out of the four applicable metrics fell into the reference condition range. This is a case where the plant community of a lake is very different from the reference condition, but our metrics do not show any impairment. When comparing the plant community of Bullhead Lake to those of the Southern reference lakes, the panel was able to see why it was flagged by the multivariate analysis. Bullhead Lake does not have any charophytes, while the Southern reference lakes do. It also has a high rel % FOO of *Lemna trisulca*, and a moderate amount of *Potamogeton amplifolius*; these are two species that the Southern reference lakes do not have in abundance. The panel decided that the differences in species composition were not due to an impairment and that the lake was in "Fair/Good" condition. There is a need for more recent survey data to confirm Bullhead Lake's condition.

CARSTENS LAKE, MANITOWOC COUNTY WBIC 66800

Multivariate Assessment

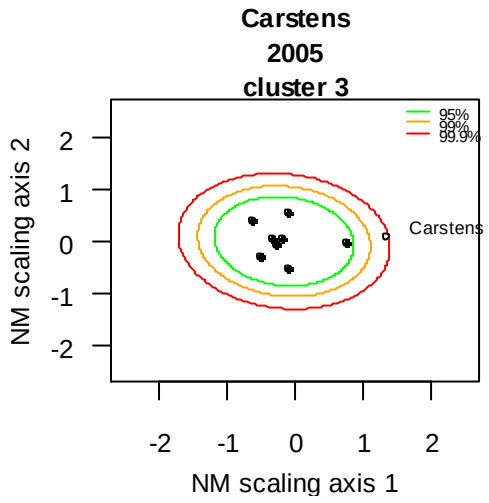

Figure 4: Results of the multivariate assessment of Carstens Lake for 2005. Reference lakes are plotted as filled circles. Carstens Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2005	0.615	0	0.622	3.7	8.66	30

Table 8: Metric values for Carstens Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

Both the multivariate and multi-metric analyses placed Carstens Lake somewhere between "Fair" and "Poor". Although several of the metrics were in the intermediate category of impairment, they were almost always on the lower part of the intermediate category. The panel did not use the most recent survey from 2010 because it was conducted in October, which is outside of the assessment timeframe. That left the panel with data from 2005. The 2005 survey only found four species of plants, the lowest species richness value of any of the assessment lakes. The 2010 survey found nine species, which could be due to better search effort.

The panel voted twice on this lake. The first vote was split evenly between "Fair" and "Poor". After looking more closely at the differences in species between the two surveys, the panel decided that the extra species added in 2010 do not constitute a plant community that is better than poor. Among the added species were *Typha* sp. and *Lemna minor*, two species with low coefficients of conservatism. Two panel members changed their votes from "Fair" to "Poor", rendering Carstens Lake as "Fair/Poor". There is a need for more recent survey data for Carstens Lake that is within the survey time period.

ENGLISH LAKE, MANITOWOC COUNTY WBIC 66100

Multivariate Assessment

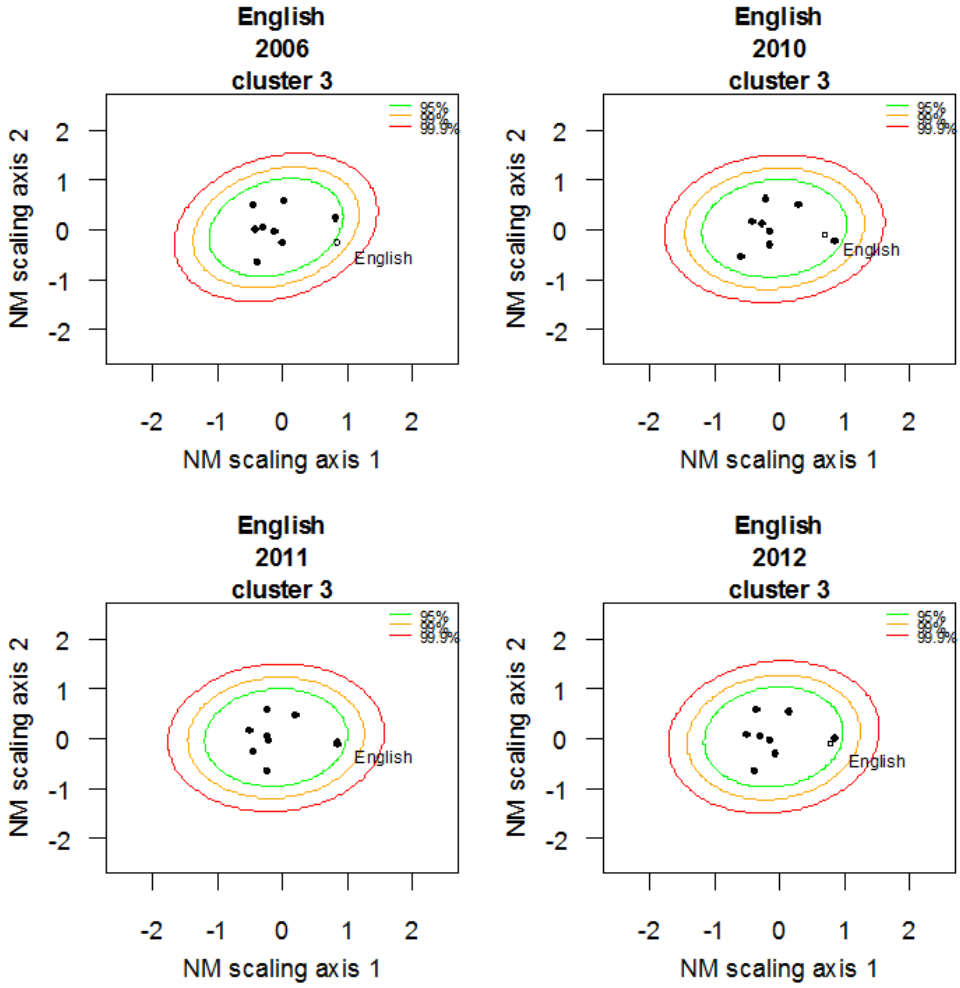

Figure 5: Results of the multivariate assessment of English Lake for 2006, 2010-2012. Reference lakes are plotted as filled circles. English Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2006	0.662	0	0.29	6.7	13.98	48
2010	0.9091	0	0.54	5.2	15	40
2011	0.7879	0	0.63	5.8	16.76	41
2012	0.7377	0	0.536	5.2	15.33	43

Table 9: Metric values for English Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

The multivariate and multi-metric analysis for English Lake gave somewhat conflicting results. The multivariate analysis put English Lake very close to Storrs Lake, which is one of our reference lakes. There is some debate within the panel as to whether Storrs Lake should be a reference lake. There were varying results from within the multi-metric analysis. For example, the rel % FOO of tolerant plant species metric clearly shows a trend toward impairment, while the maximum depth of plant growth falls within the reference range. This discrepancy could be due to the lake being colonized by Hybrid watermilfoil (HWM) in 2009. HWM rel % FOO in English Lake skyrocketed the year after colonization, which explains the trend toward impairment for tolerant plant species. HWM can also grow at deeper depths, which is probably why the maximum depth of plant growth for English Lake lies within the reference range. Several members of the panel had seen English Lake before HWM colonization and remembered it as relatively nice lake. Despite the impairment caused by HWM, the panel believed that English Lake was in better shape than Carstens Lake (due, in part, to a higher species richness) and gave it a "Fair" grade.

HARPT LAKE, MANITOWOC COUNTY WBIC 84600

Multivariate Assessment

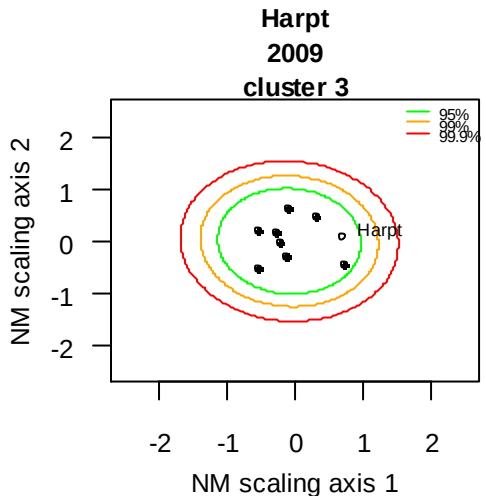

Figure 6: Results of the multivariate assessment of Harpt Lake for 2009. Reference lakes are plotted as filled circles. Harpt Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2009	0.8657	0	0.437	3.4	21.34	47

Table 10: Metric values for Harpt Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

Harpt Lake was a relatively simple lake to assess because both the multivariate and the multi-metric analyses gave similar results. The multivariate analysis placed Harpt Lake within the 95% confidence ellipse, meaning that its plant community is not statistically different from those of Southern reference lakes. Three of the five applicable metrics performed very well, falling within the range of reference lakes. The panel unanimously agreed that Harpt Lake is in "Good" condition, and should be protected.

HARTLAUB LAKE, MANITOWOC COUNTY WBIC 67200

Multivariate Analysis

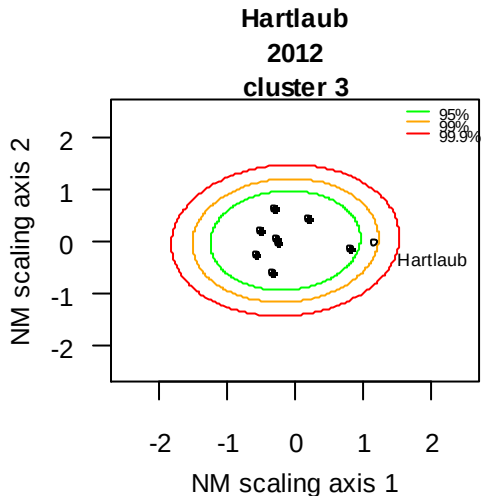

Figure 7: Results of the multivariate assessment of Hartlaub Lake for 2012. Reference lakes are plotted as filled circles. Hartlaub Lake is plotted as a hollow circle.

Multimetric Analysis

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2012	0.8442	0	0.861	3.7	12.66	35

Table 11: Metric values for Hartlaub Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

The multivariate and multi-metric analyses both pointed toward a "Fair" to "Poor" condition for Hartlaub Lake. The lake had a very high rel % FOO of tolerant plant species, and the species richness, being 8, was not very high. The only submersed plant species that was not one of the tolerant plant species was *Chara*. The panel decided to give Hartlaub Lake a solid "Fair", although they believe it is approaching the bottom of the "Fair" category.

KROHNS GREEN LAKE, KEWAUNEE COUNTY WBIC 94700

Multivariate Assessment

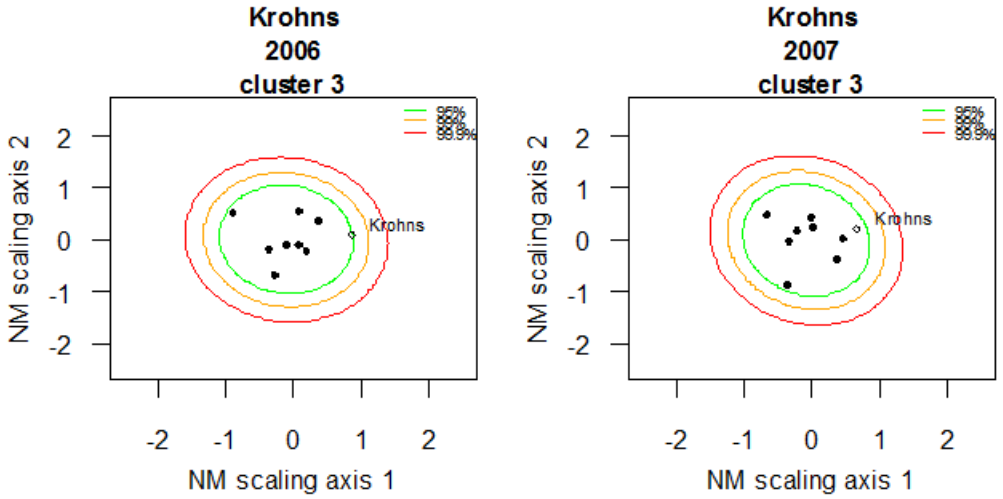

Figure 8: Results of the multivariate assessment of Krohns Lake for 2006-2007. Reference lakes are plotted as filled circles. Krohns Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2006	1	0.067	0	4.6	14	38
2007	0.958	0.121	0.03	4.6	15.51	38

Table 12: Metric values for Krohns Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

The multivariate and most parts of the multi-metric analyses ranged from intermediate to unimpaired. The major exception was the percent of the littoral area that was vegetated. Krohn's Lake has a very high littoral vegetation rate, approaching 100%. The majority of that metric comes from charophytes. A healthy population of charophytes, like the one seen in Krohns Lake, is not indicative of impairment. Rather, abundant charophytes in Southern lakes may increase a lake's resilience to perturbation, mitigate eutrophic inputs, or otherwise contribute to high-quality plant communities despite watershed impairment. One panel member suggested that perhaps a high level of charophytes should not be considered as an impairment because these species rarely reach the surface of the water. Krohns Lake does, however, have an expanding population of Eurasian watermilfoil (EWM). Since the last survey was done in 2007, the panel recommends that Krohns Lake be placed in the "Good" category, but that it should be resurveyed to assess the EWM population.

LITTLE GREEN LAKE, GREEN LAKE COUNTY WBIC 162500

Multivariate Assessment

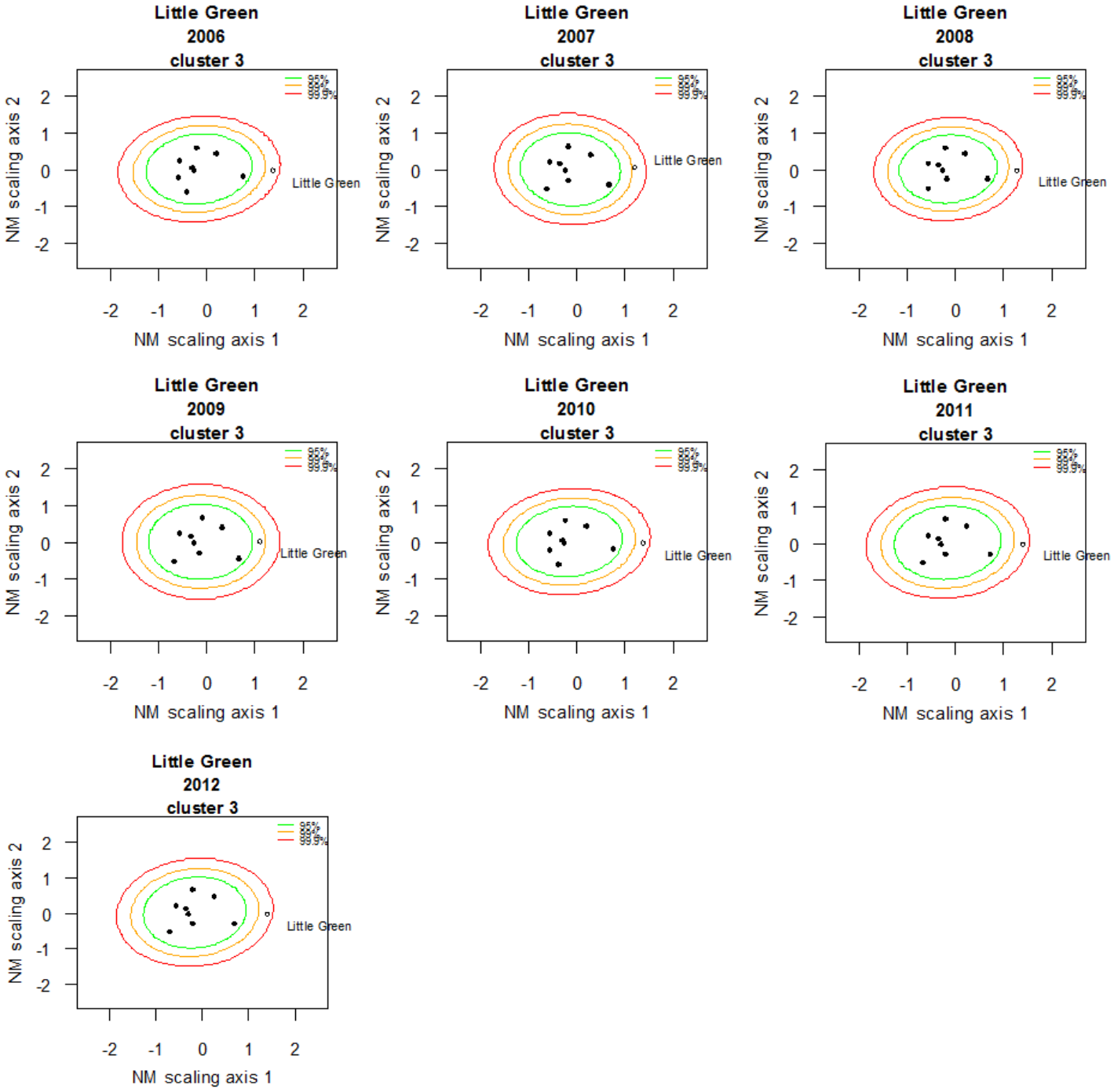

Figure 9: Results of the multivariate assessment of Little Green Lake for 2005-2012. Reference lakes are plotted as filled circles. Little Green Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2005	0.6744	0	0.791	4.9	9.5	32
2006	0.7282	0	0.498	6.1	11.84	37
2007	0.54	0	0.495	4.9	11.84	37
2008	0.4789	0	0.709	4.6	15	37
2009	0.6108	0	0.518	4	14.5	36
2010	0.5813	0	0.565	4.7	14.5	36
2011	0.7238	0	0.746	4	11.84	33
2012	0.5911	0	0.625	4.6	13.61	37

Table 13: Metric values for Little Green Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

Little Green Lake has the most years of survey data available and thus the panel is comfortable with their assessment of this lake. The multivariate analysis flagged most years of survey data as impaired. Most metrics fell within the intermediate category, with the notable exceptions of tolerant species and maximum depth of plant growth. Most years of data for Little Green Lake fell in the impaired category for tolerant plants. Looking at the species information, Little Green Lake has lots of Coontail and EWM. Curly-leaf pondweed is also present, but its levels have been decreasing lately. The maximum depth of plant growth metric lies within the reference range for most years, but this could be due to the fact that EWM can grow at deeper depths. Little Green Lake is a highly managed system; some members of the panel have experienced first-hand both harvesting and chemical treatment occurring on the same day. The non-stop harvesting regime is favoring tolerant plant species, so the panel recommends a low “Fair” grade.

LONG LAKE, MANITOWOC COUNTY WBIC 77500

Multivariate Assessment

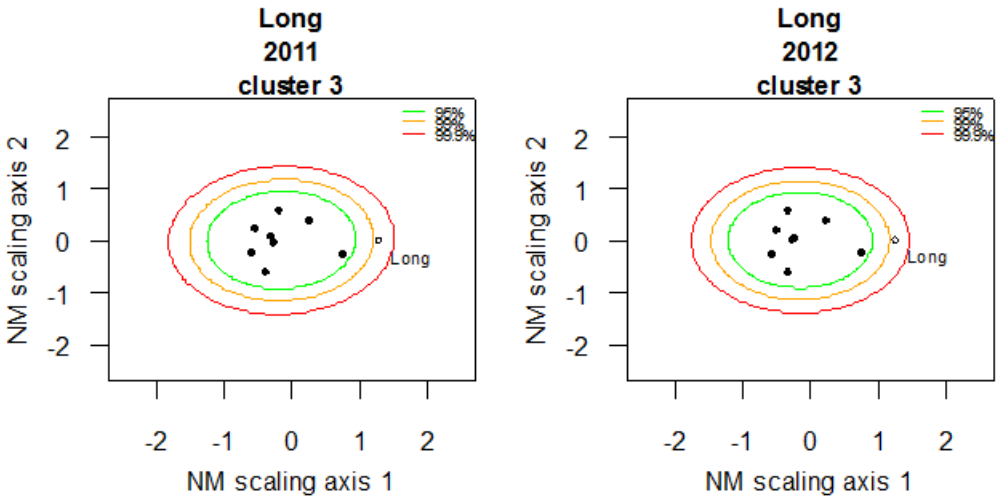

Figure 10: Results of the multivariate assessment of Long Lake for 2011-2012. Reference lakes are plotted as filled circles. Long Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2011	0.333	0	0.955	4	10.73	24
2012	0.4472	0	0.926	2.7	11.18	23

Table 14: Metric values for Long Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

Both the multivariate and multi-metric analyses flagged Long Lake as impaired. Long Lake has the lowest littoral vegetation metric value of all of the assessment lakes, which is most likely due to the fact that Long Lake flips between an algal-dominated and macrophyte-dominated state. It also has a depauperate plant community (species richness = 6). Of the macrophytes that are present, EWM and Coontail dominate. A combination of very low % littoral vegetation and a high relative % FOO of tolerant plant species helped the review panel unanimously grade Long Lake as “Poor”.

LAKE NOQUEBAY, MARINETTE COUNTY WBIC 525900

Multivariate Assessment

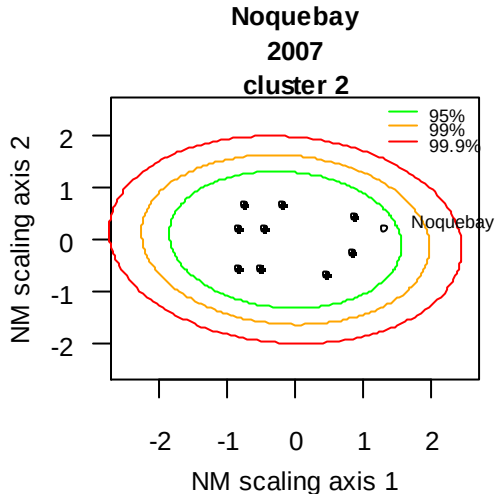

Figure 11: Results of the multivariate assessment of Lake Noquebay for 2007. Reference lakes are plotted as filled circles. Lake Noquebay is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2007	0.9516	0.035	0.075	4.4	37.22	62

Table 15: Metric values for Lake Noquebay with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

The multivariate analysis places Lake Noquebay within the 95% confidence ellipse, signifying that its plant community was not significantly different from that of the North Sand reference lake group. Though Lake Noquebay's sand content exceeds the % sand threshold, the panel agreed that it is not an oligotrophic lake and never was meant to be one. This lake is naturally enriched and has a significant amount of muck substrate. The multi-metric analysis was split between poor and excellent results. Poor results were given by the littoral vegetation and sensitive species metrics. The littoral vegetation was very high compared to an oligotrophic lake, but, as mentioned before, the panel believes this lake is naturally enriched. The lake was proposed due to having a bay filled with variable-leaf watermilfoil. The low sensitive species metric is a little concerning. The rest of the metrics fall within the range of the reference condition, with the highest traditional AMCI value of the assessment lake group. The panel recommends that the lake be placed in the "Good" category overall; the only reason why it was not recommended to be "Excellent" was the lack of sensitive species.

PIGEON LAKE, MANITOWOC COUNTY WBIC 64000

Multivariate Assessment

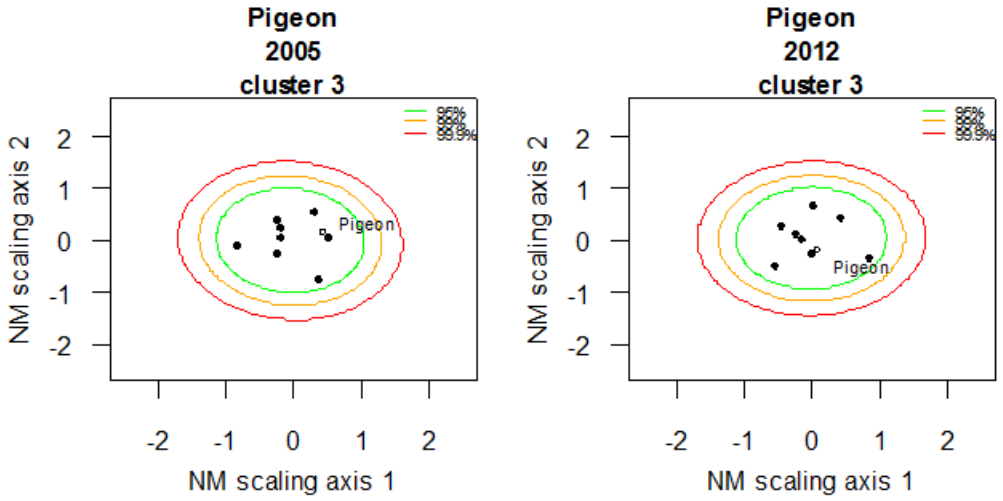

Figure 12: Results of the multivariate assessment of Pigeon Lake for 2005 and 2012. Reference lakes are plotted as filled circles. Pigeon Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2005	0.905	0	0.016	8.5	18.69	42
2012	0.8223	0	0.095	6.1	22.46	53

Table 16: Metric values for Pigeon Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

Both the multivariate and multi-metric analyses placed Pigeon Lake in the unimpaired category. This lake has high species richness compared to the other Southern lakes and has a healthy population of charophytes. Similar to Krohns Lake, the abundant charophyte population in Pigeon Lake seems to be helping to protect this lake from degradation. Two of the metrics, littoral vegetation and tolerant plant species, were in the intermediate range but only just so. The panel voted to place Pigeon lake at the upper end of the "Good" category and is considering adding it to the Southern reference lake group.

SILVER LAKE, MANITOWOC COUNTY WBIC 67400

Multivariate Assessment

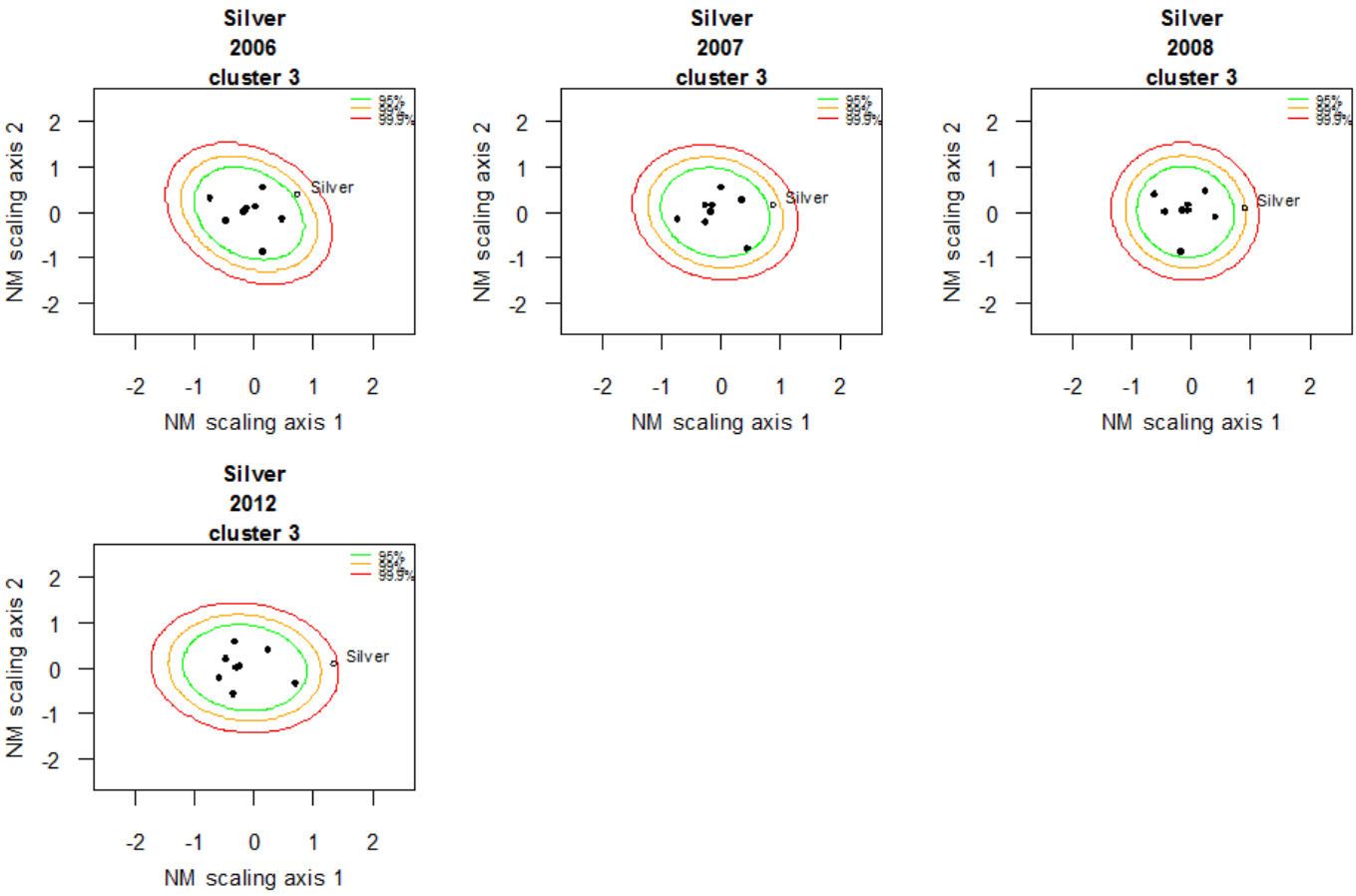

Figure 13: Results of the multivariate assessment of Silver Lake for 2006-2008 and 2012. Reference lakes are plotted as filled circles. Silver Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2006	0.1325	0	0	2.7	10.97	30
2007	0.209	0	0	2.6	14.29	38
2008	0.1818	0	0	2.6	10.97	33
2012	0.8366	0.007	0.885	5.2	14.74	34

Table 17: Metric values for Silver Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

Silver Lake was an interesting lake to assess because the panel had survey data before, leading up to, and after the colonization of EWM. There was a clear trend in the multivariate and one of the multi-metric analyses from "Good" to impaired. A notable exception to the trend was for the littoral vegetation metric. Silver Lake has an intensive management regime, including alum treatments and carp removal. Before the alum treatment, the lake was in an algae-dominated state. The alum helped the lake flip back to a macrophyte-dominated state. This trend was most likely due to the explosion of EWM in the lake. Before EWM, Silver Lake had no tolerant plant species. In 2012, EWM accounted for 88.5% of relative frequency of plants. Such a drastic change in plant community is alarming, and the panel recommends that Silver Lake be placed on the border of "Poor" and "Fair", although the lake is in better shape than it was before management.

TICHIGAN LAKE, RACINE COUNTY WBIC 763600

Multivariate Assessment

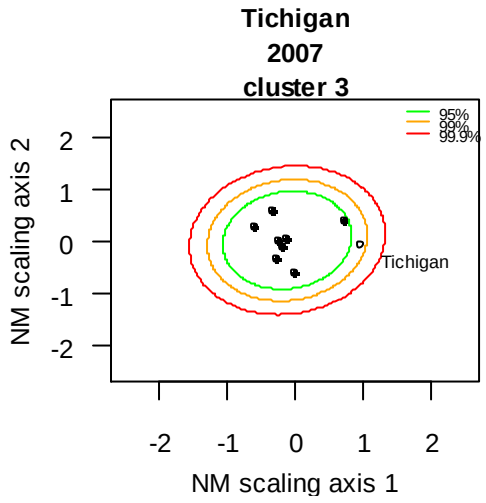

Figure 14: Results of the multivariate assessment of Tichigan Lake for 2007. Reference lakes are plotted as filled circles. Tichigan Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2007	0.801	0	0.827	4.3	13.44	36

Table 18: Metric values for Tichigan Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

The multivariate and multi-metric analyses both tended to categorize Tichigan Lake as "Fair". Although the littoral vegetation metric fell within the range of the Southern reference lakes, the rest of the metrics fell squarely in the intermediate to impaired range. Tichigan Lake has lots of Coontail, which accounts for its low score in the tolerant plants metric. The lake does not have many charophytes and has an intermediate species richness. The panel voted unanimously to place Tichigan Lake in the "Fair" category, but also recommended a resurvey since the most recent data was from 2007.

WHITE LAKE, WAUPACA COUNTY WBIC 272900

Multivariate Assessment

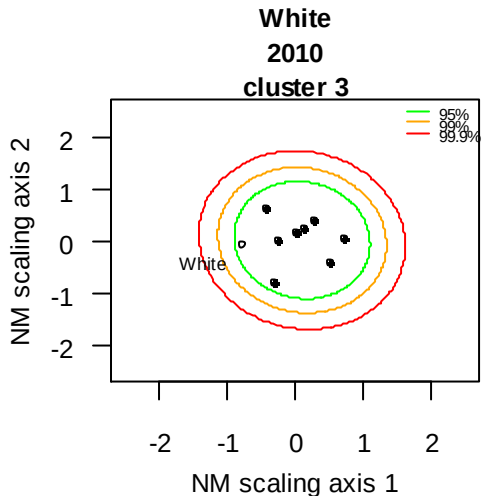

Figure 15: Results of the multivariate assessment of White Lake for 2010. Reference lakes are plotted as filled circles. White Lake is plotted as a hollow circle.

Multimetric Assessment

Year	Littoral vegetation	Sensitive species	Tolerant species	Max depth of plants (m)	FQI	AMCI
2010	0.9339	0.175	0.013	3	35.47	54

Table 19: Metric values for White Lake with corresponding impairment categorizations. Red shading is impaired, yellow shading is intermediate, and green shading is within the range of the reference condition. Grey shading corresponds to a metric where the reference range was too low to assess.

Narrative

Both the multivariate and multi-metric analysis trended toward unimpaired. Although we could not assess the sensitive species in the Southern group due to the lack of sensitive species in the Southern reference lakes, almost one fifth of the plants in White Lake are sensitive species. White Lake does, however, have curly-leaf pondweed. The survey data from later in the summer does not pick up on the problems caused by curly-leaf pondweed. One of the panel members mentioned that White Lake is planning a whole-lake Endothall treatment this summer to address the curly-leaf pondweed overgrowth. The panel hopes that the Endothall does not adversely affect the diversity and abundance of sensitive species in the lake. Based on the survey data alone, the panel was split evenly between giving White Lake an “Excellent” or “Good” grade. Prior knowledge of the lake and especially of the curly-leaf pondweed issue led the panel to downgrade to a solid “Good” ranking.

Besides the metrics that the panel used to analyze the assessment lakes, the following metrics were proposed for further consideration:

Species metrics	Physical metrics	Summary statistics metrics
Sensitive C for Southern lakes from 7-10	Stained lakes	Simpson's diversity index
	Marl as sediment type	Only count high %LITTVEG as impairment for North Sand lakes
Lack of charophytes can signify impairment in Southern lakes		
		Evenness metric; how many species does it take to get up to 80% rel FOO
Lump pondweed guilds		
		Species richness

Table 20: Proposed metrics for future research.

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