LakeScan™ 5.0 Changes and Developments 2024

Time passes and things change. LakeScan™ began over 30 years ago and was the basis for the State of Michigan's AVAS survey methods and requirements initially developed in the early 1990's. There have been four major iterations or versions of the method and algorithms in past years. As our understanding of lake ecosystems and client needs continues to evolve, and it was time to consider and initiate a number of updates as a part of v 5.0. 2024 has been the busiest year for development in the history of LakeScan™. Major changes have been made and are detailed in this note. Updates include:

1. Changes have been made to the species list to reflect changes in the arena of systematics with regard to molecular studies and hybridity.
2. Plant community AROS density and distribution weighting factors.
3. Equations used to compute the BioD 60© and MorphoD 26© metric values have been drastically changed.
4. The floristic quality index has been suspended because molecular studies have made it nearly impossible to assign subjective conservation ("C") values to individual taxa in a meaning matter.
5. In the absence of the FQI, there is greater reliance on the perceived nuisance value assigned to any species observed to contribute to ecological or recreational nuisance conditions during surveys.
6. A new metric called the submersed vegetation as critical habitat value SAVAaCH is in development and initial data is in review. The MorphD 26© metric will be a part of that calculation along with an expanded PNL value that explicitly factors in the height of the SAV in an AROS.
7. Biological Tier sizes are now factored into many calculations. AROS, which have always been dimensionless due to various uses and application are also adjusted for relative area according to Tier when used in some calculations.

Category 700 – Aquatic Vegetation Community Characterization

Objectives: As expected, goals for aquatic vegetation management communities remain static from year to year. The goal of most management programs is to provide reasonable opportunities for recreation, including angling, and to maintain the "health" of the ecosystem. There is a considerable amount of debate over "what is a healthy aquatic ecosystem" and even more debate about how we can characterize the health of aquatic plant communities. The LakeScan™ aquatic macrophyte community assessment is intended to provide a coherent and practical method of making and collecting empirical observations of the community that can subsequently be subjected analysis and various comparisons to inform good lake management decisions. The primary objectives of the methods are:

Maximum Survey Efficiency Coupled with a High Degree of Data Richness. Usually, there are insufficient resources to fund academic level data acquisition related to lake condition. Too often resources are not directed toward collecting data needed to assess the impacts of management interventions. There is the unfortunate "reality" that the time in the field must maximize data quality or richnes while data is acquired quickly. The objective may be similar to data and analysis required for academic studies and agency reviews, but the reality is mired in time and resource constraints. Lake management practitioners must be able to provide vegetation community surveys and analysis that are affordable, meaningful, and applicable to a wide range of surface water resources - or the surveys will simply not be done.

The LakeScan™ methodology strives to provide various means to characterize and evaluate surface water ecosystems and management outcomes. There are certain over-riding factors that have guided and continue to inform development of the method.

Standardized data forms and metrics: Aquatic plant taxonomy can be very difficult. LakeScan™ depends on plant lists that can be used for lake-to-lake comparisons based on data collected by field personnel who may have widely ranging abilities to identify species ore even species groups.

Although not as critical, a standardized means of assigning data (observation sites, points, transects, quadrants) is also critical. The observation site model, couple with simple gps readings is a very cost effective and data rich way to accrue critical data.

Simple Easily Understood Metrics for Comparison Purposes: Once the data has been collected, it needs to be put in a form that is easily understood by lay people and the scientific community. The metrics must provide numerical data that is consistent impressions made by most observers on a particular surface resource at a given time. There is no value in numbers that do not describe or are inconsistent with “the obvious”. Metrics must be meaningful.

Overview of Changes Incorporated in LakeScan™ 5.0 Updates

LakeScan™ Species Lists 5.0

Survey efficiency demands that a short-hand system be used to record the presence of different species and species groups. The LakeScan™ species list and system is designed to provide the means for a short-hand species/group listing but also provide a means to provide meaningful comparative data. Plant lists are largely based on the identification of individual species and LakeScan™ assigns numbers and abbreviations to facilitate rapid data acquisition. Field scientists should be not surprised that there are certain inconsistencies in the abilities of field crews to identify certain species or species groupings. It can be overly time-consuming or very difficult to identify some species in the field depending on the presence of flowers or seeds or “weird looking plants”. Molecular or genetic analysis of plant materials can support studies and academic exercises and may help to inform management decisions, but they take too long to provide rapid conveyance of critical information. Molecular testing can also be expensive when enough samples are taken to truly characterize a surface water resource.

The original AVAS method clumped similar species into groups. For example, there are over 100 species of Chara in the world and dozens in the State of Michigan. These have traditionally been lumped together as “Chara” because of the number of species and difficulty in distinguishing different species quickly. This aggregation is extended into the LakeScan™ species list.

The work of Furnier and Mustaphi (1992) suggested that by the early 1990's that there were already multiple Eurasian watermilfoil genotypes in NA. The hybridization of *Myriophyllum spicatum* x *M. sibiricum* was revealed in 2002 (Moody and Les, 2002) and Eurasian watermilfoil hybrids were first collected and then identified in Michigan in 2003 from samples collected by Aquest forwarded to by D. Les, University of Connecticut for identification. Different milfoil genotypes and hybrids react differently to competition with other plants, development of nuisance conditions, and to the impact anre response to management interventions. In field practice, it can be nearly impossible to distinguish between Eurasian watermilfoil and hybrids in the field, hence these are lumped together as "Ebrid" or Eurasian watermilfoil <u>and</u> Eurasian watermilfoil hybrids.

Pondweed identification is difficult. Pondweed hybrids exhibiting various morphologicalcharacteristics of the parental types have been known for more than a century and are known to constitute an important component of Potamogetom diversity (Kaplan and Fehrer, 2006). The mere plasticity of pondweed phenotypes can make identification extremely difficult and misleading (Kaplan, 2002; Kaplan and Fehrer, 2011). Field survey practitioners in Michigan would agree that there is obvious evidence of hybridity in common Michigan pondweeds with over-lapping distinguishing characteristics and the emergence of unexpected nuisance pondweed populations. Indeed, the most common medium and broad leaf pondweed species in Michigan are known to be promiscuous and the Flora of North America references *P. illinoiensis, P. nodosus, P. amplfolius* and *P. graminieus* hybrids (FNA, Vol. 22 @eflora.com). LakeScan™ 5.0 recognizes the inherent difficulty in arriving at accurate field identification of many of the pondweed species during surveys and therefore has reprised the lumping precedent used for the MI EGL ANC AVAS survey method and places many of the species into several broad groups based on morphotype. The medium leaf and broad leaf epithets are applied to *P. illinoiensis, P. nodosus, P. amplfolius* and *P. graminieus* and possible hybrids*.* Thin and thread leaf pondweeds are grouped into a "thin leaf pondweed" group, but not to include *Stukenia* which can be easily distinguished from the thin leaf pondweeds due to the obvious absence of a mid-rib in the leaves. The clasping leaf pondweeds, *P. richardsonii* and *P. perfoliatus* have also been combined into a "clasping leaf" grouping because of morphological similarities that seem to cause confusion among field personnel.

The LakeScan 5.0 species/species group list was developed to permit or allow better lake-to-lake comparisons where field personnel may have differing opinions on species epithets. The method includes the opportunity for surveyors to include more detailed and specific species identifications by number, but whole number are used to refer to broader species groups and this is necessary for standardization of data from different persons or groups of surveyors. Otherwise, lake-to-lake and even time-to-time comparisons would lack validity because of wide ranging abilities and perceptions of field crew / surveyor personnel.

Tier 1 and 2 Considerations: The Tier 3 through Tier 9 species list is included with this document (see appendix). Tiers 1 and 2 include plants such as cattail, swamp loosestrife, and exotic species such as purple loosetrife and phragmites. It is critical to remember that are areas characterized as wetland habitats. It would be impossible to conduct a meaningful survey of Tier 1 and 2 habitats from a boat used to survey Tiers 3 – 9; however, it is sometimes informative to record the presence of these emergent species. These recordings should be qualified as how the observation was mad and ONLY

ASSIGNED to the appropriate Tier. They should not be used to calculate SAV species richness or to calculate critical metrics. Wetland ecologists have devised elegant ways to describe and characterize these critical habitats although they still are evolving since they were introduced in the late 1970's (Carlson et al., 2024). These are a part of the LakeScan™ wetland survey category and not part of Category 700.

Critical Lake Quality Metrics

Biodiversity is used as a common indicator of ecosystem health. However, there is no single definition or empirical measure of biodiversity used to describe aquatic vegetation communities. Studies suggest that the value of biodiversity measure depends on the ecosystem being studied (organisms present, geography, etc). Some researchers concluded that Species richness may be the best way to characterize the community because of the impact that evenness indices have on lakes where there are rare species (Alahunhta et al., 2017; Hill, 1973). However, multi-metric analysis that include measures of plant abundance and percent cover, maximum growth depth, species quality (indices of conservation), exotic (invasive?) species present, disturbance tolerance, have also been considered and each approach has some positive characteristics, but once again seem to be best suited for a narrow purpose (Penning et al., 2008).

The LakeScan™ BioD 60© biodiversity metric was originally developed to provide an empirical estimate of overall condition of whole or parts of lakes. It has morphed and changed repeatedly through the years. It began as the average density weighted cumulative cover estimate for all the species found in a lake at the time of a survey or averaged over multiple surveys. This approach was adopted in part by the MI EGLE AND AVAS survey method in the early 1990's. At one point, in the early 2000's, standard terrestrial indices such as the Shannon index were used to compute the LakeScan BioD 60© metric. These "evenness" indices were appealing because of their extensive use in the scientific and peer reviewed literature. In use for analysis, it became increasingly clear that evenness indices did not provide numbers that were consistent with what was inherently obvious on the lakes to which it was applied. The problem with the application of an evenness index such Shannon Index is that the distribution of species in lakes is inherently uneven. Canals and small bays have and should be expected to support different species than are supported in offshore zones in lakes but the relative small size of these areas can result in unreasonably lower biodiversity measures. The diversity of habitats in lakes is akin to the diversity of terrestrial habitats found throughout all North America. These deficiencies have resulted in careful consideration of what factors correlate the best with even casual observations of lake condition and that can be helpful to inform management decisions.

The current, LakeScan™ 5.0 BioD 60© metric index is based on 40 years of observation. It is founded on the belief that it is critical that metric calculations yield metric values that actually reflect what seems obvious when viewing a lake. With this as a primary directive, the LakeScan™ 5.0 BioD 60© metric value is based on three considerations.

1. Species richness in the lake or area of a lake under consideration.

2. The average density/distribution value determined for the AROS in the area of a lake or lake under consideration.
3. The average number of species found at each AROS in the area of the lake or lake under consideration.

Species Richness or total species present is by most estimates a very good indicator of aquatic ecosystem health and resilience. The BioD 60© metric value assumes that the greatest number of species observed in lake is probably near 60. This is a key number that will become obvious later.

The abundance or density of vegetation at an AROS is also a critical descriptive factor. The recently revised algorithms continue to rely on cumulative cover estimates or density qualifiers adopted by the State of Michigan. The reader is reminded that the AVAS (aquatic vegetation assessment site) was a precursor term to the AROS (aquatic resource observation site) but they are virtually interchangeable. An AROS vegetation distribution estimate is also included as requested by late fisheries biologist Gary Crawford who valued the edge effect created by different distributions of plants within an AROS. Both Density and Distribution weighting values are "adjustable" and various levels are currently under review to measure the impact on the calculation of key LakeScan™ metrics. For reference, the current weighting values were adopted after an online seminar hosted by the Michigan EGLE, WRS, ANC unit in 2022. Participants expressed concerns over the mixing of "A" and "B" values on one end of the spectrum and "C" and "D" estimates on the other end of the density spectrum. The past and current weighting values are found in Table 1. The current weighting values are intended to approach 100 to describe a condition where plant growth is very dense and most if not all of the AROS is covered with some form of vegetation.

Table 1. Historical and current density and distribution weighting values for the calculation of LakeScan™ critical metrics. The uppermost table contains estimates used in the AVAS survey method used by the MI EGLE. The lower table contains current estimates. NOTE – These are under review and could change in coming years.

Density			Distribution		
Abbrev	Field Code	Weight	Abbrev	Field Code	Weight
A	1	1	S	1	N/A
B	2	10	SP	2	N/A
C	3	40	P	3	N/A
D	4	80	CP	4	N/A

Density			Distribution		
Abbrev	Field Code	Weight	Abbrev	Field Code	Weight
A	1	20	S	1	20
B	2	40	SP	2	40
C	3	80	P	3	80
D	4	100	CP	4	100

The assignment of D/D values is obviously subjective. The MI EGLE guidance document describes density assignments as follows.

> **a) = found:** one or two plants of a species found in an AVAS, equivalent to **less than 2%** of the total AVAS surface area.
> **(b) = sparse:** scattered distribution of a species in an AVAS, equivalent to **between 2% and 20%** of the total AVAS surface area.
> **(c) = common:** common distribution of a species where the species is easily found in an AVAS, equivalent to **between 21% and 60%** of the total AVAS surface area.
> **(d) = dense:** dense distribution of a species where the species is present in considerable quantities throughout an AVAS, equivalent to **greater than 60%** of the total AVAS surface area.

Another seemingly crirical factor to consider is the average number of species at an AROS or the average AROS species richness. Lakes that are afflicted by invasive plant species are often characterized by low average number of species at individual AROS where the invasive species extirpate competing plant species.

Calculating the BioD 60©

Three factors derived from observations are combined to arrive at a meaningful estimate of lake conditions as follows:

Tier Species Richness for BioD 60© Determination

Species richness or the total number of species present is one of the fundamental parts of of the BioD 60© metric calculation. 60 is presumed to be the greatest number of species that might be found in any North American inland lake in Tiers 3 through 9. The species richness for most lakes; however, range between 12 and 30. The total species richness number is transformed to a log value since there is probably a diminishing benefit associated with total species numbers greater than 30. This value is divided by the log of 60 and multiplied by 100 to create a value ranging from 0 to 100 that can be used in the BioD 60© determination.

1. ***Log(Lake Total Species Richness) / Log(60) * 100***

Vegetation Abundance (Density and Distribution)

Plant abundance and density are also obvioiusly important factors used to describe the aquatic plant communities in Tiers 3 to 9 or in other considered areas such as TmtZ. This is basically, a cumulative cover estimate based on field observations of species density and distribution (see Handbook) where these observation values are weighted by the values found in Table 1. The Density and Distribution values are averaged so that MI EGLE ANC AVAS data can be processed without extraordinary effort. The individual D/D values for each species are averaged for the Tier. The value is calculated for each Tier Values range from 0 to 100.

2. ***Averaged Weighted Density and Distribution Values for Each Species Found in Each AROS***

Tier Average Species at AROS value.

This is another way to consider species richness within a spatial context. For computational purposes, it is fundamentally the log transformed average number of all species at the AROS in a Tier divided by the log transformed number of species found in the entire lake. It is a very rough approximation of AROS heterogenecity within the Tier, but being species agnostic and because Tiers are more unform in character, it does not suffer from the same issues that a misapplied evenness index suffers from when applied to an entire lake that is characterized by various biolgoical tiers. Typical calculated values range from 0 to 100. The Tier BioD 60© value is calculated as:

3. ***Log(Average number of Species at AROS) / Log(Lake Species Richness) * 100***

An overall BioD 60© value for the whole lake is based on the average BioD 60© values derived at each biological tier. These values are adjusted for the size of Tier and the number of AROS at each Tier. This is because AROS can be of different sizes within Tiers of varying size. Tier/AROS/area weighting is a new feature in LakeScan™ 5.0. Values range from 0 to 100.

Other Computational Adjustments

For a number of critical reasons, the size of an AROS is indeterminant. For example, the size of treatment or harvesting zones varies and yet AROS are still assigned to these areas. The relative area of the AROS will fluctuate with the area of the treatment/harvesting zone and could be different than the area value used for other purposes. Similarly, the size of a Tier AROS is dynamic and is calculated as the total number of acres in a Tier by the total number of AROS found in that Tier. For the purpose of calculation, LakeScan™ 5.0 weights the values at each Tier by the area of each. Essentially, The Whole Lake BioD 60© value calculated for the lake is based on the average, weighted values at each Tier for of equations 1, 2, and 3 above. Tier values can be weighted for a *value of importance*, but this has not been done in LakeScan™ 5.0 since the value of individual Tiers could be the subject of rabid debate. Hence, the Tiers are only weighted according to area (size) since the relative area of each Tier in the lake is reasonably proportional to importance and ecosystem function.

The whole lake BioD 60© can be represented as the average of:

Log(Species Richness of Entire Lake)/Log(60)

and

Tier Area Weighted Average of Density and Distribution/2 at AROS in a Tier

and

Area Weighted Average of the mean number of species at the AROS in Tiers as per Formula 3

MorphoD 26©

The MorphD 26 was similarly recalculated to reflect the same updates made to the BioD 60© Index.

SAVaCH Metric

A new index that is tentatively been labelled SAVaCH or Submersed Aquatic Vegetation as Critical Habitat recognizes that current vegetation community metrics are essentially two dimensional. This new index is based on a three-dimensional view of the community, by species, with an emphasis on moderate plant cover or density that corresponds to ideals determined by fishery biologists for enhanced fish habitats and that correspond to attributes needed to support recreation. For reference, the BioD 60© index seeks to determine the greatest amount of cover, density and distribution. But those maximal values are not necessarily ideal for fisheries production and may not coincide with expectations for recreational activities. This is largely due to the fact that invasive species can come to totally dominate lake floras and degrade basic ecosystem functions but still increase BioD 60© values due to the density and distribution of these weeds in the lake AROS. This new index will rely on newly emerging side-scan sonar technologies and will gradually become a part of the suite of critical and meaningful LakeScan™ metrics.

SAVaCH metric values have been calculated, and the results are under review. It was hoped that values would be ready for the 2024 reports; however, there is some disconnect with obvious reflections on lake condition and these values.

Floristic Quality Index.

Plant Community Quality and "C" value metrics have been suspended pending further review. It has been 20 years since Stan Nichols proposed the this index for use as a lake characteristic. However, since Stan developed the first list for Wisconsin and Aquest (with input from Stan) developed a list of plant "C" values for Michigan inland lakes, the field of molecular biology has exploded. Currently, we recognized ebrid watermilfoil hybrids and these range in invasive threat from severe where they extirpate nearly all competition to inconspicuous plants cohabiting with endemic and native species. It would be difficult to assign a meaningful "C" value to all hybrids and genetic variants of ebrid watermilfoil given this range of habit. The prevalence of hybrid pondweeds was not clearly understood 20 years ago. Recent studies suggest that the phenological plasticity and prevalence of hybridity make the accurate identification of common pondweed species nearly impossible withing the context of practical aquatic macrophyte vegetation surveys. Some of these genetic variants present at nuisance conditions that would have been considered totally uncharacteristic twenty years ago. Given that "C" values have little meaning when applied to broad taxa categories, the calculation and presentation of the FQI is being suspended. The reader is guided to the perceived nuisance estimates as a better estimate of the quality of the vegetation community.

PNL Index

The PNL index presentation has also been temporarily suspended. Although it has been proven to be extremely useful it needs to be further clarified for field data recording. The role of plant height needs to be more closely tied to the metric since height is a function of interference for boating. Many of the references to this index have been "suspended", but it is expected to return to LakeScan™ reports in an "improved" and more descriptive form in the next several years.

Ebrid Watermilfoil Maintenance Reporting

The nuisance expression of most aquatic invasive exotic invasive species in Michigan inland lakes seem to diminish over time with the possible exception of ebrid watermilfoil. Although nuisance levels never reach those observed in the late 1970's and early 1980's, nuisance ebrid watermilfoil production still exceeds acceptable levels requiring annual efforts to maintain acceptable production levels of this pernicious weed. Curly leaf pondweed nuisance level vary considerable from year to year, but are not considered independently since nuisance levels are only observed in the early growing season and the plant is concurrently managed with ebrid watermilfoil given it's sensitivity to most registered and approved aquatic herbicides. The percent area treatment and requirements for retreatment prior to the Labor Day holiday are key features of this new report topic. The value of this section will grow with each year of data.

Category 750 – Vegetation Community Management

Clients have been looking for a more thorough coverage and recording of management impacts and outcomes. These data require input from contractors to ensure that data correspond to year-end field reports and that they are accurate. It has been difficult to gain this kind of cooperation from the herbicide application contractor management team members. Development of these metrics were done with the best data available, but should not be considered to be highly accurate. It is hoped that cooperation will improve in the future and this Category will gain in accuracy and usefulness. The new section provides a number of data points for the last year of record and for historical review.

Section 750 provides "year of" and historical analysis of:

- AROS and acres treated once or multiple times per season
- Cost of treatments
- Listing of control agents used and the total acres and AROS to which they were applied
- Listing of all species AROS cover and the percent of that area that is exposed to herbicides diring the year of record.
- The species richness, and BioD 60© metric values associated with the treatment zones as a measure of intentional and unintentional impacts.

Preliminary data review has often been "surprising". Numbers don't lie and memories fade. Not all Category 750 data is included in reports.

References

Alahunhta, J., M. Toivanen, J. Jjoprt,F. Ecke, L.B. Johnson, L. Sass, J. Heino. 2017. Species richness and taxonomic distinctness of lake macrophytes along environmental gradients in two continents. Freshwater Biology 62(7) 1194-1206

Carlson, K.; Buttenfield, B.P.; Qiang, Y. 2024. Wetland Classification, Attribute Accuracy, and Scale. ISPRS Int. J. Geo-Inf., 13, 103. https://doi.org/10.3390/ijgi13030103 Academic Editors: Dev Raj Paudyal

Flora of North America. FNA/Family List/FNA vol. 22/Potamogetonaceas/Potomogeton @eflora.com

Furnier, G. R., and M. M. Mustaphi. 1992. Isozyme variation in Minnesota populations of Eurasian watermilfoil. Aquatic Botany 43: 305-309.

Hill, M. O. 1973. Diversity and evenness: a unifying notation and its consequences. *Ecology*, 54(2), 427-432.

Kaplan, Z. 2002. Phenotypicplasticity in Potamogeton (Potamogetonaceae. Folia Geobotanica. 37: 141-170

Kaplan, Z., J. Fehrer. 2006. Comparison of natural and artificial hybridization in Potamogeton. Preslia 78: 303-316

Kaplan, Z., J. Fehrer. 2011. Erroneous identities of Potamogeton hybrids corrected by molecular analysis of plants from type clones. Taxon 60(3): 758-766.

Moody , M. L. and D. H. Les . 2002 . Evidence of hybridity in invasive watermilfoil (*Myriophyllum*) populations . *Proceedings of the National Academy of Sciences USA* 99 : 14867 – 14871 .

Penning,W.E., B. Dudley, M. Mjelde, S.Hellsten, J.Hanganu, A.Kolada, M.van den Berg, S.Poikane, G.Phillips, N.Willby, F.Ecke. 2008. Using aquatic macrophyte community indices to define the ecological status of European lakes. Aquat Ecol.42:253-264