Tiered Aquatic Life Uses

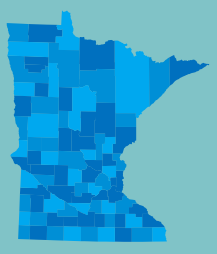
March 2022

Development of a tiered aquatic life use framework for Minnesota lakes

Based on Fish Index of Biotic Integrity scores and thresholds

MINNESOTA

Pollution Control Agency
Department of Natural Resources



wq-bsm4-03

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Document number: wq-bsm4-03

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Acronyms or abbreviations

1W1P	One Watershed One Plan
BCG	Biological Condition Gradient
BWSR	Board of Water and Soil Resources
CWA	Clean Water Act (33 U.S.C. § 1251 et seq.)
EPA	U.S. Environmental Protection Agency
FIBI	Fish-based Index of Biotic Integrity
FMA	Fisheries Management Area
FQI	Floristic Quality Index
GAM	Generalized additive model
HUC 8	8-digit Hydrological Unit Code
IBI	Index of Biotic Integrity
LGU	Local Government Unit
LOBS	Lakes of Biological Significance
Minn. R.	Minnesota Rules
Minn. Stat.	Minnesota Statutes
MN	Minnesota
MNDNR	Minnesota Department of Natural Resources
MPCA	Minnesota Pollution Control Agency
SID	Stressor Identification
TALU	Tiered Aquatic Life Uses
TP	Total Phosphorus
U.S.C.	United States Code
WQS	Water Quality Standards
WRAPS	Watershed Restoration and Protection Strategy

Definitions

The following definitions of terms used in this document are based on standard use and provided for the convenience of the reader. Unless otherwise specified, these definitions are specific to this document.

Aquatic Biota: The aquatic community composed of game and nongame fish, minnows and other small fish, mollusks, insects, crustaceans and other invertebrates, submerged or emergent rooted vegetation, suspended or floating algae, substrate-attached algae, microscopic organisms, and other aquatic-dependent organisms that require aquatic systems for food or to fulfill any part of their life cycle, such as amphibians and certain wildlife species. See Minn. R. 7050.0150, subp. 4.

Aquatic Life Use: A designated use that protects aquatic biota including fish, insects, mollusks, crustaceans, plants, microscopic organisms and all other aquatic-dependent organisms. Attainment of aquatic life uses are measured directly in Minnesota using Indices of Biological Integrity (IBIs) and biological criteria. Chemical and physical standards are also used to protect aquatic life uses.

Aquatic Life Use Goals: A goal for the condition of aquatic biota; required by the Clean Water Act (CWA). Minimum aquatic life use goals are established using the CWA interim goal ("…water quality which provides for the protection and propagation of fish, shellfish, and wildlife…"). The objectives for these goals are established in Minnesota Rule using narrative standards, numeric standards, or both. Attainment of these goals is directly measured in Minnesota using IBIs and associated "Biological Criteria" or "Biocriteria."

Beneficial Use: A designated use described under Minn. R. 7050.0140 and listed under Minn. R. 7050.0400 to Minn. R. 7050.0470 for each surface water or segment thereof, whether or not the use is being attained. (The term "designated use" may be used interchangeably.) See also "Existing Use."

Biological Assessment: An evaluation of the biological condition of a water body using surveys of the structure and function of an assemblage of resident biota. It also includes the interdisciplinary process of determining condition and relating that condition to chemical, physical, and biological factors that are measured along with the biological sampling. Guidance for performing biological assessments in Minnesota is described in MPCA (2018a; https://www.pca.state.mn.us/sites/default/files/wq-iw1-04j.pdf). (The term "bioassessment" may be used interchangeably.)

Biological Criteria,[1] Narrative or Biocriteria, Narrative: Written statements describing the attributes of the structure and function of aquatic assemblages in a water body necessary to protect the designated aquatic life beneficial use. See Minn. R. 7050.0150, subp. 4.

Biological Criteria,[1] Numeric or Biocriteria, Numeric: Specific quantitative measures of the attributes of the structure and function of aquatic communities in a water body necessary to protect the designated aquatic life beneficial use. See definition in Minn. R. 7050.0150, subp. 4.

[1] The term "biological criteria" can be used interchangeably with "biological standard." Minnesota rule uses the term "standard" to mean "*a number or numbers established for a pollutant or water quality characteristic to protect a specified beneficial use*" (Minn. R. 7050.0218, subp. 3). The EPA's use of the term "criteria" is similar to Minnesota's use of "standard." "Biological criteria" and "biocriteria" are the terms most commonly used in the United States to refer to numerical values, which represent the biological condition or health necessary to protect designated uses. Using Minnesota rule terminology, these values would be called "biological criteria" or "biocriteria" before promulgation and "biological standards" following promulgation in rule. However, to be consistent with the terminology used by federal agencies and by other states and tribes, the terms "biological criteria" and "biocriteria" are used in this document and in rule to refer to both the promulgated and unpromulgated values.

Biological Integrity: The ability of an aquatic ecosystem to support and maintain an assemblage of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region.

Biological Monitoring: The measurement of a biological entity (taxon, species, assemblage) as an indicator of environmental conditions. Ambient biological surveys and toxicity tests are common biological monitoring methods. (The term "biomonitoring" may be used interchangeably.)

Clean Water Act (CWA): An act passed by the U.S. Congress to control water pollution (formally referred to as the Federal Water Pollution Control Act of 1972). 33 U.S.C. § 1251 et seq.

Criteria: Narrative descriptions or numerical values which describe the chemical, physical, or biological conditions in a water body necessary to protect designated uses. See also the definitions for "biological criteria/biocriteria" and "standard".

Designated Use: See "beneficial use."

Index of Biological Integrity or Index of Biotic Integrity (IBI): An index developed by measuring attributes of an aquatic community that change in quantifiable and predictable ways in response to human disturbance, representing the health of that community. See MPCA 2017a, b.

Standard: Regulatory limits on a particular pollutant, or a description of the condition of a water body, presumed to support or protect the beneficial use or uses. Standards may be narrative or numeric and are commonly expressed as a chemical concentration, a physical parameter, or a biological assemblage endpoint. See also the definitions for "biological criteria/biocriteria" and "criteria".

Stratified or dimictic lake: In this document, stratified or dimictic refers to lakes which mix twice a year in the spring and fall and are stratified during the summer and winter.

Stressors: Physical, chemical, and biological factors that can adversely affect aquatic organisms. The effect of stressors is apparent in biological responses because stressor conditions are outside the conditions for which an organism is adapted. This leads to changes in the fitness of organisms and changes in the composition of organisms found in aquatic communities. Examples of stressors in aquatic systems are eutrophication, low levels of dissolved oxygen, pesticides and toxic pollutants, habitat alteration, altered hydrology, and reduced connectivity.

Water Quality Standards (WQS): A law or regulation that consists of the beneficial use or uses of a water body, the narrative or numerical WQS that are necessary to protect the use or uses of that particular water body, and antidegradation.

A. Overview

The Minnesota Pollution Control Agency (MPCA) and Minnesota Department of Natural Resources (MNDNR) have developed recommended revisions to Minnesota water quality rules to identify lake condition using fish communities and improve protection for biological communities and their habitats in Minnesota lakes. These revisions will implement a Tiered Aquatic Life Use (TALU) framework for classifying lakes based on the aquatic life present or attainable within a lake, similar to the framework used in assessing Minnesota streams. Currently, General Use[2] biocriteria are used as numeric translators for narrative standards for determining biological impairments for lakes based on their fish communities. This amendment would add an Exceptional Use tier with associated biocriteria for lakes with diverse and unique fish communities, as indicated by a high Fish Index of Biotic Integrity (FIBI) score. Numerous lakes, both in watersheds with minimal human disturbance and in watersheds with increasing human disturbance, currently have exceptional fish communities, and would benefit from a TALU approach. The higher protection attained by adding an Exceptional Use biocriteria will limit the amount of degradation that can occur in high quality lakes before remediation is needed. In addition, the TALU framework will continue to identify lakes with degraded fish communities that do not meet Clean Water Act minimum goals (i.e., do not meet General Use goals) and to guide restoration and protection activities for lakes that do not support exceptional fish communities.

Adoption of a TALU framework for lakes in Minnesota will meet the following needs:

1. Incorporate subcategories or tiers in aquatic life beneficial use (Class 2) classification to address the diversity of lake resources in Minnesota. Minnesota's aquatic resources are varied and diverse and the existing "one-size-fits-all" approach fails to recognize critical differences, which can result in less effective management of these waters. The TALU framework results in attainable and appropriate goals for aquatic life beneficial uses in lakes. It is consistent with the concept of protecting existing uses while simultaneously providing higher goals for waters with demonstrated exceptional biological quality and maintaining current goals for General Use waters. To accomplish this, Class 2 aquatic life beneficial uses will be refined for lakes by the addition of Exceptional and General TALU tiers to the base Class 2 designation. These tiers can be described as follows
    a. Exceptional Use: Exceptional Use lakes are those that are closest to natural or undisturbed conditions. There is a need to protect and maintain high quality lakes in Minnesota. Establishing an Exceptional Use tier will help ensure that existing water quality rules, such as antidegradation, can adequately protect high quality lakes.
    b. General Use: The General Use maintains the current default aquatic life use goal (Class 2B). These waters support good biological communities consistent with the CWA's interim goal (i.e., "…water quality which provides for the protection and propagation of fish, shellfish, and wildlife…").
2. Improve standards by incorporating numeric biological criteria directly into rule. WQS can be either narrative or numeric. Narrative standards describe water quality conditions that are not allowed because the conditions negatively affect beneficial uses (e.g., "the species composition shall not be altered materially" Minn. R. 7050.0150, subp. 3). Numeric standards establish numeric thresholds for pollutants that, when violated, indicate a polluted condition (e.g., a minimum of 5 mg/L of dissolved oxygen). The MPCA currently uses biological criteria to

[2] Although not currently defined as "General Use" in Minnesota rule, the current protections for aquatic life in lakes under Class 2 are equivalent to the recommended General Use.

quantitatively translate the narrative biological standards in Minn. R. 7050.0150, subp. 3. The TALU framework brings biological criteria directly into rule as a clear numeric standard. Numeric biological criteria stratified by lake type and TALU tier are recommended to be added to Minn. R. 7050.0222 to better clarify the biological expectations for Minnesota's lakes. Such added clarity about biological expectations provides greater certainty to stakeholders and regulated parties. The TALU biological criteria for Minnesota lakes is recommended to consist of General Use biological criteria for four lake types and Exceptional Use biological criteria for two lakes types.

3. Create more clarity in rule by documenting the methods used to establish biological conditions and biological criteria. For clarity, consistency in application, and transparency, the TALU framework amendments are recommended to include descriptions of each tiered aquatic life use (i.e., Exceptional and General). These revisions will also provide an explanation of the specific scientific methods used to measure biological condition and derive the biological criteria. This includes documentation of the development of Minnesota's fish IBI and the BCG, which together support biological condition determinations and biological criteria.
4. Improve targeting of water management resources. Biological assessments are used to make decisions about water quality management activities. Greater assessment accuracy leads to increased water quality management efficiency because resources are not used to restore waters beyond what is currently attainable nor are high quality waters under-protected. The TALU framework refines Minnesota's aquatic life use classification framework and improves the management of lakes by assigning appropriate and attainable beneficial use classifications. The TALU framework thereby recognizes the diversity of attainable conditions in Minnesota lakes so that management of these waters can be tailored to these conditions. This results in better use of protection and restoration resources with a goal of maintaining and improving conditions.
5. Designation of a subset of Exceptional Use lakes. A subset of lakes monitored as part of the Intensive Watershed Monitoring (IWM) framework will be reclassified where adequate existing monitoring data has demonstrated the need for a more accurate use designation. This subset of lakes provides a demonstration of how the MPCA will document these types of changes in future rulemakings and the type of data necessary to support future proposals. The MPCA intends to make future TALU proposals periodically following the IWM schedule or as needed. These future rule changes will follow the Minnesota Administrative Procedures Act (APA).

B. Introduction

Water quality standards in Minnesota are intended to protect water resources for aquatic life and recreational use. Chemical and biological standards are included in lake assessments. Minnesota currently uses four FIBI models to assess the biological condition of different lake types for assessing aquatic life use goals. FIBIs were developed for four groups of Minnesota lakes that are deep enough to support fish populations, between 100 and 10,000 acres (see Bacigalupi et al., 2021). The lake groups are referred to as groups 2, 4, 5, and 7 and were determined using a hierarchical cluster analysis that grouped lakes with similar physical features and geographic position (total area, maximum depth, percent littoral area (<4.6m or 15 ft), shoreline development index (SDI, shoreline length relative to the shoreline length of a perfectly circular lake of equal area), total alkalinity, volume, area:shoreline ratio, and growing degree days.

Lakes in Group 2 generally have the highest volume, a range of habitat types, low littoral area, seasonal thermal stratification, and consequently highest species richness. They span a wide range of sizes and geographic locations. Group 4 lakes are also deep, often thermally stratify, are generally smaller with

less complex habitats than Group 2 lakes, and are primarily located in central and northern Minnesota. Group 5 and 7 lakes range in size and are typically much shallower with lower species richness. Group 5 lakes are shallow to moderately deep, mostly littoral, and are primarily located in central and northern Minnesota. Group 7 lakes are the shallowest lakes, with over 80% of the lake area littoral and are primarily located in southern and western Minnesota.

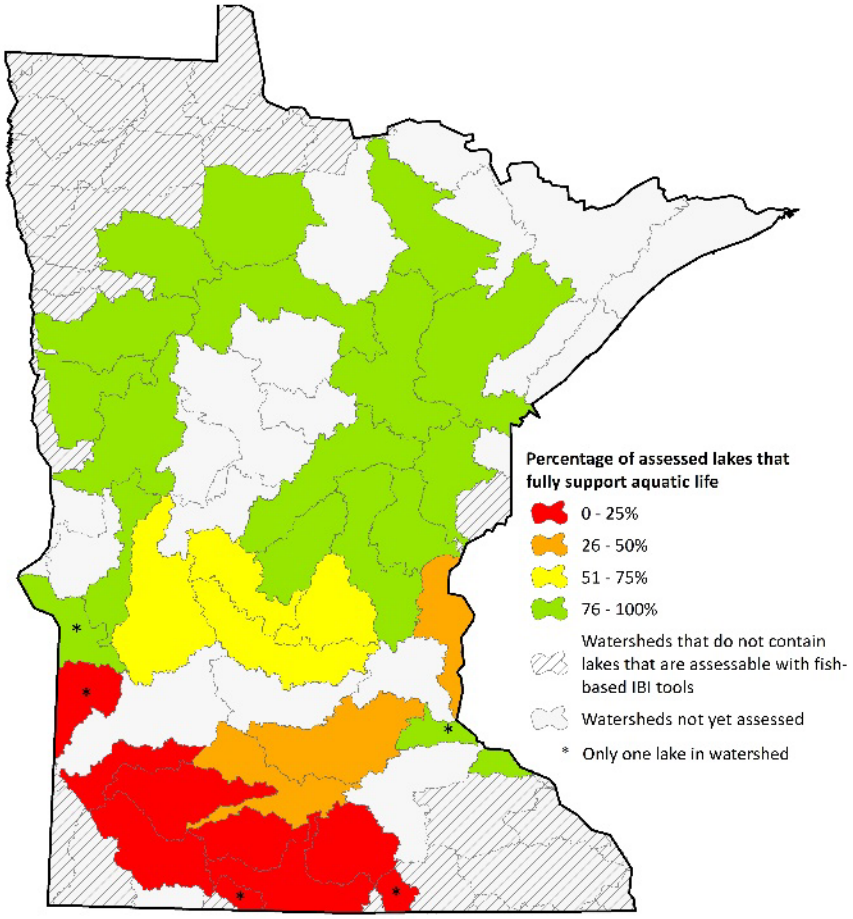
Each FIBI is numbered to correspond to the lake group (i.e., FIBI 2, 4, 5, and 7). FIBIs are composed of 8 to 15 metrics, which include richness metrics (the number of native species or number of species within tolerance, feeding, habitat, and family groups) and gear-specific metrics describing assemblage composition (proportional biomass of a feeding group sampled in trap net and gill net gear types and proportion of intolerant and/or habitat dependent individuals sampled with nearshore (i.e., backpack electrofishing and seining) gears types) (Table 1). Metrics included in each FIBI had a significant relationship with one or more stressor variables. For richness metrics with a significant relationship to lake surface area, linear regression was used to identify the relationship and the metric score was adjusted accordingly so that the metric response would represent differences in lake integrity rather than differences due to lake size. FIBI scores were calculated by summing metrics and scaling each composite FIBI from 0 – 100.

Table 1. Fish Index of Biotic Integrity (FIBI) metrics used in some or all FIBIs and the relationship with the overall FIBI score. A "+" indicates that a higher metric value corresponds to a higher FIBI score, a "-" indicates that a higher metric value corresponds to a lower FIBI score. (From Bacigalupi et al., 2021)

FIBI metric	Relationship
Number of species captured that are native species (all gears)	+
Number of species captured that are intolerant of stressors (all gears)	+
Number of species captured that are tolerant of stressors (all gears)	-
Number of species captured that are insectivores (all gears)	+
Number of species captured that are omnivores (all gears)	-
Number of species captured that are cyprinids (all gears)	+
Number of species captured that are small benthic-dwelling (all gears)	+
Number of species captured that are vegetation-dwelling (all gears)	+
Proportion of individuals captured in the nearshore gears that are classified as intolerant of stressors	+
Proportion of individuals captured in the nearshore gears that are classified as small benthic-dwelling	+
Proportion of individuals captured in the nearshore gears that are classified as vegetation-dwelling	+
Proportion of biomass in trap nets from insectivores	+
Proportion of biomass in trap nets from omnivores	-
Proportion of biomass in trap nets from species classified as tolerant of stressors	-
Proportion of biomass in gill nets from top carnivores	+
Presence/absence of a species classified as intolerant of stressors in the gill net	+

In order to use the FIBIs to assess the health of Minnesota lakes, biocriteria were developed that identified impairment and exceptional quality thresholds for each FIBI. Biological Condition Gradient (BCG) models for fish assemblages in Minnesota lakes were developed independently of the FIBIs to define changes to the fish communities along a gradient of increasing anthropogenic stressors (Gerritsen and Stamp, 2014). The General Use impairment biocriteria have been in use since 2015 to assess the condition of 605 lakes in 33 major watersheds from 2015 – 2021 (Figure 1).

Figure 1. Percentage of lakes sampled within an assessed watershed that fully support aquatic life, as measured by fish indices of biotic integrity. Percentage calculations exclude lakes that had insufficient or inconclusive information to make an assessment decision.



Although protective of overall good fish communities, the General Use impairment biocriteria allow for loss of species and moderate changes in community structure before an impairment is identified. As a result, the General Use biocriteria do not afford protection for lakes that support unique, high quality native fish communities. Many Minnesota lakes, particularly in the northern, forested area of the state, support high biodiversity and are nearly always associated with high quality habitat required to support fish species intolerant of disturbance. Some of the species sampled are species of greatest conservation need in Minnesota (e.g., Lake Sturgeon, Least Darter, Northern Longear Sunfish, and Pugnose Shiner). The aquatic and shoreline habitats that support exceptional fish communities also often support high quality amphibian, bird, and plant communities.

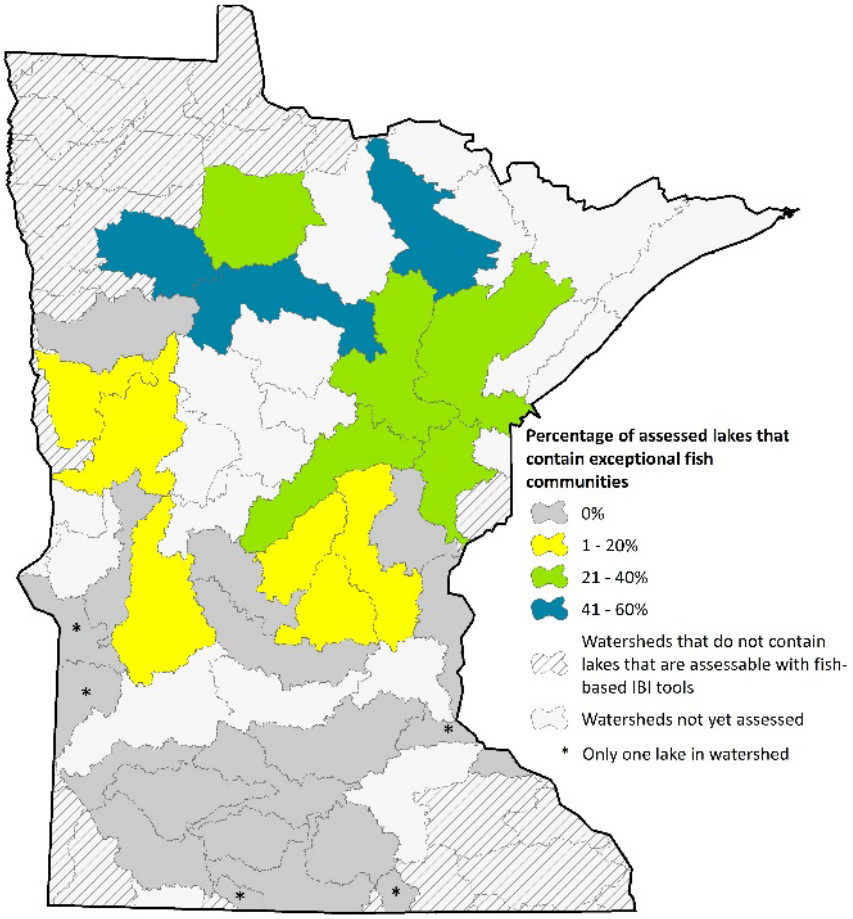
General Use impairment thresholds are developed and are in use for all FIBIs (2, 4, 5, and 7). Exceptional Use thresholds are developed for lakes scored with two of the FIBIs (FIBIs 2 and 4) and would be used in future assessments following the adoption of the lake TALU framework. Lakes with low human disturbance in Groups 2 and 4 have diverse fish communities that include species intolerant of disturbance, small benthic dwelling species, vegetation dwelling species, and often cold-water fish species. Exceptional Use is not proposed for moderate depth and shallow lakes (FIBIs 5 and 7) because fish diversity is typically low and intolerant species are uncommon in shallow lakes, even shallow lakes with low disturbance and high quality habitat. This is likely due to the lack of habitat complexity, lack of cold-water habitat, and recent or historical naturally induced partial winterkills in some shallow lakes.

An Exceptional Use designation within a Tiered Aquatic Life Use (TALU) framework was established to protect Minnesota streams that contain exceptional fish communities from future degradation (Gerritsen et al., 2017). The approach proposed for lakes is similar, except that only two tiers have been developed for lakes: Exceptional and General Use. The TALU framework for streams also includes a Modified Use which applies to streams with legally altered habitat (e.g., many ditches and channelized stream). However, no Modified Use category was developed for lakes because there is not a widespread, analogous situation for lakes that meets the requirements (40 CFR § 131.10 (g)) for the removal of designated use specified in section 101(a)(2) of the CWA.

In this report, we summarize assessments on 605 lakes to date using the General Use impairment threshold and evaluate the application of an Exceptional Use impairment threshold within the TALU framework for lakes that have been assessed to date, and lakes surveyed using FIBI methodology but not yet assessed. Two examples of TALU implementation are described. Example 1 considered 182 lakes sampled from 2010-2019 with one or more scores above the proposed exceptional biocriteria. This large number of potentially exceptional lakes highlights the importance and urgency of adopting an Exceptional Use threshold to adequately protect aquatic life in these unique, high quality lakes that are often located in watersheds where little human disturbance has occurred, but not always protected from future disturbance. Example 2 describes three upcoming watershed assessments in lake-rich watersheds with very different landscapes, and examines potential use classifications in each watershed.

The FIBIs and General Use thresholds are currently used to guide clean water planning, restoration, and protection efforts and to complement pollutant-based water quality sampling efforts in lakes during the Minnesota watershed assessment process. While the exceptional biocriteria is not yet used as a formal category during assessment, MNDNR has been identifying lakes with FIBI scores above the draft exceptional threshold for a couple of purposes since 2015 (Figure 2). Currently, lakes with scores above the proposed exceptional threshold: receive additional points in a scoring regime for potential MNDNR Fisheries acquisitions and are included on a list of lakes of biological significance (LOBS). The lakes with exceptionally high FIBI score and LOBS lists are provided to the Board of Water and Soil Resources (BWSR), MPCA, local government units (LGUs), and other interested parties for prioritization exercises including Watershed Restoration And Protection Strategies (WRAPS) and One Watershed One Plan (1W1P) for each watershed, forestry planning groups, and are also often considered during environmental review of projects impacting lakeshore and water quality. The formal adoption of the TALU framework for lakes and an Exceptional Use tier would enhance these existing programs and provide needed protections for high quality and sensitive lakes.

Figure 2. Percentage of lakes sampled within an assessed watershed that contain an exceptional fish community, as measured by fish indices of biological integrity. Percentage calculations exclude lakes that had insufficient or inconclusive information to make an assessment decision.



C. Development of biocriteria

Biocriteria were developed by aligning Biological Condition Gradient (BCG) levels with FIBI scores to develop thresholds for Minnesota lakes using a Tiered Aquatic Life Uses (TALU) framework that included General and Exceptional Uses (see Bacigalupi et al., 2021; Table 2). Lakes meeting the Exceptional Use biocriteria support fish communities that are characterized as being near the natural condition. The General Use tier applies to the remaining lakes and are characterized as having good fish communities with the function of the assemblage largely maintained although some sensitive species may have been lost and replaced by more tolerant taxa.

Table 2. Tiered aquatic life use biological criteria for Minnesota lakes.

Lake type	Exceptional use	General use
Deepest, high shoreline development index, tend to stratify	64	45
Deep, lower shoreline development index, tend to stratify, primarily central and northern Minnesota	59	38
Moderate depth, often heavily vegetated, primarily central and northern Minnesota	-	24
Shallow (>80% littoral), primarily southern and western Minnesota	-	36

The BCG models for Minnesota lakes were developed by Tetra Tech, Inc. with participation of aquatic biologists from MPCA, MNDNR, Midwest Biodiversity Institute, and an independent fisheries biologist (Gerritsen and Stamp, 2014). Methods of calibrating BCG models and developing thresholds were similar to those used for developing biocriteria for Minnesota streams (Gerritsen et al., 2017). BCG models for each lake group were developed, calibrated, and confirmed for fish communities in lakes with FIBI survey data, and scoring for each BCG model was adjusted based on lake size (Gerritsen and Stamp, 2014). FIBIs and BCG models were developed independently and BCG assignments were compared to FIBI scores after development.

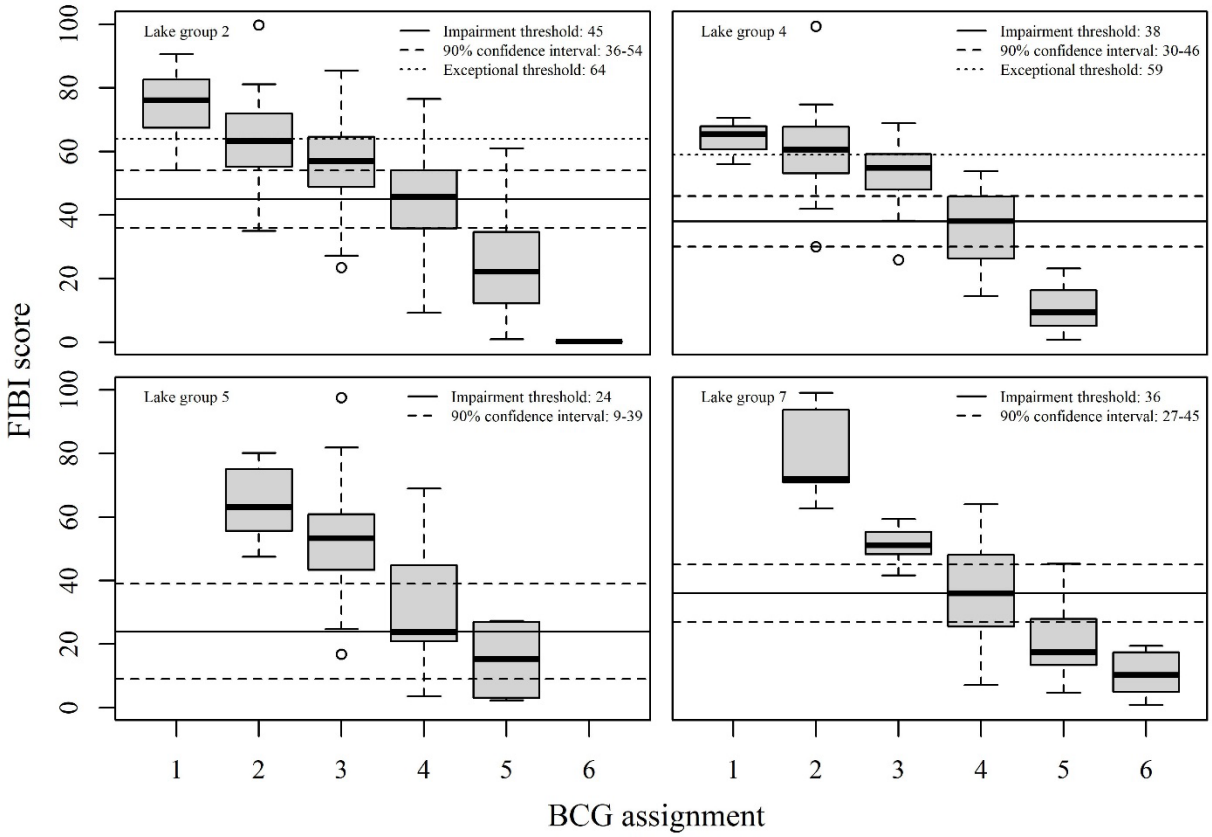
i. General Use and Exceptional Use thresholds for FIBIs

For each FIBI, the median FIBI score for each BCG level was calculated and Levels 4 and 5 were considered for a General Use threshold assignment. For the Exceptional Use, FIBI scores for BCG Levels 2 and 3 were considered for threshold assignment. Similar to impairment threshold development for Minnesota streams (Bouchard et al., 2016), for each lake group, the score corresponding to the median of BCG Level 4 was assigned as the General Use impairment threshold (Figure 3). Repeat surveys conducted within three years were evaluated using ANOVA to calculate the 90% confidence interval around the General Use impairment threshold. The 90% confidence interval for each FIBI varied from 8 to 15 points (Figure 3). These are similar to 90% confidence intervals reported for FIBIs for Minnesota streams, which vary from 9 to 16 points, with a median of 10, on a 100 point scale (J. Sandberg, personal communication, 2021).

Lakes with FIBI scores near the General Use impairment threshold generally contained a lower diversity and proportion of intolerant species, a higher proportion of biomass from tolerant species, and a higher proportion of biomass from omnivores relative to insectivores. These observations were consistent with the description provided by Davies and Jackson (2006), where BCG Level 4 corresponds with moderate changes in the structure of the biotic community due to replacement of some sensitive taxa by more tolerant taxa.

The proposed Exceptional Use threshold was assigned for FIBIs 2 and 4 at scores corresponding to the upper quartile of BCG Level 3, which was very similar in value to the median of BCG Level 2 (Figure 3). Lakes with FIBI scores above the Exceptional Use threshold generally contained a high number of intolerant and small benthic-dwelling species and a low number or zero tolerant species. Likewise, insectivores, top carnivores, and vegetation-dwelling species represented a large proportion of the catch in these lakes. These observations were also in alignment with the descriptions of BCG Levels 2 and 3, where either virtually all native taxa are maintained or where some changes in biotic community structure have occurred due to loss of some rare native taxa but where sensitive taxa are still common and abundant (Davies and Jackson, 2006).

Figure 3. Box-and-whisker plots showing the distribution of FIBI scores for each biological condition (modified from Bacigalupi et al., 2021).



D. Implementation of general and exceptional use FIBI thresholds in assessment

In Minnesota, a major (HUC 8) watershed framework is used to monitor, assess, and restore impaired waters, and to protect unimpaired waters. Monitoring and assessment is led by the MPCA, in collaboration with local governments, MNDNR and other state agencies, and Tribes. A comprehensive description of the Minnesota watershed approach to monitoring and assessment can be found at https://www.pca.state.mn.us/water/water-monitoring-and-assessment.

FIBI survey information is collected on lakes, summarized and reviewed by MNDNR Fisheries staff, and used by MPCA for lake assessments in each major watershed with suitable lakes. Assessments use FIBI data to determine biological condition of lakes: identifying impaired lakes, lakes vulnerable to future impairment, and lakes fully supporting the aquatic life use. In some cases, the FIBI survey data is inconclusive or insufficient for an assessment determination. Currently, lakes of exceptional biological quality with scores above the proposed exceptional threshold are identified, but are held to the General Use impairment threshold.

i. Biological survey methodology

MNDNR staff use four traditional fisheries gears to sample the fish communities in lakes 100 – 10,000 acres (40–4,050 hectares) between mid-June and early-September. In each surveyed lake, double frame 19 mm mesh trap nets and standard graduated mesh gill nets (i.e., five 15.2 m long x 1.8 m deep panels of 19 mm, 25 mm, 32 mm, 38 mm, and 51 mm bar mesh) are used to sample littoral and limnetic areas, respectively (MNDNR, 2017). All fish are identified to species, measured to the nearest mm, and a subset are weighed to the nearest gram. A combination of seines (i.e., 15.2 and 4.6 m long x 1.5 m deep with 3 mm bar mesh) and backpack electrofishers are used to sample nearshore, wadeable areas of each lake along 30.5 m stations. There are sampling protocols to address difficult to sample shorelines (e.g., boat assisted seining along steep shorelines and boat assisted backpack electrofishing among or along stands of aquatic vegetation) to ensure sufficient sampling effort in a wide variety of lakes. All fish captured in nearshore gears are identified to species and enumerated, and a subset of specimens from each species are vouchered and independently verified in a lab setting.

The numbers of gill nets and trap nets set and number of nearshore sampled followed MNDNR lake survey methods (MNDNR, 2017) and were determined by the size and characteristics of the lake. Typically, trap nets are set in 9–15 locations, gill nets in 6–15 Locations, and sampling with nearshore gears is completed at 10–24 locations. Net sites were chosen in historic surveys systematically to represent available habitat within each lake. Nearshore sampling stations were equally spaced around the shoreline of the lake from a random starting point. See MNDNR (2017) for further details.

ii. Assessment data and methods

FIBI survey data is collected prior to assessment, typically within a six-year window just prior to assessment. For each lake, typically one or two surveys are completed within the six-year window, but occasionally more are completed when time permits, when results are ambiguous, or when randomly selected as a repeat survey (conducted on at least 10% of lakes annually). Only FIBI surveys meeting minimum sampling requirements and collected within the summer survey season (mid-June to early September) are included as primary assessable information. Older survey data or survey data collected with non-standard effort or timing is considered as supporting information to the assessment.

Often, multiple scores are considered when making an assessment on an individual lake. But because FIBI scores are similar among surveys conducted within seasons and between years relative to the range of scores observed (Bacigalupi et al., 2021), data from just one or two survey events may be used in most cases for determining lake condition and making a biological assessment decision. When FIBI scores are disparate or fall close to a threshold (within the 90% Confidence Interval), an effort is made to collect additional survey data.

The FIBI survey data and assessment recommendations are reviewed first by a panel of MNDNR experts, and later by MPCA biological, water quality, and watershed experts to make a final assessment determination. In addition to scores, other factors are considered such as survey effort or timing, natural condition, or the influence of connected lakes. Lakes that are recommended to be listed as

impaired by MPCA and MNDNR staff are then reviewed by local and regional water resource staff. The list of impaired waters are presented at public meetings, then open to public review and comment, and finally submitted to the United States Environmental Protection Agency (EPA) for approval. See MPCA (2021) and https://www.pca.state.mn.us/water/defining-impaired-waters for more details on the assessment and impaired waters listing process.

Fish-based IBI scores and supporting information are used to place lakes into an assessment category: fully supporting (FS), not supporting (impaired) (NS), inconclusive information (IC) or insufficient information (IF). Generally, if the FIBI scores fall above the General Use impairment threshold, a lake is assessed as fully supporting (FS) the aquatic life use. If scores fall below the General Use impairment threshold, a lake is assessed as not supporting (NS) the aquatic life use. When repeated surveys fall on either side of an impairment threshold, the lake is typically assessed as having inconclusive information (IC). When data is old or survey collection is incomplete, a lake is assessed as having insufficient information (IF). Lakes that are currently FS or IC can also be given a subcategory of vulnerable (V) indicating that scores are near the impairment threshold and stressors are present in the lake, suggesting the lake may become impaired if protective or restoration actions are not initiated. Lakes that are fully supporting with an exceptionally high score are identified (FS-E). Rarely, a lake is classified as not assessable (NA) when a lake is unrepresentative of lakes used during FIBI development (e.g., smaller than 100 acres (40 hectares) or routinely affected by severe winterkill).

In addition to assessing lakes, DNR staff study stressors affecting the biological communities found in impaired and vulnerable lakes. Numerous stressors are considered during this process, but most often, the focus is on the impacts of water quality and shoreline habitat on the fish community. Stressor identification investigations and reporting (SID) involves evaluation of several of the most likely stressors to fish communities specifically for each impaired or vulnerable lake (MNDNR 2018).

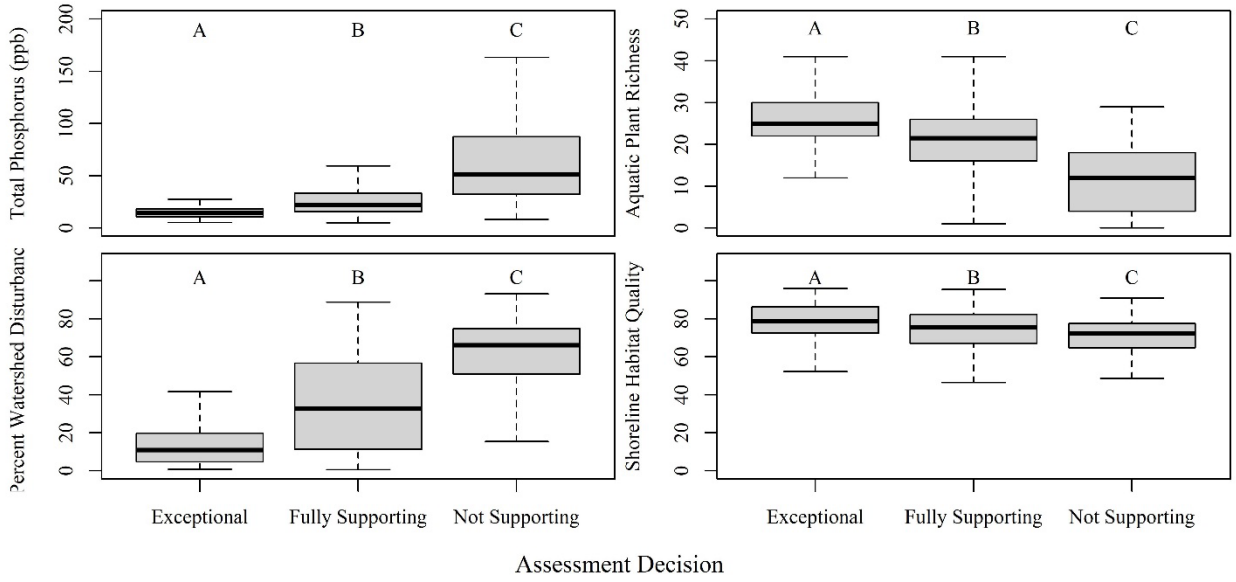
iii. Water quality, land use, shoreline condition relationships with assessment decisions

FIBIs were developed to include metrics responsive to stressors impacting lake habitat (Bacigalupi et al., 2021). During FIBI development, stressors considered for metric selection included disturbance within a lake's contributing watershed (i.e., percent agriculture, percent urban, percent forested, and overall percent watershed disturbance as defined in Cross and Jacobson (2013)) as a measure of water quality, sedimentation, hypolimnetic oxygen availability, and regime shifts. Aquatic plant richness and Floristic Quality Index (FQI) were considered measures of structural fish habitat, and dock density (Beck et al., 2013) was used as a measure of shoreline disturbance and recreational pressure.

For lakes used during development of each of the FIBIs, scores were negatively correlated with percent watershed disturbance and positively correlated with FQI. Scores were also negatively correlated with dock density; however, these correlations were not statistically significant (Bacigalupi et al., 2021).

Similarly, since implementation of assessments, most FIBI impairments using the General Use impairment threshold are lakes with watershed disturbance occurring in more than half of the upstream catchment and lakes with high levels of total phosphorus (TP). Meanwhile, most lakes that have been identified to this point as containing exceptional fish communities are located in predominantly forested watersheds, with higher aquatic plant species richness, lower TP levels, and higher quality shorelines (Figure 4).

Figure 4. Relationships between four variables representative of aquatic habitat stressors and aquatic life use assessments, including exceptional, fully supporting, and not supporting determinations based on the FIBI. Total phosphorus is calculated as the 10-year average of measurements obtained from MPCA and updated annually. Aquatic plant richness is summarized from MNDNR aquatic plant survey data. Percent watershed disturbance is calculated as the percentage of land in each lake's contributing watershed that was classified as developed, agricultural, or barren based on 2016 National Land Cover Database land use data. Land use categories are described in Jin et al. (2019). Calculations of watershed disturbance from Watershed Health Assessment Framework (MNDNR 2021). Shoreline habitat quality is measured by Score the Shore scores (Perleberg et al. 2019) which assess the integrity of lakeshore habitat. Letters above boxplots denote significant differences between determination categories.



iv. Exceptional Use Determination

Currently, lakes identified as having exceptionally high scores have do not have strict data requirements as the category has been informal and used strictly for prioritization. However, determination of Exceptional Use as an official assessment category and consequently a higher impairment threshold, based on the FIBI will include strict data requirements as well as professional review.

Survey data must be collected per the FIBI methodology described in the previous sections. In addition, a lake must have meet one or more of the following criteria:

1. One FIBI score at least 10 points above the proposed exceptional threshold (see Figure 7), or
2. Two or more surveys with scores above the exceptional threshold. The surveys must be in different years, and using separate trap net and nearshore data.

In addition, a professional review by MNDNR will be completed to consider supporting information such as older surveys, FQI, data on other biological communities (LOBS), and data on stressors impacting the lake (such as water chemistry data, shoreline disturbance, watershed disturbance).

If any scores within the previous 10 years fall below the exceptional threshold, in most cases, the lake will not be classified as exceptional. Exceptions may include if a lower scoring survey had non-standard or low effort, if water temperatures during sampling were lower than 21°C surface temperature, or if there were other quality assurance/quality control concerns.

If a lake is classified as Exceptional Use, and then in a subsequent assessment scores below the exceptional threshold, the lake will be designated as impaired and stressor identification be completed.

Similarly, an exceptional lake could be designated as vulnerable to future impairment and suggested as a priority for protection and/or restoration actions.

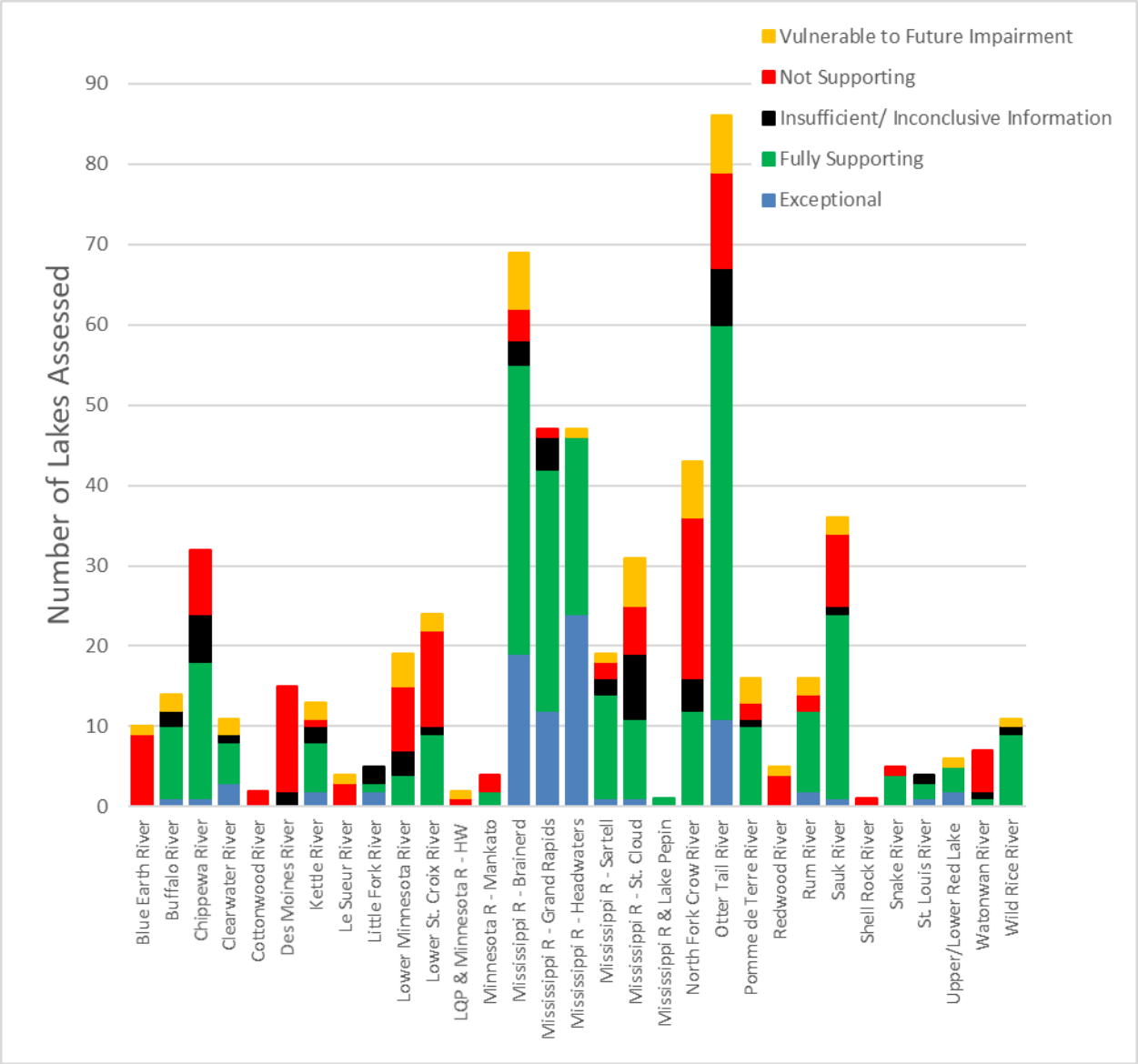
A lake that was formerly designated as General Use can be changed to Exceptional Use if there is survey data and supporting information to support the designation change.

i. Examples

Since 2015, MNDNR has completed biological assessments in 605 lakes in 33 watersheds (Figure 5). MNDNR and MPCA biologists have used the data to determine that 21% of those lakes are not supporting the aquatic life use (i.e., not meeting standards). Another 9% of lakes were identified as vulnerable to future impairment based on fish IBI scores near the impairment threshold coupled with evidence of stressors in the watershed and/or in the shoreline zone. The MNDNR is also maintaining a list of lakes with exceptionally high FIBI scores which includes 14% of lakes assessed to date.

Existing General Use impairment biocriteria allow for a loss of some species and moderate changes in community structure before an impairment is identified. Many Minnesota lakes, particularly in the northern, forested area of the state, support high biodiversity, and are nearly always associated with high quality habitat required to support fish species intolerant of disturbance. Some of the species sampled are species of greatest conservation need in Minnesota (e.g., Lake Sturgeon, Least Darter, Northern Longear Sunfish, and Pugnose Shiner). Numerous lakes currently have exceptional fish communities, and would benefit from a TALU approach.

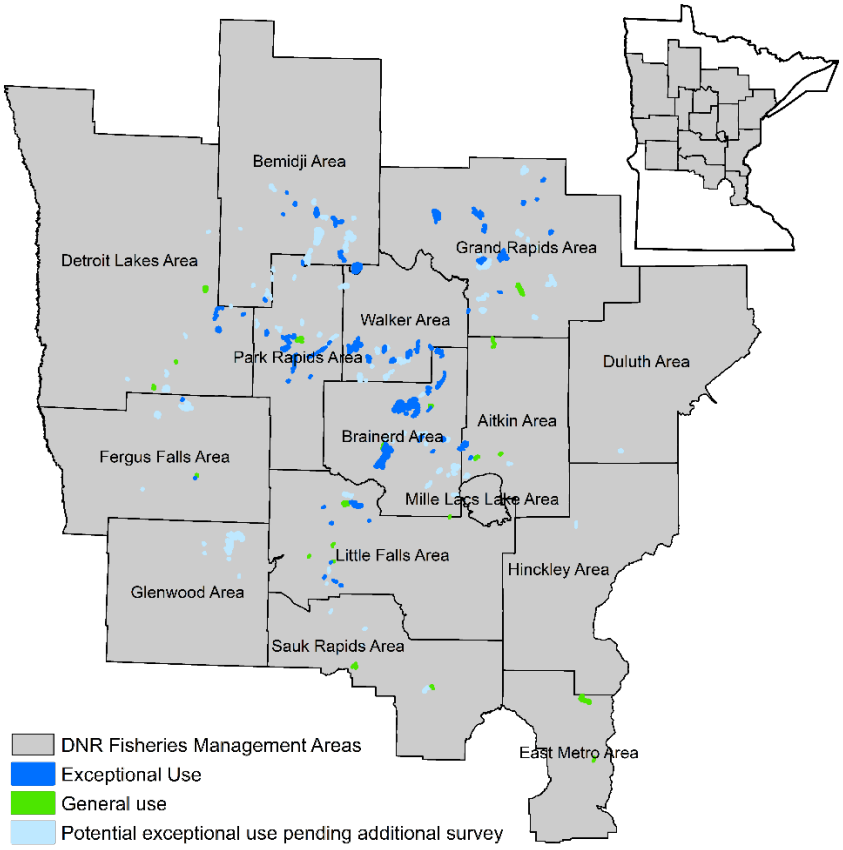
Figure 5. The number of lakes assessed and determinations for watersheds assessed 2015 - 2021.



a. Example 1: Mock Assessments for Exceptional Use Determination

Part of the process of evaluating the recommended Exceptional Use tier and biocriteria included an assessment exercise for lakes that would be potential candidates for an Exceptional Use assignment. The exercise included evaluating all lakes that had at least one recent survey (2010 – 2019) and one or more scores above the exceptional threshold (314 surveys on 182 lakes). The 182 lakes were located primarily in northern Minnesota, in 14 MNDNR Fisheries Management Areas (FMAs) (Figure 6).

Figure 6. Map showing location of lakes with one or more surveys above the exceptional threshold. Exceptional Use (dark blue) indicates lakes with multiple surveys above the threshold or one survey 10 or more points above the threshold. Potential (light blue) indicates lakes with scores less than 10 points above the threshold. General Use (green) indicates lakes with scores from multiple surveys both above and below the threshold.



The 182 lakes were put into three categories for evaluation:

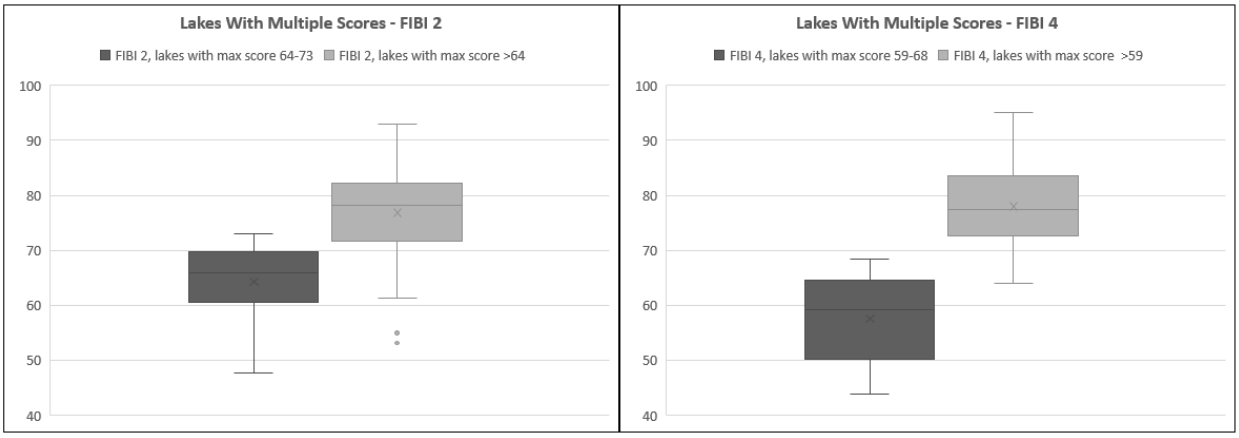
- Proposed Exceptional Use (77 lakes):
  - Either: 1) one FIBI score at least 10 points above the proposed exceptional threshold, or 2) two or more surveys with scores above the exceptional threshold.
  - And, no recent scores (since 2013[3]) below the exceptional threshold unless there were mitigating circumstances (low effort or non-standard effort, low water temperatures noted, other).
- Potential Exceptional Use, pending an additional survey (for actual assessments, we would complete an additional survey to make this determination) (86 lakes): One FIBI score above exceptional threshold, but less than 10 points above.
- Proposed General Use (19 lakes): Recent, full effort FIBI scores mixed, above and below the exceptional threshold or older FIBI score(s) above, but more recent score(s) below.

Two or more surveys are always preferred, but in some cases logistically difficult. Ten points above the threshold was used as a cut-off for making a determination for lakes with just one survey because no

[3] No FIBI protocol changes have occurred since 2013 so data collected after this date are less likely to be affected by methodological changes versus actual changes in fish community condition.

FIBI 4 lakes and only three FIBI 2 lakes that had one score 10 points or more above the exceptional threshold also had a recent survey scoring below the exceptional threshold (Figure 7). In addition, 10 points is stricter than the 90% confidence interval for each tool (see Figure 3).

Figure 7. Range of FIBI scores for lakes multiple surveys, including one or more exceptional FIBI score. The dark gray boxes show the range, median, and average scores for lakes with the maximum score less than 10 Points above the respective exceptional threshold. The light gray boxes show the range, median, and average scores for lakes with the maximum score 10 or more points above the respective exceptional threshold.



FMA Supervisors or their delegates were asked to use their professional judgement to evaluate the Exceptional Use biocriteria and comment on if the Exceptional Use designation seemed appropriate for each lake. For each lake, FIBI scores, survey notes, and stressor information were provided to the FMA Supervisor. FMA Supervisors indicated that the exceptional biocriteria seemed appropriate and lined up very well with their knowledge of the fish community diversity and habitat quality. They expressed overwhelming support for adding additional recognition and protection for the highest quality lakes. Several noted that many of the exceptional lakes were well connected to large chains of lakes or rivers, and that many of the exceptional lakes were connected to one another. For these well-connected lakes, several FMA Supervisors indicated a preference to consider the connections in making a determination for General or Exceptional Use.

The results of the Area review of each lake are summarized in Table 3. In 86% of the lakes, the FMA review agreed with the mock use determination based on their local knowledge of the fish community and lake habitat. The FMA disagreed with 12% of the mock assessment recommendations and the FMA did not have enough knowledge of the lake or gave no response for 3% of the lakes.

Table 3. Summary of FMA review and response to mock assessment, including 182 lakes with one or more surveys with scores above an exceptional use threshold.

Mock Assessment Category	FMA Review & Response	Number of Lakes (%)
Exceptional Use	Agree; good Exceptional Use candidate.	69 (38%)
Exceptional Use	Disagree; Area does not consider a good candidate for Exceptional Use due to high levels of shoreline and/or watershed disturbance or water quality problems that adversely impact fish habitat.	8 (4%)
Potential Exceptional Use pending an additional survey	Agree; good Exceptional Use candidate.	72 (40%)
Potential Exceptional Use pending an additional survey	Disagree; Area does not consider a good candidate for Exceptional Use due to high levels of shoreline and/or watershed disturbance or water quality problems that adversely impact fish habitat.	8 (4%)
Potential Exceptional Use pending an additional survey	No response from Area or Area does not enough information about the lake.	5 (3%)
General Use standards	Agree; hold to the General Use.	15 (8%)
General Use standards	Disagree; Area believes lake should be a candidate for Exceptional Use based on its habitat and fish community.	5 (3%)
Total number of lakes Reviewed		182

b. Example 2: Application of TALU in upcoming watershed assessments: Crow Wing River, Big Fork River, and Mississippi River Twin Cities Watersheds

Three watersheds with numerous lakes that will be assessed in 2022 and 2023 are presented as case examples for this report. Note that for several lakes in each watershed, additional survey data will be collected during the upcoming field season(s). Final use classification and assessment recommendations will be made during assessment for each watershed using professional review of the most up to date FIBI survey data and other supporting information. The three watersheds presented include: a watershed with numerous exceptional lakes that are likely at high risk of degradation due to increasing human disturbance within the watershed, a watershed with little human disturbance and numerous exceptional lakes, and a watershed with high human disturbance including areas of intense urban development with numerous lakes scoring below the General Use impairment threshold.

Crow Wing River Watershed

The FIBI will be used to assess 69 lakes in the Crow Wing River Watershed during winter/spring of 2022. FIBI survey data has been collected in the watershed since 1999, however only the most recent survey data will be used as primary assessment information (2016 – 2021). On lakes with recent data, older FIBI survey data will be used as supporting information.

Through 2020, 114 FIBI surveys were completed on 66 Lakes (77 surveys are primary information and 37 are older surveys used as supporting information). An additional 17 surveys are planned in 2021. Sixty-three lakes have recent data (2016 – 2020), of which 12 lakes have additional surveys planned in 2021. Three lakes have older data (2003 – 2012) with surveys planned in 2021 and three lakes are scheduled for their first FIBI survey in 2021.

The Crow Wing River Watershed is primarily forested land (41%) and wetland (23%), but there is substantial land use classified as developed (4%), cultivated (10%), or pasture/hay (10%) (MNDNR 2021 based on NLCD land cover classifications described in Homer et al., 2012). Despite increasing

agricultural, residential, and other development in the watershed, the watershed still contains numerous high quality natural resources, with 38% of lakes sampled having at least one score above the exceptional threshold. Several of the potential Exceptional Use lakes in the Crow Wing River Watershed are connected, which likely leads to higher habitat and fish species diversity. Given the increasing watershed development, the Crow Wing River watershed is a good example of a watershed where there is urgency to implement protection for exceptional lakes. Of the 66 lakes with data, 20% have an FIBI score 10 or more points above the Exceptional Use threshold, and an additional 18% of lakes have one score above the Exceptional Use threshold, with an additional FIBI survey planned in 2021 (Figure 8). It is also possible that some of the lakes with their first FIBI surveys scheduled in 2021 will be added to this list.

Two Lakes (Bad Medicine and Bass (03012700)) have multiple recent surveys with scores above and below the General Use impairment threshold and are likely vulnerable for future impairment. An additional lake (Sibley) survey has one FIBI score near the impairment threshold and is scheduled for an additional survey in 2021. These lakes should be prioritized for protection and restoration actions to prevent them from becoming impaired. One lake, West Crooked, has multiple recent FIBI score below the General Use impairment threshold.

Big Fork River Watershed

The FIBI will be used to assess 27 lakes in the Big Fork River Watershed during winter/spring of 2023. FIBI survey data has been collected in the watershed since 2005, however only the most recent survey data will be used as primary assessment information (2016 – 2022). On lakes with recent data, older FIBI survey data will be used as supporting information.

Through 2020, 27 FIBI surveys were completed on 20 lakes (15 surveys are primary information and 12 are older surveys used as supporting information). An additional 16 surveys are planned in 2021 and 2022. Fifteen lakes have recent data (2016 – 2020). Five lakes have older data (2005 – 2012) with surveys planned in 2021 or 2022 and seven lakes are scheduled for their first FIBI survey in 2021 or 2022.

The Big Fork River Watershed is primarily wetland (64%) and forested land (26%) with less than 3% of the land cover classified as developed or agricultural (MNDNR 2021 based on NLCD land cover classifications described in Homer et al., 2012). As such, the watershed contains numerous high quality natural resources and is a good example of a relatively pristine watershed that will benefit from implementation of a TALU framework to ensure protection of exceptional resources into the future. Of the 20 lakes with data, 35% have scores above the exceptional threshold (Figure 8). It is possible that some of the seven lakes with their first FIBI surveys scheduled in 2021 or 2022 will be added to this list.

One lake, Round (31089600) has one recent FIBI score near the General Use impairment threshold; an additional survey is planned in 2021 to determine the FIBI assessment recommendation.

Mississippi River - Twin Cities Watershed

The FIBI will be used to assess 30 Lakes in the Mississippi River - Twin Cities Watershed during winter/spring of 2022. FIBI survey data has been collected in the watershed since 1998, however only the most recent survey data will be used as primary assessment information (2016 – 2021). On lakes with recent data, older FIBI survey data will be used as supporting information.

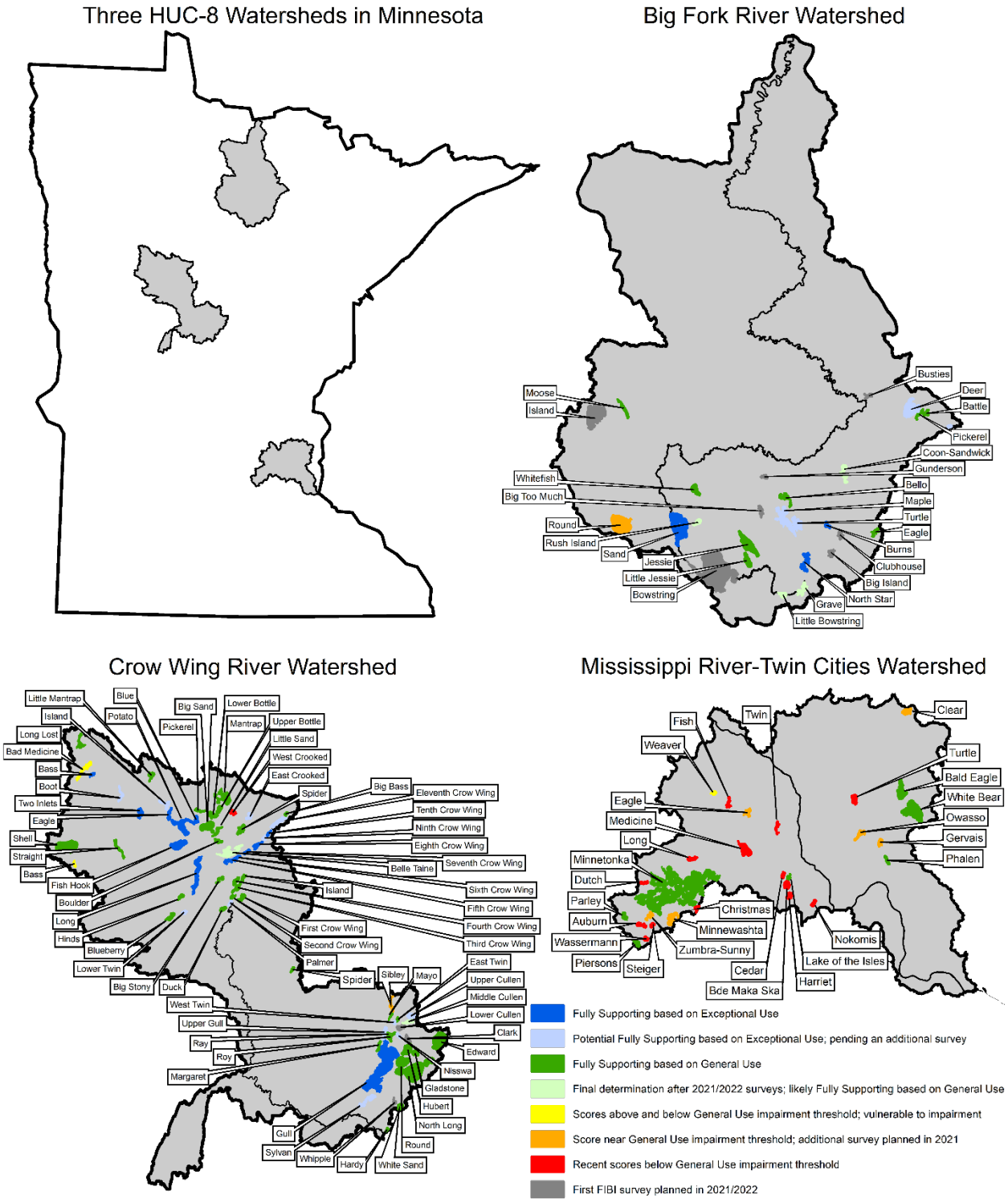
Through 2020, 75 FIBI surveys were completed on 30 lakes (30 surveys are primary information and 45 are older surveys used as supporting information). An additional six surveys are planned in 2021. Twenty-seven lakes have recent data (2016 – 2020), of which three lakes have additional surveys planned in 2021. Three lakes have older data (1999 – 2011) with surveys planned in 2021.

The Mississippi River - Twin Cities Watershed is primarily developed land use (54%), and also includes substantial amounts of cultivated (8%) and pasture/hay land (9%) (MNDNR 2021 based on NLCD land

cover classifications described in Homer et al., 2012). In the Mississippi River drainage, the FIBI scores generally decrease and watershed disturbance increases, from the headwaters to the lower portions of the drainage (Figure 5). The same suite of species are present in most of the drainage and therefore it is likely that the primary driver of lower FIBI scores is human disturbance. The Mississippi River Headwaters, Mississippi River – Grand Rapids, and Mississippi River – Brainerd watersheds all have numerous lakes scoring above the exceptional thresholds (26-51% of assessed lakes), and few impairments. In the Mississippi River – Sartell, most lakes were fully supporting based on the general use threshold with a few lakes vulnerable to impairment or impaired based on the FIBI, with 1 lake scoring above the exceptional threshold. Similarly, one lake had a score above the exceptional threshold in the Mississippi River – St. Cloud watershed and 39% of lakes were determined to be impaired or vulnerable to impairment based on the general use threshold.

In the Mississippi River - Twin Cities Watershed, a large proportion of the lakes are likely to be listed as impaired based on the FIBI General Use threshold. No lakes in the watershed are likely to be proposed as Exceptional Use. Of the 30 lakes with data, 1 lake, White Bear Lake, had one score equal to the Exceptional Use threshold, but additional surveys scores were well below the Exceptional Use threshold. Based on data through 2020, 30% of lakes have FIBI scores above the General Use threshold, 47% of lakes have scores below the General Use threshold, and 1 lake (Weaver) has scores on each side of the threshold and is likely vulnerable to future impairment. Additional surveys are planned on 6 lakes, all with older or recent scores very near the General Use impairment threshold (Figure 8).

Figure 8. Example of application of TALU in three upcoming watershed assessments: Crow Wing River, Big Fork River, and Mississippi River Twin Cities Watersheds.



c. Assessment summary

Examples 1 and 2 demonstrate the need for and reasonableness of a TALU framework for lakes. Within many watersheds there are a large number of lakes that currently meet Exceptional Use thresholds especially lakes with abundant natural shoreline habitat and good water quality in the northern forested portions of the state that would benefit from a TALU framework and implementation of an Exceptional Use threshold. In addition, in central Minnesota watersheds, a smaller number of lakes remain that meet the Exceptional Use threshold, and should be prioritized for protection in landscapes experiencing land use changes and other stressors. The General Use impairment biocriteria currently used for all lakes allows for degradation before an impairment is identified. The Exceptional Use threshold is more appropriate for high quality lakes.

In addition, Example 1 in particular demonstrates that the proposed thresholds are appropriate. The results of the mock assessment match expectations of Fisheries Area staff who have decades of experience and correspond with watershed disturbance and other stressors. By requiring a second survey or a score above the 90% Confidence limit and professional review, we can be confident that lakes determined as Exceptional Use are appropriate.

A. Summary

The adoption of a TALU framework for lakes will provide more clarity in rule by codifying fish biocriteria and associated documentation and more options for the protection of high quality, unique lakes. This framework will consist of the adoption of two aquatic life use tiers into Minnesota rule in Class 2: General and Exceptional use. Biological criteria for these two tiers will be adopted into rule along with supporting documentation incorporated by reference into rule. There is extensive experience implementing these fish monitoring and assessment tools as part of a CWA program which demonstrate their feasibility and the benefit of using fish as indicators in Minnesota lakes. The methods have been both tested through implementation as a numeric translator for narrative standards (i.e., General Use) and through a mock designation and assessment exercise (i.e., Exceptional Use). These tests have demonstrated that the implementation of a TALU framework for lakes is reasonable and is supported by water quality programs in Minnesota. Adding the Exceptional Use tier to Minnesota's lake assessment tools provides additional options for the management of these waters and formally acknowledges the high quality of these lakes. Assigning Exceptional Use goals to lakes which indicate this high quality is an existing use, will provide the benefits of protecting these important and valuable resources. Protecting these lakes is more cost effective than working to restore them once they have been degraded (Radomski and Carlson 2018).

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