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# Fish index of biological integrity monitoring and assessment: Baseline conditions in Minnesota lakes

DEPARTMENT OF NATURAL RESOURCES

WILDLIFE & SPORT FISH RESTORATION

CLEAN WATER LAND & LEGACY AMENDMENT

## Authors

MNDNR

## Contributors/acknowledgements

The many Fisheries staff across the state who have helped and continue to help collect fish index of biological integrity data.

## Cover photo

Gradient of lake conditions and fish species sampled using fish index of biological integrity methods.

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# Executive summary

The Minnesota Department of Natural Resources (MNDNR), in coordination with the Minnesota Pollution Control Agency (MPCA), completed the first 10-year cycle of fish index of biological integrity (IBI) monitoring and assessment across lakes statewide. This effort was primarily funded by the Clean Water, Land, and Legacy Amendment through the Clean Water Fund and implemented in alignment with MPCA's watershed monitoring schedule. These results represent the most comprehensive assessment to date of fish community integrity in Minnesota lakes.

Statewide, 77% of lakes were assessed as fully supporting aquatic life, based on fish IBI scores that were above their respective impairment threshold. Conversely, 23% were assessed as impaired for aquatic life, based on fish IBI scores that were below their respective impairment threshold. Key stressors—primarily nutrient enrichment, shoreline and aquatic habitat alteration, and non-native species—were strongly associated with impaired fish communities, highlighting the need for continued monitoring and targeted management. Overall, Minnesota lakes show predominantly healthy fish communities, but targeted restoration and protection are needed in specific regions and lake groups.

The results establish a statewide baseline for fish community integrity, identify lakes that are impaired, vulnerable to future impairment (i.e., 'Nearly Impaired'), or support exceptional fish communities, and inform future monitoring and assessment. Together, these findings support management aimed at restoring or protecting Minnesota's lake ecosystems and fisheries.

# Background and purpose

Fish communities are widely used as indicators of waterbody health because they integrate the effects of multiple environmental stressors over time, including water quality, habitat condition, and watershed disturbance. Fish indices of biological integrity (IBI) provide standardized, biologically-based measures of fish community condition relative to expectations for healthy systems, making them a valuable tool for assessing lake condition across diverse landscapes and stressor gradients.

In Minnesota, monitoring and assessment are conducted within a statewide major watershed (HUC 8) framework coordinated by the Minnesota Pollution Control Agency (MPCA); see MPCA's Watershed Approach to Water Quality webpage. Under this approach, surface waters are monitored on a rotating schedule designed to provide comparable information across the state over a 10-year cycle. A summary of recent results from this framework is available in MPCA's Flowing Forward: Trends in Minnesota's Lakes and Rivers report. As an important part of this statewide effort, fish IBI monitoring in lakes is conducted by the Minnesota Department of Natural Resources (MNDNR) to support integrated assessment of biological, chemical, and habitat conditions at multiple spatial scales. Funding for fish IBI sampling in lakes comes primarily from the Clean Water, Land, and Legacy Amendment through the Clean Water Fund, with additional support from sources such as the Wildlife and Sport Fish Restoration Program.

This report summarizes results from the first complete 10-year cycle of statewide fish IBI monitoring and assessment in Minnesota lakes, which corresponds with MPCA's Intensive Watershed Monitoring (IWM) years 2013–2023. Although MPCA's first cycle of watershed monitoring began in 2006 with corresponding assessments occurring in 2008, the first cycle of watershed assessments using lake fish community data began in assessment year 2015, after development of fish IBIs for Minnesota lakes was completed. The primary purpose of the report is to establish a baseline of fish community integrity both statewide and across lake types and ecoregions. Secondary objectives are to summarize stressor relationships and fish community characteristics and to explore implications for future monitoring and assessment.

The scope of this report is limited to summarizing patterns in fish IBI results from the first monitoring and assessment cycle, at watershed and statewide scales. It does not attempt to determine causal relationships at individual lakes or prescribe site-specific management actions. Instead, this report serves as a synthesis product that complements related stressor summary documents, stressor identification reports, and publicly available datasets. Together, these products support a comprehensive understanding of lake conditions and provide a foundation for monitoring and management activities.

# Fish IBI methods

## Lake selection and inclusion criteria

Lakes were selected to ensure representativeness across lake types and regions. Eligible lakes met minimum size (i.e., 100 acres) and accessibility requirements and were classified into one of four lake groups based on physical, chemical, and ecological characteristics. These lake groups were characterized as "deep, complex", "deep, simple", "moderately shallow, vegetated", or "shallow, productive". Certain

lake types (e.g., highly modified, riverine, winterkill, and Boreal Shield) were excluded from analysis because fish IBI methods have not been developed for these systems. The resulting dataset represents a broad range of lake conditions across Minnesota.

## Fish sampling

Fish were collected at multiple sites per lake using standardized sampling protocols that included trap nets, gill nets, beach seines, and backpack electrofishing, as appropriate for species and habitat conditions (Figure 1). These methods are used to characterize species composition and abundance for comparison across lakes.

**Figure 1. Fish index of biological integrity sampling methods (top left: beach seine, top right: gill net, bottom left: trap net, and bottom right: backpack electrofishing).**

## Fish IBI scoring and interpretation

Four fish IBI models are used to account for natural variation among the four lake groups. Each model uses multiple fish community metrics, including diversity, composition, and ecological function. Additional fish IBI information can be found on the MNDNR Lake Index of Biological Integrity webpage.

Fish IBI scores provide an integrated measure of overall fish community condition and are interpreted using standardized categories that reflect relative biological integrity. Fish IBI scores range from 0 to 100, where 0 represents severely degraded condition and 100 represents minimally disturbed ecological condition.

A calculated fish IBI score is compared to the expectation for a healthy lake within the same lake group. Consequently, impairment thresholds—the numeric values used to identify biologically degraded (i.e., "impaired") waters—vary based on lake group and designated use. Under Minnesota's Tiered Aquatic Life Use (TALU) framework, designated use reflects specific ecological expectations for a lake: "General Use" lakes are expected to support typical aquatic life and recreational activities, while "Exceptional Use" lakes are managed to maintain outstanding, minimally impacted ecological conditions. Thresholds for each lake group are:

- **Deep, complex lakes:** General Use ≥ 45; Exceptional Use ≥ 64
- **Deep, simple lakes:** General Use ≥ 38; Exceptional Use ≥ 59
- **Moderately shallow, vegetated lakes:** General Use ≥ 24; Exceptional Use not established[1]
- **Shallow, productive lakes:** General Use ≥ 36; Exceptional Use not established[1]

## Fish IBI and stressor data analysis

Fish IBI results were evaluated at both the lake and statewide level in relation to chemical, physical, and landscape stressor data from MPCA, MNDNR, associated monitoring programs, and remote sensing datasets. While detailed stressor evaluations for impaired and vulnerable lakes are housed in watershed-specific reports, those findings were synthesized to provide a broader statewide overview. Additionally, lakes were categorized by biological condition (i.e., impaired, fully supporting, and exceptional) to compare distributions of primary watershed and shoreline stressors and identify meaningful differences across condition categories.

# Key findings

## Statewide patterns

Fish IBI data from 1,444 surveys conducted between 2006 and 2025 were used to inform aquatic life assessments for 908 lakes[2] across 47 watersheds statewide. Of these surveyed lakes, 808 (89%) had sufficient data for a conclusive assessment. Among these, 77% were found to fully support aquatic life, while 23% were classified as not supporting (i.e., impaired) based on fish IBI scores relative to the impairment threshold (Figure 2).

The remaining 100 lakes yielded either insufficient or inconclusive data. For the insufficient data subset (*n* = 59), exclusions were primarily due to temporal misalignment with the standard six-year monitoring window, undocumented winterkill impacts, or deviations from established sampling methodologies. For the inconclusive data subset (*n* = 41), conflicting results from multiple surveys—with fish IBI scores both above and below the impairment threshold—precluded a definitive assessment. Detailed assessment

[1] Insufficient reference lake density and inconsistent metric response to stressors prevented the statistical separation of an Exceptional Use tier.

[2] Although some MPCA assessments are conducted at the subbasin level, lakes in this report are summarized at the basin level to align with Minnesota DNR Fisheries management.

results are available via the Water Quality Assessment Results Data Viewer and Minnesota's Impaired Waters List.

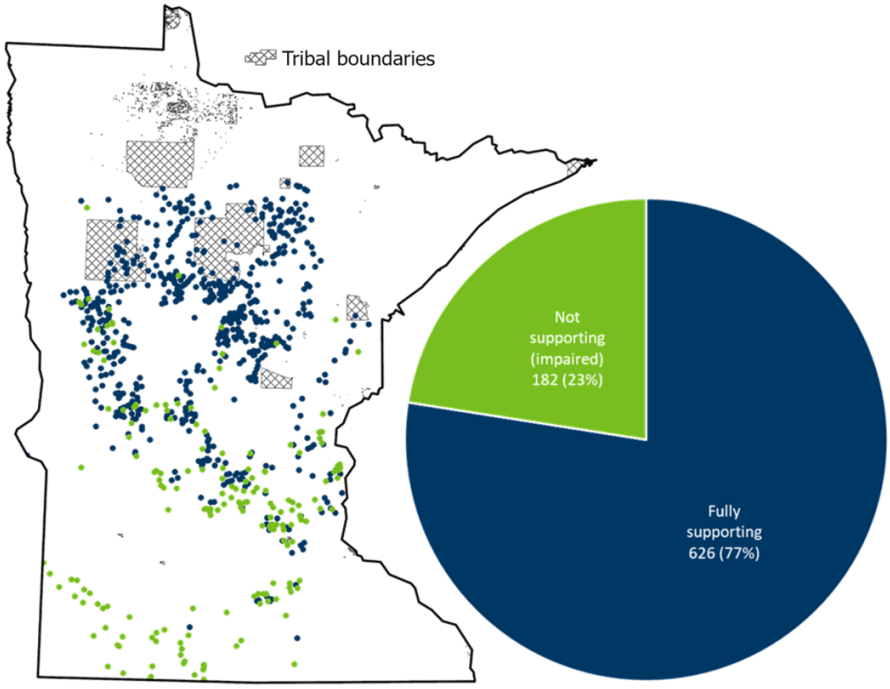


**Figure 2. Map and pie chart depicting the number (and percentage) of Minnesota lakes that are fully supporting or not supporting aquatic life, based on fish index of biological integrity scores. Percentage calculations exclude lakes that had insufficient or inconclusive information to make an assessment decision.**

Several lakes located wholly within Tribal nations were included in this report to provide context at the watershed and state level, with fish IBI data collected in collaboration with Tribal staff. However, these lakes were not formally assessed for aquatic life use by the state, consistent with jurisdictional authority under the Federal Clean Water Act. Many Tribal nations have, or are pursuing, authorization from the Environmental Protection Agency (EPA) to be treated in a similar manner as a state for the purposes of implementing and managing water quality standards under the Clean Water Act. Many also have, or are developing, their own water quality standards programs. More information is available on EPA's Tribes and Water Quality Standards webpage.

While this report focuses on fish IBI monitoring and assessment results in lakes, a comparison with other aquatic life indicators reinforces these findings. Notably, chloride and chlorpyrifos impairments—chemical indicators of aquatic life use—co-occurred exclusively within the fish-impaired subset. Four of these lakes were listed for chloride and one for chlorpyrifos, whereas no lakes categorized as fully supporting based on the fish IBI were found to be impaired for either chemical indicator.

To further aid prioritization and planning, 9% of the 908 monitored and assessed lakes were identified as vulnerable to future impairment (i.e., 'Nearly Impaired'). This classification was determined through best professional judgment, incorporating both proximity to the impairment threshold—typically within the 90% confidence interval—and a holistic assessment of current and projected watershed stressors.

Conversely, 18% of the 908 lakes have the potential to be proposed as Exceptional Use lakes under the TALU framework, based on fish IBI scores that are above their respective Exceptional Use thresholds.

Assessment results also varied across the four different lake groups; however, the majority of lakes within each group met the respective General Use impairment threshold. When excluding lakes with insufficient or inconclusive data, full support was indicated for 92% of moderately shallow, vegetated lakes; 86% of deep, simple lakes; 75% of deep, complex lakes; and 54% of shallow, productive lakes.

Because the four lake groups incorporate a different combination of metrics and scoring thresholds, fish IBI scores and associated variability metrics are reported separately for each. Fish IBI scores were highest on average for deep, complex lakes (51.9) and deep, simple lakes (49.9; Figure 3), although the fish community expectations and associated impairment thresholds for these lake groups were also higher. Average fish IBI scores were lower for moderately shallow, vegetated lakes (45.9) and shallow, productive lakes (33.9), but the fish community expectations and associated impairment thresholds for these lake groups were also lower. Variability in fish IBI scores was similar across lake groups. Detailed information for each surveyed lake, including lake group classification and IBI scores, can be found in the Minnesota Geospatial Commons Lakes with DNR Fisheries IBI Scores dataset.

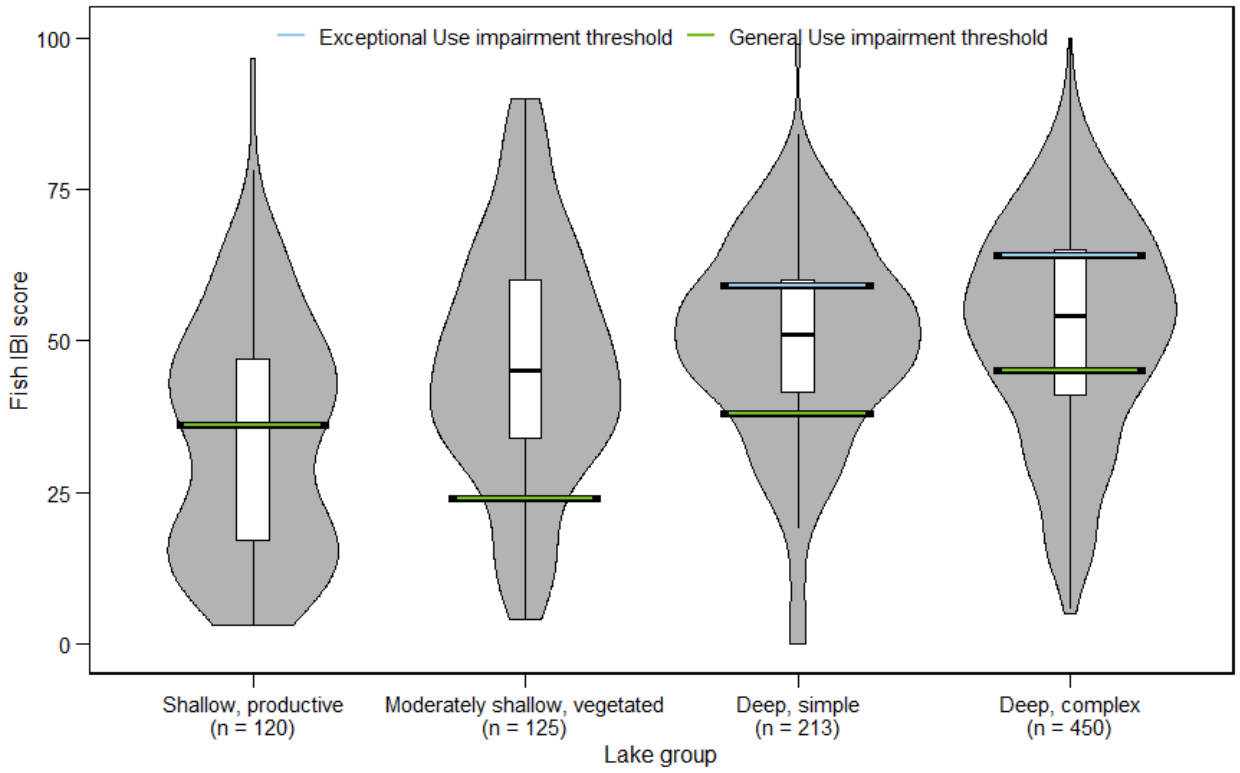


**Figure 3. Distribution of mean fish index of biological integrity (IBI) scores for unique lakes across four lake groups. Gray violins show the full distribution of IBI scores, with white boxes representing the interquartile range and median. Colored horizontal lines indicate lake-group–specific General Use (green) and Exceptional Use (blue) impairment thresholds. Sample sizes (n) represent the number of unique lakes within each lake group.**

## Geographical patterns

At the major watershed scale, 24 watersheds have over 75% of assessed lakes supporting aquatic life use and 13 have fewer than 25% supporting aquatic life use, when excluding lakes with insufficient or inconclusive information (Figure 4). Additionally, 12 watersheds have over 20% of assessed lakes that contain exceptional fish communities (Figure 4).

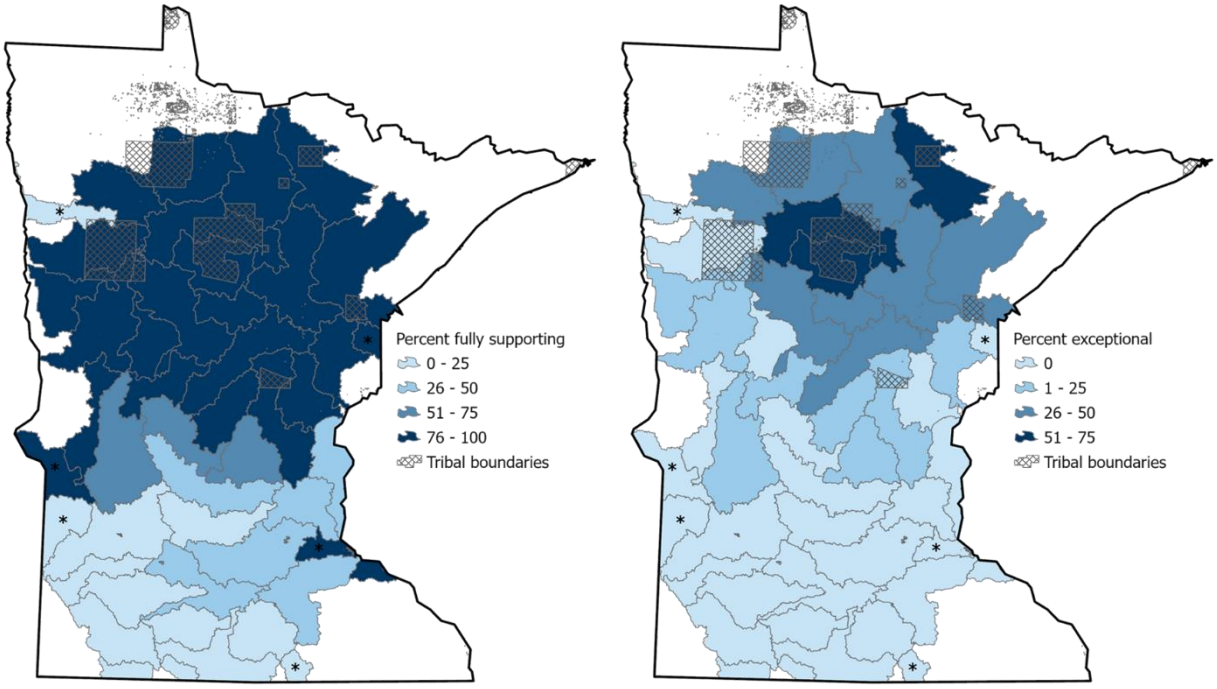


**Figure 4. Maps of percentages of assessed lakes that fully support aquatic life (left) and that contain exceptional fish communities (right), based on fish index of biological integrity (IBI) scores. Percentage calculations exclude lakes that had insufficient or inconclusive information to make an assessment decision. An * indicates that only one lake was included in percentage calculation.**

At the ecoregion scale (Figure 5), lakes within the Western Corn Belt Plains, Northern Glaciated Plains, and Lake Agassiz Plain ecoregions exhibited the highest likelihood of degraded fish communities, with only 19% supporting aquatic life use. Lakes in the North Central Hardwood Forests ecoregion exhibited an intermediate likelihood of degraded fish communities, with 67% supporting aquatic life use. Lakes in the Northern Lakes and Forests ecoregion were least likely to have degraded fish communities, with 98% supporting aquatic life use. Consistent with this pattern, 84% of lakes with exceptional fish communities occurred in the Northern Lakes and Forests ecoregion, while the remaining 16% were in the North Central Hardwood Forests ecoregion.

Patterns in land disturbance mirror aquatic life use assessments, as the Western Corn Belt Plains, Northern Glaciated Plains, and Lake Agassiz Plain ecoregions exhibit the highest proportions of disturbed land, largely attributable to agricultural land use, which likely contributes to the observed patterns in fish community condition (Figure 5). While the North Central Hardwood Forests ecoregion contains a comparatively greater proportion of undisturbed land, agricultural and urban development remain

widespread. In contrast, the Northern Lakes and Forests ecoregion contains the lowest proportion of disturbed land and is predominantly characterized by forest and wetland land cover.

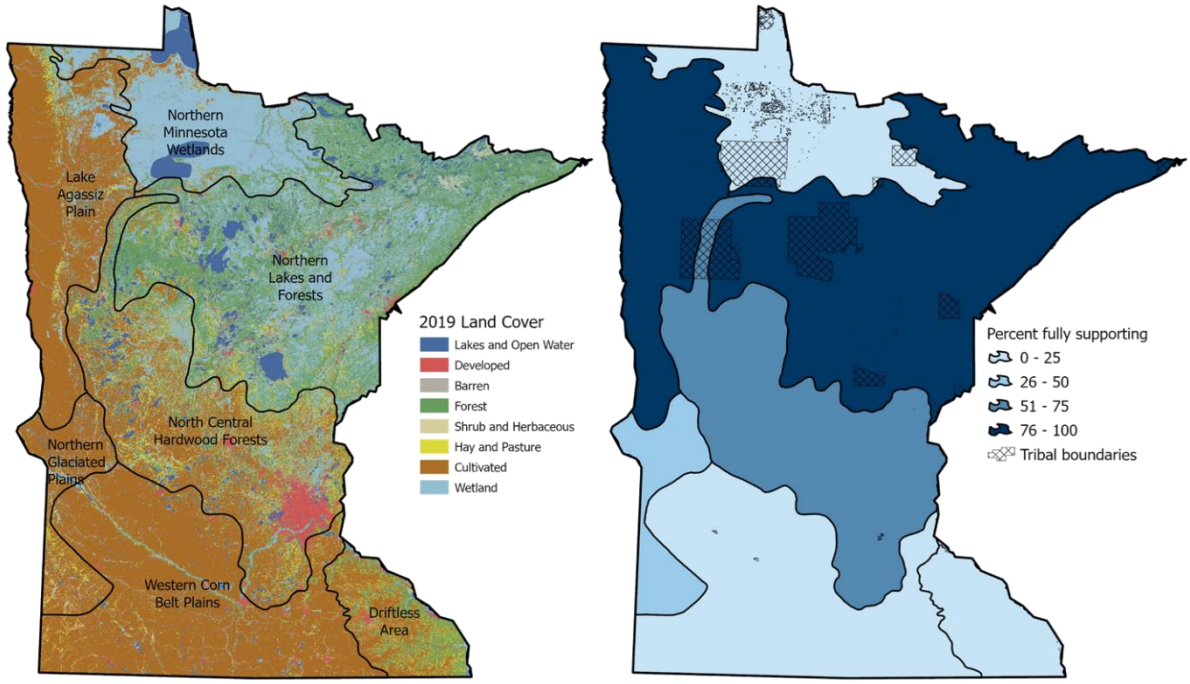


**Figure 5. Maps of land cover types, derived from 2019 National Land Cover Data, and percentages of assessed lakes that fully support aquatic life, based on fish index of biological integrity (IBI) scores, across Minnesota's ecoregions (Omernik Level III). Percentage calculations exclude lakes that had insufficient or inconclusive information to make an assessment decision.**

## Stressor relationships

The resource Stressors to Biological Communities in Minnesota's Lakes provides a comprehensive framework for understanding how factors like water quality degradation and habitat loss impact aquatic life in Minnesota lakes and defines stressors that are considered during MNDNR's formal stressor identification process. Applying this framework across impaired lakes reveals that multiple stressors often influence fish communities cumulatively; eutrophication was identified as a candidate stressor in 81% of cases, followed by physical habitat alteration (60%), altered interspecific competition (18%), and changes in temperature and dissolved oxygen (3%). Geographic patterns reflected these stressors, with eutrophication and habitat alteration most prevalent in the Western Corn Belt Plains, Northern Glaciated Plains, and Lake Agassiz Plain ecoregions, followed by the North Central Hardwood Forests and Northern Lakes and Forests. For more localized information, stressor identification reports for impaired and vulnerable lakes are available on MPCA's Watershed Information webpage under the specific watershed of interest. Additionally, lake-specific information can be found in the Minnesota Geospatial Commons Stressors to Impaired or Vulnerable Lakes dataset and on the Watershed Health Assessment Framework: Lakes webpage.

Impaired lakes generally exhibited higher total phosphorus concentrations, greater proportion of watershed disturbance, and lower shoreline habitat quality compared to lakes that fully support aquatic life, while lakes with exceptional fish communities had the lowest phosphorus and disturbance and the highest shoreline habitat quality (Figure 6). Dock density did not differ across lake condition categories; however, shoreline habitat quality still varied, indicating that factors other than dock presence contributed to differences in habitat condition. Non-native species also appear to influence lake condition, although they have not been as extensively evaluated. For example, high densities of Common Carp are associated with negative impacts on fish communities, whereas the effects of other non-native species, such as Zebra Mussels, are less consistent. Continued monitoring of both fish communities and stressors is important to better understand and disentangle these relationships over time.

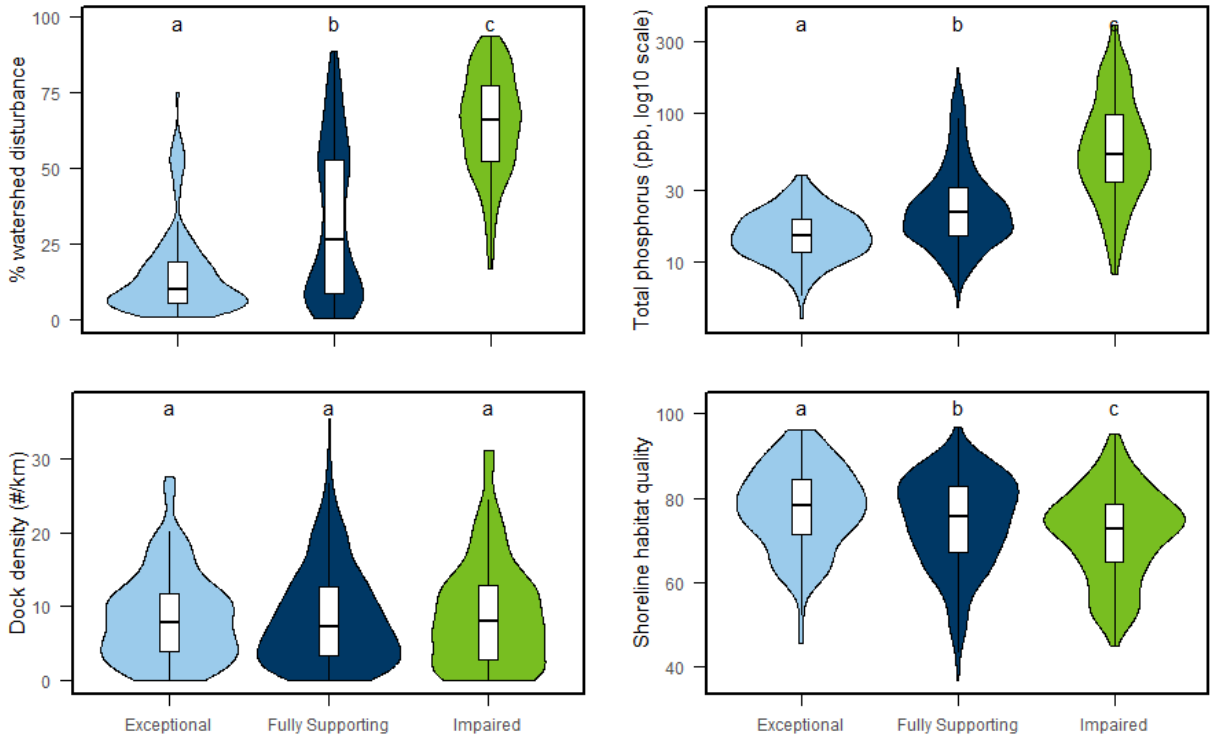


**Figure 6. Distribution of four stressor variables across three lake condition classes. Violin plots depict the full distribution per lake condition class, with embedded white boxplots indicating the median and interquartile range. Letters indicate significant differences based on Kruskal-Wallis tests followed by Dunn's post-hoc pairwise comparisons with Benjamini-Hochberg adjustment ($p < 0.05$).**

## Fish community characteristics

Across the 1,444 surveys, over 3.7 million individual fish encompassing 89 different species were sampled, including 25 species that are considered intolerant to stressors and five that are considered species in greatest conservation need (SGCN). The most frequently encountered SGCN fish during these surveys included Pugnose Shiner (state threatened), Least Darter (state special concern), and Northern Sunfish (state special concern). Within the MNDNR lake survey database, IBI-specific sampling

accounted for over 72%, 67%, and 24% of all records for these three species, respectively—a trend mirrored among other small-bodied fishes. Therefore, these assessments provide dual benefits for evaluating both overall aquatic life condition and species of conservation concern. Additional information about fish species in lakes can be found on the Classification of Fish Species for Use in Fish IBI and Minnesota's Wildlife Action Plan webpages.

Lakes with exceptional fish communities generally supported more diverse assemblages, with greater numbers of intolerant species and feeding and habitat specialists, than lakes that just meet the fully supporting classification (Figure 7). Both classes, however, supported more diverse assemblages than impaired lakes, which exhibited lower diversity and higher numbers of tolerant and omnivorous species. A larger proportion of biomass from omnivores was also present in trap net and gill net catches in impaired lakes (Figure 8). These generalist species are typically more tolerant of environmental stressors, and their dominance reflects simplified food webs and degraded ecological condition. Conversely, the higher relative biomass of feeding specialists (i.e., insectivores and carnivores) in exceptional and fully supporting lake categories indicates more complex trophic structure and greater ecological integrity.

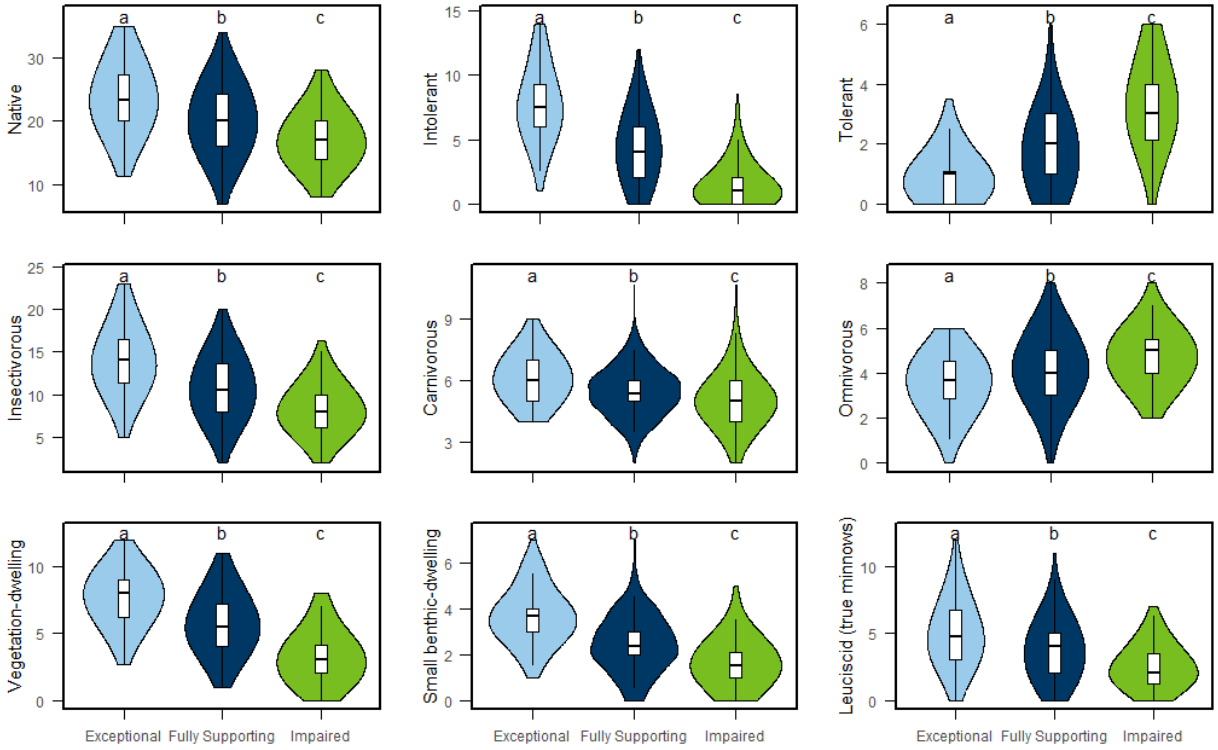


**Figure 7. Distribution of lake-level mean species richness across three lake condition classes for nine functional groups. Violin plots depict the full distribution of mean species richness per lake condition class, with embedded white boxplots indicating the median and interquartile range. Letters indicate significant differences based on Kruskal-Wallis tests followed by Dunn's post-hoc pairwise comparisons with Benjamini-Hochberg adjustment ($p < 0.05$).**

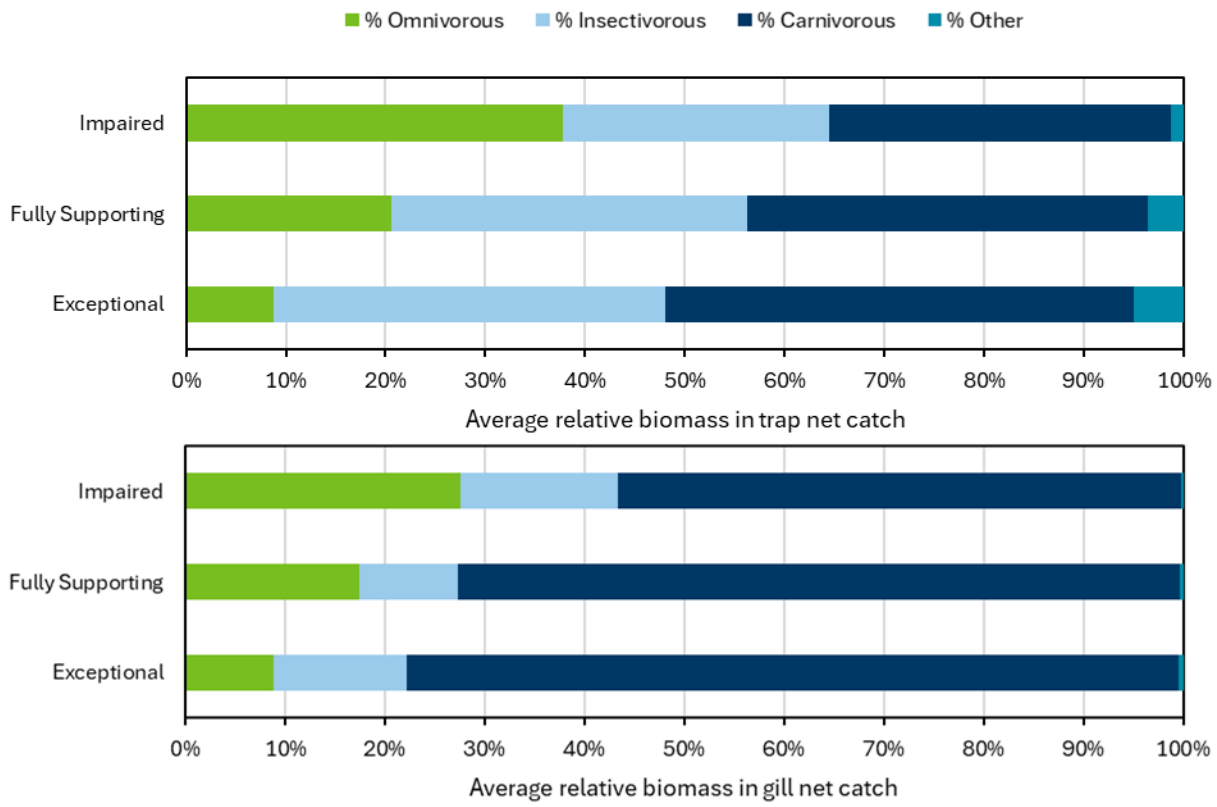


**Figure 8. Lake-averaged relative biomass of omnivorous, insectivorous, and carnivorous species in trap net (top) and gill net (bottom) catches across three lake condition classes.**

Geographically, lakes in central Minnesota watersheds exhibited the highest species diversity (Figure 9). While lakes in western and central watersheds had the highest average nearshore catches, measured as number per sampling station, those in southern Minnesota watersheds—where agricultural land use is most intensive—recorded the highest average biomass, measured as pounds per gill net or trap net lift. Although high biomass is often associated with elevated productivity, it does not necessarily reflect ecological integrity or balanced fish communities.

In Minnesota, elevated biomass is frequently an indicator of ecological imbalance resulting from eutrophication and watershed disturbance. Data trends indicate that as lake conditions shift from exceptional to impaired, total fish biomass may more than double. This increase is not reflected in the sport fish populations valued by the public; rather, it is driven by a significant expansion of disturbance-tolerant species, such as Common Carp and Black Bullhead. In some instances, the biomass of these tolerant species increases more than 100-fold in impaired waters, displacing the diverse communities found in healthier systems. In contrast, lakes in less disturbed, forested watersheds tend to support lower overall biomass but exhibit higher species diversity, better habitat conditions, and a greater likelihood of exceptional fish communities.

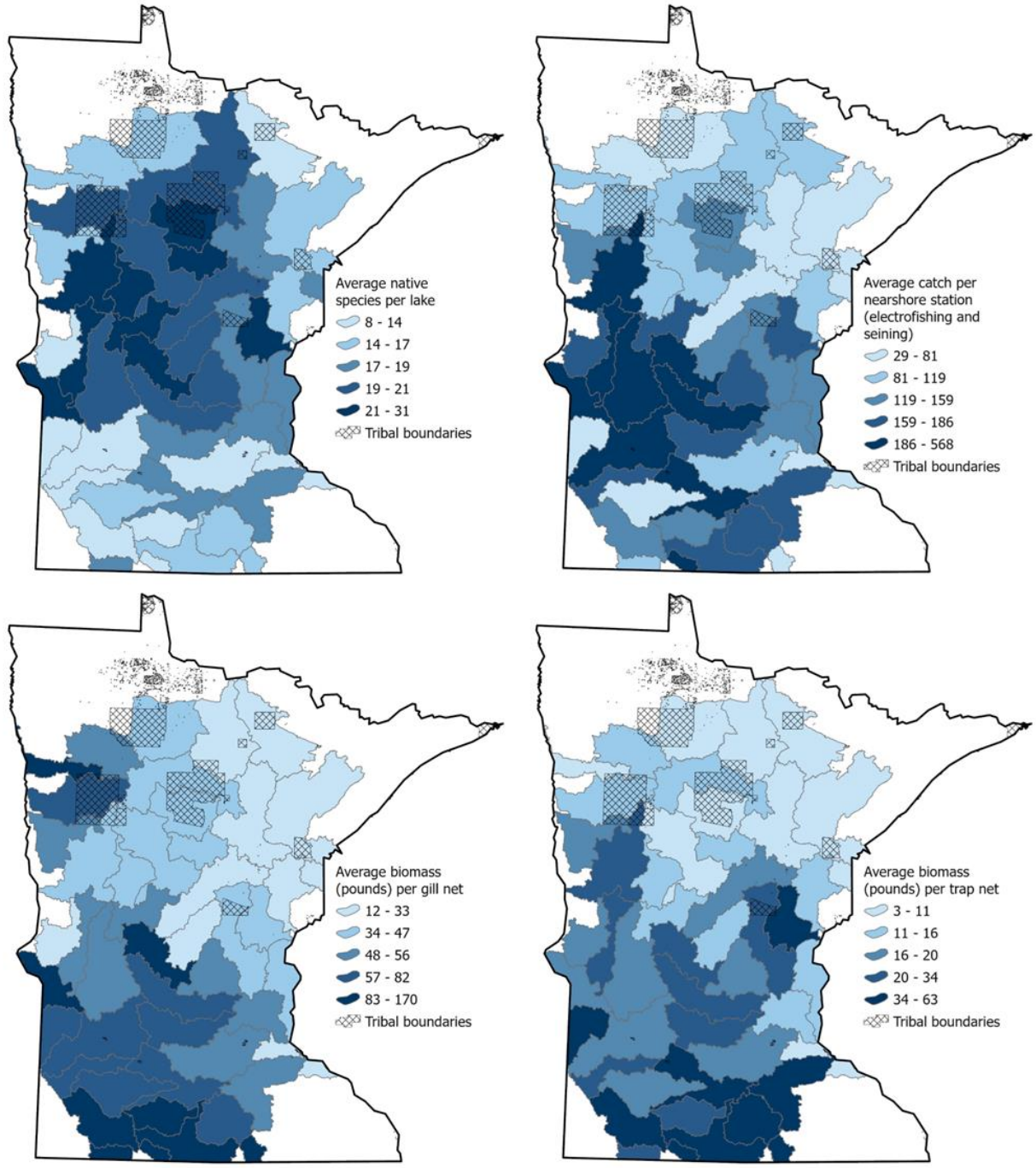


**Figure 9. Average number of native species, catch of individuals per nearshore electrofishing and seining station, biomass in pounds per gill net, and biomass in pounds per trap net, averaged across lakes within each major watershed.**

Higher fish IBI scores were significantly associated with an increased probability of lakes supporting coldwater species, SGCN taxa, native Muskellunge populations, and quality Northern Pike populations

(Figure 10). Associations with self-sustaining Walleye and quality sunfish populations were also significant, though the predictive strength was comparatively low. The coldwater species metric included lakes proposed for designation as stratified Cisco, Lake Whitefish, or Lake Trout lakes, while the SGCN metric was based on the presence of one or more SGCN taxa during monitoring. Sport fish metrics were derived from the Lakes of Biological Significance fish community dataset and the Quality Sunfish Initiative. To ensure biological accuracy, coldwater species and native Muskellunge analyses were restricted to lakes within each species' native range. Similarly, only non-stocked lakes identified as containing quality Northern Pike populations were included to better isolate environmental conditions—such as abundant aquatic vegetation and suitable spawning habitat—favorable to natural recruitment and the species' full life-history requirements.

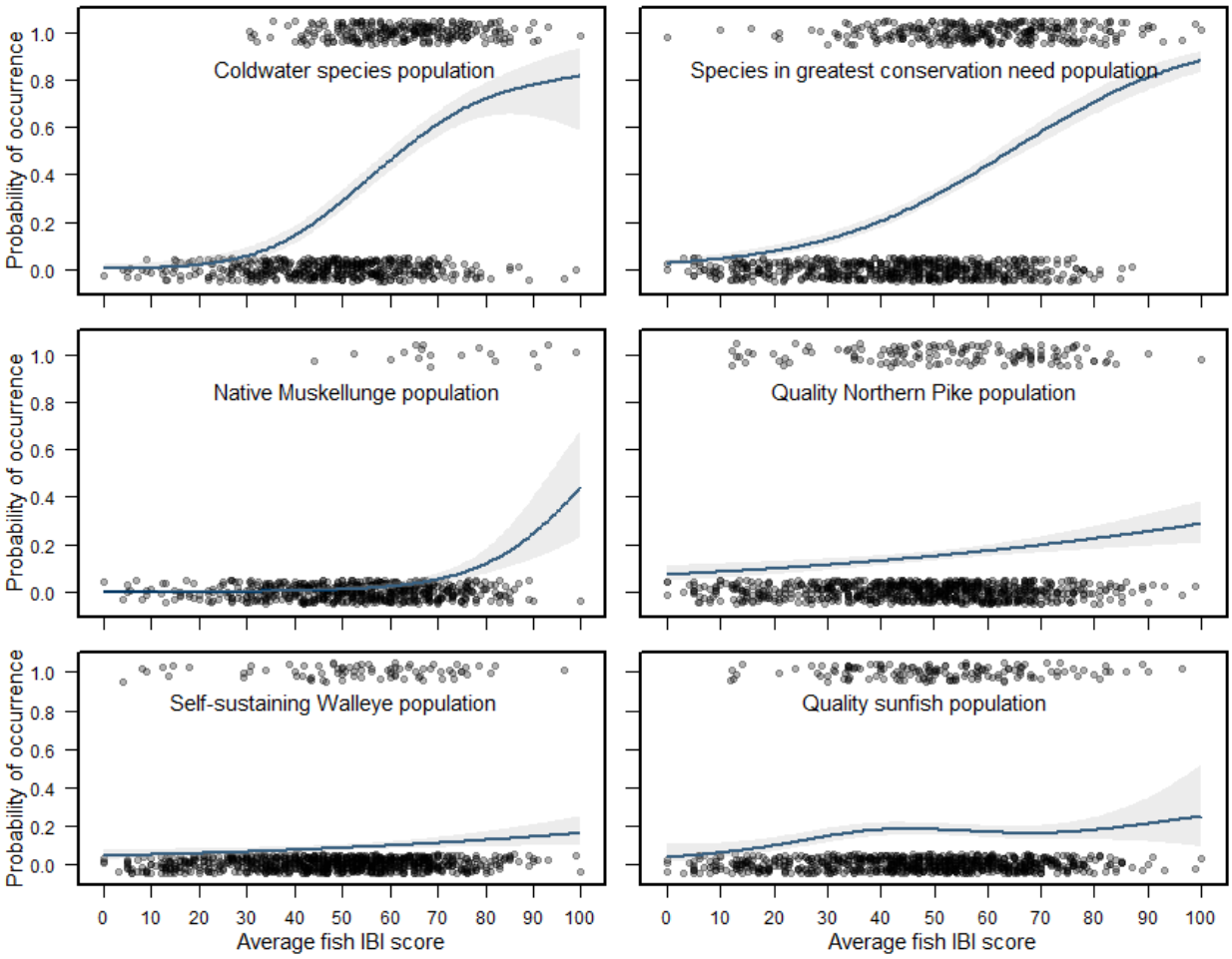


**Figure 10. Relationships between average fish index of biological integrity (IBI) score and the probability of occurrence of populations of coldwater species, species in greatest need, native Muskellunge, quality Northern Pike, self-sustaining Walleye, and quality sunfish. Curves represent fitted binomial generalized additive models (GAMs) with a logit link, and shaded bands indicate 90% confidence intervals. Points show observed binary responses (jittered for visualization).**

# Implications for monitoring and assessment

The completion of the first 10-year cycle of fish IBI monitoring and assessment provides an essential baseline required for the adaptive management of Minnesota's lakes. Building on this foundation, the second 10-year monitoring cycle emphasizes targeted efforts to support watershed trend detection, equity considerations, and locally relevant decision-making. To ensure trend detection is reliable, the cycle utilizes Anchor Lakes, which are a stratified, random sample of up to 15 lakes per major watershed. This sample is stratified by lake size, watershed position, and lake group, and it incorporates Sentinel Lakes to leverage their long-term datasets. The sample size was selected to provide an 80% probability of detecting meaningful changes in fish IBI scores within each watershed over time. Beyond Anchor Lakes, efforts focus on lakes prioritized by local communities, those in environmental justice areas, and those vulnerable to future impairment. Monitoring will also be completed on lakes previously identified as impaired to evaluate restoration success and provide the evidence necessary for formal delisting. By focusing resources on representative and high-priority subsets, these targeted efforts balance statewide coverage with available resources while enhancing the ability to evaluate management success, detect emerging issues, and support adaptive strategies at both the watershed and statewide scales.

Ongoing stressor monitoring also remains important for understanding biological changes and informing strategic management decisions. Paired water chemistry data, combined with continued characterization of habitat stressors, is needed to enhance understanding of cause-and-effect relationships between fish communities and environmental conditions. Furthermore, expanded monitoring is warranted for stressors where data are currently limited, such as for pesticides, climate-driven changes, and destruction of in-lake habitats (e.g., removal of fallen wood and aquatic plants). Addressing these key data gaps will reduce uncertainty in assessments and strengthen future restoration and protection decisions. Future work will also focus on connecting observed trends in fish communities and aquatic life condition to restoration activities and implementation of best management practices (BMPs) within watersheds. This will help evaluate the effectiveness of past management actions, support adaptive strategies, and guide future investment in restoration and protection efforts. Additionally, monitoring lakes targeted for protection will help verify that preventative measures maintain high biological condition over time.

Results also point to broader considerations related to the continued refinement of assessment frameworks and biological standards. Two projects that are in progress include: 1) incorporation of coldwater aquatic life standards into state rule, which are described in the Development of Water Quality Standards to Protect Coldwater Lake Habitats in Minnesota report, and 2) development of assessment methods for fish communities in Boreal Shield lakes. When incorporated into the monitoring and assessment framework, these may help address important gaps and ensure that management expectations and policy decisions are grounded in appropriate regional and ecological contexts. Such refinements can improve the consistency, defensibility, and applicability of assessment outcomes across lake types and support adaptive management under changing environmental conditions.

# Management and policy considerations

Beyond documenting current conditions, the results from the first cycle of lake fish IBI monitoring and assessment provide a consistent biological context that aligns management objectives, regulatory frameworks, and implementation strategies across state, regional, and local levels to better inform

aquatic life protection, restoration, and long-term resource stewardship. This integration is realized through Minnesota's Integrated Watershed Management framework, an approach largely supported by the Clean Water Fund, which provides critical resources needed for monitoring and implementation. As the fish IBI provides a direct measure of biological health, it serves as an important component of this framework, helping managers to prioritize Clean Water Fund projects and track their actual ecological "return on investment." With the Clean Water Fund and broader Legacy Amendment up for voter re-authorization in 2034, the ability to demonstrate these measurable outcomes through fish IBI data is essential for maintaining long-term support.

From a management perspective, the results support a tiered approach that aligns restoration, protection, and proactive measures with biological condition and risk at multiple scales. This approach provides a transparent basis for prioritizing management actions across major watersheds and for aligning regulatory programs, funding mechanisms, and voluntary initiatives with clearly defined management objectives. Emphasizing protection for high-quality and Exceptional Use lakes, while directing restoration resources toward biologically impaired systems, helps ensure that limited resources are applied in a manner that maximizes long-term ecological benefit. Lakes identified as vulnerable further complement this strategy, as early intervention through targeted protection often provides a more cost-effective means of preventing impairment than later restoration.

When prioritizing lakes for protection, decision-makers can consider two complementary approaches based on goals and resources. The first targets lakes nearest to their respective impairment threshold, with higher levels of human disturbance and minimal surrounding protected land, as these systems have the most immediate potential to benefit from proactive protection. The second focuses on lakes farthest from impairment and with fewer stressor impacts, representing the most pristine systems that warrant preservation to prevent future degradation. Lakes designated as Exceptional Use under the TALU framework have particularly strong implications within this category, as they represent some of the most biologically diverse and ecologically intact systems in the state. Prioritizing these lakes for protection helps ensure the long-term maintenance of rare or unique fish assemblages and preserves reference conditions that can be used to inform expectations and goals for other lakes. These lakes are also incorporated into complementary prioritization efforts, such as the Lakes of Biological Significance, where they are identified as outstanding lakes, reinforcing their conservation value. A hybrid approach that includes both categories can help ensure balanced protection efforts, spreading risk and maximizing long-term ecological and societal benefits across the landscape.

Applying this prioritization framework requires a direct focus on the stressors impacting biological health. Consistent with stressor identification reports and the strategic guidance outlined in Minnesota's Fish Habitat Plan, protection and restoration efforts are most effective when guided by an understanding of how watershed conditions and nearshore disturbance influence aquatic habitat quality. Policies and programs focused on nutrient reduction, watershed and shoreline protection and restoration, and non-native species prevention remain central to sustaining or restoring aquatic life and ecosystem function. Protecting forested land, maintaining natural shorelines—which are disappearing at an estimated 1–2% per decade according to Minnesota's Vanishing Natural Shorelines Report—and limiting in-lake habitat loss, which can occur through the removal of aquatic plants and fallen wood or the installation of riprap or sand blankets, are essential for preserving biological integrity in lakes prioritized for protection or preventative management.

Assessment and stressor identification results and corresponding management approaches should continue to be integrated into local watershed plans, lake management plans, and implementation strategies outlined in Watershed Restoration and Protection Strategies (WRAPS) and One Watershed, One Plan (1W1P) reports. This data-driven approach supports locally led prioritization, improves coordination among partners, and strengthens the scientific basis for management decisions and stakeholder communication. Collaboration and partnerships will continue to be a key component of this work, as opportunities exist to coordinate with other state and federal agencies, Tribal nations, local watershed organizations, and community stakeholders to leverage resources and share data. Strengthening these collaborations ensures an integrated approach to lake protection, restoration, and adaptive management, allowing agencies to better justify the efforts that the public values.

A variety of regulatory tools and grants, such as those found on the Board of Water and Soil Resources (BWSR) Grant Information and Resources webpage, are available to turn these strategies into action. Beyond the Clean Water Fund, there is also a significant opportunity to leverage the Outdoor Heritage Fund, which focuses specifically on restoring and protecting fish and wildlife habitat. By aligning fish IBI priorities with both Clean Water Fund and Outdoor Heritage Fund grants, managers can address both water quality and habitat complexity. Targeted use of these resources ensures they are applied strategically, reinforcing stakeholder engagement and helping achieve measurable success across both impaired and high-quality lakes and their associated watersheds.

In addition to supporting aquatic life, lake protection and restoration actions often generate multiple societal and ecological benefits. Improvements in water quality, recreational opportunities, and sport fish populations, as well as the preservation of habitat for other wildlife, demonstrate the broader value of investing in lake and watershed management. Many lakes sampled also support SGCN taxa, illustrating that actions to maintain or enhance biological integrity can simultaneously protect rare or sensitive species. Recognizing these co-benefits can help guide resource allocation, strengthen stakeholder engagement, and justify integrated management strategies that deliver ecological and community outcomes simultaneously.

Collectively, these management and policy considerations highlight the value of integrating biological assessment results into decision-making across programs and scales. Applying this information in a coordinated manner supports more effective prioritization, strengthens protection and restoration outcomes, and improves consistency among lake management, watershed planning, and conservation efforts. Together, these considerations provide a policy foundation for translating assessment results into on-the-ground actions and adaptive management strategies.

# Additional resources

Classification of Fish Species in for Use in Fish IBI – explains how fish species in Minnesota lakes are grouped into tolerance, feeding, and habitat categories to support the lake fish IBI, which assesses water quality and habitat conditions based on fish communities. These classifications help scientists interpret ecological health by linking species composition to environmental stressors.

Clean Water Fund – explains Minnesota's Clean Water Fund, which receives 33% of the sales tax revenue from the Clean Water, Land, and Legacy Amendment to protect, enhance, and restore water quality in lakes, rivers, streams, and groundwater and to safeguard drinking water sources. The resource

describes how these funds are allocated among agencies and projects that support collaborative water resource management and restoration across the state.

Development of Fish-based Indices of Biological Integrity for Minnesota Lakes – describes the technical development of fish IBIs for Minnesota lakes, including species and lake classification, metric evaluation, and threshold development.

Development of Water Quality Standards to Protect Coldwater Lake Habitats in Minnesota – describes the technical development of standards for the protection of coldwater fish in lakes and the coldwater lake habitat use designation review process.

Flowing Forward: Trends in Minnesota's Lakes and Rivers – highlights statewide monitoring and assessment results that show improving trends in water clarity and biological health across many regions. The report outlines ongoing challenges and emerging threats to water quality while providing a roadmap for future monitoring and protection strategies.

Grant Information and Resources – provides competitive grants to local governments and partner organizations to implement targeted water quality improvement and protection projects across Minnesota watersheds. The program supports collaborative, science-based approaches to reduce pollution, restore aquatic habitats, and enhance watershed health through coordinated local actions.

Lake Index of Biological Integrity – describes a scientific system for evaluating lake ecological condition by comparing observed fish communities to expected conditions for healthy lakes. The index supports resource managers and partners in prioritizing lake protection and restoration efforts.

LakeFinder – provides searchable information about individual Minnesota lakes, including fish survey results, public access, water clarity, and aquatic invasive species (AIS). The tool supports public use, resource management, and water planning efforts.

Lakes of Biological Significance – classifies Minnesota lakes based on biological criteria such as high-quality aquatic plant, fish, amphibian, and bird communities. These classifications support conservation prioritization and guide protection and management decisions.

Lakes with DNR Fisheries IBI Scores – provides spatial data that supports mapping of fish IBI scores for Minnesota lakes. The metadata links to several additional spatial datasets including Lakes with Aquatic Life Use Judgement and Stressors to Impaired or Vulnerable Lakes.

Minnesota's Fish Habitat Plan – outlines strategic priorities and collaborative approaches for protecting and restoring fish habitats across Minnesota's watersheds. The plan provides a framework for coordinated action among agencies and partners to enhance aquatic habitat health.

Minnesota's Impaired Waters List – identifies lakes and streams that do not meet state water quality standards for designated uses based on monitoring data. The list guides restoration priorities and pollutant reduction efforts and is updated biennially.

Minnesota's Vanishing Natural Shorelines – describes the loss of natural shorelines due to development and the resulting impacts on water quality, habitat, and ecological function. It emphasizes the importance of preserving and restoring vegetated shorelines to protect aquatic ecosystems.

Minnesota's Wildlife Action Plan – presents a long-term, partnership-based conservation strategy focused on sustaining native wildlife and habitats, particularly SGCN. The plan prioritizes actions to address key threats such as habitat loss, fragmentation, and climate change.

Sentinel Lakes – describes a long-term monitoring program that tracks changes in lake ecosystems related to climate change, land use, and AIS. The program uses intensive, repeated measurements to detect trends and inform adaptive lake management.

Stressors to Biological Communities in Minnesota's Lakes – summarizes how biological communities respond to stressors such as water quality degradation, shoreline alteration, and land-use change. The information supports stressor identification and guides lake restoration and management decisions.

Stressors to Impaired or Vulnerable Lakes – provides spatial data that supports mapping of stressors to impaired or vulnerable lakes in Minnesota. The metadata links to several additional spatial datasets including Lakes with DNR Fisheries IBI Scores and Lakes with Aquatic Life Use Judgement.

Tribes and Water Quality Standards – explains how Tribal nations in Minnesota can be authorized by the Environmental Protection Agency (EPA) to be treated in a similar manner as states (TAS) for implementing and managing water quality standards under the Clean Water Act. The resource describes how Tribes establish and apply water quality standards, supporting their efforts to protect lakes, rivers, and streams within Tribal jurisdiction.

Watershed Approach to Water Quality – describes a watershed-based management framework that guides monitoring, assessment, planning, and implementation across Minnesota's 80 major watersheds. Led by the MPCA in partnership with state agencies, Tribal nations, local governments, and stakeholders, the approach supports targeted protection and restoration efforts.

Watershed Health Assessment Framework – presents an organized system for evaluating watershed health using five core ecological components: biology, connectivity, geomorphology, hydrology, and water quality. The framework provides maps, scores, and reports to support comparison of watershed conditions and management planning.

Watershed Health Assessment Framework: Lakes – evaluates lake health by assigning scores and grades based on water quality, biology, and hydrology. The tool assesses current conditions and land-use risks against expectations for specific lake types to help prioritize stewardship of lakes across Minnesota.

Watershed Information – provides detailed information on Minnesota's watersheds, including watershed boundaries, drainage areas, and associated rivers and basins. The resource also includes contacts and tools to support watershed planning and coordination.

Water Quality Assessment Results Data Viewer – offers an interactive dashboard for viewing and downloading water quality monitoring and assessment results for Minnesota's lakes, rivers, and streams. The tool shows whether waters meet state standards for designated uses and supports data-driven decision-making.

Wildlife and Sport Fish Restoration Program – describes how Minnesota uses federal Wildlife Restoration and Sport Fish Restoration funds to support fisheries, wildlife, and aquatic habitat management across the state. The resource explains eligible activities, funding priorities, and how these programs help maintain public access, monitoring, research, and conservation efforts.