INDICATOR: Water Quality in Inland Lakes

Startegic Direction: Reduce Threats

Target: N/A

Theme: Pressures on Ontario's Biodiversity — Pollution

Previous versions:
Water Quality in Inland Lakes 2015
Water Quality in inland lakes 2021

Background Information

Lakes and streams have a very important role in sustaining biodiversity (Environment Canada 2008). Along with aquatic species, many terrestrial amphibians, birds and invertebrates depend on freshwater bodies at some point in their life-cycle. Ontario has more than 225,000 lakes greater than 1 hectare in area (Cox 1978). Most of these lakes are found in relatively natural settings and their water chemistry reflects the geology of the surrounding landscape and inputs from inflowing streams. Pollution alters the water quality of lakes directly from point sources (industrial waste, wastewater from urban and suburban development), non-point sources (runoff) and indirectly from airborne pollution deposits. In 1991, the Canada-United States Air quality agreement was signed to address transboundary air pollution leading to acid rain, affecting water quality and both countries continue to monitor acid deposition and ambient levels of ground-level ozone (ECCC 2020).

Water samples from inland lakes across Ontario are collected as part of Ontario's Broad-Scale Monitoring Program (BSM) to help with the fisheries management across the province. This program assesses the current state of fishes and other aquatic resources, identifying stresses on these resources, and reporting on changes over time. The program monitors lakes (20 - 250,000 ha in size) across the province on 5-year cycles to provide information critical to effective fisheries management, including water quality. At the time of this report three Broad-Scale Monitoring cycles have been completed — cycle 1 includes lakes sampled from 2008-2012, cycle 2 lakes sampled from 2013-2017, and cycle 3 lakes sampled from 2018-2024 (Figure 1).

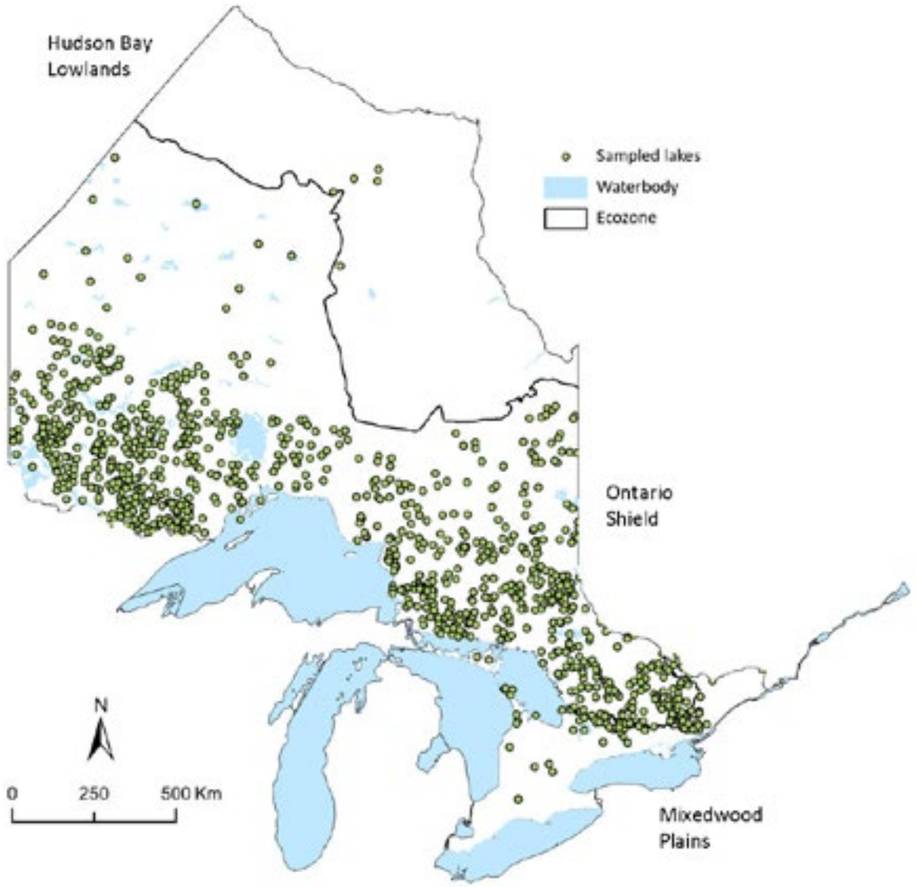

Figure 1. Ecozones, and the lakes sample through the Broad-Scale Monitoring program cycle 1, 2 and 3 for water quality.

This indicator provides an assessment of water quality in Ontario's inland lakes by examining three parameters that have a strong influence on aquatic biodiversity — pH, and concentrations of calcium and total phosphorus. This assessment of lake water quality sampled in Broad-Scale Monitoring cycle 1, cycle 2 and cycle 3 compares measured levels to those that can impact biodiversity (Table 1). Trends will be assessed and compared in this indicator every five years through the results of the BSM Program.

Pressures on Biodivesity

Table 1. Lake water quality parameters used in indicator assessment.

Parameter	Relevance to biodiversity[1]
Calcium	Calcium is a mineral that organisms require to survive. Low levels of calcium (< 1.5 mg/L) can cause problems for small planktonic crustaceans and affect the food chain. There is evidence of widespread calcium declines in many lakes including in Ontario (Jeziorski 2008, OMOE 2013). Long-term calcium patterns may reflect a combination of factors including climatic changes, forest harvesting activities and leaching by acid deposition (Keller et al. 2001). Calcium rich lakes (> 20 mg/L) with high pH (> 7.4) are most vulnerable to invasion by Zebra Mussel (Neary and Leach 1992).
pH	pH is a measure of the concentration of hydrogen ions in the water. Acidic water below pH 6.5 and basic water above 8.5 can cause problems for aquatic life (MOEE 1994). pH levels can be affected by industrial effluents and runoff or atmospheric deposition (acid rain).
Total Phosphorus	Phosphorus is an important nutrient in lakes. However, too much phosphorus can lead to blue-green algal blooms and excessive plant growth that reduces oxygen levels in lakes. These impacts are generally avoided when total phosphorus levels are below 20 µg/L (MOEE 1994). Three broad categories exist with respect to nutrient status. Lakes with less than 10 µg/L total phosphorus are considered oligotrophic, these are dilute, unproductive lakes that rarely experience nuisance algal blooms. Lakes with levels between 10 and 20 µg/L are termed mesotrophic and are in the middle with respect to trophic status. these lakes show a broad range of characteristics and can be clear and unproductive at the bottom end of the scale or susceptible to moderate algal blooms at concentration near 20 µg/L. Lakes over 20 µg/L are classed as eutrophic and may exhibit persistent, nuisance algal blooms (MECP 2024).

[1]some lakes may naturally have water quality values that are beyond the threshold levels that can have impacts on biodiversity (e.g., low pH, high phosphorus).

Data Analysis

Data collected through Ontario's BSM, on water quality in lakes across Ontario are compared across ecozones and over time. Calcium, pH and total phosphorus levels are collected using a standard protocol (unpublished, modified from Ingram et al. 2011). Using data from the BSM water quality assessments, this indicator compares calcium, pH and phosphorus levels in individual lakes against known thresholds that can impact biodiversity in lakes.

The BSM program is conducted in 5-year intervals; cycle 1 includes samples taken between 2008-2012, cycle 2 includes samples taken from 2013-2017, and cycle 3 includes data from samples taken between 2018-2024 (longer time-span due to delays in field work during covid).

The sampled lakes include only those between 5 and 250,000 hectares, so numerous smaller lakes are not represented in this indicator. It is impractical to monitor all the lakes in Ontario, so a sample of lakes from each zone is selected for monitoring. Fifty hectares was chosen as the smallest lake size based on the ability to access and use sampling gear in the lake, while 250,000 hectares was the largest because lakes larger than this are already intensively monitored by the ministry (MNR 2024).

Based on data from the BSM program (MNR 2025) a total of 765 lakes were included in cycle 1, 729 were included in cycle 2 and 467 were included in cycle 3 for this indicator. A total of 333 of those sampled in cycle 1 were also sampled in the following 2 cycles (Table 2).

In each cycle, most sampled lakes were found in the Ontario Shield ecozone, the lakes within the Mixedwood Plains were sampled in smaller numbers, and lakes within the Hudson Bay Lowlands ecozone were sampled in cycle 1, and not in cycle 2 or cycle 3.

Table 2. Number of lakes sampled by the BSM program per cycle (MNR 2025).

Ecozone	Sampled during cycle 1	Sampled during cycle 2	Sampled during cycle 3	Sampled in cycle 1, 2, and 3
Ontario Shield	709	680	419	300
Mixedwood Plains	51	49	48	33
Hudson Bay Lowlands	5	0	0	0
Total	765	729	467	333

The status of lakes for each water quality parameter – calcium, pH, and total phosphorus – showing their status with respect to threshold levels are summarized by ecozone (Figures 2, 3 and 4).

It is important to note that some lakes may naturally have water quality values that are beyond the threshold levels that can have impacts on biodiversity (e.g., low pH, high phosphorus). It will be important to assess the trends in these key water quality parameters as successive 5-year cycles of the Broad-Scale Monitoring Program are completed. Additional information on the water quality of Ontario's inland lakes is available from sampling conducted by the Ministry of the Environment, Conservation and Parks and its Lake Partner Program, as well as the Ontario Geological Survey. For information on a more regional scale, there are other intensive lake water quality monitoring programs that are undertaken continuously within regions for 5-10 years, including the Muskoka Watershed Council, Kawartha Lakes Stewards Association, Haliburton U-Links and Conservation Authorities with lakes, such as Otonabee Conservation and Kawartha Conservation, and more. The Great lakes have been monitored for decades as well.

Pressures on Biodivesity

Results

Trend:No change | **Data Confidence:** High | **Geographic Extent:** Provincial

Status

Calcium levels

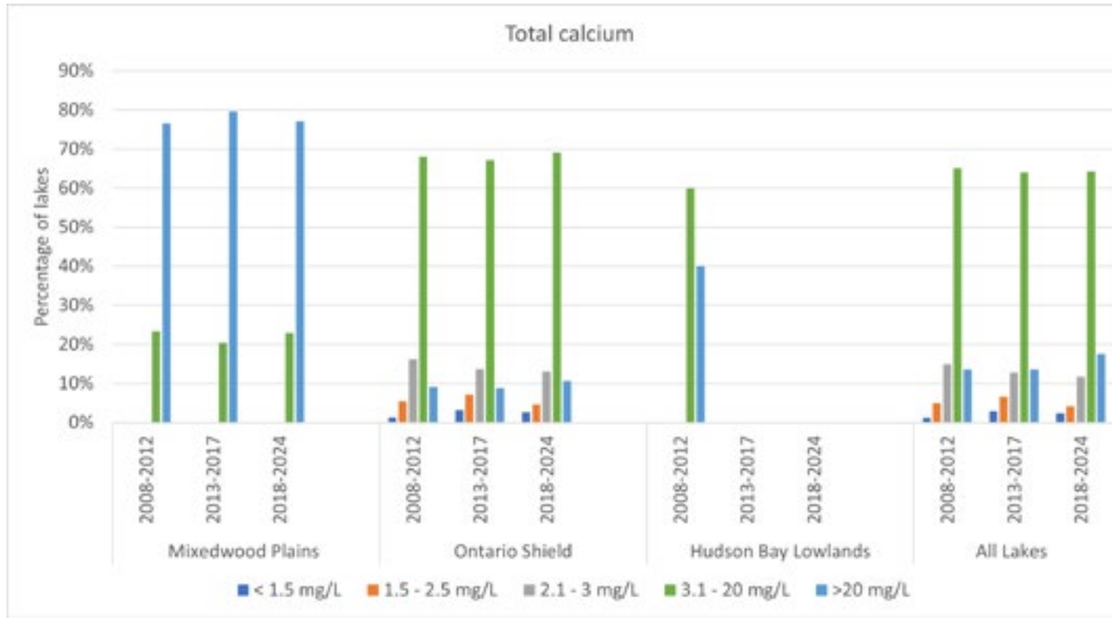

Figure 2. Status of total calcium levels in Ontario lakes sampled for calcium during cycle 1 (n=734), cycle 2 (n= 711), and cycle 3 (n=462), and percentage of lakes by ecoregion.

- Results in cycle 3 show that a total of 2% of the sampled lakes (11 lakes) had critically low calcium levels (< 1.5 mg/L). Previous cycles showed 3% (2013–2017) and 1% (2008–2012). Sixteen percent of the lakes sampled had calcium levels close to this threshold (1.5–3.0 mg/L). Previous cycles both had lakes within this range at 20%, in all cases lakes within this range were in the Ontario Shield ecozone. The Ontario Shield is an area where calcium levels are naturally low and there is evidence of declining calcium levels in soils and aquatic ecosystems.

- In cycle 3, a total of 77% of the lakes within the Mixedwood Plains ecozone were calcium rich (> 20 mg/L); previous cycles had similar results (80% in cycle 2 and 77% in cycle 1), making them more vulnerable to Zebra Mussel invasion. The Mixedwood Plains ecozone is situated on limestone and dolostone formation, making calcium levels in lakes naturally high. Calcium rich lakes also occur in the northern part of the Ontario Shield ecozone. All calcium rich lakes in cycle 3 (n=81) have pH values greater than 7.4, which is conducive to supporting Zebra Mussels.

pH levels

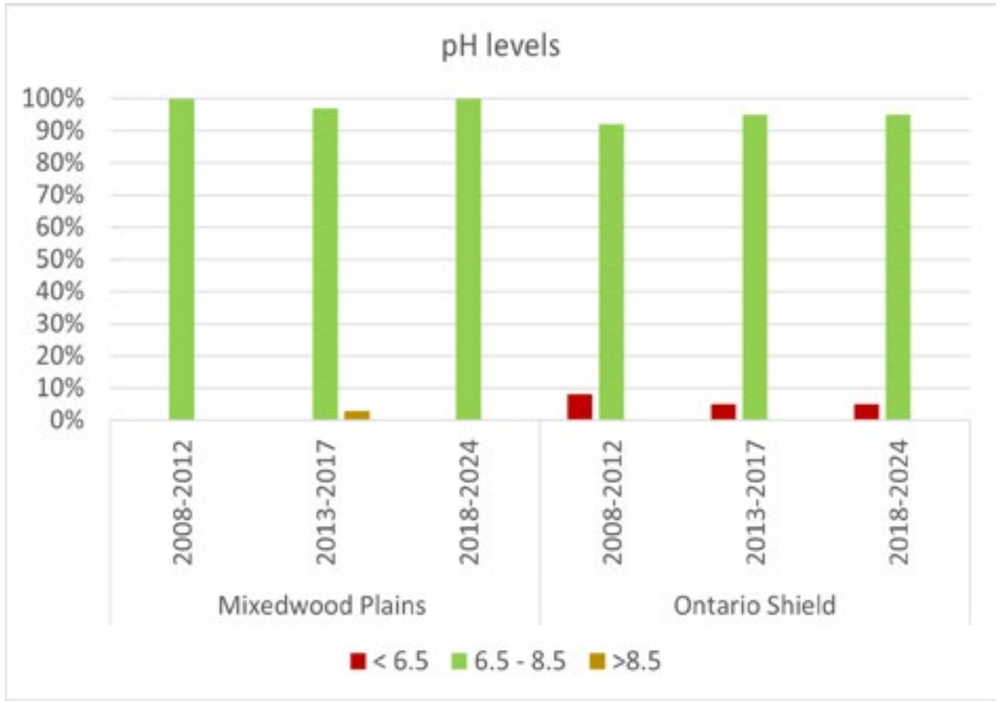

Figure 3. Status of total pH levels in Ontario lakes sampled for pH during cycle 1 (n=754) cycle 2 (n= 729), and cycle 3 (n=468), and a percentage of lakes by ecoregion.

- Between 2018–2024 (cycle 3), 95% of sampled lakes had pH values within the 6.5 – 8.5 range recommended for the protection of aquatic life. Previous sample cycles showed similar results with 93% during cycle 2 (2013–2017) and 90% of lakes during cycle 1 (2008–2012). Consistent with previous cycles, all the lakes with low pH (< 6.5) in cycle 3 were found in the Ontario Shield ecozone (n=22). Low pH values in this region can be due to a combination of factors including— the bedrock composition which leads to low pH levels in the lakes and streams, acidic soils and industrial runoff, etc.

Total phosphorus

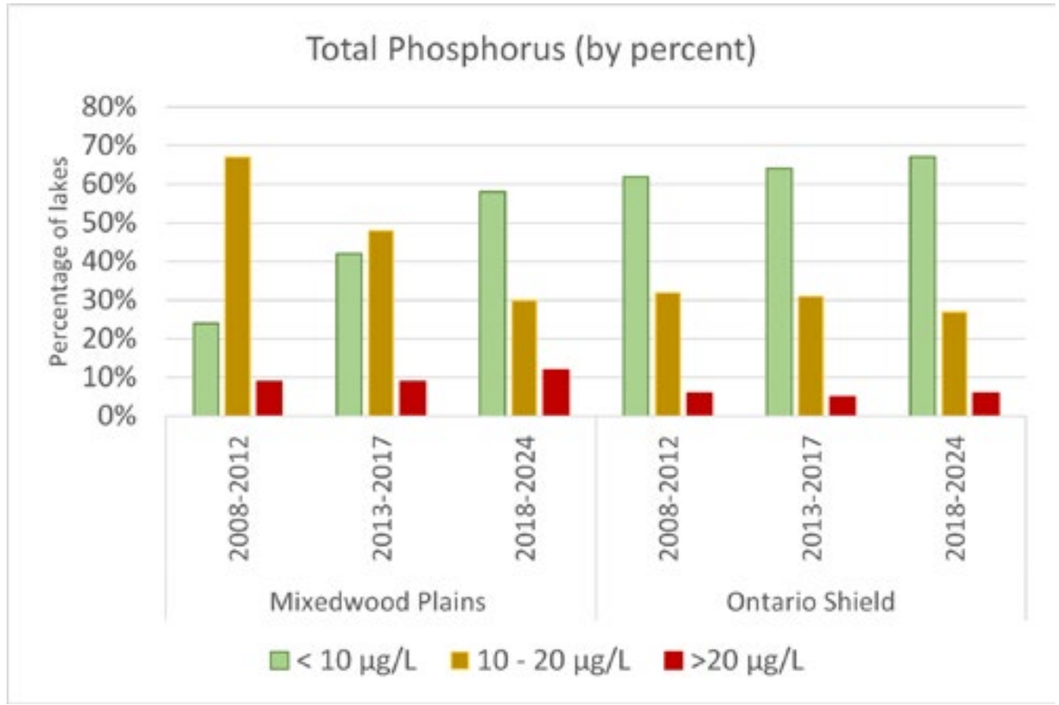

Figure 4. Status of total phosphorus levels in Ontario lakes sampled during cycle 1 (n=764) cycle 2 (n= 729), and cycle 3 (n=467), and percentage of lakes by ecoregion.

- Results show that during each sampling period (2008-2012, 2013-2017, and 2018-2024), 94% or more of the lakes were below the 20 µg/L threshold for total phosphorus, indicating there is an acceptable level of nutrients. Lakes where phosphorous levels are above 20 µg/L can result in algal blooms and excessive plant growth. Like previous cycles, the majority of the sampled lakes in the Ontario Shield (68%) have low levels of total phosphorus (< 10 µg/L).
- The Mixedwood Plains area did see some change related to lakes with low levels of total phosphorus (<10 ug/L). In cycle 3, 58% of sampled lakes were under 10ug/L, which is higher than previous cycles (26% and 43% in cycles 1 and 2, respectively), showing a trend of reduced phosphorus. Phosphorus management programs and best management guides to reduce the amount of runoff into lakes and streams in this area have been introduced over the last decade.

Links

Related Targets: 6. By 2030, the release of ecologically damaging pollutants is reduced to a level that is not harmful to biodiversity and ecosystem services.

Related Themes: N/A

Web Links

Government of Canada - Canada-United States Air Quality Agreement: overview - Canada.ca

Lake Partner Program, Data catalogue - https://data.ontario.ca/dataset/ontario-lake-partner

Ontario Geological Survey data https://www.ontario.ca/page/ontario-geological-survey

Ontario Ministry of Environment Conservation and Parks, Total Phosphorus report - https://www.ontario.ca/page/total-phosphorus-report?id=71010001

Ontario Ministry of Natural Resources - Ontario's Broad Scale Monitoring Program - https://www.ontario.ca/page/broad-scale-monitoring-program

References

Cox, E.T. 1978. Counts and measurements of Ontario lakes. Ontario Ministry of Natural Resources, Toronto, ON.

Environment and Climate Change Canada (2025) Canadian Environmental Sustainability Indicators: Phosphorus levels in the offshore waters of the Great Lakes. Consulted on March 3, 2025.

Ingram, R. G., R. E. Girard, A. M. Paterson, P. Sutey, D. Evans, R. Xu, J. Rusak, C. Thomson, and C. Masters. 2013. Dorset Environmental Science Centre: lake sampling methods. Ontario Ministry of the Environment, Dorset, ON.

Jeziorski, A., and 14 co-authors. 2008. The widespread threat of calcium decline in freshwaters. Science 322:1374-1377

Ministry of Environment and Energy (MOEE). 1994. Water management policies, guidelines and provincial water quality objectives of the Ministry of Environment and Energy. Queen's Printer for Ontario, Toronto, ON. [Available at: http://www.ontario.ca/document/water-management-policies- guidelines-provincial-water-quality-objectives]

Neary B.P., and J.H. Leach. 1992. Mapping the potential spread of the zebra mussel (Dreissena polymorpha) in Ontario. Canadian Journal of Fisheries and Aquatic Sciences 49:406–15.

Ontario Ministry of the Environment. 1979. Rationale for the establishment of Ontario's Provincial Water Quality Objectives. Queen's Printer for Ontario. 236 p.

Pressures on Biodivesity

Ontario Ministry of the Environment (OMOE). 2013. Water quality in Ontario: 2012 report. Queen's Printer for Ontario, Toronto, ON. [Available at: https://www.ontario.ca/environment-and-energy/water-quality-ontario-report-2012].

W Keller, S S Dixit, and J Heneberry. 2001. Calcium declines in northeastern Ontario lakes. Canadian Journal of Fisheries and Aquatic Sciences. 58(10): 2011-2020. https://doi.org/10.1139/f01-142

Citation
Ontario Biodiversity Council. 2025. State of Ontario's Biodiversity [web application]. Ontario Biodiversity Council, Peterborough, Ontario. [Available at: www.sobr.ca (Updated: May 12, 2025).