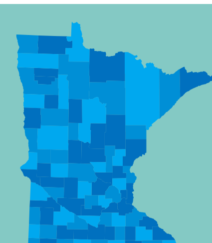
Lake assessment

November 2020

# National Lakes Assessment 2017

A synopsis of water chemistry data collected in Minnesota lakes as part of the U.S. Environmental Protection Agency's 2017 National Lakes Assessment

MINNESOTA POLLUTION CONTROL AGENCY



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# Contents

# Summary

Minnesota lakes were sampled in 2017, as part of the larger nation-wide U.S. Environmental Protection Agency (EPA) survey to assess the nation's water quality.

This nation-wide survey has taken place in 2007, 2012, and is planned again for 2022. The Minnesota Pollution Control Agency (MPCA) and partners sampled 155 lakes, equally distributed over the state's three major ecoregions, as part of EPA's 2017 National Lake Assessment (NLA).

Fifty of the sampled lakes were part of the EPA's selection of lakes, but Minnesota was unique in the nation because we added in 100 more lakes to the survey to ensure that we can look for significant water quality differences within our state. Lakes sampled in 2017 ranged in size from small (less than 10 acres) to very large. The largest lake sampled was Flat Lake in Becker County (1,835 acres).

Key water quality take homes:

- The main differences in parameter values were driven by differences in location, as has been documented in past NLA surveys and historical MPCA lake monitoring databases.
- Lakes in the northern-eastern part of the state tended to have the lowest nutrient levels and highest lake clarity, while lakes in the southwest part of the state tended to have the highest nutrient levels and lowest lake clarity.
- Overall, the NLA datasets showed that one-time visits were useful proxies of the trophic state of both lakes statewide and by ecoregion.
- The median phosphorus concentration of MPCA's recently assessed lakes was in the mesotrophic range (~ 30 µg/L), similar to the average trophic state of the Sentinel Lakes. Given the findings from past NLA surveys, this value could be considered the approximate trophic condition of Minnesota lakes.

# Introduction

## National Lakes Assessment overview, lake selection, and report focus

The EPA is responsible for measuring the health of the nation's water resources. In the early 2000s a number of independent organizations, including the Government Accountability Office and the National Research Council, noted that the EPA and the states did not have a uniform, consistent approach to answer key questions about water quality; in response, the EPA, states, tribes, academics, and other federal agencies began collaborating on a series of statistically-based surveys called the National Aquatic Resource Surveys to provide the public and decision-makers with improved water quality information (see the EPA NLA website). The nation's first National Lakes Survey occurred in 2007, with follow up surveys in 2012 and 2017. The NLA was designed to answer the following questions about U.S. lakes (EPA, 2016):

1. What is the current biological, chemical, physical, and recreational condition of lakes?
    a. What is the extent of degradation among lakes?
    b. Is degradation widespread (e.g., national) or localized (e.g., regional)?

2. Is the proportion of lakes in the most disturbed condition getting better, worse, or staying the same over time?
3. Which environmental stressors are most strongly associated with degraded biological condition in lakes?

The EPA used a randomized statistical sampling approach to select lakes for the 2017 assessment, which was intended to reflect the full range in character and variation among lakes across the U.S. (EPA, 2016). To be included in the 2012 and 2017 surveys, a water body had to be either a natural or human-made freshwater lake, pond, or reservoir greater than 2.47 acres (1 hectare), at least 3.3 feet (1 meter) deep, with a minimum quarter acre (0.1 hectare) of open water. In 2007, the minimum lake area was 4 hectares (~ 10 acres, similar to Minnesota's typical minimum definition for the size of a lake basin). The 2012 and 2017 survey design was expanded to be more representative of lakes in the U.S. by including smaller lakes between 1 and 4 hectares of surface area, increasing the number of potential lakes to assess nationwide from approximately 50,000 in 2007 to 111,818 in 2012 and 2017 (EPA, 2016).

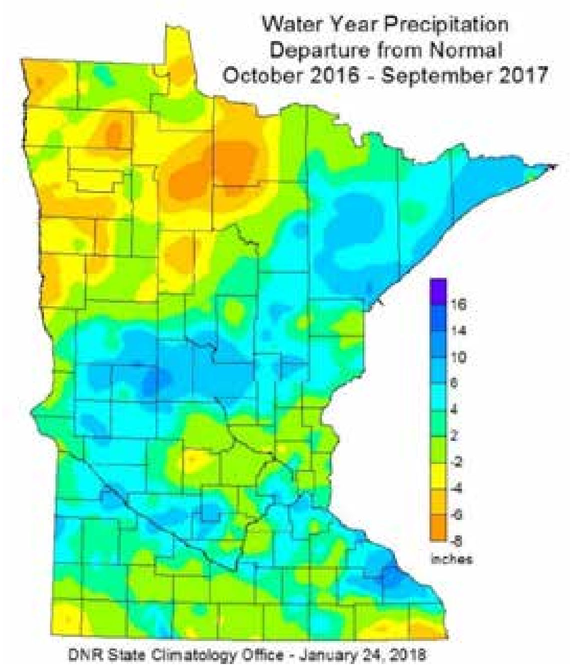
In all survey years, Minnesota received 50 lakes to sample statewide from the targeted EPA draw (referred to as "federal lakes" in the rest of this report). In 2012 and again in 2017, Minnesota choose to sample an additional 100 lakes to monitor for condition at an ecoregion scale. (Engel, 2018) (referred to as "state lakes" in the rest of this report). Minnesota worked with the EPA to ensure that the additional lakes were also selected through the EPA's random-stratified selection process. Minnesota was one of only two states who increased their sampling draw, and the only state to increase the draw by such a significant amount. Combining the 150 lakes and five additional lakes sampled by Tribal partners or EPA as part of their Reference Lakes network, yielded 155 lakes sampled within Minnesota for the 2017 NLA. Three lakes were resampled per QA protocols, yielding 158 lake visits in the summer of 2017.

For the 2017 survey, a large range of data were collected and analyzed in partnership with multiple agencies and Tribal staff, including lake samples for nutrients, herbicides, zooplankton, phytoplankton, algal toxins, emerging contaminants, sediment chemistry, and pesticides (Engel, 2018). This report focused on key water quality parameters for MPCA's lake assessment and reporting requirements, such as nutrients, chlorophyll, Secchi transparency, algal toxins, and other basic limnological parameters with longer-term sampling records in Minnesota lakes. In addition, a Tableau workbook will be published online (MPCA NLA Data Viewer) to allow partners and lake practitioners to view all available water quality data collected for the 2017 NLA. Reports on other sampling results can be accessed on the PCA website (MPCA NLA web page). Additionally, nation-wide results for parameters can be seen via the EPA data dashboard, although currently this tool only uses 2007 and 2012 data (EPA NLA Dashboard).

## Climate conditions, summer 2017

The summer of 2017 was characterized as close to the 20-year climate normal for both temperature and precipitation. The statewide average temperature was 66.2 degrees; 2017 was the coolest summer since 2009 (MN DNR 2017 Temperature Summary ). Precipitation in meteorological summer (June to August) statewide averaged 11.57 inches or .42 inches above normal (MN DNR 2017 Precipitation Summary). On a water year basis, precipitation was slightly above normal in northeast and central Minnesota, and below normal in the northwest / north central (*Figure 1*).

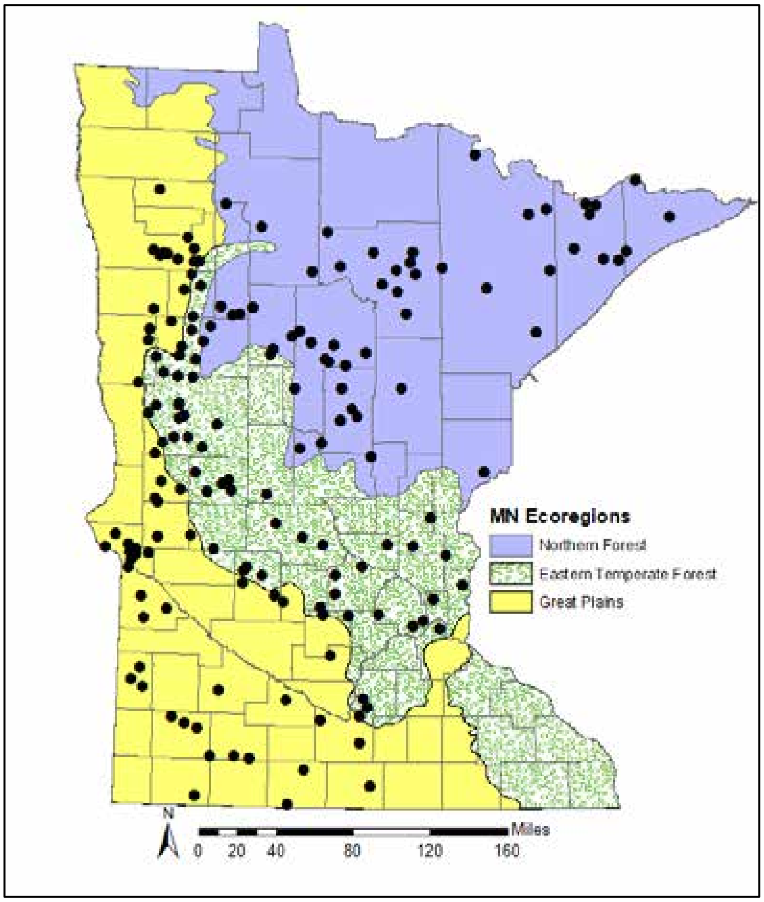
**Figure 1. 2017 Water year precipitation departure from normal. Colors indicate the amount of departure from normal precipitation in inches across the state of Minnesota in 2017. Blue areas represent areas with higher than normal precipitation and yellow and orange represent areas with less than normal precipitation.**




# Methods summary

The lakes selected for the 2017 survey were spread out so that 50 lakes were sampled in each of the state's three aggregated Level III ecoregions (Northern Forests, Eastern Temperate Forests and Great Plains; *Figure 2*). Ecoregions are areas with similar land and water resources (based on ecology, landforms, soils, vegetation, climate, land use, wildlife, and hydrology), and are often used as a spatial framework for looking at bigger-picture patterns (Omernik 1987). Using a combination of desktop and in-person reconnaissance, lakes from the EPA's stratified random population were individually evaluated for meeting depth and open water area criteria, as well as physical access feasibility and permissions for lakes surrounded by private land. If a lake was not accessible, or access was denied, the next lake in the draw was evaluated until 50 federal lakes and a total in 50 in each ecoregion were selected. Staffing resources had to be increased to sample lakes in the most remote parts of Minnesota, such as the Boundary Waters Canoe Area Wilderness, Voyageurs National Park, and the Red Lake Nation; in some of these lakes, it took crews of six people one full day of travel to visit and sample a lake.

**Figure 2. 2017 National Lake Survey lakes. 2017 National Lake Survey lakes in Minnesota, showing 50 lakes per each major aggregated Level III Ecoregion (ecological areas with similar land and water resources) in the state.**




Lakes were sampled using consistent EPA or MPCA field protocols and standard operating procedures (EPA, 2017; MPCA, 2018). The majority of water samples and the sediment cores were collected from the deepest point of the lake. Federal lakes had more rigorous monitoring, including a physical habitat assessment at 10 randomized locations along the lakeshore, and collection of aquatic macroinvertebrates, lake sediment for contaminants, dissolved gases, bacteria, and zooplankton. State lakes were only sampled at the index location – in the main basin at the approximate location of max depth.

For the state lakes, the MPCA sent water samples to the Minnesota Department of Health laboratory using established protocols. Most lakes were visited once during the summer index period; three federal lakes were visited twice, per quality assurance methods.

This report focused on the 2017 water quality results from within Minnesota; the EPA has not yet publically released their nationwide data analysis.

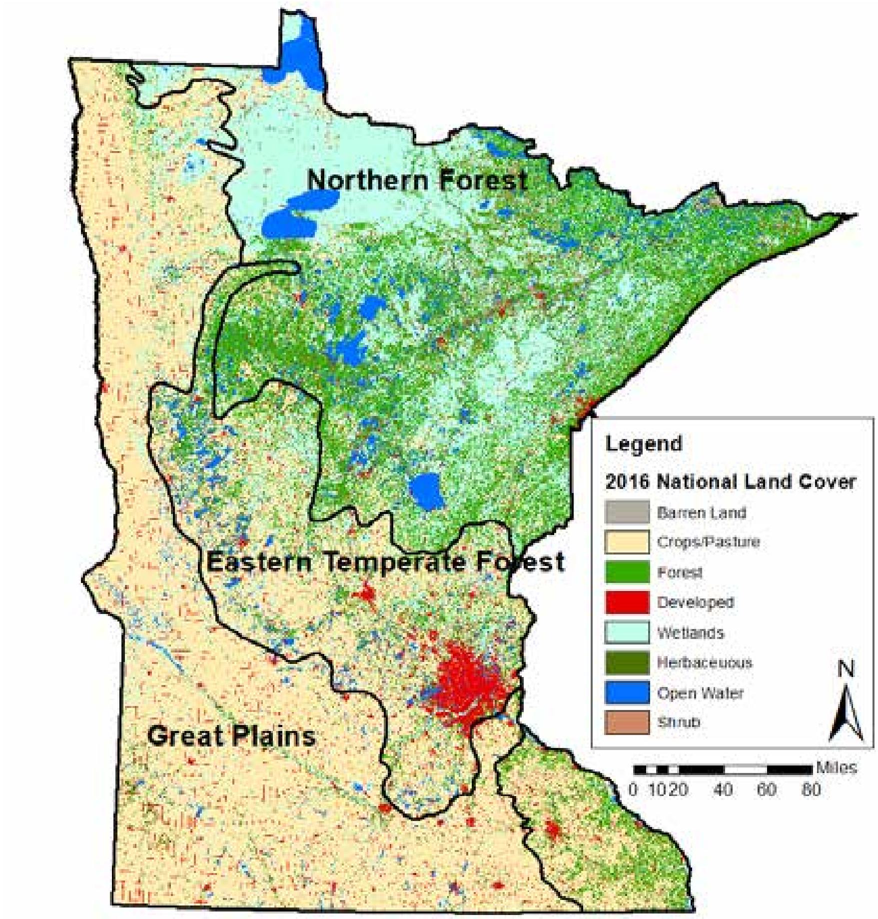
# Results and discussion

The 2017 NLA lakes varied in size from less than 10 acres to the largest lake sampled, Flat Lake in Becker County (1,835 acres, *Table 1*). Of all Minnesota's lakes greater than 10 acres, approximately 50% are located in the Northern Forests ecoregion, 40% in the Eastern Temperate Forest ecoregion, and 10% in the Great Plains ecoregion. Maximum depth for the surveyed lakes ranged from two feet (*i.e.*, slightly deeper than the cutoff for inclusion) to 259 feet for the Pennington Mine Pit Lake in Crow Wing County. Average lake size did not significantly differ among the three ecoregions. However, depth was greatest in the Northern Forest and lowest in the Great Plains lakes – similar to what has been documented in the MPCA's historical monitoring databases (Heiskary, and Wilson 2005). Land-cover was dominated by forest and wetland in the Northern Forests, agriculture in the Great Plains, with a mix of forest, agriculture, urban and other uses in the Eastern Temperate Forests (*Figure 3*).

**Table 1. Morphometry data for the 2017 NLA lakes within Minnesota.**

| 2017 NLA Dataset | Average Area (acres; Range) | Avg. Max. Depth (feet; Range) |
|---|---|---|
| Statewide, N= 155 | 153 (4 – 1835) | 17 (2 – 259) |
| Northern Forest Ecoregion, N= 55 | 150 (6 – 1835) | 29 (3 – 259) |
| Eastern Temperate Forest ecoregion, N= 50 | 160 (4 – 1155) | 15 (3 – 76) |
| Great Plains ecoregion, N=50 | 148 (8 – 1328) | 7 (2 – 30) |

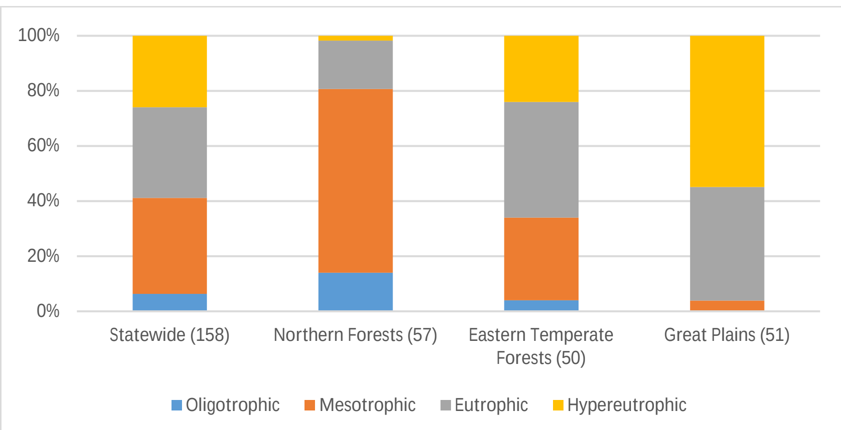
**Figure 3. Landuse in Minnesota's three major ecoregions. Land cover categories across the state of Minnesota, based on the 2016 National Land Cover database.**

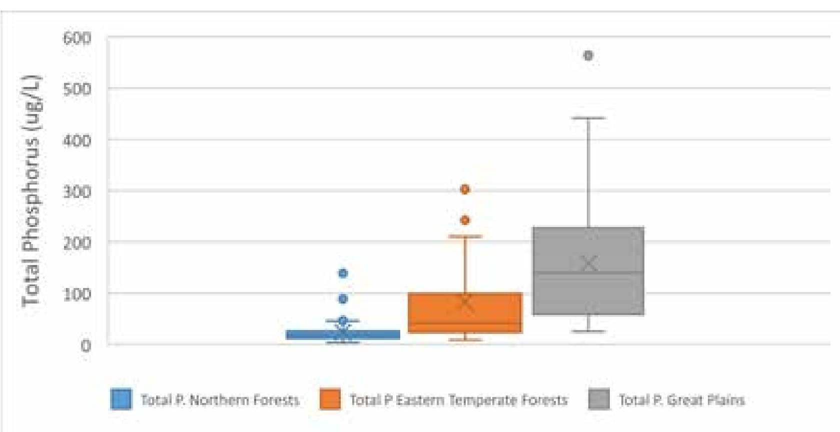


## Trophic status indicators

The term "trophic status" describes nutrient abundance and the amount of biological productivity (i.e., growth) that can be supported by those nutrients. Trophic status is assessed by looking at the concentration of the primary limiting nutrient for growth in water (phosphorus), chlorophyll-a (chl-a) (an indicator of phytoplankton biomass), and transparency (expressed as Secchi depth). The fundamental trophic status indicators of total phosphorus (TP), chl-a, and Secchi transparency were collected on all NLA lakes. As has been documented in historical MPCA reports and incorporated in lake eutrophication criteria (Heiskary and Wilson 1989; 2008), the distinct regional nature of trophic status across Minnesota's three ecoregions was again clearly evident in the 2017 NLA datasets. Trophic state based on TP tended to be lowest in the Northern Forests, highest in the Great Plains, with a transition in the Eastern Temperate Forests (*Figure 4*). Median TP concentrations were 19, 42, and 140 µg/L across the three ecoregions respectively. On a state-wide basis, about 41% of the lakes were in the oligotrophic /mesotrophic range, the remainder were eutrophic to hypereutrophic (*Figure 4*). Nation-wide in 2017, 10% of lakes were oligotrophic, 23% mesotrophic, 44% eutrophic, and 24% hypereutrophic (Pollard, 2019).

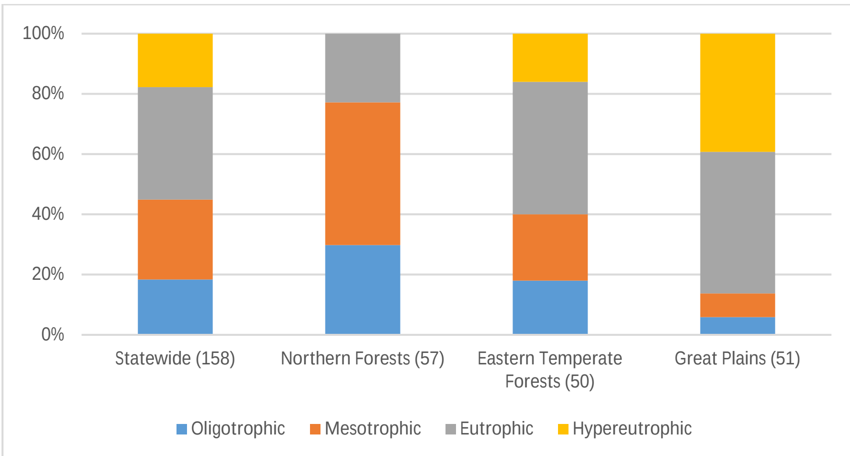
**Figure 4. 2017 Total phosphorus. Total phosphorus regional distributions and box plots for 2017 NLA datasets. Categories corresponded to Carlson's (1977) TSI as follows: oligotrophic <12, mesotrophic 12-30, eutrophic 30-100, and hypereutrophic > 100 µg/L, and were consistent with previous MPCA NLA reports.**

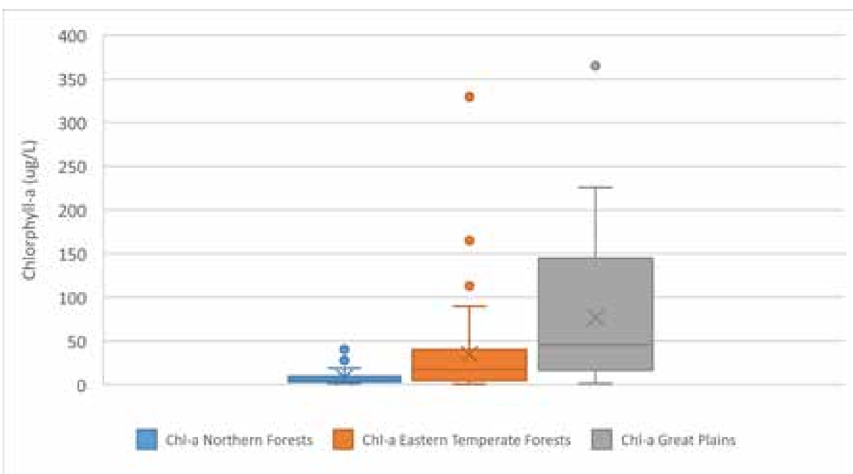


Similar to phosphorus, chl-a concentrations were lowest in the Northern Forests ecoregion, followed by the Eastern Temperate Forests and highest in the Great Plains (*Figure 5*). Variability increased along this gradient as well, and the highest range in chl-a values was in the Great Plains lakes. Median chl-a concentrations were 5.1, 17.1, and 45.5 µg/L respectively, per ecoregion. On a statewide basis, 45% of lakes were oligotrophic to mesotrophic, and 55% of lakes were eutrophic to hypereutrophic.

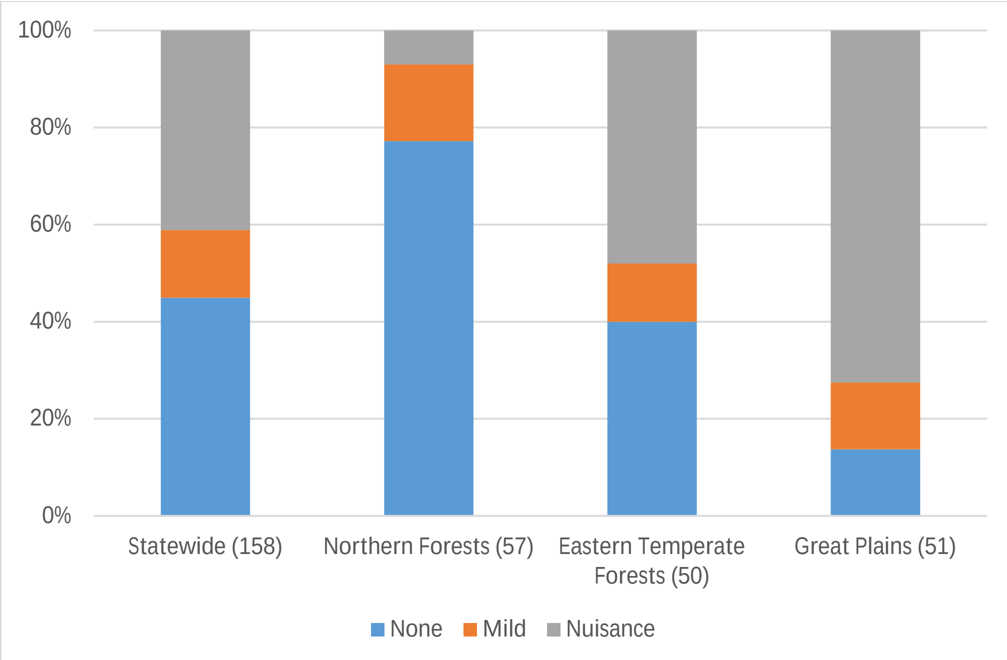
**Figure 5. 2017 Chlorophyll a. Chl-a regional distributions and box plots for 2017 NLA datasets. Categories corresponded to Carlson's TSI as follows: oligotrophic <3.5, mesotrophic 3.5-10, eutrophic 10-60, and hypereutrophic > 60 µg/L, and were consistent with previous MPCA NLA reports.**



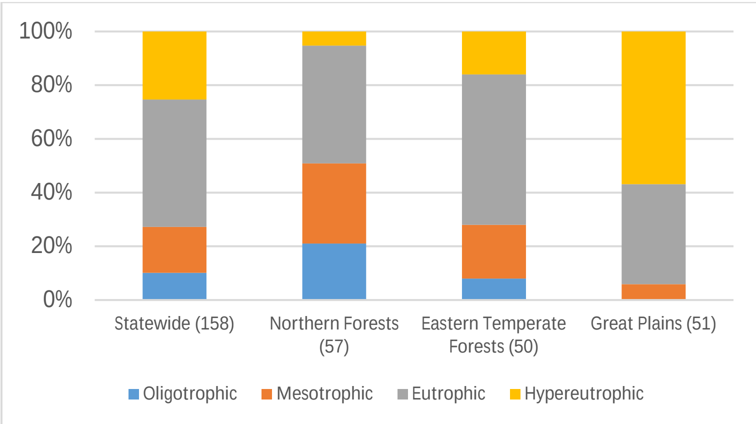

The 2017 chl-a dataset was also compared to previously established thresholds related to algal bloom severity (Heiskary and Walker, 1988, *Figure 6*). Statewide, there was about an equal amount of the 158 lakes sampled classified as "no bloom" or "nuisance". Few lakes in the Northern Forests were above the "no bloom" threshold, while 72% of sampled lakes in the Great Plains had chl-a concentrations indicative of nuisance blooms (> 20 µg/L). The maximum chl-a concentration (365 µg/L) was recorded on Long Lake, a very shallow lake northwest of the city of Windom in Cottonwood County. The "very severe nuisance" threshold concentration of 60 µg/L was exceeded in 20 lakes in the Great Plains ecoregion and eight in the Eastern Temperate Forests.

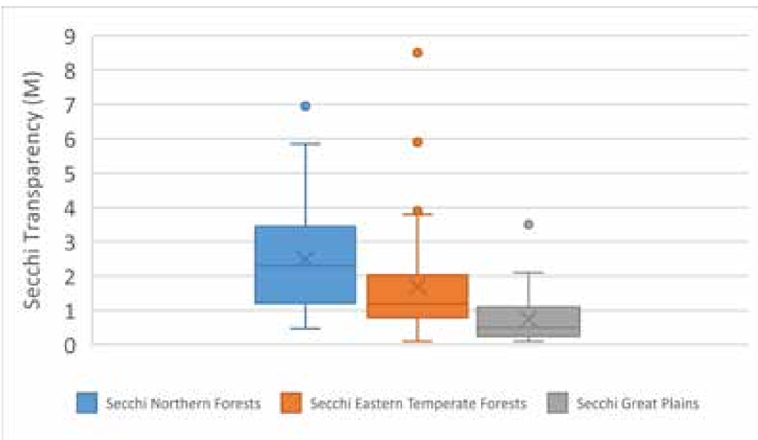
**Figure 6. Chlorophyll a bloom frequencies. Chl-a nuisance bloom frequencies. Categories were as follows: no bloom - < 10 µg/L, mild bloom 10-20 µg/L, nuisance blooms - > 20 µg/L.**




As with phosphorus and chl-a, distinct regional patterns were evident in Secchi transparency (*Figure 7*). Secchi was highest in the Northern Forests, and lowest in the Great Plains. Median transparency was 2.3 meters in the Northern Forests (7.5 feet), 1.6 meters in the Eastern Temperate Forests (5.2 feet) and 0.9 meters in the Great Plains (2.9 feet). Individually, transparency ranged from 8.5 meters on an unnamed lake in Otter Tail County, to 0.1 meters on four lakes. Statewide, 27% of lakes were in the oligotrophic to mesotrophic range, versus 73% eutrophic to hypereutrophic. The proportion of statewide lakes classified as eutrophic was highest for Secchi, compared to TP or chl-a. This was likely influenced by several shallow lakes which may have had naturally low transparency due to wetland influence (primarily lakes in the Northern Forests), or the 2017 sampling of many shallow lakes with measured maximum depths less than the mesotrophic transparency range (2 meters).

**Figure 7. 2017 Secchi transparency. Secchi transparency regional distributions and boxplots. Trophic categories were as follows: oligotrophic > 3.5 m, mesotrophic 3.5 – 2.0, eutrophic 0.7 – 2.0, and hypereutrophic <0.7 m. Five observations were recorded as equal to lake depth (Secchi disk visible on lake bottom).**




# Algal toxins

Three algal toxins were collected for the 2017 NLA: microcystin, cylindrospermopsin, and anatoxin-a. Microcystin was collected on all 155 lakes, while the other two toxins were only collected on the federal lakes. Microcystin results were put in three categories: below the 0.15 µg/L detection limit, exceeding the 8 µg/L recommended EPA ambient water quality criterion protective of recreation (i.e. swimming; EPA, 2019), and between the detection limit and the recommended criterion. In Minnesota lakes, microcystin was detected in 50% of the lakes (79 of 158 lake visits), and most detections were well below the recommended EPA water quality criterion. Microcystin concentrations exceeded the criterion in 9 lakes, or 6% of all sampled lakes (*Figure 8*). Median microcystin concentrations were quite low overall: below detection in the Northern Forests ecoregion, 0.27 µg/L in the Eastern Temperate Forests, and 0.82 µg/L in the Great Plains. Seven of the 9 lakes exceeding the EPA criterion were in the Great Plains, where the maximum concentration was in an unnamed lake near Ulen in Clay County. This concentration was high (118 µg/L), noticeably exceeding the EPA criterion and the World Health Organization's threshold for high risk of microcystin exposure while swimming (WHO, 2003). Nationally, microcystin was not detected in 81% of lakes, detected but below the draft benchmark in 17% of lakes, and exceeded the benchmark in 2% of lakes (Pollard, 2019).

Several studies have used the national NLA datasets to document both weak relationships (see this weak relationship presentation) and stronger relationships (Yuan and Pollard, 2019) between microcystin concentration and either phytoplankton bio-volume or cyanobacteria abundance. However, there are many lake-specific environmental and weather factors responsible for both algal abundance and algal toxin production, and a single sample from a randomly selected lake is not necessarily the most appropriate sampling scale to identify such relationships. For example, in the 79 Minnesota lakes with detected microcystin concentrations, there was no statistical relationship ($R^2 = 0.003$) between microcystin and algal abundance (chl-a; *Figure 9*). Log-transforming the data increased the strength of the relationship between the two parameters, but the $R^2$ was still low (0.21) and likely not statistically significant. There was considerable variation in chl-a levels at low microcystin concentrations; the highest microcystin concentrations were not associated with the highest chl-a concentrations (*Figure 9*). Additionally, at microcystin concentrations below detection, chl-a concentrations ranged from near the detection limit to severe bloom levels (0.6 – 121 µg/L).

Although microcystin was present at low but detectable levels in approximately half of the sampled NLA lakes, the other two algal toxins (sampled only in the federal lakes) were rarely found. Cylindrospermospsin was below detection levels (0.1 µg/L) on all lakes and anatoxin-a was detected in eight lakes, but the maximum concentration was quite low (0.83 µg/L). Nationally, cylindrospermopsin was not detected in 92% of lakes, detected in 8% of lakes, and no lakes exceeded the draft benchmark of 8 µg/L (Pollard, 2019). As was apparent in the Minnesota microcystin results, the results for the other algal toxins point to the episodic nature of both bloom formation and the algal toxin production. Numerous weather and environmental factors can contribute to bloom formation and toxin production and the connections are not fully understood; hence, the confounding correlations with chl-a concentration and microcystin observed in the 2017 NLA dataset. The MPCA and our partners continue to promote a “When in Doubt, Stay Out” message, protecting lake users from the health impacts of harmful algal blooms.

**Figure 8. 2017 Microcystin results. Microcystin concentrations from 2017 NLA Lakes. Categories were as follows: not detected - < 0.15 µg/L, 0.15 – 8 µg/L, and > 8 µg/L. Greater than 8 µg/L is the recommended EPA criterion for protecting recreation in ambient waters.**

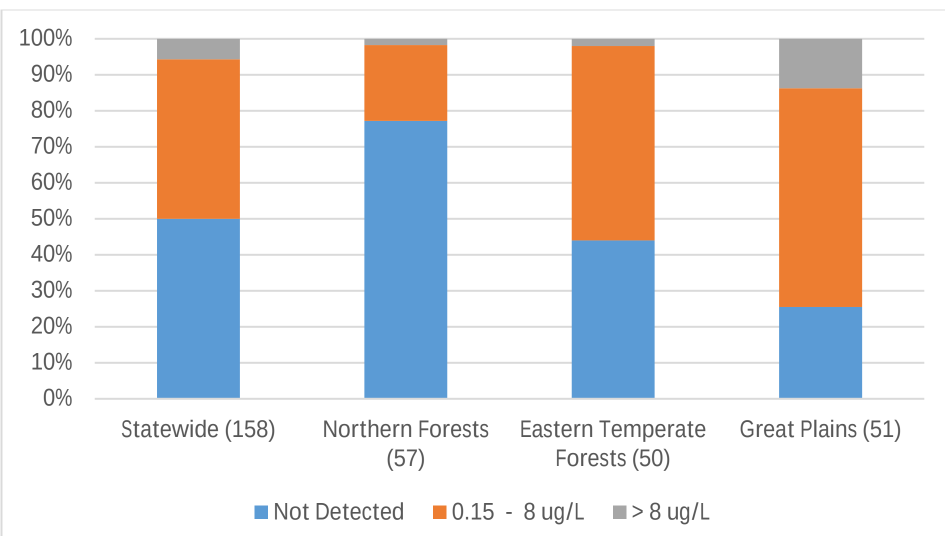
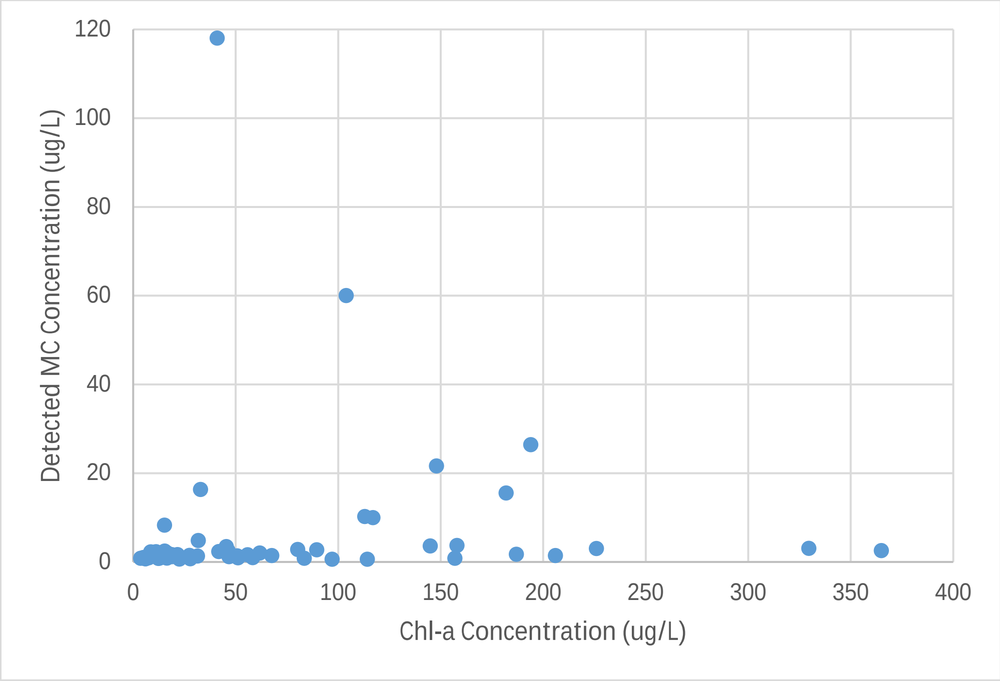


**Figure 9. Chlorophyll a and microcystin. Detected microcystin concentrations versus chl-a concentration in the 2017 NLA dataset; N=79.**




# Other NLA parameters

Concentrations of other parameters relevant to describing the water quality of Minnesota lakes were similar to regional conditions documented in past NLA surveys (Heiskary 2010, and 2014). Briefly, color and organic carbon were highest in the Northern Forest ecoregion, likely due to watershed influence from surrounding forests and wetlands. Ion chemistry, summarized by pH, acid neutralizing capacity and specific conductance indicated that waters were more dilute in the northeast and highest in the southwest Great Plains. The dominant cations in Minnesota lakes, calcium and magnesium, followed this same pattern. For example, median calcium concentration was 14 mg/L in the Northern Forest, 27 mg/L in the Eastern Temperate Forest, and 40 mg/L in the Great Plains.

Chloride is a conservative pollutant and is elevated in many Minnesota waters due to impacts from road salt application, permitted wastewater discharges, water softeners, and agricultural chemicals (MPCA, 2019). Similar to the parameters described above, chloride increased from northeast to southwest across Minnesota. Median concentrations were 0.7, 12.1, and 18.3 mg/L respectively across the north, central, and southern ecoregions. The maximum concentration was 173 mg/L in South Lake near Winsted in McLeod County. In 2017, no lakes exceeded the state chloride standard of 230 mg/L.

Sulfate is another dominant ion in Minnesota waters. The MPCA currently has a 10 mg/L sulfate standard in rule to protect waters with wild rice. In 2017, 22 lakes (14% of the total lakes) were below the 0.5 mg/L detection limit for sulfate. Median sulfate concentrations ranged from 0.6 mg/L in the Northern Forest, 6.5 mg/L in the Eastern Temperate Forest, and 52.5 mg/L in the Great Plains. A similar gradient was found in past NLA surveys, and is likely due to geologic influence (Heiskary, 2016; Gorham *et al.*, 1983). In 2017, 63 lakes exceeded the 10 mg/L water quality standard, but many of these lakes were in the southwestern portion of Minnesota and thus well beyond the range of the wild rice in Minnesota waters (MPCA Interactive Tool for Wild Rice Waters).

Lastly, *E.coli* bacteria was sampled on the federal lakes, and was present above the detection limit in 35 of 56 lakes. Generally, concentrations were very low; the maximum concentration was 46 colonies per 100 mL, much lower than the MPCA's standard protective of aquatic recreation in *streams and rivers* (126 as a geometric mean, or 1,260 for individual samples). The MPCA's metric for aquatic recreation in lakes is based on eutrophication (TP, chl-a, and Secchi transparency).

The Tableau data-viewer associated with this project allows the lake practitioner to further view data from all sampled NLA water quality parameters on a statewide and ecoregion scale (MPCA Tableau Data Viewer).

# Temporal trends and patterns in NLA datasets

NLA surveys of Minnesota lakes have taken place in 2007, 2012, and 2017. Although a small sub-set of lakes remained the same across all three years, the majority of lakes were not sampled in every year. Fewer lakes were sampled in 2007 (n= 64), versus approximately 150 in 2012 and 2017 – reflective of 50 lakes in each of the state's three major ecoregions. Additionally, the change in lake minimum size from four to one hectares starting in 2012 resulted in the sampling of several small water bodies in 2012 and 2017 that could be considered similar to large open water wetlands. The median size of sampled lakes dropped from 77 hectares in 2007 to 19 and 25 hectares in 2012 and 2017, respectively. Because of these caveats, formal statistical trends were not calculated from the data from the three time periods. With further iterations of the NLA, more robust temporal and spatial trend statistics nationally, state-wide, and by ecoregion will be available. However, medians for multiple chemicals, ecoregion-based comparisons for microcystin and trophic status indicators, and color values were all compared for the Minnesota NLA data from 2007, 2012 and 2017.

Yearly medians for select parameters were calculated for two of the main trophic status indicators, microcystin and for other chemical parameters of interest (Table 2). Overall, similar patterns were present in each year. For the three time periods microcystin concentrations in NLA datasets were low; median concentrations were often below or near the method detection limit. This differs significantly from the much higher concentrations found in the MPCA's targeted studies or incident-based investigations (Heiskary et. al., 2014).

**Table 2. Multi-Year NLA parameter results. Statewide median concentrations for select NLA parameters, 2007, 2012, and 2017. These calculations used only index site data.**

| Parameter | 2007 NLA | 2012 NLA | 2017 NLA |
|---|---|---|---|
| Total Phosphorus (µg/L) | 20 | 29 | 41 |
| Chlorophyll-a (µg/L) | 7.6 | 13.8 | 12.3 |
| Secchi Transparency (m) | 1.7 | 1.0 | 1.2 |
| Total Nitrogen (µg/L) | 807 | 1,300 | 780 |
| Microcystin (µg/L) | 0.2 | <0.15 | 0.16 |
| pH (std. units) | 8.5 | 8.5 | 8.5 |
| Spec. Cond. (us/cm) | 321 | 303 | 311 |
| Color (Pt. Co. Units) | 12 | 30 | 20 |
| DOC (mg/L) | 8.6 | 12.6 | 8.9 |
| Calcium (mg/L) | 26 | 24 | 25 |
| Sulfate (mg/L) | 6.2 | 10.4 | 2.9 |

The trophic status indicators TP and chl-a were compared among sample years, by ecoregion. Secchi transparency was not included in these comparisons, since Secchi depth was unknown on shallow lakes where lake depth was less than Secchi depth (*i.e.*, the disk was visible on lake bottom) which occurred in 3% of the lakes in 2017 and 2007 and in 20% of the lakes in 2012. For TP, the central tendency of the dataset (height of box plots) did not significantly change on a state-wide basis among the three time periods (*Figure 10*). Similar patterns were visible in the chl-a data (*Figure 11*). In 2007, 2012 and 2017, both TP and chl-a were lowest in the Northern Forest ecoregion, moderate in the Eastern Temperate Forests ecoregion and highest in value and variability in the Great Plains ecoregion. In all three NLA years, the regional pattern in microcystin was similar to other trophic state parameters in the three ecoregions (*Figure 8*; Heiskary et. al., 2014).

**Figure 10. Total phosphorus. Statewide and ecoregion NLA trends for TP in 2007, 2012, and 2017. Means were represented by X's.**

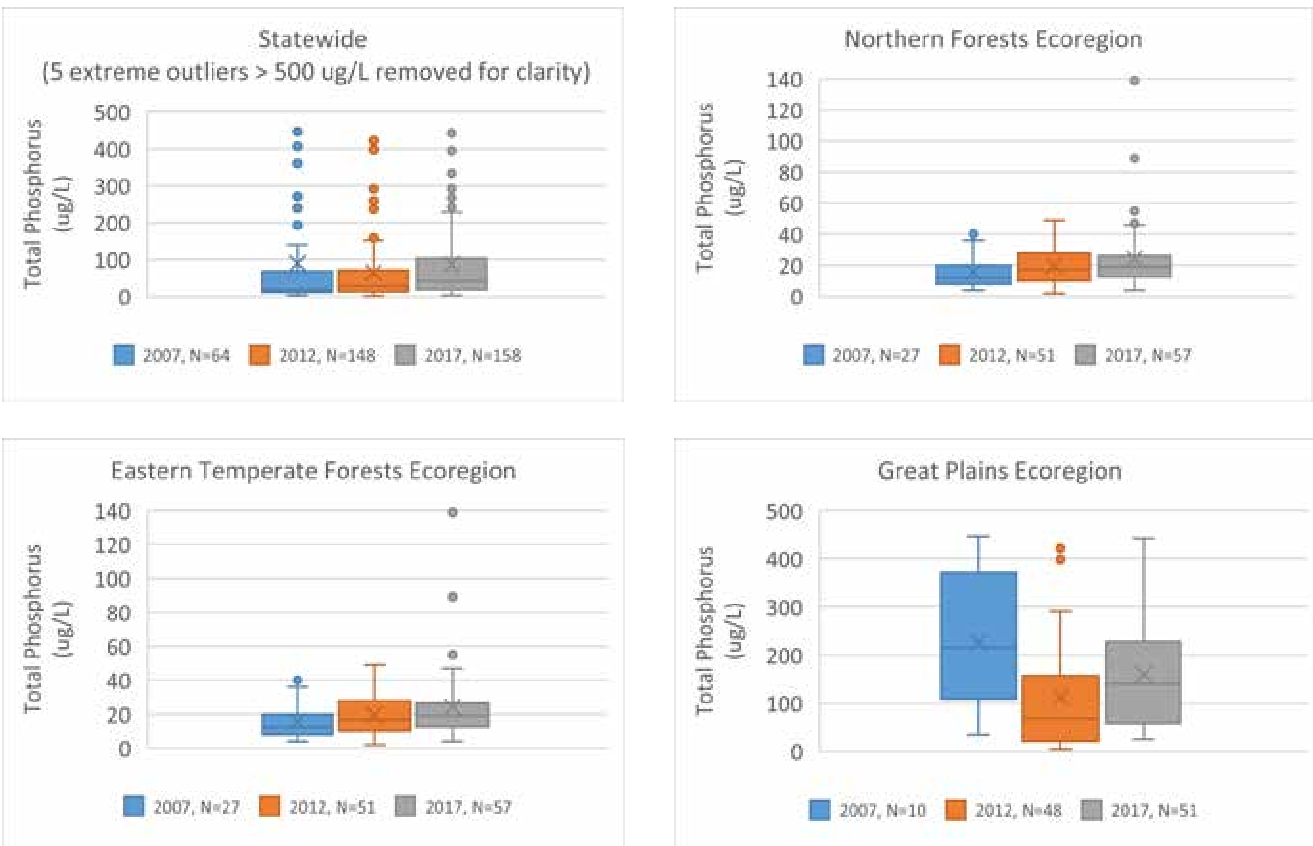
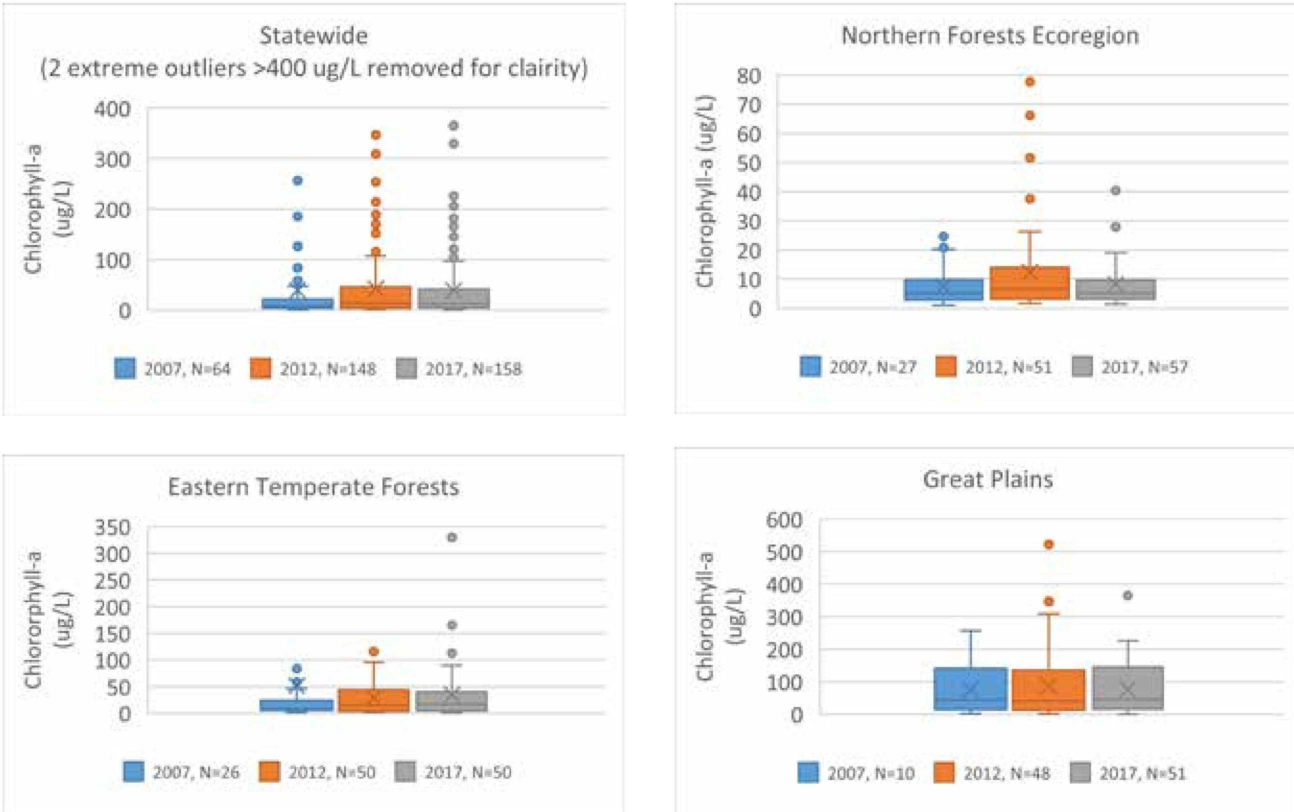


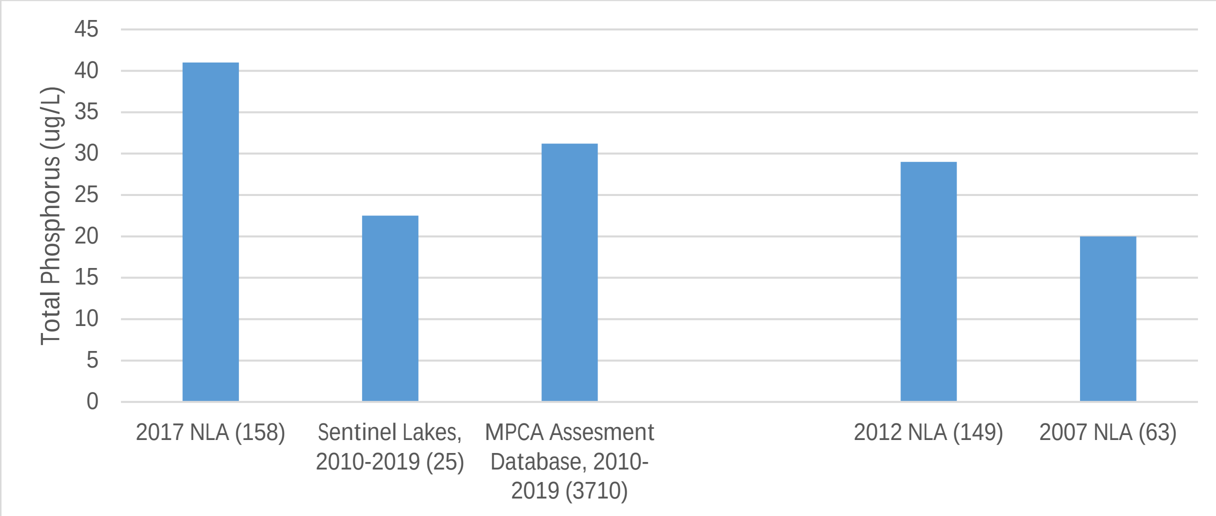
**Figure 11. Chlorophyll a. Statewide and ecoregion NLA trends for chl-a in 2007, 2012, and 2017.**




A comparison of TP from the three NLA time periods and two MPCA long-term datasets (Sentinel Lakes, and the larger MPCA Water Quality assessment database) supported the differences based on ecoregion, and indicated that NLA sampling data values were consistent with other sampled values. The 25 sentinel lakes represent lake types across a gradient of trophic state and depth across the state's diverse ecoregions (Sentinel Lakes), and the Water Quality Assessment database reports summer-average values for all lakes with eutrophication monitoring over the most recent 10 years. With the passage of the Clean Water Legacy Amendment in 2008, the MPCA and partners have been able to sample and assess most large to medium sized lakes (> 100 acres) within the state (n=3,710) over this 2010-2019 timeframe.

Median TP was highest in the 2017 NLA data and lowest in the Sentinel Lakes (*Figure 12*). This was influenced by the sample frame of the datasets, since the NLA lakes included more shallow eutrophic lakes and came from a population that was not equally representative of lake distribution across the ecoregions. Minnesota's lake population is not equally spread across the state and approximately 90% of all of the state's lakes are in the Northern Forest and Eastern Temperature Forest ecoregions. The assessment dataset and the Sentinel Lakes dataset were more reflective of this. In the assessment database, only about 10% of the lakes were from the Great Plains. As such, the median phosphorus concentration from the MPCA assessment database was between NLA and the Sentinel Lakes. Median TP over the NLA time periods increased from approximately 20 to 41 µg/L, although the central tendency of the phosphorus dataset over the three time periods was similar (*Figure 10*). The median phosphorus concentration of MPCA's recently assessed lakes was in the mesotrophic range (~ 30 µg/L), similar to the average trophic state of the Sentinel Lakes. Given the findings from past NLA surveys, this value could be considered the approximate trophic condition of Minnesota lakes. Overall, the NLA datasets showed that one-time visits were useful proxies of the trophic state of both lakes statewide and by ecoregion.

**Figure 12. Long-term TP medians. Median TP concentrations from NLA and MPCA long-term datasets; the former are June-September averages from 2010-2019.**




## Multi-year lakes

Twelve lakes were sampled all three NLA years, spanning two of the three ecoregions (Northern Forests and Eastern Temperate Forests). Total phosphorus and chl-a results varied by individual lake (*Table 3*). Some lakes were very consistent among years (such as Long Lake, 31-0266-01), while others varied considerably (such as South Lake). In general, deeper lakes within the Northern Forests had more stable TP and chl-a concentrations.

**Table 3. Total phosphorus and chl-a concentrations (µg/L) for lakes sampled all three NLA time periods.**

| Lake Name | Lake ID Number | 2007 TP | 2012 TP | 2017 TP | | 2007 Chl-a | 2012 Chl-a | 2017 Chl-a |
|---|---|---|---|---|---|---|---|---|
| Long | 31026601 | 18 | 22 | 18 | | 9 | 8 | 6 |
| Spring | 69012900 | 12 | 44 | 20 | | 5 | 6 | 2 |
| Lookout | 18012300 | 20 | 36 | 34 | | 6 | 14 | 5 |
| Darling | 21008000 | 15 | 48 | 20 | | 6 | 3 | 3 |
| Long | 11048000 | 6 | 21 | 14 | | Missing | 4 | 3 |
| Richey | 16064300 | 36 | 25 | 21 | | Missing | 4 | 9 |
| Snail | 62007300 | 13 | 20 | 10 | | 5 | 3 | 8 |
| Eagle | 7006001 | 239 | 159 | 243 | | 126 | 93 | 114 |
| Round | 56047600 | 9 | 56 | 16 | | 3 | 3 | 3 |
| South | 43001400 | 1,184 | 524 | 770 | | 936 | 122 | 330 |
| Flat | 3024200 | 24 | 46 | 47 | | 9 | 3 | 9 |
| Jennie | 47001500 | 69 | 38 | 42 | | 32 | 3 | 21 |

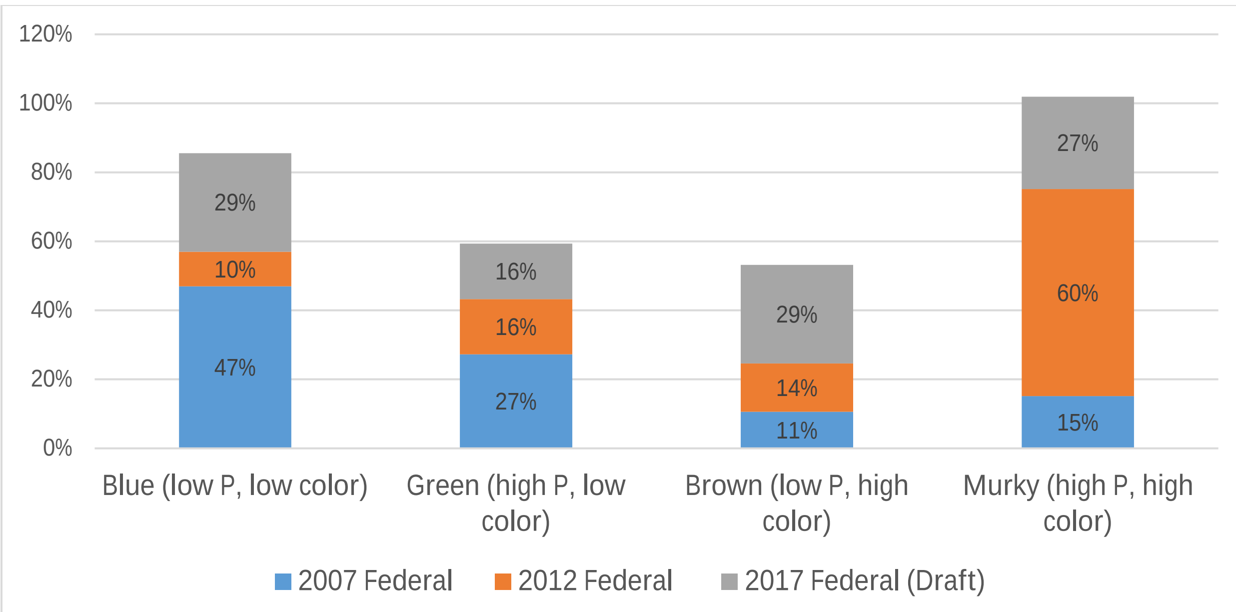
## Lake color

Lake color can be used to examine trends in lake productivity, and this was explored using Minnesota's NLA dataset. Lakes were placed in to categories based on work by Leech *et al*. (2018), who used the national 2007 and 2012 NLA datasets to place lakes into four basic categories based on TP and color:

- Blue (oligotrophic), low phosphorus, low color
- Green (eutrophic), high phosphorus, low color
- Brown (dystrophic), low phosphorus, high color
- Murky (mesotrophic), high phosphorus, high color

Results comparing the 2007 and 2012 indicted that nationally, "blue" lakes were decreasing and "murky" lakes were increasing, while there were no statistical differences in the number of "green" or "brown" lakes. The loss of oligotrophic lakes and streams ubiquitously across the country is a key finding from NLA datasets, especially in wilderness areas (Stoddard et. al., 2016). These general trends also held true for the Minnesota lakes from 2007 to 2012; the proportion of blue lake declined substantially, while murky lakes increased (*Figure 13*). One caveat was that more Northern Forest lakes and fewer Great Plains lakes were sampled in 2007, and the latter were more likely to fall into the higher nutrient categories. From 2012 to 2017 in Federal lakes within Minnesota, the proportion of "blue" lakes increased while "murky" lakes declined.

**Figure 13. Statewide color categories. Statewide and ecoregion NLA trends for lake color categories in 2007, 2012, and 2017. Color categories incorporated TP values and lake color, and were based on Leech *et al.* (2018).**




# Summary: Key findings

The MPCA and partners sampled 155 lakes, equally distributed over the state's three major ecoregions as part of EPA's 2017 National Lake Assessment. The randomized sample frame of EPA's NLA provided statistically based sampling of lake condition across Minnesota, and the approximately 50 samples per ecoregion allowed additional inferences of lake conditions across these landscapes. The distinct regional nature of trophic status across Minnesota's three ecoregions was clearly evident in the 2017 NLA dataset, and matched patterns documented in past NLA surveys and in other MPCA long-term water quality monitoring datasets. Both trophic state and parameters describing ionic chemical composition (*i.e.*, concentrations of dissolved solids and major cations and anions) were generally lowest in the northern portion of the state, highest in the southwest, with a transition zone in between. These patterns followed land-cover characteristics (and proportions of disturbed land use) in these regions, with forests and wetlands dominating in the north and agricultural land use in the south and southwest, with a transition in between within the Eastern Temperate Forest ecoregion (Heiskary and Wilson, 2008; Heiskary, 2016).

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# Appendix 1. Minnesota's 2017 NLA lakes

| NLA ID # | Federal or State Lake | DOW # | Date Sampled | Lake Name | County | Area (acres) | Depth (m) | Ecoregion |
|---|---|---|---|---|---|---|---|---|
| NLA17_MN-10001 | Federal lake | 31026601 | 8/1/2017 | Long Lake | Itasca | 360.2 | 10.4 | Northern Forest |
| NLA17_MN-10002 | Federal lake | 7006001 | 7/20/2017 | Eagle Lake | Blue Earth | 461.3 | 3.0 | Eastern Temperate Forest |
| NLA17_MN-10003 | Federal lake | 43001400 | 9/14/2017 | South Lake | Mcleod | 173.5 | 1.0 | Eastern Temperate Forest |
| NLA17_MN-10004 | Federal lake | 21008000 | 8/9/2017 | Lake Darling | Douglas | 1155.9 | 18.9 | Eastern Temperate Forest |
| NLA17_MN-10005 | Federal lake | 69012900 | 7/17/2017 | Spring Lake | St Louis | 98.6 | 7.6 | Northern Forest |
| NLA17_MN-10006 | Federal lake | 18012300 | 7/24/2017 | Lookout Lake | Crow Wing | 226.4 | 4.9 | Northern Forest |
| NLA17_MN-10007 | Federal lake | 11048000 | 7/12/2017 | Long Lake | Cass | 260.4 | 24.4 | Northern Forest |
| NLA17_MN-10008 | Federal lake | 16064300 | 8/15/2017 | Richey Lake | Cook | 103.9 | 2.1 | Northern Forest |
| NLA17_MN-10009 | Federal lake | 47001500 | 8/23/2017 | Lake Jennie | Meeker | 1058.4 | 4.3 | Eastern Temperate Forest |
| NLA17_MN-10010 | Federal lake | 62007300 | 7/10/2017 | Snail Lake | Ramsey | 157.5 | 9.1 | Eastern Temperate Forest |
| NLA17_MN-10011 | Federal lake | 56047600 | 8/8/2017 | Round (Maine) Lake | Otter Tail | 85.4 | 10.4 | Eastern Temperate Forest |
| NLA17_MN-10012 | Federal lake | 3024200 | 9/11/2017 | Flat Lake | Becker | 1835.9 | 2.7 | Northern Forest |
| NLA17_MN-10014 | Federal lake | 69075700 | 8/15/2017 | Net Lake | St Louis | 98.4 | 3.7 | Northern Forest |
| NLA17_MN-10016 | Federal lake | 3075100 | 9/7/2017 | Unnamed | Becker | 9.8 | 1.8 | Eastern Temperate Forest |
| NLA17_MN-10017 | Federal lake | 56081000 | 8/29/2017 | Unnamed | Otter Tail | 33.5 | 2.1 | Great Plains |
| NLA17_MN-10018 | Federal lake | 38062300 | 8/16/2017 | Spree Lake | Lake | 29.7 | 3.4 | Northern Forest |
| NLA17_MN-10019 | Federal lake | 49013900 | 8/7/2017 | Unnamed | Morrison | 6.7 | 3.0 | Northern Forest |
| NLA17_MN-10020 | Federal lake | 69092000 | 9/6/2017 | Stuart Lake | St Louis | 27.0 | 12.2 | Northern Forest |
| NLA17_MN-10021 | Federal lake | 30007200 | 7/10/2017 | Long Lake | Isanti | 349.2 | 3.4 | Eastern Temperate Forest |
| NLA17_MN-10022 | Federal lake | 58001300 | 8/31/2017 | Greigs Lake | Pine | 48.4 | 20.7 | Northern Forest |

| NLA ID # | Federal or State Lake | DOW # | Date Sampled | Lake Name | County | Area (acres) | Depth (m) | Ecoregion |
|---|---|---|---|---|---|---|---|---|
| NLA17_MN-10023 | Federal lake | 26007100 | 9/13/2017 | Unnamed | Grant | 53.2 | 3.8 | Eastern Temperate Forest |
| NLA17_MN-10025 | Federal lake | 11013600 | 7/12/2017 | Lake Lomish | Cass | 264.0 | 4.6 | Northern Forest |
| NLA17_MN-10026 | Federal lake | 86023000 | 7/19/2017 | Somers Lake | Wright | 444.3 | 5.5 | Eastern Temperate Forest |
| NLA17_MN-10027 | Federal lake | 77003500 | 8/8/2017 | Beauty Lake | Todd | 230.0 | 8.8 | Eastern Temperate Forest |
| NLA17_MN-10028 | Federal lake | 38049200 | 8/22/2017 | Neglige Lake | Lake | 34.3 | 17.7 | Northern Forest |
| NLA17_MN-10030 | Federal lake | 17005601 | 8/30/2017 | Double Lake (North Portion) | Cottonwood | 123.1 | 2.1 | Great Plains |
| NLA17_MN-10032 | Federal lake | 31020000 | 9/7/2017 | Unnamed (Mississippi) | Itasca | 13.7 | 1.5 | Northern Forest |
| NLA17_MN-10033 | Federal lake | 29029600 | 7/31/2017 | Unnamed | Hubbard | 15.5 | 7.5 | Northern Forest |
| NLA17_MN-10034 | Federal lake | 56017102 | 9/12/2017 | Peterson Lake | Otter Tail | 35.3 | 2.4 | Eastern Temperate Forest |
| NLA17_MN-10037 | Federal lake | 56084600 | 9/11/2017 | Iverson Lake | Otter Tail | 52.4 | 5.5 | Eastern Temperate Forest |
| NLA17_MN-10038 | Federal lake | 9005000 | 7/10/2017 | Jaskari Lake | Carlton | 83.8 | 2.0 | Northern Forest |
| NLA17_MN-10042 | Federal lake | 73042500 | 8/7/2017 | Unnamed | Stearns | 12.0 | 2.6 | Eastern Temperate Forest |
| NLA17_MN-10044 | Federal lake | 69020800 | 8/24/2017 | Nibin Lake | St Louis | 40.2 | 3.4 | Northern Forest |
| NLA17_MN-10045 | Federal lake | 3020900 | 9/5/2017 | Carman Lake | Becker | 116.2 | 8.2 | Northern Forest |
| NLA17_MN-10046 | Federal lake | 34020600 | 7/25/2017 | Andrew Lake | Kandiyohi | 752.1 | 7.9 | Eastern Temperate Forest |
| NLA17_MN-10047 | Federal lake | 18014600 | 7/25/2017 | Unnamed | Crow Wing | 23.8 | 4.8 | Northern Forest |
| NLA17_MN-10048 | Federal lake | 31051200 | 8/14/2017 | Gale Lake | Itasca | 74.3 | 15.2 | Northern Forest |
| NLA17_MN-10049 | Federal lake | 44015500 | 8/1/2017 | Unnamed | Mahnomen | 32.8 | 1.7 | Eastern Temperate Forest |
| NLA17_MN-10051 | State lake | 56049000 | 8/29/2017 | Round Lake | Otter Tail | 80.3 | 4.3 | Eastern Temperate Forest |
| NLA17_MN-10052 | State lake | 4001400 | 7/31/2017 | Popple Lake | Beltrami | 93.9 | 1.6 | Northern Forest |
| NLA17_MN-10053 | State lake | 22002200 | 6/19/2017 | South Walnut Lake | Faribault | 340.2 | 0.6 | Great Plains |

| NLA ID # | Federal or State Lake | DOW # | Date Sampled | Lake Name | County | Area (acres) | Depth (m) | Ecoregion |
|---|---|---|---|---|---|---|---|---|
| NLA17_MN-10054 | State lake | 3039300 | 9/6/2017 | Unnamed | Becker | 10.5 | 3.2 | Eastern Temperate Forest |
| NLA17_MN-10055 | State lake | 56085300 | 8/30/2017 | Unnamed | Otter Tail | 34.3 | 1.9 | Eastern Temperate Forest |
| NLA17_MN-10056 | State lake | 73024100 | 6/21/2017 | Black Oak Lake | Stearns | 99.9 | 4.9 | Eastern Temperate Forest |
| NLA17_MN-10057 | State lake | 60007800 | 8/1/2017 | Solbery Lake | Polk | 15.6 | 1.4 | Great Plains |
| NLA17_MN-10058 | State lake | 34032100 | 6/29/2017 | Swenson Lake | Kandiyohi | 104.6 | 4.3 | Eastern Temperate Forest |
| NLA17_MN-10059 | State lake | 38051000 | 7/19/2017 | Cattyman Lake | Lake | 17.3 | 2.7 | Northern Forest |
| NLA17_MN-10060 | State lake | 26022800 | 6/22/2017 | Hodgson Lake | Grant | 50.3 | 1.3 | Great Plains |
| NLA17_MN-10061 | State lake | 17002400 | 6/20/2017 | String Lake | Cottonwood | 336.0 | 1.8 | Great Plains |
| NLA17_MN-10062 | State lake | 56011300 | 8/28/2017 | Unnamed | Otter Tail | 36.1 | 1.6 | Eastern Temperate Forest |
| NLA17_MN-10063 | State lake | 15010700 | 7/27/2017 | Miskogineu Lake | Clearwater | 135.1 | 1.0 | Northern Forest |
| NLA17_MN-10064 | State lake | 3062700 | 8/2/2017 | Unnamed | Becker | 19.0 | 2.0 | Eastern Temperate Forest |
| NLA17_MN-10065 | State lake | 30006000 | 7/20/2017 | Section Lake | Isanti | 125.0 | 1.2 | Eastern Temperate Forest |
| NLA17_MN-10066 | State lake | 73031700 | 6/21/2017 | Unnamed | Stearns | 13.2 | 1.5 | Eastern Temperate Forest |
| NLA17_MN-10067 | State lake | 44014000 | 8/1/2017 | Circle Lake | Mahnomen | 38.0 | 2.8 | Eastern Temperate Forest |
| NLA17_MN-10068 | State lake | 69005000 | 8/10/2017 | Big Lake | St Louis | 788.6 | 8.5 | Northern Forest |
| NLA17_MN-10069 | State lake | 37002601 | 6/27/2017 | Unnamed | Lac Qui Parle | 21.4 | 1.0 | Great Plains |
| NLA17_MN-10070 | State lake | 15027900 | 8/2/2017 | Unnamed | Clearwater | 12.1 | 1.5 | Northern Forest |
| NLA17_MN-10071 | State lake | 38002401 | 7/18/2017 | Crooked Lake | Lake | 170.0 | 5.5 | Northern Forest |
| NLA17_MN-10072 | State lake | 6026600 | 6/22/2017 | Unnamed | Big Stone | 61.7 | 1.4 | Great Plains |
| NLA17_MN-10074 | State lake | 56043000 | 8/9/2017 | Fiske Lake | Otter Tail | 242.5 | 7.9 | Eastern Temperate Forest |

| NLA ID # | Federal or State Lake | DOW # | Date Sampled | Lake Name | County | Area (acres) | Depth (m) | Ecoregion |
|---|---|---|---|---|---|---|---|---|
| NLA17_MN -10076 | State lake | 27002900 | 7/26/2017 | Edina Lake | Hennepin | 23.6 | 1.2 | Eastern Temperate Forest |
| NLA17_MN -10078 | State lake | 1010000 | 7/20/2017 | Jenkins Lake | Aitkin | 111.6 | 11.6 | Northern Forest |
| NLA17_MN -10079 | State lake | 29014400 | 6/27/2017 | Sunday Lake | Hubbard | 63.1 | 1.2 | Eastern Temperate Forest |
| NLA17_MN -10080 | State lake | 72005001 | 6/20/2017 | High Island Lake | Sibley | 1328.1 | 2.7 | Great Plains |
| NLA17_MN -10081 | State lake | 56049200 | 8/29/2017 | Horseshoe Lake | Otter Tail | 9.6 | 4.2 | Eastern Temperate Forest |
| NLA17_MN -10082 | State lake | 31089300 | 8/7/2017 | Lower Pigeon Lake | Itasca | 285.5 | 6.1 | Northern Forest |
| NLA17_MN -10083 | State lake | 53002402 | 6/20/2017 | Lake Ocheda (Middle Bay) | Nobles | 714.6 | 1.5 | Great Plains |
| NLA17_MN -10084 | State lake | 37010000 | 8/31/2017 | Unnamed | Lac Qui Parle | 25.4 | 1.5 | Great Plains |
| NLA17_MN -10085 | State lake | 43007600 | 6/28/2017 | Bear Lake | Mcleod | 169.9 | 2.7 | Eastern Temperate Forest |
| NLA17_MN -10086 | State lake | 56057800 | 8/2/2017 | Holbrook Lake | Otter Tail | 147.8 | 4.3 | Eastern Temperate Forest |
| NLA17_MN -10087 | State lake | 11024100 | 6/26/2017 | Tamarack Lake | Cass | 44.0 | 1.1 | Northern Forest |
| NLA17_MN -10088 | State lake | 11015000 | 6/26/2017 | Tamarack Lake | Cass | 28.5 | 1.1 | Northern Forest |
| NLA17_MN -10089 | State lake | 31029800 | 7/31/2017 | Walters Lake | Itasca | 120.0 | 5.2 | Northern Forest |
| NLA17_MN -10090 | State lake | 21006000 | 8/28/2017 | Kruegers Slough | Douglas | 40.8 | 15.8 | Eastern Temperate Forest |
| NLA17_MN -10091 | State lake | 3041400 | 8/2/2017 | Gandrud Lake | Becker | 24.6 | 1.2 | Eastern Temperate Forest |
| NLA17_MN -10092 | State lake | 26020500 | 6/22/2017 | Unnamed | Grant | 64.8 | 1.5 | Great Plains |
| NLA17_MN -10094 | State lake | 56014700 | 8/28/2017 | Unnamed | Otter Tail | 29.3 | 3.5 | Eastern Temperate Forest |
| NLA17_MN -10095 | State lake | 18043900 | 8/7/2017 | Pennington Mine Lake | Crow Wing | 47.9 | 78.9 | Northern Forest |
| NLA17_MN -10096 | State lake | 27017901 | 6/28/2017 | Little Long Lake (North Bay) | Hennepin | 49.0 | 23.2 | Eastern Temperate Forest |
| NLA17_MN -10097 | State lake | 31040700 | 8/8/2017 | Hay Lake | Itasca | 53.2 | 12.5 | Northern Forest |

| NLA ID # | Federal or State Lake | DOW # | Date Sampled | Lake Name | County | Area (acres) | Depth (m) | Ecoregion |
|---|---|---|---|---|---|---|---|---|
| NLA17_MN-10098 | State lake | 13006100 | 7/20/2017 | Unnamed | Chisago | 31.4 | 1.1 | Eastern Temperate Forest |
| NLA17_MN-10099 | State lake | 86006500 | 6/21/2017 | Unnamed | Wright | 59.6 | 2.5 | Eastern Temperate Forest |
| NLA17_MN-10101 | State lake | 61018900 | 8/21/2017 | Unnamed | Pope | 28.9 | 1.7 | Great Plains |
| NLA17_MN-10102 | State lake | 3023600 | 9/6/2017 | Unnamed | Becker | 16.0 | 1.2 | Northern Forest |
| NLA17_MN-10103 | State lake | 75020500 | 6/26/2017 | Unnamed | Stevens | 10.0 | 1.3 | Great Plains |
| NLA17_MN-10104 | State lake | 14008100 | 8/1/2017 | Unnamed | Clay | 17.8 | 1.5 | Great Plains |
| NLA17_MN-10105 | State lake | 27000400 | 6/28/2017 | Penn Lake | Hennepin | 46.5 | 2.1 | Eastern Temperate Forest |
| NLA17_MN-10107 | State lake | 26020400 | 6/22/2017 | Graham Lake | Grant | 133.5 | 2.1 | Great Plains |
| NLA17_MN-10108 | State lake | 58020500 | 8/14/2017 | Unnamed | Pine | 29.3 | 1.2 | Northern Forest |
| NLA17_MN-10109 | State lake | 61011100 | 6/21/2017 | Pelican Lake | Pope | 510.8 | 10.4 | Eastern Temperate Forest |
| NLA17_MN-10110 | State lake | 16023600 | 6/28/2017 | Lac Lake | Cook | 60.8 | 7.6 | Northern Forest |
| NLA17_MN-10112 | State lake | 47006200 | 6/28/2017 | Greenleaf Lake | Meeker | 228.8 | 5.5 | Eastern Temperate Forest |
| NLA17_MN-10117 | State lake | 18009500 | 6/27/2017 | Chrysler Lake | Crow Wing | 110.4 | 1.1 | Northern Forest |
| NLA17_MN-10118 | State lake | 31014200 | 7/31/2017 | Unnamed | Itasca | 33.0 | 12.2 | Northern Forest |
| NLA17_MN-10122 | State lake | 69024900 | 7/18/2017 | Colby Lake | St Louis | 502.8 | 9.1 | Northern Forest |
| NLA17_MN-10123 | State lake | 14010300 | 9/6/2017 | Cromwell Lake | Clay | 28.6 | 1.3 | Great Plains |
| NLA17_MN-10127 | State lake | 36001200 | 7/24/2017 | Miller Lake | Koochiching | 17.6 | 14.6 | Northern Forest |
| NLA17_MN-10159 | Federal lake | 16018200 | 8/15/2017 | Ball Club Lake | Cook | 216.5 | 8.2 | Northern Forest |
| NLA17_MN-10161 | Federal lake | 34003300 | 7/24/2017 | Ella Lake | Kandiyohi | 141.4 | 3.4 | Great Plains |
| NLA17_MN-10162 | State lake | 40009800 | 7/18/2017 | Unnamed | Le Sueur | 4.2 | 1.6 | Eastern Temperate Forest |
| NLA17_MN-10164 | State lake | 3030300 | 8/3/2017 | Bear Lake | Becker | 29.2 | 4.2 | Eastern Temperate Forest |

| NLA ID # | Federal or State Lake | DOW # | Date Sampled | Lake Name | County | Area (acres) | Depth (m) | Ecoregion |
|---|---|---|---|---|---|---|---|---|
| NLA17_MN-10165 | State lake | 21072900 | 8/30/2017 | Unnamed | Douglas | 5.5 | 1.7 | Eastern Temperate Forest |
| NLA17_MN-10166 | State lake | 82003100 | 9/11/2017 | Terrapin Lake | Washington | 124.1 | 2.0 | Eastern Temperate Forest |
| NLA17_MN-10179 | Federal lake | 3007700 | 8/2/2017 | Unnamed | Becker | 56.1 | 1.0 | Northern Forest |
| NLA17_MN-10180 | Federal lake | 56013400 | 8/29/2017 | Unnamed | Otter Tail | 86.2 | 1.7 | Eastern Temperate Forest |
| NLA17_MN-10183 | Federal lake | 6012000 | 8/21/2017 | Cup Lake | Big Stone | 51.1 | 3.4 | Great Plains |
| NLA17_MN-10187 | Federal lake | 11048700 | 7/11/2017 | Little Twin Lake | Cass | 108.6 | 9.1 | Northern Forest |
| NLA17_MN-10188 | Federal lake | 10010700 | 8/24/2017 | Braunworth Lake | Carver | 37.0 | 1.1 | Eastern Temperate Forest |
| NLA17_MN-10189 | Federal lake | 11004700 | 7/19/2017 | Mule Lake | Cass | 60.3 | 10.7 | Northern Forest |
| NLA17_MN-10191 | Federal lake | 3019900 | 9/6/2017 | Johnson Lake | Becker | 150.1 | 1.8 | Northern Forest |
| NLA17_MN-10192 | Federal lake | 34044000 | 8/22/2017 | Johnson Lake | Kandiyohi | 105.7 | 1.0 | Great Plains |
| NLA17_MN-10193 | Federal lake | 18043000 | 8/9/2017 | Unnamed | Crow Wing | 8.7 | 2.1 | Northern Forest |
| NLA17_MN-10194 | Federal lake | 31062300 | 8/15/2017 | Boy Lake | Itasca | 30.9 | 12.2 | Northern Forest |
| NLA17_MN-10195 | State lake | 60001500 | 8/7/2017 | Whitefish Lake | Polk | 231.0 | 5.5 | Eastern Temperate Forest |
| NLA17_MN-10196 | State lake | 56063000 | 8/29/2017 | Unnamed | Otter Tail | 102.1 | 3.1 | Eastern Temperate Forest |
| NLA17_MN-10198 | State lake | 69004400 | 6/28/2017 | Butterball Lake | St Louis | 438.7 | 1.8 | Northern Forest |
| NLA17_MN-10199 | State lake | 6000500 | 6/22/2017 | Unnamed | Big Stone | 47.7 | 1.9 | Great Plains |
| NLA17_MN-10202 | State lake | 16039900 | 6/27/2017 | Unnamed | Cook | 11.9 | 1.5 | Northern Forest |
| NLA17_MN-10204 | State lake | 18012700 | 7/24/2017 | Coles Lake | Crow Wing | 115.8 | 1.5 | Northern Forest |
| NLA17_MN-10205 | State lake | 38058000 | 9/12/2017 | Horseshoe Lake | Lake | 202.8 | 12.2 | Northern Forest |
| NLA17_MN-10230 | State lake | 46004900 | 6/19/2017 | Iowa Lake | Martin | 680.5 | 2.7 | Great Plains |
| NLA17_MN-10239 | State lake | 87003200 | 6/27/2017 | Mud Lake | Yellow Medicine | 13.5 | 1.2 | Great Plains |
| NLA17_MN-10246 | State lake | 6005000 | 6/21/2017 | Otrey Lake | Big Stone | 450.4 | 2.4 | Great Plains |

| NLA ID # | Federal or State Lake | DOW # | Date Sampled | Lake Name | County | Area (acres) | Depth (m) | Ecoregion |
|---|---|---|---|---|---|---|---|---|
| NLA17_MN-10254 | State lake | 3047800 | 9/6/2017 | Baker Lake | Becker | 34.5 | 1.1 | Great Plains |
| NLA17_MN-10260 | State lake | 19001100 | 7/26/2017 | Kegan Lake | Dakota | 28.1 | 2.3 | Great Plains |
| NLA17_MN-10278 | State lake | 60024400 | 8/1/2017 | Unnamed | Polk | 19.2 | 2.6 | Great Plains |
| NLA17_MN-10283 | State lake | 42003600 | 6/27/2017 | Jacobsons Marsh | Lyon | 28.0 | 1.0 | Great Plains |
| NLA17_MN-10291 | State lake | 26011100 | 6/26/2017 | Patchen Lake | Grant | 254.4 | 1.8 | Great Plains |
| NLA17_MN-10294 | State lake | 32003300 | 6/19/2017 | Pearl Lake | Jackson | 117.0 | 1.8 | Great Plains |
| NLA17_MN-10303 | State lake | 34024700 | 6/29/2017 | Unnamed | Kandiyohi | 8.6 | 1.0 | Great Plains |
| NLA17_MN-10315 | State lake | 47012700 | 6/28/2017 | Goose Lake | Meeker | 121.4 | 3.7 | Great Plains |
| NLA17_MN-10326 | State lake | 42006600 | 6/27/2017 | Section Thirty-Three Lake | Lyon | 97.5 | 2.3 | Great Plains |
| NLA17_MN-10330 | State lake | 83004300 | 6/20/2017 | St. James Lake | Watonwan | 193.5 | 4.6 | Great Plains |
| NLA17_MN-10346 | State lake | 51002700 | 6/20/2017 | Smith Lake | Murray | 95.0 | 2.7 | Great Plains |
| NLA17_MN-10353 | State lake | 56100200 | 8/29/2017 | Unnamed | Otter Tail | 47.9 | 2.3 | Great Plains |
| NLA17_MN-10357 | State lake | 24006700 | 6/19/2017 | Unnamed | Freeborn | 87.0 | 3.0 | Great Plains |
| NLA17_MN-10405 | State lake | 14008800 | 9/6/2017 | Unnamed | Clay | 25.1 | 1.3 | Great Plains |
| NLA17_MN-10437 | State lake | 6018800 | 6/21/2017 | Unnamed | Big Stone | 52.1 | 3.6 | Great Plains |
| NLA17_MN-10439 | State lake | 75003400 | 6/26/2017 | Bjork Lake | Stevens | 47.1 | 1.8 | Great Plains |
| NLA17_MN-10453 | State lake | 76016600 | 6/22/2017 | Unnamed | Swift | 28.8 | 2.1 | Great Plains |
| NLA17_MN-10485 | State lake | 46011600 | 8/29/2017 | Round Lake | Martin | 44.5 | 1.3 | Great Plains |
| NLA17_MN-10531 | State lake | 81000300 | 8/15/2017 | St. Olaf Lake | Waseca | 89.0 | 9.1 | Great Plains |
| NLA17_MN-10537 | State lake | 42003200 | 8/30/2017 | Lake of the Hill | Lyon | 110.8 | 2.0 | Great Plains |
| NLA17_MN-10548 | State lake | 32004000 | 8/29/2017 | Summer Marsh | Jackson | 27.1 | 1.1 | Great Plains |
| NLA17_MN-10556 | State lake | 34019400 | 9/14/2017 | Unnamed | Kandiyohi | 49.8 | 2.5 | Great Plains |
| NLA17_MN-10568 | State lake | 47011600 | 9/14/2017 | Hoosier Lake | Meeker | 104.9 | 2.1 | Great Plains |
| NLA17_MN-10579 | State lake | 41002200 | 8/30/2017 | Slough Lake | Lincoln | 159.9 | 1.5 | Great Plains |

| NLA ID # | Federal or State Lake | DOW # | Date Sampled | Lake Name | County | Area (acres) | Depth (m) | Ecoregion |
|---|---|---|---|---|---|---|---|---|
| NLA17_MN-10620 | State lake | 17004802 | 8/29/2017 | Long Lake | Cottonwood | 196.7 | 1.5 | Great Plains |
| NLA17_MN-10643 | State lake | 26028200 | 8/9/2017 | Lightning Lake | Grant | 526.5 | 3.4 | Great Plains |
| NLA17_MN-10842 | Federal lake | 15001000 | 9/13/2017 | Elk Lake | Clearwater | 279.3 | 28 | Northern Forest |
| NLA17_MN-HP002 | Federal lake | 4019300 | 9/12/2017 | Green Lake | Beltrami | 61.2 | 19.0 | Northern Forest |
| NLA17_MN-HP003 | Federal lake | 69076800 | 7/11/2017 | Martin Lake | St. Louis | 63.7 | 22.6 | Northern Forest |
| NLA17_MN-HP004 | Federal lake | N / A | 7/13/2017 | Unnamed | Cass | 6.9 | 6.0 | Northern Forest |