Indiana Lake Water Quality Assessment Report
For 2015-2018

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Cover: Crooked Lake, Whitley County. September 2015

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<u>**INDIANA CLEAN LAKES PROGRAM**</u>

The Indiana Clean Lakes Program was created in 1989 as a program within the Indiana Department of Environmental Management's (IDEM) Office of Water Management. The program is administered through a grant to Indiana University's School of Public and Environmental Affairs (SPEA) in Bloomington. The Indiana Clean Lakes Program is a comprehensive, statewide public lake management program having five components:

1. Public information and education
2. Technical assistance
3. Volunteer lake monitoring
4. Lake water quality assessment
5. Coordination with other state and federal lake programs.

This document is a summary of lake water quality assessment (LWQA) results for 2015 to 2018.

Lake Water Quality Assessment

The goals of the LWQA include: (a) identifying water quality trends in individual lakes, (b) identifying lakes that need special management, and (c) tracking water quality improvements due to industrial discharge and runoff reduction programs (Jones 1996).

This program only samples public lakes that generally have boat trailer access from a public right-of-way. Public lakes are defined as those that have navigable inlets or outlets, or those that exist on or adjacent to public land. Sampling occurs in late June, July, and August of each year to coincide with the period of thermal stratification and the period of poorest annual water quality in lakes (Figure 1). Most Indiana lakes with maximum depths of 16 to 23 feet (5–7 m) or greater undergo thermal stratification during the summer. The warming of lake surface water by sunlight and higher air temperatures cause the water to become less dense. The less dense water will then rise above the cold, denser water at the lake's bottom. Summer wind and waves may not be strong enough to overcome the density differences between the surface and bottom waters and ***thermal stratification*** occurs. In a stratified lake, the surface waters (***epilimnion***) circulate and are well mixed throughout the summer while the bottom waters (***hypolimnion***) may stagnate because they are isolated from the surface. Thus, water characteristics in the epilimnion and hypolimnion of a given lake may be considerably different during stratification.

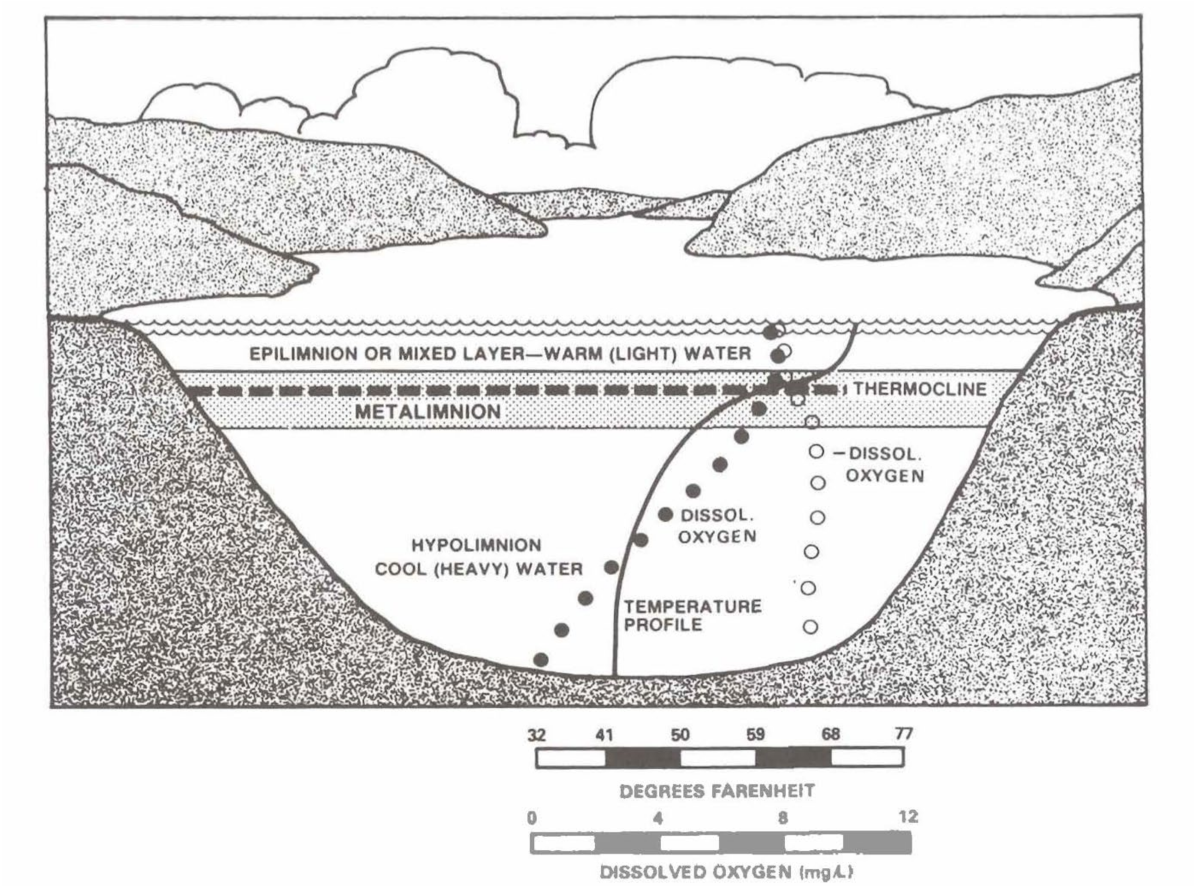

Figure 1 – Cross-section of a lake experiencing summer thermal stratification. Adapted from Olem and Flock (1990).

To account for potential differences between the epilimnion and hypolimnion of stratified lakes, water samples are collected from the top two meters of the surface and from one to two meters above the bottom. In addition, dissolved oxygen and temperature are measured at one-meter intervals from the surface to the bottom of each lake.

Lakes were randomized and selected from our list of all public lakes and impoundments having a) a minimum surface area of 5 acres, and b) a usable boat ramp. This process was similar to that used by the United States Environmental Protection Agency (USEPA) in the National Lakes Assessment (NLA) of 2007, 2012, and 2017. The resulting list contained a total of 329 lakes and impoundments. We randomize the candidate lake list each survey year. We sampled lakes from this list beginning with the first lake at the top and working downward until we had sampled 80 lakes each survey year, repeating the randomization for the next year. Using this sampling scheme, our 2015-2018 results should be statistically significant for the entire state and we could then better discuss lake water quality in Indiana.

The 329 lakes in our randomized pool are a small fraction of the 1475 lakes, reservoirs, and ponds in our master lake list for Indiana. However, many of these other lakes are private, smaller than 5 acres in surface area, and/or have no usable boat ramp. While the randomized sampling scheme allows us to gain a better understanding of Indiana lake quality each year, it is possible that the sampling frequency for any given lake would create long gaps between individual lake surveys.

Water Quality Parameters Included in Lake Assessments

Monitoring lakes requires many different parameters to be sampled. The parameters analyzed in this assessment include:

pH

pH is the measure of the acidity of a solution of water. The pH scale commonly ranges from 0 to 14 (Figure 2). The scale is not linear but rather logarithmic. For example, a solution with a pH of 6.0 is ten times more acidic than a solution with a pH of 7.0. Pure water is said to be neutral, with a pH of 7.0. Water with a pH below 7.0 is considered acidic while water with pH greater than 7.0 is considered basic or alkaline. The pH of most natural waters in Indiana is between 6.5 and 8.0. However, acidic deposition may cause lower pH in susceptible waters and high phytoplankton productivity (which consumes CO_2, a weak acid) can result in pH values exceeding 9.0.

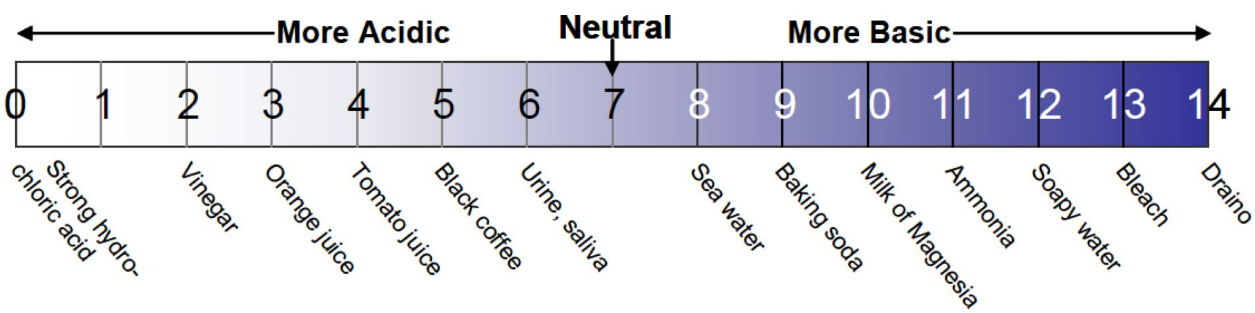

Figure 2 – The pH scale compared with common solutions. Source: Addy et al. (2004).

Conductivity

Conductivity is a numerical expression of an aqueous solution's capacity to carry an electric current. This ability depends on the presence of ions, their total concentration, mobility, valence, relative concentrations, and on the temperature of the liquid (APHA 2005). Solutions of most inorganic acids, bases, and salts are relatively good conductors. Conductivities of natural lakes in Indiana generally range from 50 to 1,000 µmhos/cm, but the conductivity of old coal mine lakes can be as high as 3,000 µmhos/cm. In contrast, the conductivity of distilled water is less than 1 µmhos/cm. As conductivity is the inverse of resistance, the unit of conductance is the mho, or in low-conductivity natural waters, the micromho (µmhos).

Alkalinity

Alkalinity is the sum total of components in the water that tend to elevate the pH to the alkaline side of neutrality, and is expressed commonly as milligrams per liter as calcium carbonate (mg/L as $CaCO_3$). Alkalinity is a measure of the *buffering capacity* (ability to resist changes in pH) of the water, and since pH has a direct effect on organisms as well as an indirect effect on the toxicity of certain pollutants in the water, the buffering capacity is important to water quality. Commonly occurring materials in water that increase alkalinity are carbonates, bicarbonates, phosphates, and hydroxides. Limestone bedrock and thick deposits of glacial till are good sources of carbonate buffering. Lakes within such areas are usually well-buffered.

Phosphorus

Phosphorus is an essential plant nutrient and most often controls aquatic plant (algae and macrophyte) growth in freshwater. It is found in fertilizers, human and animal wastes, and yard waste. There is no atmospheric (vapor) form of phosphorus. Because there are few natural sources of phosphorus and the lack of an atmospheric cycle, phosphorus is often a *limiting nutrient* in aquatic systems. This means that the relative scarcity of phosphorus may limit the ultimate growth and production of algae and rooted aquatic plants. Therefore, management efforts often focus on reducing phosphorus input to a receiving waterway because: (a) it can be managed, and (b) reducing phosphorus can reduce algae production. Two common forms of phosphorus are:

> ***Soluble reactive phosphorus (SRP)*** – SRP is dissolved phosphorus readily usable by algae. SRP is often found in very low concentrations in phosphorus-limited systems where the phosphorus is tied up in the algae and cycled very rapidly. Sources of SRP include fertilizers, animal wastes, and septic systems.
>
> ***Total phosphorus (TP)*** – TP includes dissolved and particulate forms of phosphorus. TP concentrations greater than 0.03 mg/L (or 30g/L) can cause algal blooms in lakes and reservoirs.

Nitrogen

Nitrogen is an essential plant nutrient found in fertilizers, human and animal wastes, yard waste, and the air. About 80 percent of the atmosphere is nitrogen gas. Nitrogen gas diffuses into water where it can be “fixed” (converted) by blue-green algae to ammonia for algal use. Nitrogen can also enter lakes and streams as inorganic nitrogen and ammonia. Because nitrogen can enter aquatic systems in many forms, there is an abundant supply of available nitrogen in these systems. The three common forms of nitrogen are:

Nitrate (NO_3^-) – Nitrate is an oxidized form of dissolved nitrogen that is converted to ammonia by algae under anoxic (low or no oxygen) conditions. It is found in streams and runoff when dissolved oxygen is present, usually in the surface waters.

Ammonia (NH_4^+) – Ammonia is a form of dissolved nitrogen that is readily used by algae. It is the reduced form of nitrogen and is found in water where dissolved oxygen is lacking such as in a eutrophic hypolimnion. Important sources of ammonia include fertilizers and animal manure. In addition, ammonia is produced as a by-product by bacteria as dead plant and animal matter are decomposed.

Organic Nitrogen (Org-N) – Organic nitrogen includes nitrogen found in plant and animal materials and may be in dissolved or particulate form. In the analytical procedures, total Kjeldahl nitrogen (TKN) was determined in 2015. Organic nitrogen is TKN minus ammonia. In 2016, the analytical procedures were changed, and total nitrogen (TN) was determined. Organic nitrogen is TN minus nitrate and ammonia.

Light Transmission

This measurement uses a light meter (photocell) to determine the *rate* at which light transmission is diminished in the upper portion of the lake's water column. Another important light transmission measurement is the determination of the 1% light level. The 1% light level is the water depth at which one percent of surface light penetrates. The 1% light level is considered the lower limit of algal growth in lakes and this area and above is referred to as the *euphotic zone*.

Dissolved Oxygen

Dissolved oxygen (DO) is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. DO enters water by diffusion from the atmosphere and as a by-product of photosynthesis by algae and plants. The concentration of DO in epilimnetic waters continually equilibrates with the concentration of atmospheric oxygen to maintain 100 percent DO saturation. Excessive algae growth can over-saturate (greater than 100 percent saturation) the water with DO when the rate of photosynthesis is greater than the rate of oxygen diffusion to the atmosphere. Hypolimnetic DO concentration is typically low as there is no mechanism to replace oxygen that is consumed by respiration and decomposition. Fish need at least 3-5 mg/L of DO to survive.

Secchi Disk Transparency

Secchi disk transparency refers to the depth to which a black and white Secchi disk can be seen in the lake water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Particulates (soil or dead leaves) may be introduced into the water by either runoff or sediments already on the bottom of the lake.

Erosion from construction sites, agricultural lands, and riverbanks all lead to increased sediment runoff. Bottom sediments can be resuspended by bottom-feeding fish such as carp, by motorboats, or by strong winds in shallow lakes.

Plankton

Plankton are important members of the aquatic food web. The plankton include phytoplankton or algae (microscopic plants) and zooplankton (tiny shrimp-like animals that eat algae). The phytoplankton are primary producers that convert light energy from the sun to plant tissue through the process of photosynthesis. This forms the foundation of the aquatic food chain. Small microscopic shrimp-like crustaceans – called zooplankton – eat the phytoplankton. In turn, the zooplankton are extremely important food for young fish (Figure 3).

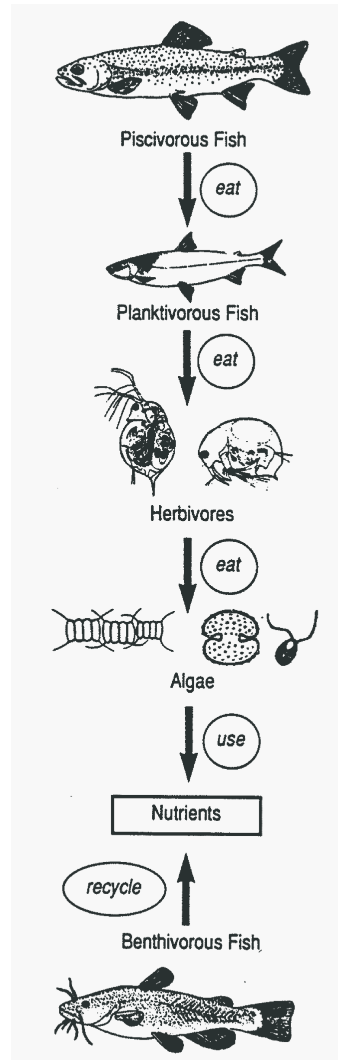

Figure 3 – A simplified aquatic food chain.

The phytoplankton are organized taxonomically largely by color. Important phyla (groups) include: Cyanobacteria (blue-green algae), Chlorophyta (green algae), Chrysophyta (yellow-brown algae), and Bacillariophyta (diatoms). The cyanobacteria are of particular interest to limnologists and lake users because members of this group are those that often form nuisance blooms and their dominance in lakes may indicate poor water conditions. Some species of cyanobacteria are known toxin producers.

Chlorophyll-a

The plant pigments of algae consist of the chlorophylls (green color) and carotenoids (yellow color). Chlorophyll-a is the most dominant chlorophyll pigment in green algae (Chlorophyta), but is only one of several pigments in blue-green algae (Cyanophyta), yellow-brown algae (Chrysophyta), and others. Despite this, chlorophyll-a is often used as a direct estimate of algal biomass although it might underestimate the production of algae that contain multiple pigments.

LAKE CLASSIFICATION

There are many factors that influence the condition of a lake including physical dimensions (*morphometry)*, nutrient concentrations, oxygen availability, temperature, light, and fish species. In order to simplify the analysis of lakes, there are a variety of lake classifications that are used. Lake classifications serve to aid in the decision-making process, in prioritizing, and in creating public awareness. Lakes can be classified based on their origin, thermal stratification regime, or by trophic status.

Lake Origin Classification

Hutchinson (1957) classified lakes according to how they were formed which resulted in 76 different classifications; the following are several important lake types in Indiana.

Glacial Lakes

As the glacier ice sheets moved south and then receded some 10,000 to 12,000 years ago, they created several types of lakes including scour lakes and kettle lakes. **Scour lakes** were formed when the sheet moved over the land creating a groove in the surface of the earth which later filled with meltwater. **Kettle lakes** were formed when large chunks of ice, deposited by the retreating glacier, left depressions in the thick deposits of *till* (sand and gravel ground up by the glacier) that covered the landscape. When the ice blocks melted the depressions filled in with water and lakes were formed. The majority of lakes in Indiana are kettle lakes including Lake Tippecanoe, the deepest lake (123 feet), and Lake Wawasee, the largest glacial lake (3,410 acres). Glacial lakes in Indiana are primarily in the north and are found between the western Valparaiso Morainal Area and the eastern Steuben Morainal Area where the Lake Michigan, Saginaw, and Erie lobes occurred (Figure 4). Glacial lakes are thus limited to this part of the state.

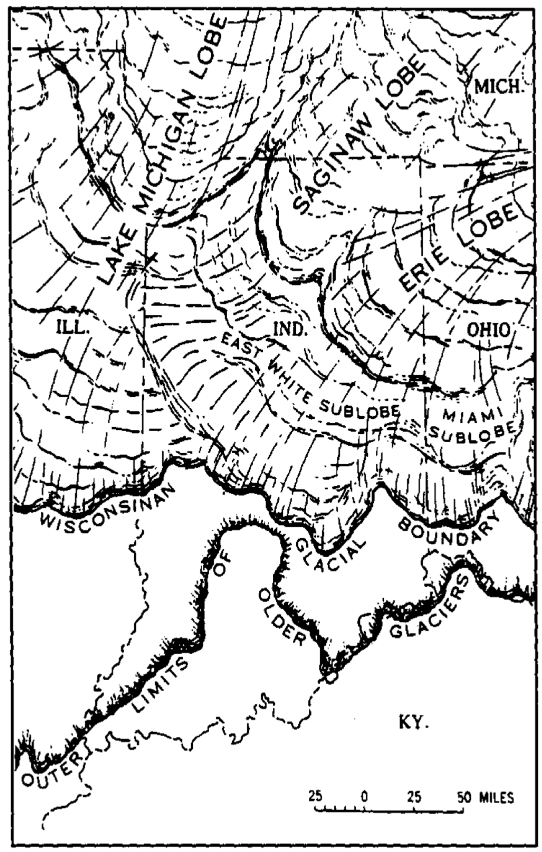

Figure 4 – The Lake Michigan, Saginaw, and Erie lobes of the most recent glacial episode affecting northern Indiana.

Solution Lakes

Solution lakes form when water collects in basins formed by the solution of limestone found in regions of karst topography. These lakes tend to be circular and are primarily found in the Mitchell Plain of southern Indiana.

Oxbow Lakes

Oxbow lakes are formed from former river channels that have been isolated from the original river channel due to deposition of sedimentation or erosion. Oxbow lakes can be found throughout the state of Indiana.

Artificial Lakes

Artificial lakes are created by humans due to excavation of a site or to damming a stream or river. Artificial lakes include ponds, strip pits, borrow pits, quarries, and reservoirs (Jones 1996). Reservoirs, also called impoundments, are typically elongated with many branches representing the tributaries of the former stream or river. Strip pits are coal mine lakes found in southwestern Indiana where coal mines are located. Many coal mine lakes formed when water filled the final cut excavated during surface mining. Borrow pits were originally excavated as a source of fill dirt for highway and other large construction projects. For our purposes, we aggregated strip pits, borrow pits, and quarry pits into a singular classification, surface mine lakes (SML).

Trophic Classification

Trophic state is an indication of a lake's nutritional level or biological productivity. The following definitions are used to describe the trophic state of a lake:

> *Oligotrophic* **-** lakes with clear waters, low nutrient levels (total phosphorus < 6 µg/L), supports few algae, hypolimnion has dissolved oxygen, and can support salmonids (trout and salmon).
>
> *Mesotrophic* - water is less clear, moderate nutrient levels (total phosphorus 10-30 µg/L), support healthy populations of algae, less dissolved oxygen in the hypolimnion, and lack of salmonids.
>
> *Eutrophic* **-** water transparency is less than 2 meters, high concentrations of nutrients (total phosphorus > 35 µg/L), abundant algae and weeds, lack of dissolved oxygen in the hypolimnion during the summer.
>
> *Hypereutrophic* **-** water transparency less than 1 meter, extremely high concentrations of nutrients (total phosphorus > 80 µg/L), thick algal scum, dense weeds.

Eutrophication is the biological response observed in a lake caused by increased nutrients, organic material, and/or silt (Cooke et al. 1993). Nutrients enter the lake through runoff or through eroded soils to which they are attached. Increased nutrient concentrations stimulate the growth of aquatic plants. Sediments and plant remains accumulate at the bottom of the lake decreasing the mean depth of the lake. The filling-in of a lake is a natural process that usually occurs over thousands of years. However, this natural process can be accelerated by human activities such as increased watershed erosion and increased nutrient loss from the land. Thus, ***cultural eutrophication*** can degrade a lake in as little as a few decades.

Although it is widely known that nutrients, especially phosphorus, are responsible for increased productivity, the concentration of nutrients alone cannot determine the trophic state of a lake. Other factors such as the presence of algae and weeds aid in the determination of the trophic status, and other factors such as light and temperature impact the growth of algae and weeds.

Trophic State Indices

Due to the complex nature and variability of water quality data, a trophic state index (TSI) is used to aid in the evaluation of water quality data. A TSI assigns a numerical value to different levels of standard water quality measurements. The sum of these points for all parameters in the TSI represents the standardized trophic status of a lake that can be compared in different years or can be compared to other lakes. When using a TSI for comparison, it is important to not neglect the actual data as these data may help in explaining other differences between lakes. As with any index, when the data are reduced to a single number for a TSI, some information is lost.

The Carlson Trophic State Index

The Carlson Trophic State Index, developed by Carlson (1977) is the most widely used TSI in the United States (Figure 5). Carlson used mathematical equations developed from the relationships observed between summer measurements of Secchi disk transparency, total phosphorus, and chlorophyll-a in north temperate lakes. With Carlson's TSI, one parameter, Secchi disk transparency, total phosphorus, or chlorophyll-a, can be used to yield a TSI value for that lake. One parameter can also be used to predict the value of the other parameters. Values for the Carlson's TSI range from 0 to 100 and each increase of 10 trophic points represents a doubling of algal biomass.

Not all lakes exhibit the same relationship between Secchi disk transparency, total phosphorus, and chlorophyll-a that Carlson's lakes show. However, in these cases Carlson's TSI gives valuable insight into the functioning of a particular lake.

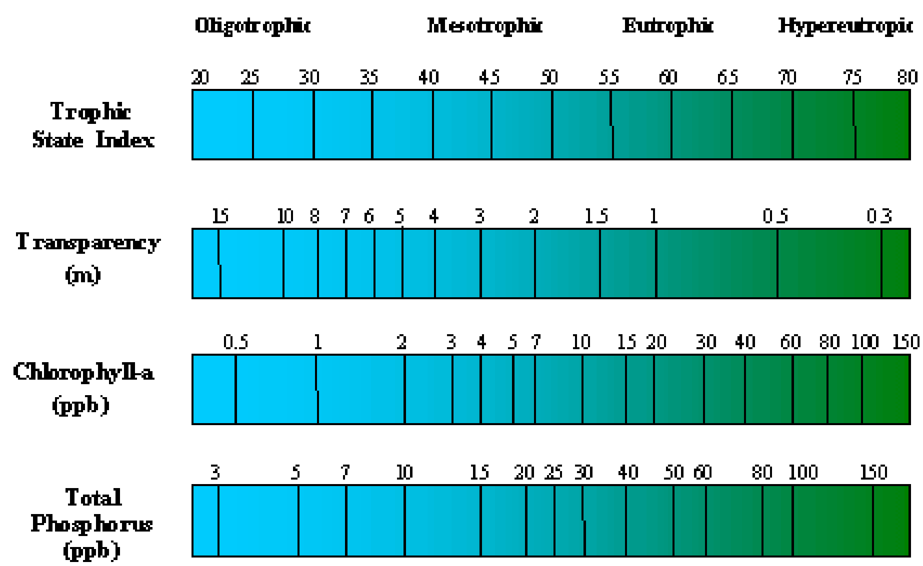

Figure 5 – The Carlson Trophic State Index.

Ecoregion Descriptions

The connection between lakes and their associated watersheds is evident in processes that include soil types, land slope, and watershed land use. These relationships can be expanded to a larger scale – the ecoregion – that incorporate these relationships across a larger geographic area. Omernik and Gallant (1988) defined ecoregions in the Midwest; the boundaries of these ecoregions were determined through the examination of land use, soils, and potential natural vegetation. These ecoregions have similar ecological properties throughout their range and these properties can influence lake water quality characteristics. Six ecoregions are present in Indiana (Figure 6). Descriptions of the ecoregions are as follows:

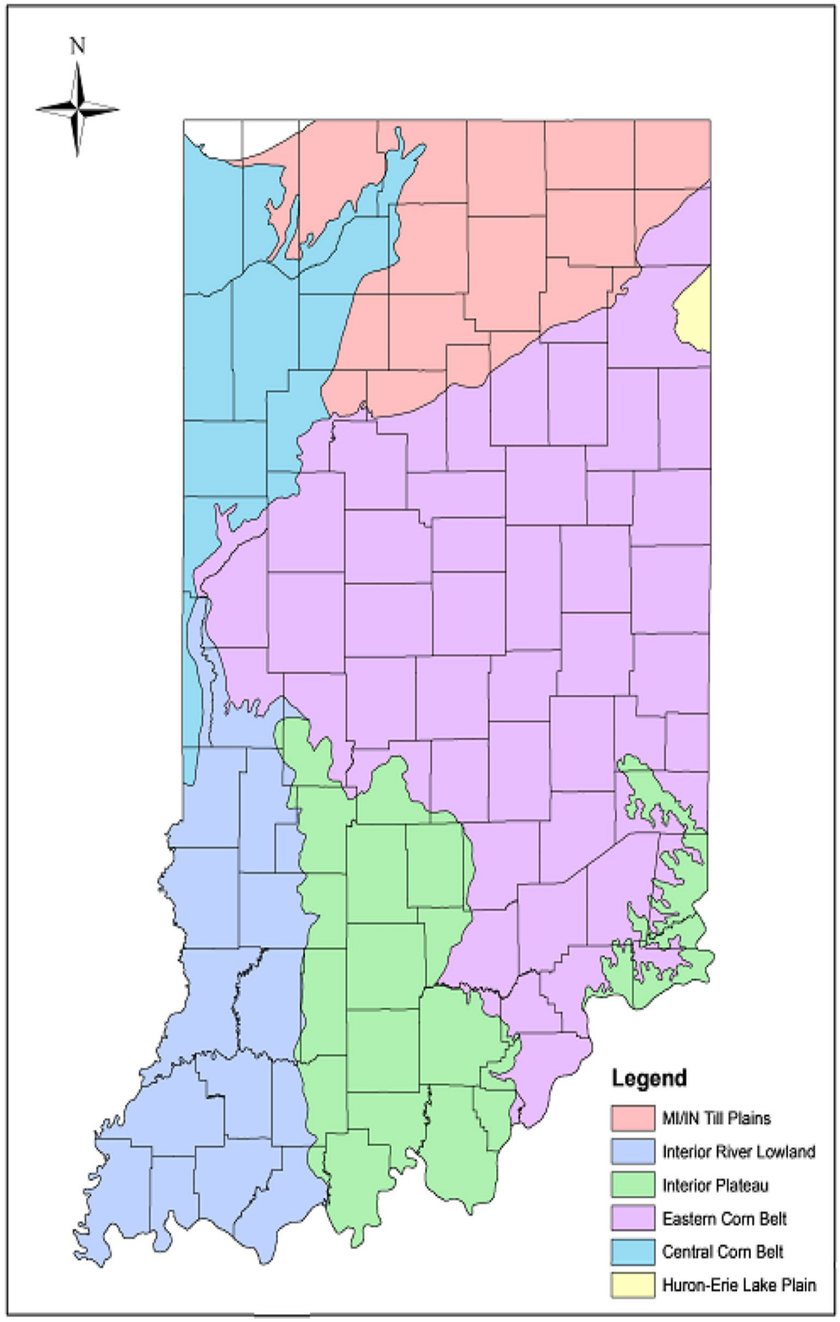

Figure 6 – Ecoregions of Indiana.

Central Corn Belt Plains (#54): This ecoregion covers 46,000 square miles of Indiana and Illinois. This ecoregion is primarily cultivated for feed crops, only 5 percent of the area is woodland. Crops and livestock are responsible for the nonpoint source pollution in this region.

Eastern Corn Belt Plains (#55): This ecoregion covers 31,800 square miles of Indiana, Ohio, and Michigan. Hardwood forests can thrive in this area; 75 percent of the land is used for crop production. Few natural lakes or reservoirs are located in this area.

Southern Michigan/Northern Indiana Till Plain (#56): This region covers 25,800 square miles of Michigan and Indiana. Oak-hickory forests are the dominant vegetation in this area; however, 25 percent of this area is urbanized.

Huron/Erie Lake plain (#57): This region covers 11,000 square miles of Indiana, Ohio, and Michigan. This area used to be occupied by forested wetlands; however, the primary use is now farming and 10 percent of this region is urbanized. There are no lakes in this region that could be assessed by the present study.

Interior Plateau (#71): This area occupies 56,000 square miles from Indiana and Ohio down to Alabama. Land is used for pasture, livestock, and crops. Woodlands and forests remain in this area. There are many quarries and coal mines in this area; however, there are few natural lakes.

Interior River Lowland (#72): This area covers 29,000 square miles in Indiana, Kentucky, Illinois, and Missouri. One third of this area is maintained as oak-hickory forest; other land uses include pasture, livestock, crops, timber, and coal mines. Water quality disturbances come from livestock, crops, and surface mining.

METHODS

Field Procedures

Water samples are collected from the epilimnion and hypolimnion, generally 1 meter below the surface and from 1-2 meters above the bottom of the lake. Epilimnetic water samples were collected using a 2-meter long integrated sampler that samples an undisturbed column of water from the surface to a depth of 2-meters. The sampler is emptied into a clean, rinsed pitcher where it is thoroughly mixed before filling the sample bottles. Water samples were taken for soluble reactive phosphorus (SRP), total phosphorus (TP), nitrate (NO_3^-), ammonia (NH_4^+), and total nitrogen (TN). SRP is filtered in the field using a 47 µm membrane filter. Prior to sampling, the TP, nitrate/ammonia, and TN bottles are acidified with sulfuric acid (H_2SO_4) resulting in a pH of the sample between 1 and 2.

Dissolved oxygen (DO), temperature, conductivity, and pH are measured using an In-Situ multi-parameter sonde. Measurements are taken at 1-meter intervals through the water column to the lake bottom.

Secchi disk transparency is measured by lowering a black and white disk through the water column until it is no longer visible. Light penetration is measured with a LiCor Spherical Quantum Sensor.

Phytoplankton were sampled using a 2-meter integrated sampler. The sampler is emptied into a clean, rinsed pitcher where it is thoroughly mixed before filling the sample bottles. The phytoplankton samples were preserved with glutaraldehyde during post-sampling activities. Zooplankton were collected with a tow net through the whole water column, utilizing a 80-micron mesh on the net and bucket. Zooplankton samples were preserved with 95% ethyl alcohol.

Chlorophyll-a is collected with an integrated sampler that reaches to a 2-m depth. The apparatus is shut, retrieved, and poured into a pitcher. The sample is shaded and filtered with Whatman GF/F filter paper using a hand pump. The sample is filtered until the flow of water passing through the filter is minimal and the volume of sample filtered is then recorded. The filter paper is removed, placed in a bottle, and kept thoroughly chilled.

Lab Procedures
SRP is determined using an ascorbic acid method and then measured colormetrically on a spectrophotometer (APHA 2005). Prior to 2016, TP samples were analyzed using a nitric and sulfuric acid digestion to convert particulate phosphorus to dissolved phosphorus. After pH adjustment, the samples are analyzed for SRP.

NO_3^- is analyzed using the cadmium reduction method (US EPA Method 353.3) using segmented flow analysis. NH_4^+ is processed using in-line gas diffusion (US EPA Method 350.1) (US EPA 1993). TN samples are digested in an alkaline persulfate solution then processed as nitrite-nitrate using the cadmium reduction method. TP samples are digested in an alkaline persulfate solution releasing particulate bound phosphorus and analyzed using the ascorbid acid method. Segmented flow analysis is performed on an Alpkem Flow Solution Model 3570 autoanalyzer. TKN (2015 only) samples are first digested in hot acid before being analyzed with an autoanalyzer.

For zooplankton analysis, one milliliter of water is transferred to a Sedgwick-Rafter Cell for identification and enumeration. The entire cell is scanned and all zooplankton are counted. Whole water samples of phytoplankton were concentrated to insure sufficient cell density using Utermoehl settling chambers. Counts are made using a nannoplankton chamber (PhycoTech, Inc.) and a phase contrast light microscope (2015-2017). In 2018, whole water samples of phytoplankton were concentrated using vacuum filtration and HPMA mounting (PhycoTech 2018). Plankton identifications are made according to: Ward and Whipple (1959), Prescott (1982), Whitford and Schumacher (1984), Wehr and Sheatch (2003), and St. Amand (2010). After identification, the following parameters can be calculated:

1. ***Natural Unit density (NU/L)*** – this is the historic unit used for many years to quantify plankton in Indiana lakes. A natural unit represents a single organism, irregardless of whether the organism is single-celled or a multi-celled colonial form. The size range of natural units may be several orders of magnitude (100 – 1000x).

2. ***Cell density (cells/mL)*** – Counting and recording at the cell level is preferred by phycologists and limnologists today. Each phytoplankton cell can live and reproduce

independently of other cells, even in those taxa that aggregate in colonies. Public health warnings regarding toxigenic cyanobacteria are determined, in part, by cell densities.

3. ***Blue-green dominance (%)*** – This valuable variable is the percentage of a plankton population that is dominated by cyanobacteria. Since cyanobacteria are more likely to become a nuisance in aquatic systems, this simple indicator is still useful. Caution is necessary in interpreting this metric because dominance by cyanobacteria in a lake with a low density of phytoplankton does not necessarily indicate a problem in that lake.

For chlorophyll-a analysis, filters are placed in the freezer upon arriving to the lab. Once frozen, the filters are ground and chlorophyll-a is extracted using 90% aqueous acetone and measured using spectrophotometer. Samples are corrected for pheophyton pigments with dilute acid.

All sampling techniques and laboratory analytical methods were performed in accordance with procedures in APHA (2005). Details can be found in the Quality Assurance Protection Plan (QAPP).

RESULTS

Information about the lakes sampled from 2015 to 2018 is included in Appendix A and B. Raw data for all lakes assessed are available on the Indiana Clean Lakes Program website at: http://www.indiana.edu/~clp.

Lakes Assessed

We assessed a total of 329 lakes during this four-year period; 81 in 2015, 86 in 2016, 80 in 2017, and 82 in 2018 (Figure 7).

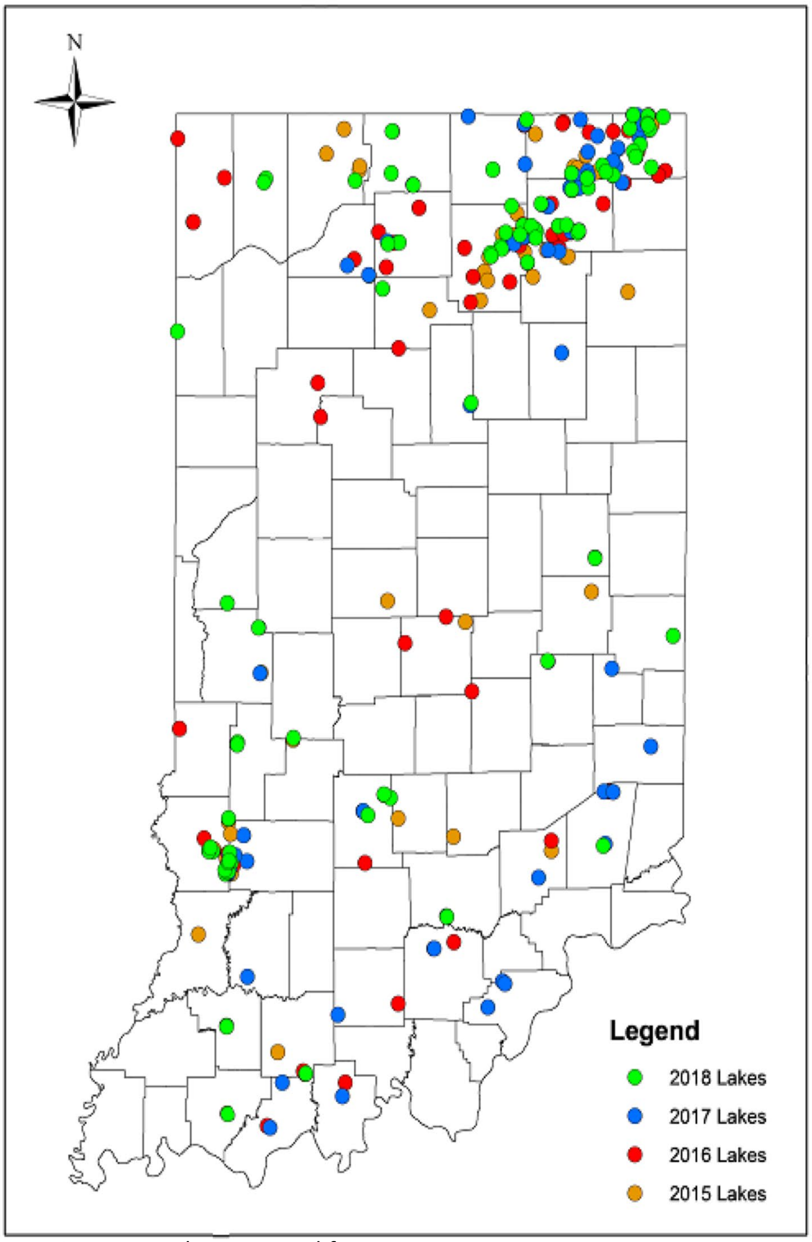

Figure 7 – Lakes assessed from 2015 to 2018.

Lake surface area ranged from 0.30 hectares (Skunk Lake) to 4353.75 hectares (Monroe Reservoir), with a median surface area of 26.31 ha (Figure 8). Twenty lakes had surface areas greater than 500 ha, while 64.7 percent (n = 213) of all lakes sampled were under 50 ha.

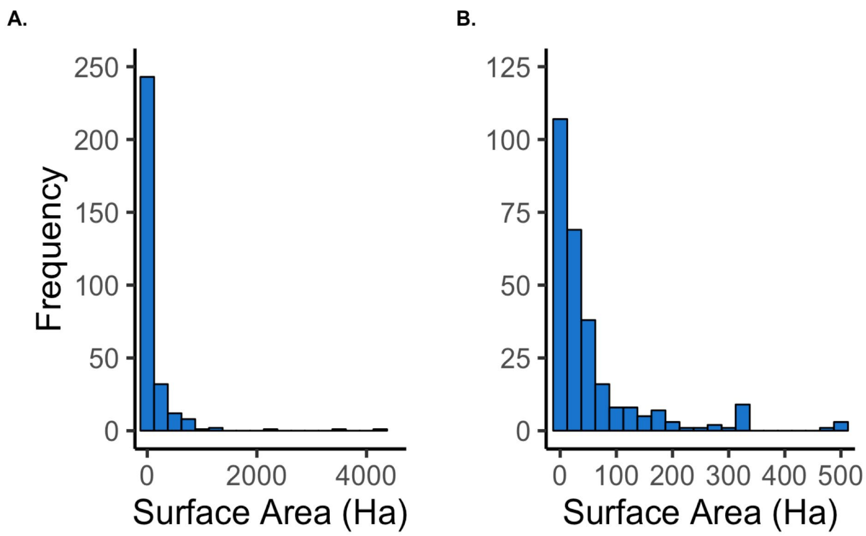

Figure 8 – Surface area distribution for **(A)** all 329 lakes sampled from 2015 to 2018, and **(B)** the distribution of lakes under 500 hectares.

Maximum depth ranged from 1.4 meters (Nasby Mill Pond) to 37 meters (Tippecanoe Lake), with a median of 9.1 meters (Figure 9). Natural lakes had the deepest median maximum depth (10.7 meters), followed by surface mine lakes (7.62 meters) and impoundments (6.4 meters).

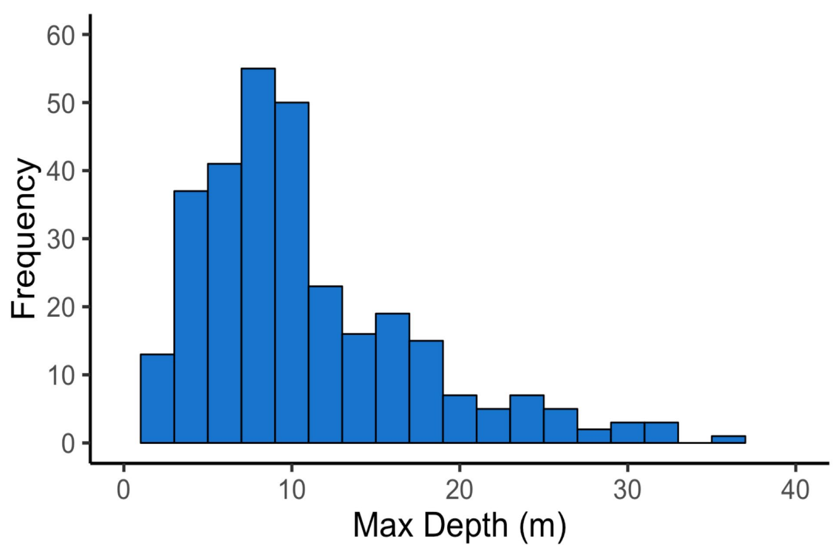

Figure 9 – Maximum depth distribution for 329 lakes sampled from 2015 to 2018.

Water Characteristics

pH, Conductivity, and Alkalinity

Epilimnetic pH ranged from 5.8 to 9.4 for all lakes sampled. Schlamm Lake had the lowest epilimnetic pH of 5.8 and Bobcat Lake – a surface mine lake – had the highest epilimnetic pH of 9.4(Figure 10). Median epilimnetic pH for all lakes was 7.9. Hypolimnetic pH was comparable to epilimnetic pH, with a median hypolimnetic pH of 7.2. Schlamm Lake and Bobcat Lake again represented the lowest and highest hypolimnetic pH, with a pH of 5.7 and 9.5, respectively.

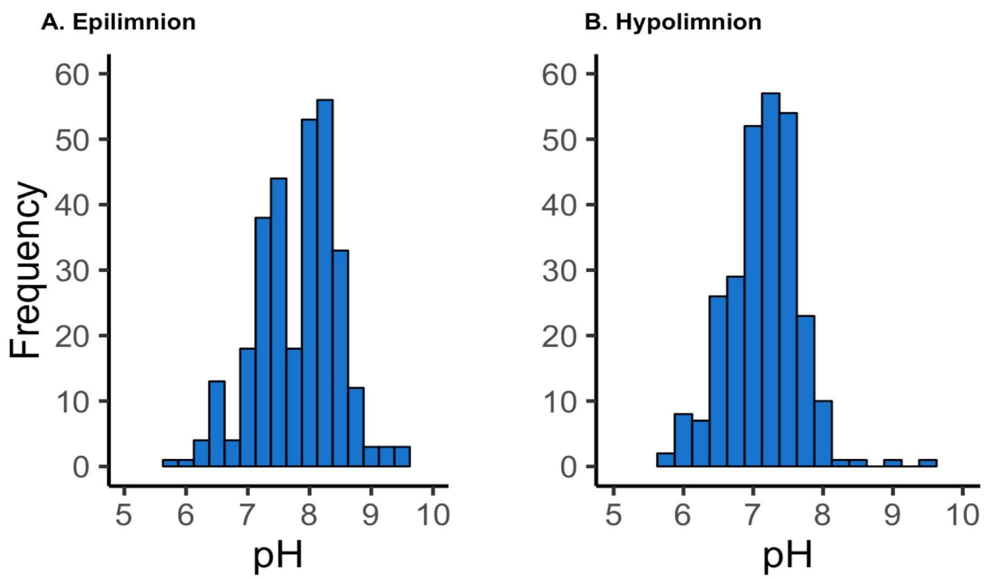

Figure 10 – pH distribution for 329 lakes from 2015 to 2018 by **(A)** epilimnion and **(B)** hypolimnion.

Median epilimnetic and hypolimnetic values were comparable for both conductivity and alkalinity (Figure 11). Minimum epilimnetic and hypolimnetic conductivity values were 46 umhos/cm and 113 umhos/cm, respectively. Maximum hypolimnetic conductivity was also higher than maximum epilimnetic conductivity, with values of 467.4 and 2,800 umhos/cm, respectively. Both of these lakes are surface mine lakes – Trimble Lake and Hale Lake – located in Greene and Sullivan County. Median epilimnetic conductivity was 416.5 umhos/cm compared to 467.4 for hypolimnetic samples.

The median alkalinity concentration for epilimnetic samples was 143.5 mg $CaCO_3$/L and 182 mg $CaCO_3$/L for hypolimnetic samples. Sycamore Lake (343 mg $CaCO_3$/L) and Airline Lake (182 mg $CaCO_3$/L) represented the maximum values for both samples, and are both surface mine lakes located in Greene County.

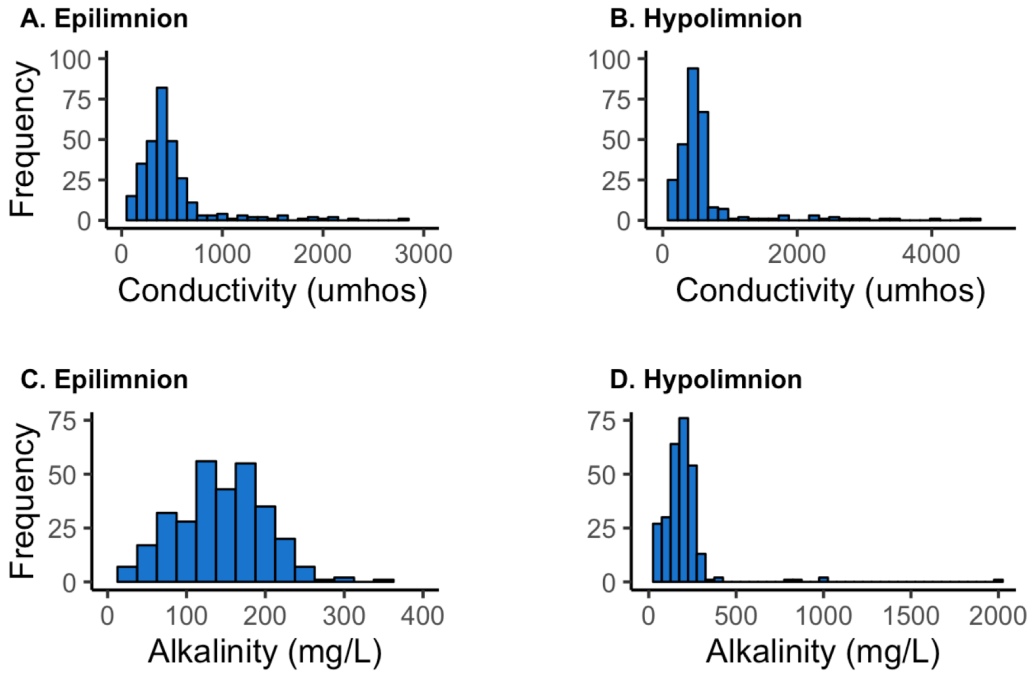

Figure 11 – Conductivity and alkalinity distribution for 329 lakes sampled from 2015 to 2018 by **(A)** epilimnetic conductivity, **(B)** hypolimnetic conductivity, **(C)** epilimnetic alkalinity, and **(D)** hypolimnetic alkalinity.

SRP and TP

Epilimnetic SRP concentrations were generally low across all lakes, with a median concentration of 0.008 mg/L (Figure 12). Fifty-one lakes (15.5 percent) were at or below the method detection limit of 0.002 mg/L. However, Shakamak Lake in Sullivan County had a SRP concentration of 1.227 mg/L. Hypolimentic SRP were higher than epilimnetic samples, with a median concentration of 0.160 mg/L. Only 16 lakes (4.9 percent) of lakes were at or below the method detection limit. Riddles Lake had the highest concentration of 1.489 mg/L.

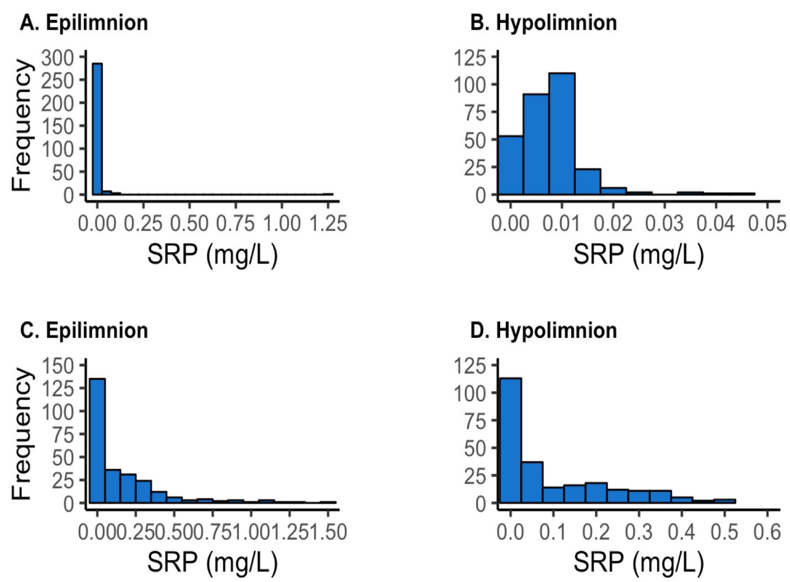

Figure 12 – Soluble reactive phosphorus (SRP) distribution for 329 lakes sampled from 2015 to 2018 by (A) total distribution of epilimnetic SRP concentrations, (B) epilimnetic SRP concentrations under 0.05 mg/L, (C) all hypolimnetic SRP concentrations, and (D) hypolimnetic SRP concentrations under 0.60 mg/L.

Epilimnetic TP concentrations were lower compared to hypolimnetic samples, with median concentrations of 0.0.031 and 0.098 mg/L, respectively (Figure 13). Loomis Lake (Porter County) had the highest epilimnetic TP concentration of 0.609 mg/L and Airline Lake had the highest hypolimnetic concentration of 3.97 mg/L.

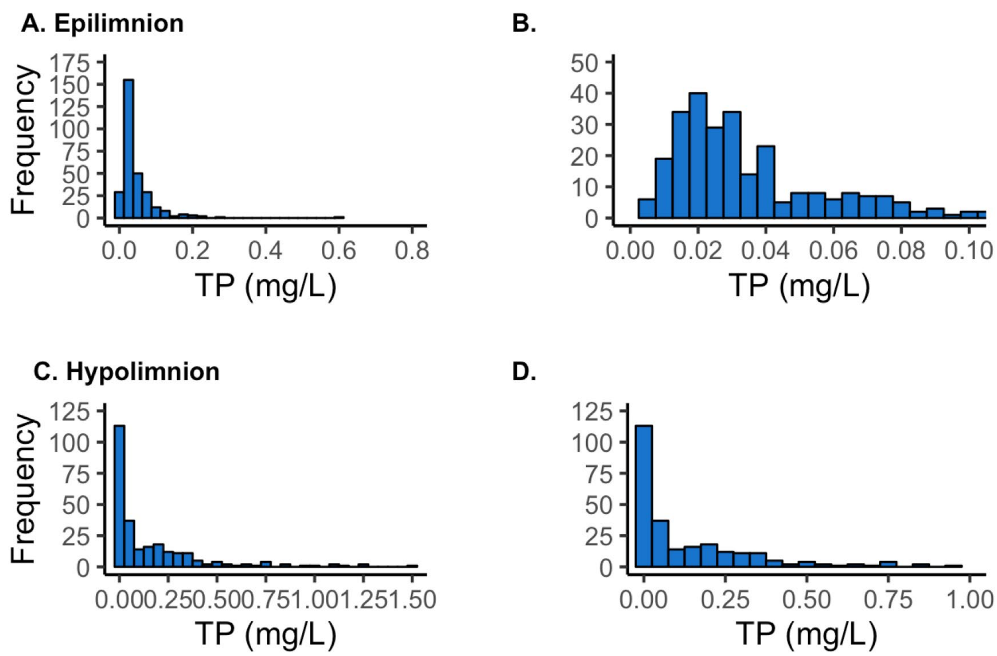

Figure 13 – Total phosphorus (TP) distribution for 329 lakes sampled from 2015 to 2018 by (A) the total distribution of epilimnetic TP concentrations, (B) epilimnetic TP concentrations under 0.10 mg/L, (C) all hypolimnetic TP concentrations, and (D) hypolimnetic TP concentrations under 1.00 mg/L.

NO_3-N, NH_3-N, and Org-N

Nitrate-nitrogen median epilimnetic and hypolimnetic concentrations were similar, with concentrations of 0.014 and 0.013 mg/L, respectively (Figure 14). For the 329 lakes sampled, 77 lakes had epilimnetic nitrate-nitrogen concentrations below the method detection limit of 0.008 mg/L, and 74 lakes had hypolimnetic concentrations below the method detection limit.

Ammonia-nitrogen concentrations were higher in the hypolimnion than the epilimnion (Figure 14). The median epilimnetic ammonia-nitrogen concentration was 0.018 mg/L, with 21.3 percent of lakes sampled below the method detection limit of 0.014 mg/L. In contrast, the median hypolimnetic concentration was 0.748 mg/L with only 3 percent of lakes below the method detection limit. Airline Lake (Greene Co.) had the highest hypolimnetic concentration of 52.801 mg/L.

The median organic-nitrogen concentration was 0.260 mg/L (Figure 14). While North Twin Lake (LaGrange Co.) had the highest organic-nitrogen concentration of 8.542 mg/L, organic-nitrogen concentrations across the 329 lakes were more normally distributed compared to nitrate-nitrogen and ammonia-nitrogen.

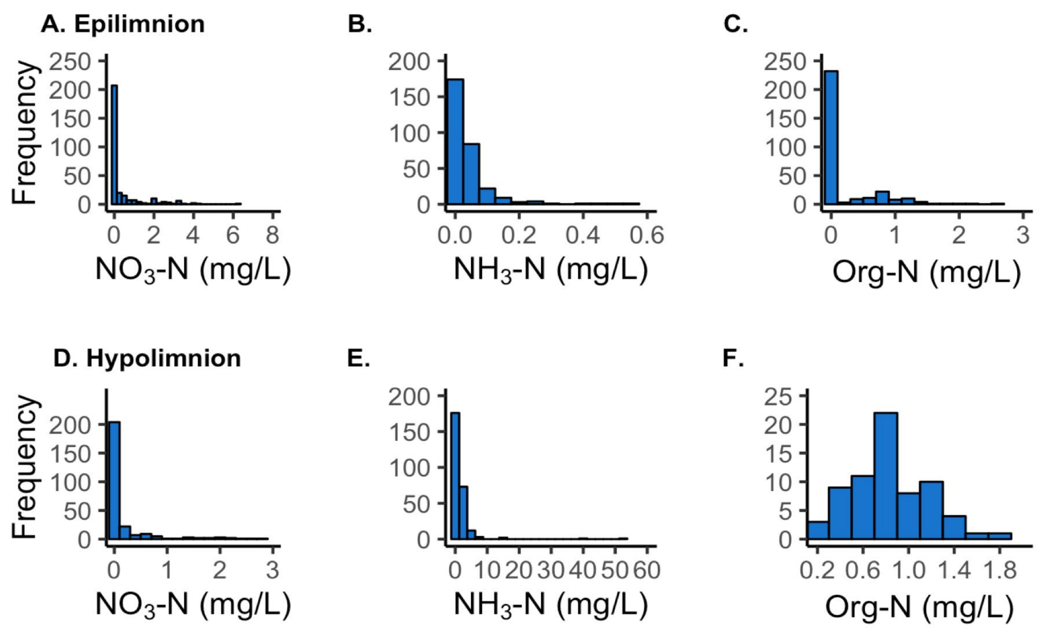

Figure 14 – Nitrate-nitrogen (NO_3-N), ammonia-nitrogen (NH_3-N), and organic-nitrogen (Org-N) distributions for 329 lakes sampled from 2015 to 2018 by **(A)** epilimnetic NO_3-N, **(B)** epilimnetic NH_3-N, **(C)** epilimnetic Org-N, **(D)** hypolimnetic NO_3-N, **(E)** hypolimnetic NH_3-N, and **(F)** hypolimnetic Org-N.

Chlorophyll-a and Phytoplankton

Chlorophyll-a concentrations ranged from 0.398 ug/L (Gambill Lake, Sullivan Co.) to 146.595 ug/L (Waveland Lake, Montgomery Co.), with a median concentration of 6.966 ug/L. Chlorophyll-a concentrations were highest in impoundments with a mean concentration of 17.90 ug/L, compared to 7.432 ug/L for natural lakes and 3.183 ug/L for surface mine lakes (Figure 15). Hypereutrophic lakes had the highest mean chlorophyll-a concentration of 59.269 ug/L, followed by eutrophic lakes (16.681 ug/L), mesotrophic lakes (4.298 ug/L), and oligotrophic lakes (1.263 ug/L) (Figure 16).

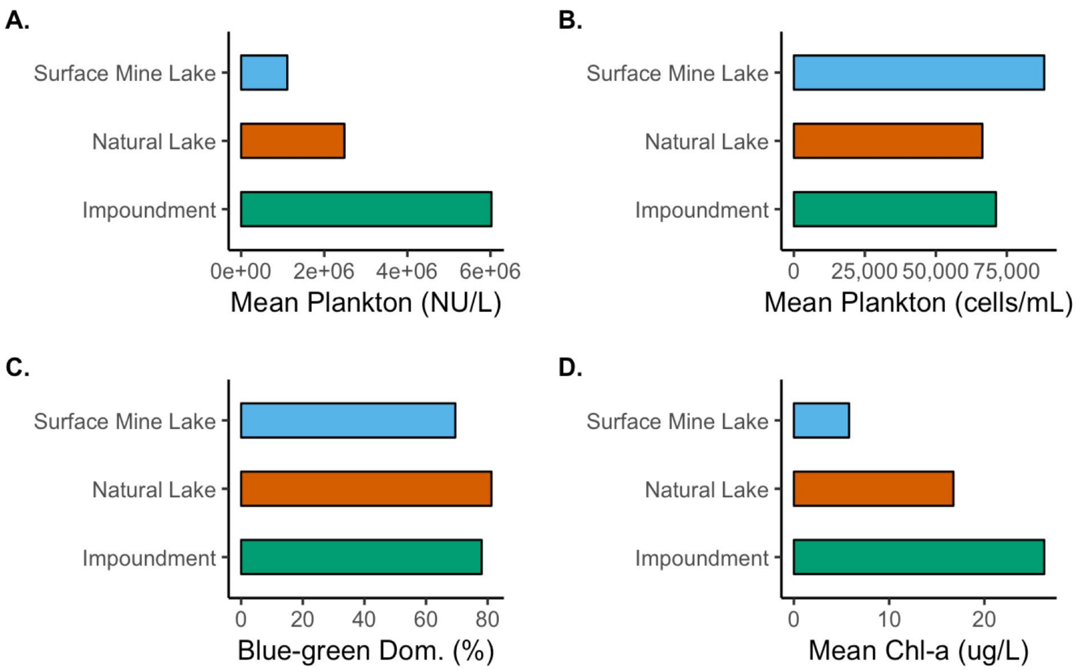

Figure 15 – Distribution of **(A)** mean plankton natural units, **(B)** mean plankton cells, **(C)** blue-green cell dominance, and **(D)** mean chlorophyll-a concentration by lake type for 329 lakes sampled from 2015 to 2018.

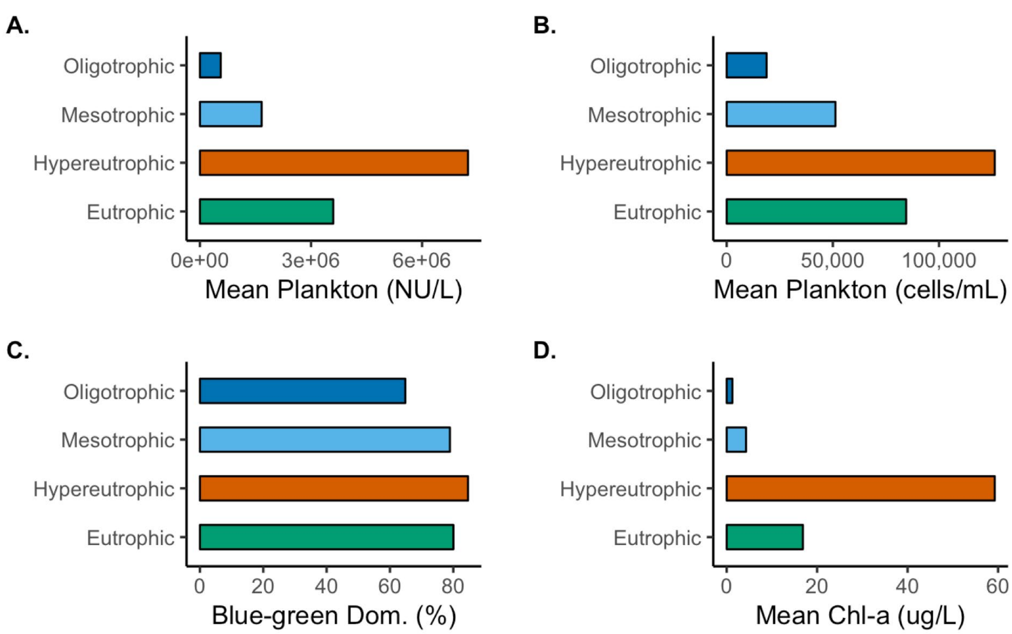

Figure 16 – Distribution of **(A)** mean plankton natural units, **(B)** mean plankton cells, **(C)** blue-green dominance, **(D)** mean chlorophyll-a concentrations by trophic state for 329 lakes sampled from 2015 to 2018.

Mean phytoplankton cell concentration was 71,954.74 cells/mL. Three lakes had concentrations exceeding 1 million cells/mL: Canada Lake (Porter Co.), Fish Lake (LaPorte Co.), and Sycamore Lake (Green Co.). Phytoplankton cell concentrations followed similar treads to that of chlorophyll-a in terms of lake type and trophic state. Mean cell concentrations were highest for impoundments (19,022 cells/mL), followed by natural lakes (13,4800 cells/mL) and surface mine lakes (5,611 cells/mL). Hypereutrophic lakes had the highest phytoplankton cell concentration, with a mean concentration of 126,248 cells/mL. The mean cell concentration for eutrophic lakes was 86,354 cells/mL. Mesotrophic and oligotrophic lakes had the lowest mean cell concentrations of 51,269 and 18,793 cells/mL, respectively.

Blue-green algae (cyanobacteria) were most dominant in hypereutrophic lakes, accounting for 84.7 percent of all algal cells. Oligotrophic lakes had the lowest percent of blue-green algae present at 64.86 percent. Blue-green dominance had no notable variation for lake type. Natural lakes had the highest blue-green dominance of 87 percent, followed by 86 percent for impoundments and 84.5 percent for surface mine lakes.

Secchi Disk Transparency and Trophic State

Median Secchi depth for all lakes sampled was 1.7 meters (Figure 17). Impoundments has the lowest median Secchi depth of 1.05 meters, whereas surface mine lakes had a median Secchi depth of 3.1 meters. While natural lakes had a median Secchi depth of 1.70 meters, natural lakes represented the minimum and maximum Secchi depths of all lakes. Cedar Lake — in Lake County — has a Secchi depth of 0.15 meters, and Golden Lake — in Steuben County had a Secchi depth of 19 meters.

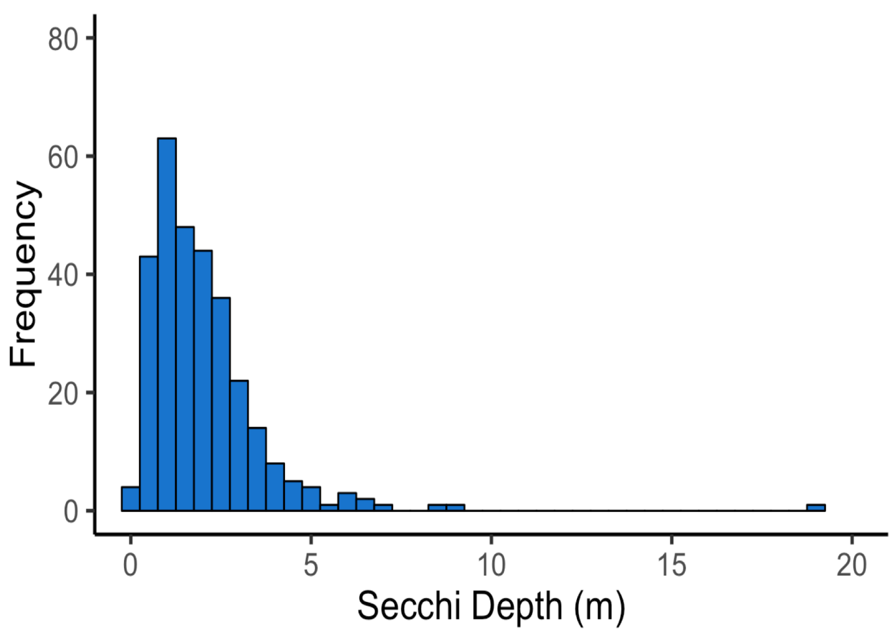

Figure 17 – Secchi depth distribution for 329 lakes sampled from 2015 to 2018.

Mesotrophic lakes were the most common based on TSI[chl-a], accounting for 44 percent of all lakes sampled (Figure 18). Eutrophic lakes accounted for 31 percent of lakes sampled. Only 9 percent of lakes sampled were oligotrophic. Airline Lake, in Greene County, had the lowest TSI[chl-a] of 22, whereas Waveland Lake, in Montgomery County, had a TSI[chl-a] of 79. Median TSI[chl-a] for all lakes sampled was 50.

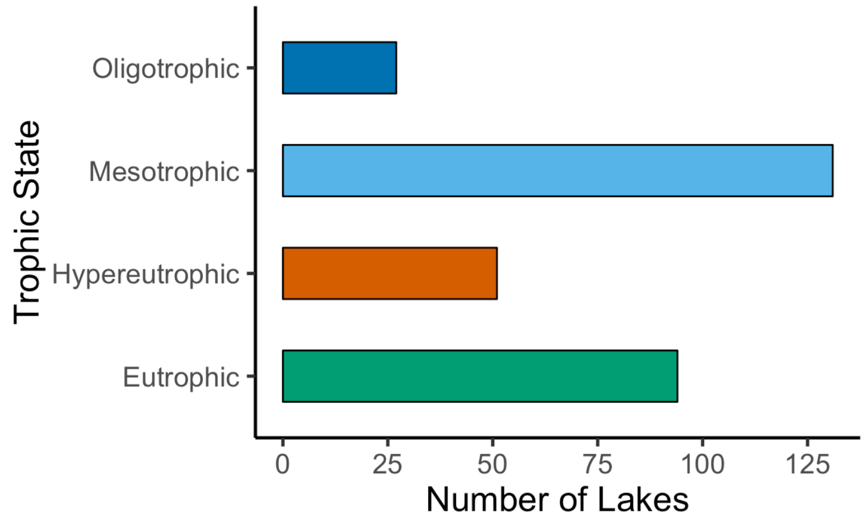

Figure 18 – Number of lakes sampled from 2015 to 2018 (n = 329) by Carlson TSI [chl-a].

While TSI[chl-a] is reported consistently throughout this report, the relationship between TSI[chl-a] and TSI[TP] is important for the sampled lakes (Figure 19). Over half of the lakes sampled from 2015 to 2018 fall below the predicted relationship (red line in Figure 19) between chlorophyll-a and total phosphorus according to Carlson (1977).

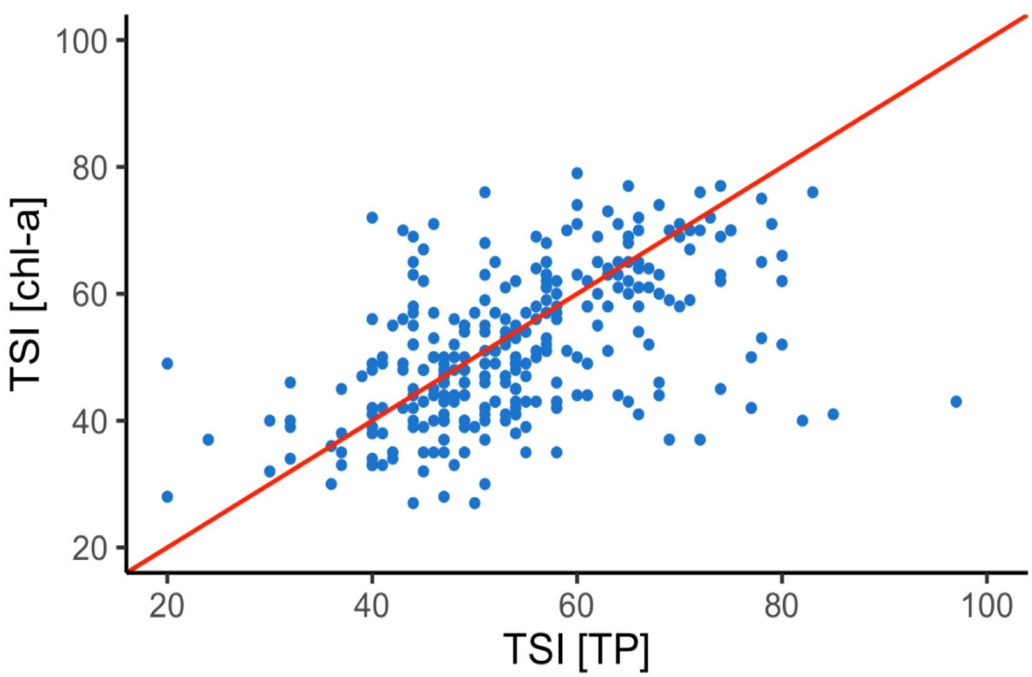

Figure 19 – Carlson TSI [TP] plotted against Carlson TSI [chl-a] for 329 lakes sampled from 2015 to 2018. The red line indicated the predicted relationship between TSI [TP] and TSI [chl-a].

Spatial Patterns

The 329 lakes sampled from 2015 to 2018 were located in 5 of the 6 ecoregions in Indiana (Figure 20). The Huron-Erie Lake Plain (Ecoregion 57) was the only ecoregion without a lake sampled. A majority of lakes sampled were in northeastern Indiana, with 58 percent occurring in the Southern Michigan/Northern Indiana Till Plain (Ecoregion 56).

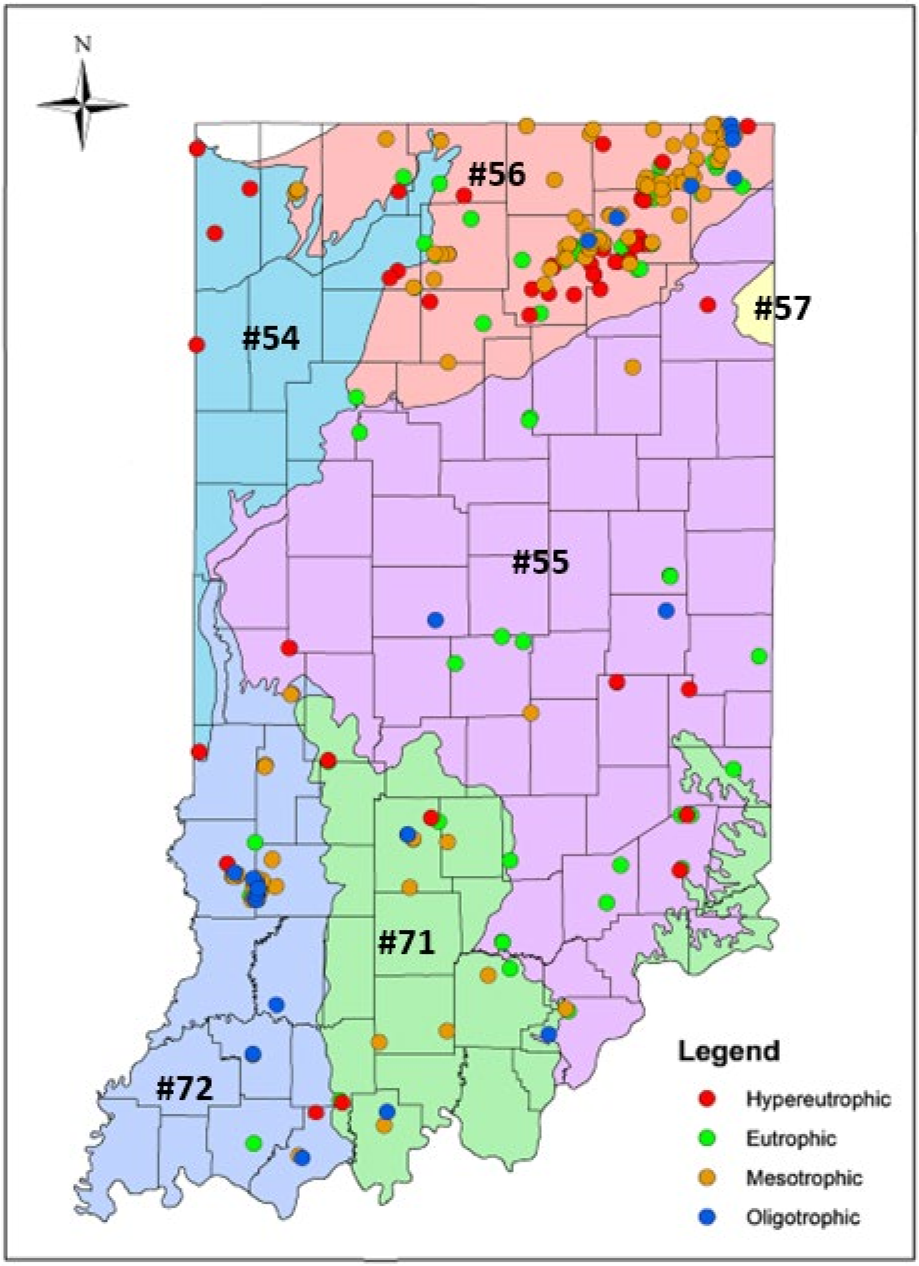

Figure 20 – Location of lakes from 2015 to 2018 (n = 329) by Carlson TSI [chl-a] overlain on Indiana ecoregions (represented by color and corresponding number).

The Eastern Corn Belt Plains (Ecoregion 55) and the Central Corn Belt Plains (Ecoregion 54) had the highest median chlorophyll-a concentrations of 61.5 ug/L and 58 ug/L, respectively (Figure 21). The Interior River Lowland (Ecoregion 72) had the lowest median chlorophyll-a concentration of 43.5 ug/L.

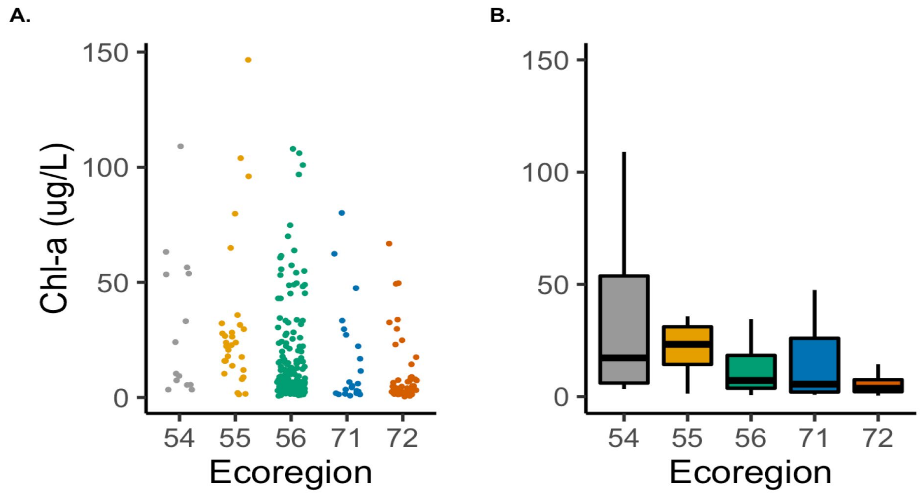

Figure 21 – Chloropyll-a (chl-a) distribution by ecoregion for 329 lakes sampled from 2015 to 2018. Figure **(A)** illustrates the total distribution by a dot plot and **(B)** illustrates the same distribution with a box pot.

Total phosphorus concentrations followed similar spatial patterns to that of chlorophyll-a concentrations (Figure 22). Ecoregion 54, 55, and 56 had higher median TP concentrations compared to that of Ecoregion 72 and 73. Median TP concentration was highest in Ecoregion 54 with a concentration of 0.123 mg/L, and Ecoregion 71 had the lowest median concentration of 0.039 mg/L.

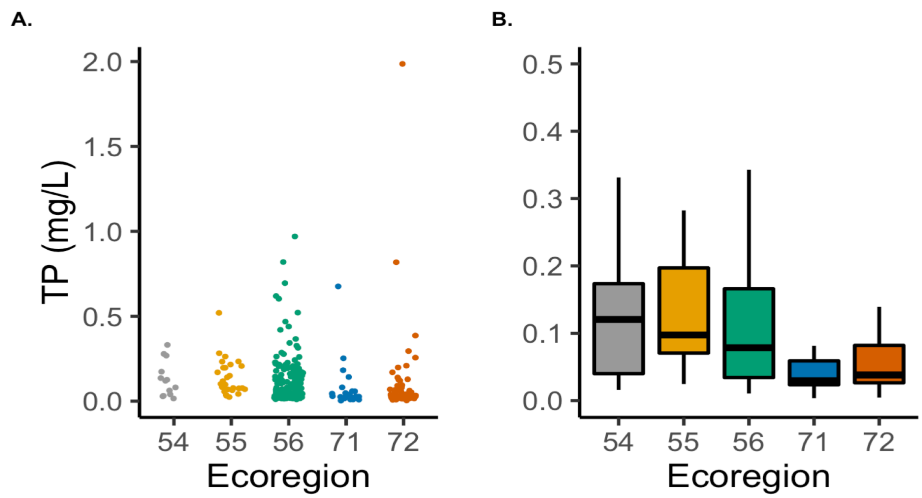

Figure 22 – Total phosphorus (TP) distribution by ecoregion for 320 lakes sampled from 2015 to 2018 by the **(A)** total TP distribution and the **(B)** TP distribution under 0.50 mg/L.

Median Secchi depths were highest in Ecoregion 72 (2.55 meters) and 56 (1.70 meters) (Figure 23). Ecoregion 55 — the Eastern Corn Belt Plains — had the lowest median Secchi depth of 0.90 meters. While the Southern Michigan/Northern Indiana Till Plain (Ecoregion 56) had a median Secchi depth of 1.70 meters, the ecoregion also contained the lake with the highest Secchi depth (Golden Lake, Steuben Co.) of 19 meters.

TSI[chl-a] median values followed similar trends across ecoregions with chlorophyll-a and total phosphorus (Figure 24). Median TSI[chl-a] values were highest in Ecoregion 54 and 55, both of which were above the bottom limit of the eutrophic classification of 51. Ecoregion 72 had the lowest median TSI[chl-a] value of 43.5.

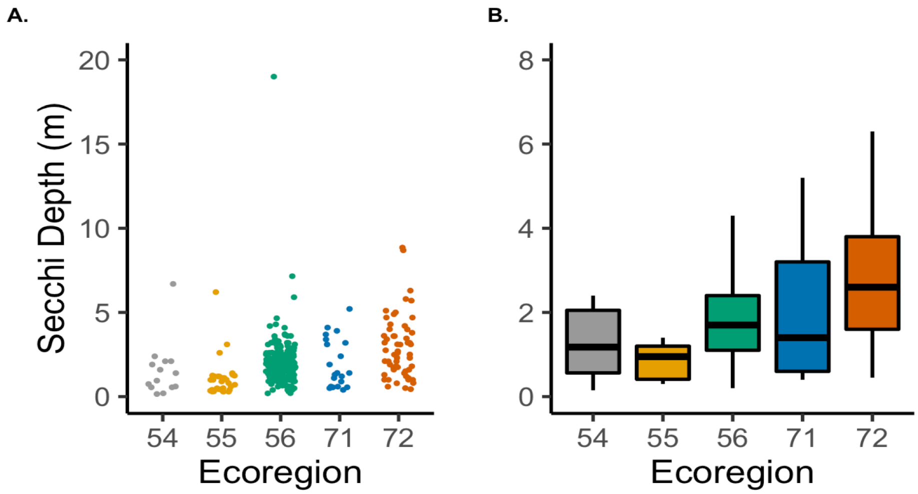

Figure 23 – Secchi depth distribution by ecoregion for 329 lakes sampled from 2015 to 2018 by the **(A)** total Secchi depth distribution and **(B)** Secchi depth values under 8 meters.

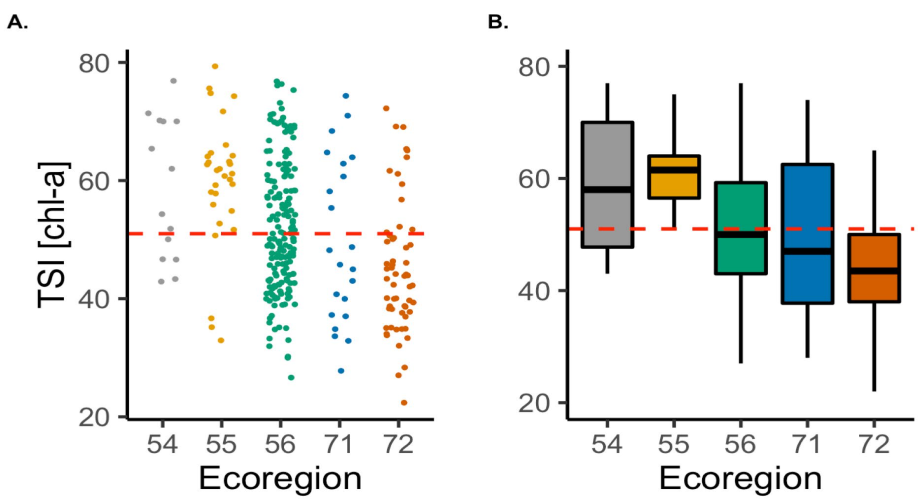

Figure 24 – Carlson TSI [chl-a] distribution by ecoregion for 329 lakes from 2015 to 2018. Figure **(A)** illustrates the total distribution by a dot plot and **(B)** illustrates the same distribution with a dox plot. The dashed line indicates the TSI break between eutrophic and mesotrophic.

Lake Type Characteristics

Natural lakes represented the most common lake type sampled during the project, accounting for 58 percent of all lakes sampled. Impoundments, or reservoirs, represented 24 percent of lakes sampled, and 17 percent of lakes were surface mine lakes.

Impoundments had the highest median surface area of all lake types, but the lowest median maximum depth (Figure 25, Figure 26). Impoundments also had the largest variation in surface area from 0.81 to 4,353.75 hectares. While the median surface area of natural lakes was less than half of the median for impoundments, natural lakes were the deepest of the three lake types. The median surface area and maximum depth for natural lakes was 30.35 hectares and 10.70 meters, respectively. Median surface area for surface mine lakes was the smallest of the three lake types, with a value of 2.63 hectares. Surface mine lakes were generally deeper than that of impoundments but shallower compared to natural lakes, with a median maximum depth of 7.62 meters. The largest lake sampled was Lake Monroe (Monroe Co.) and Tippecanoe Lake (Kosciusko Co.) was the deepest lake sampled.

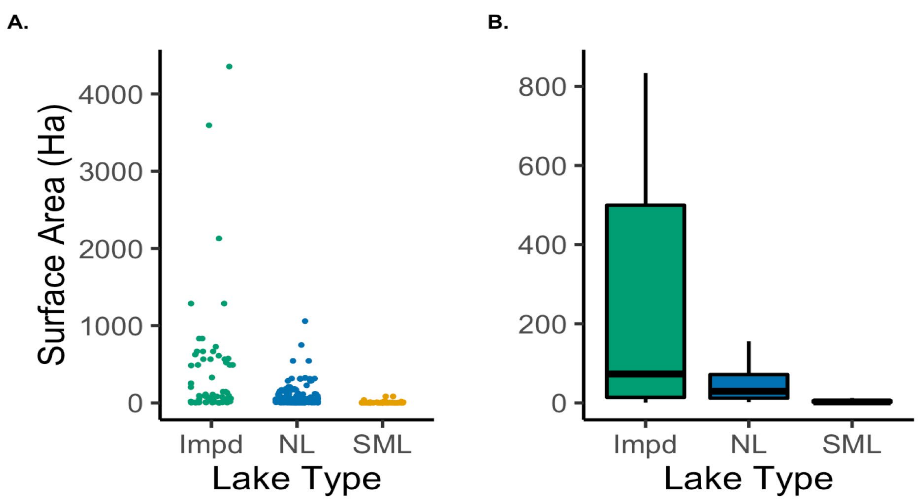

Figure 25 – Surface area distribution by lake type for 329 lakes sampled from 2015 to 2018 by the **(A)** total surface are distribution and **(B)** distribution under 850 hectares (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

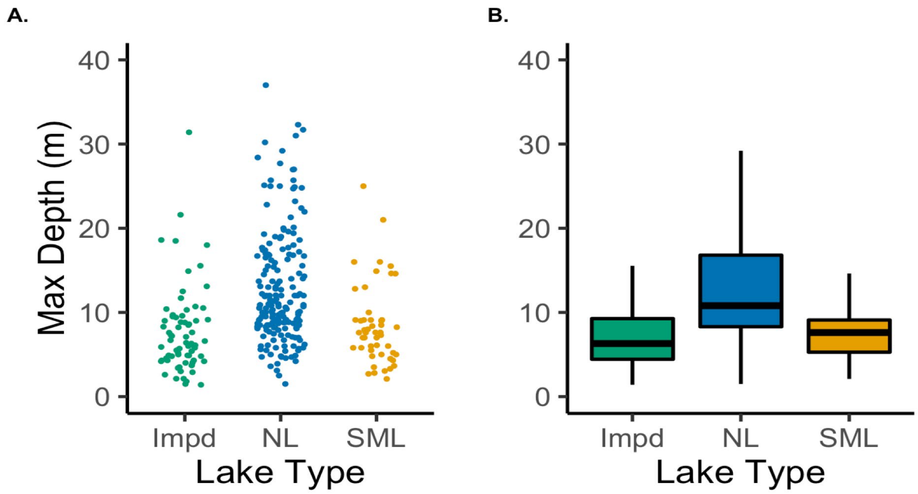

Figure 26 – Maximum depth distribution by lake type for 329 lakes sampled from 2015 to 2018. Figure **(A)** illustrates the total distribution by a dot plot and **(B)** illustrates the same distribution with a box plot (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

Natural lakes had the highest median average alkalinity concentration of 187.5 mg CaCO3/L (Figure 27). Median alkalinity concentration for surface mine lakes was 153 mg CaCO3/L, and surface mine lakes had the greatest alkalinity variation of the three lake types (47 to 1037.5 mg CaCO3/L). The median alkalinity concentration for impoundments was 115.5 mg CaCO3/L.

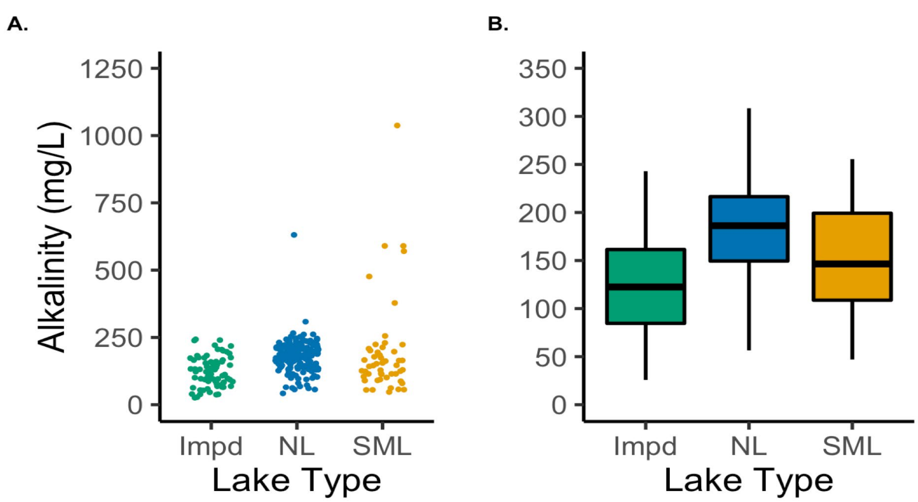

Figure 27 – Alkalinity distribution by lake type for 329 lakes sampled from 2015 to 2018 by **(A)** total alkalinity distribution and **(B)** distribution under 350 mg $CaCO_3$/L (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

Median average conductivity in surface mine lakes was almost twice the median of natural lakes, with conductivities of 872.50 and 457.83 umhos/cm, respectively (Figure 28). Surface mine lakes also had the greatest variation in conductivity, with values ranging from 158.15 to 2987.00 umhos/cm. Impoundments had the lowest conductivity of the lake types, with a median conductivity of 300.54 uhmos/cm.

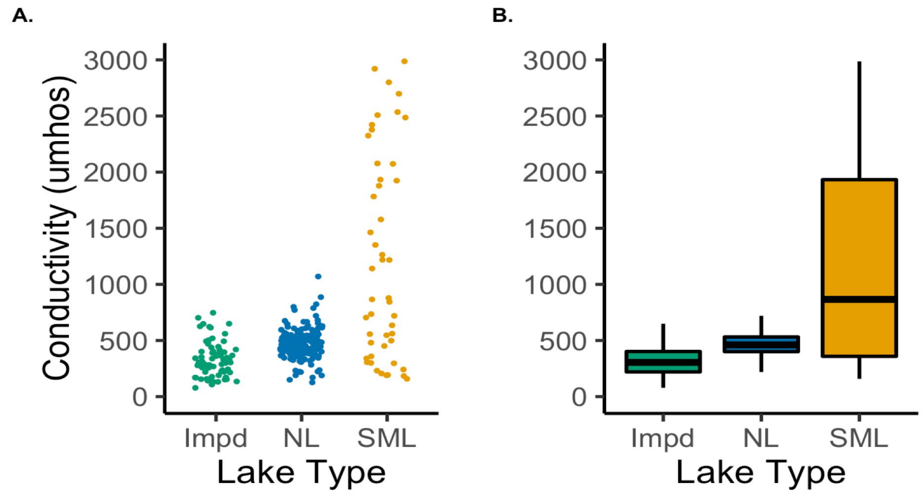

Figure 28 – Conductivity distribution by lake type for 329 lakes sampled from 2015 to 2018. Figure **(A)** illustrates the total distribution by a dot plot and **(B)** illustrates the same distribution with a box plot (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

Average pH values were consistent across the lake types, with only a 0.10 deviation between median pH values (Figure 29). Natural lakes had a median average pH of 7.6, and impoundments and surface mine lakes had the same median pH of 7.5.

Natural lakes had the highest median concentrations of NO_3-N, NH_3-N, and TP (Figure 30, Figure 31, Figure 32). Median concentrations of NO_3-N and NH_3-N in natural lakes were also more than twice the median concentration of impoundments and surface mine lakes. Median TP concentrations were less variable, with a variation of 0.01 mg/L between natural lakes and impoundments.

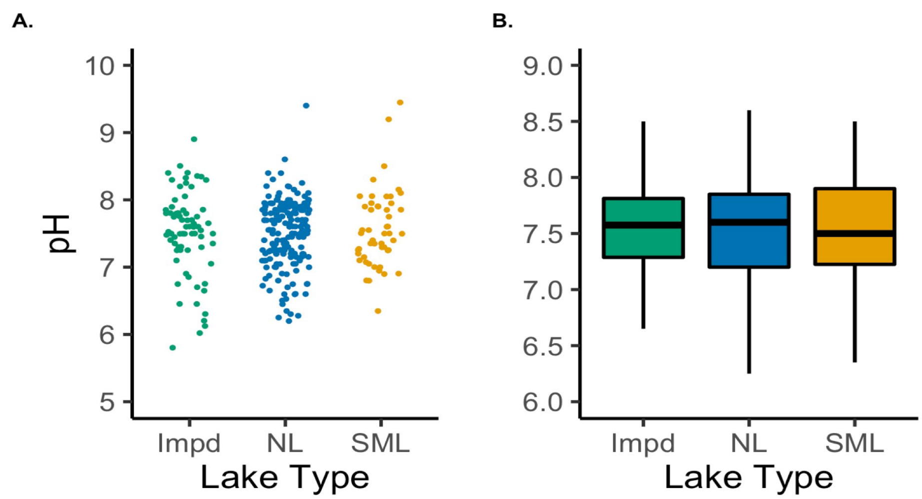

Figure 29 – pH distribution by lake type for 329 lakes sampled from 2015 to 2018 by **(A)** total pH distribution and **(B)** distribution from 6 to 9 pH units (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

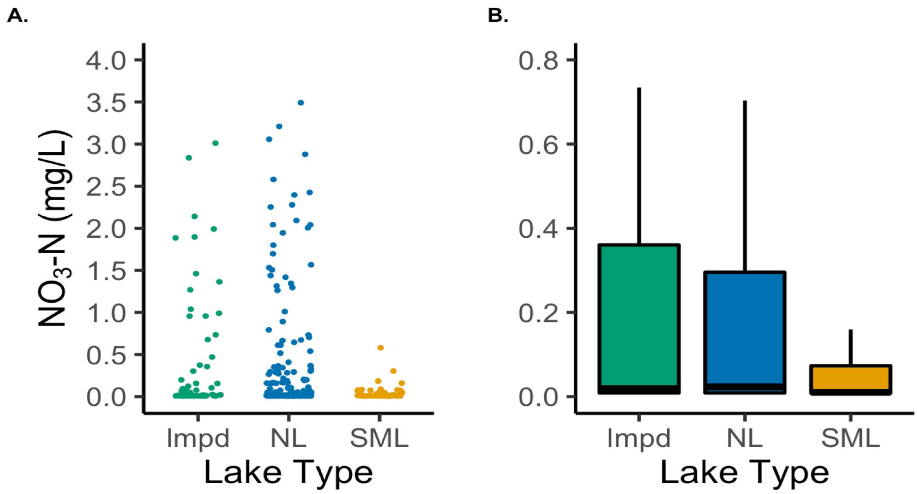

Figure 30 – Nitrate-nitrogen (NO_3-N) distribution by lake type for 329 lakes sampled from 2015 to 2018 by **(A)** total NO_3-N distribution and **(B)** distribution under 0.80 mg/L (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

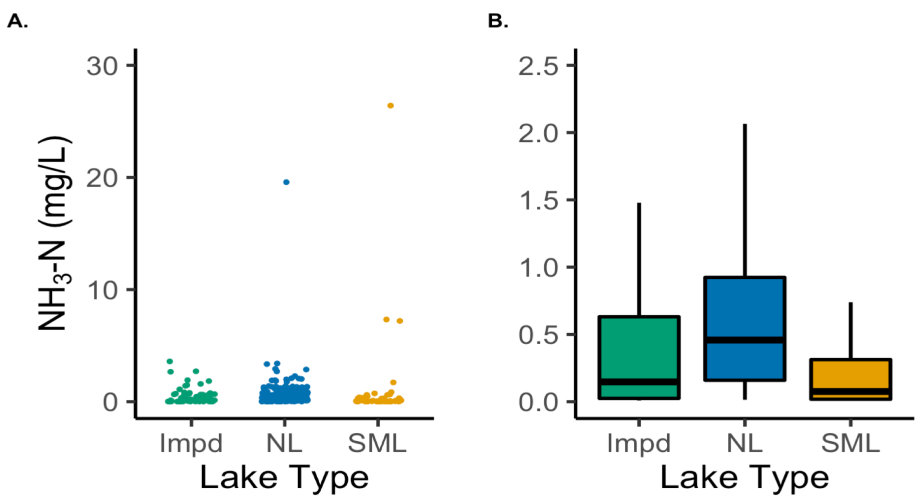

Figure 31 – Ammonia-nitrogen (NH_3-N) distribution by lake type for 329 lakes sampled from 2015 to 2018 by **(A)** total NH_3-N distribution and **(B)** distribution under 2.50 mg/L (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

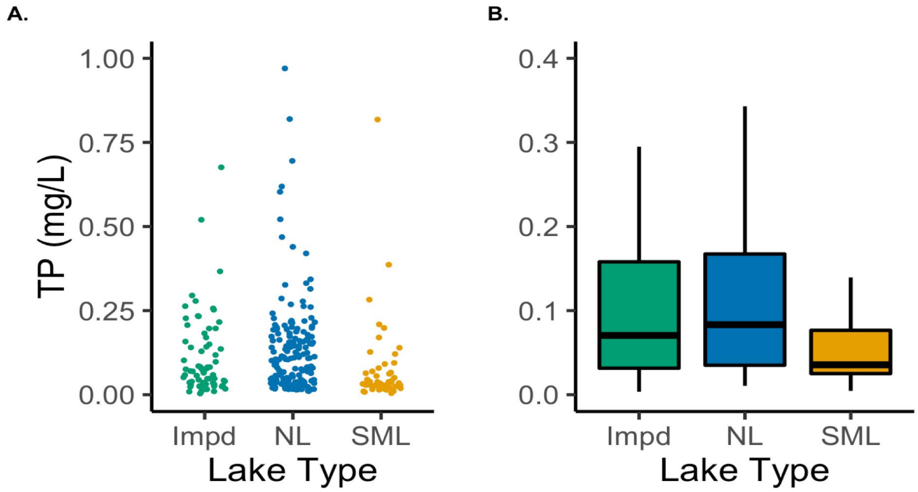

Figure 32 – Total phosphorus (TP) distribution by lake type for 329 lakes sampled from 2015 to 2018 by **(A)** total TP distribution and **(B)** distribution under 0.40 mg/L (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

Chlorophyll-a concentrations were highest in impoundments, with a median chlorophyll-a concentration of 17.900 ug/L (Figure 33). The maximum chlorophyll-a concentration across all lakes sample of 146.596 was also an impoundment. Natural lakes had the second highest median chlorophyll-a concentration of 7.423 followed by surface mine lakes of 3.183.

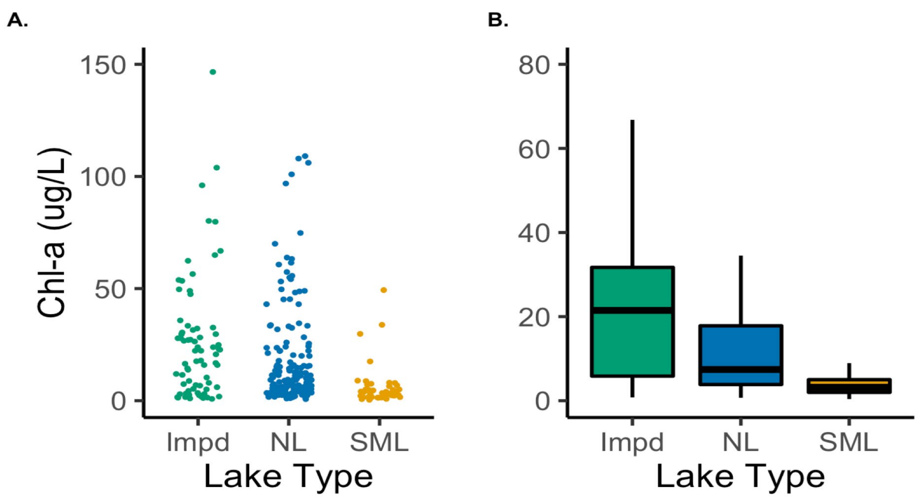

Figure 33 – Chlorophyll-a (chl-a) distribution by lake type for 329 lakes sampled from 2015 to 2018 by **(A)** total chl-a distribution and **(B)** distribution under 80 ug/L (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

Secchi depths by lake type followed an inverse relationship to that of chlorophyll-a (Figure 34). Median Secchi depth for surface mine lakes was 3.10 meters, 1.70 meters for natural lakes, and 1.05 meters for impoundments.

Median TSI[chl-a] values for impoundments were greater than the bottom limit for the eutrophic interpretation, with a median of 59 (Figure 35). The median value for natural lakes was only 1 unit from the bottom of the eutrophic limit as well, with a value of 50. Median TSI[chl-a] for surface mine lakes was 42. Overall, 60 percent of impoundments were either eutrophic or hypereutrophic, compared to 46 percent of natural lakes and 14 percent of surface mine lakes.

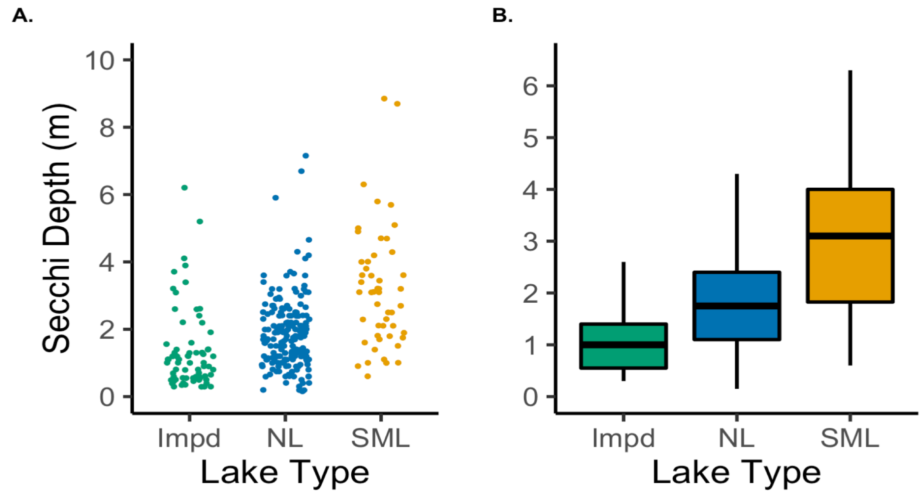

Figure 34 – Secchi depth distribution by lake type for 329 lakes sampled from 2015 to 2018 by **(A)** total Secchi depth distribution and **(B)** distribution under 6 meters (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

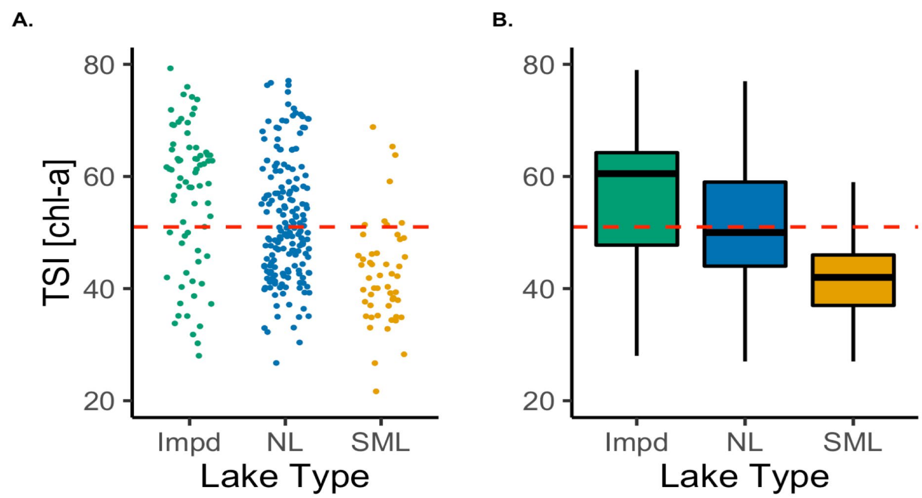

Figure 35 – TSI [chl-a] distribution by lake type for 329 lakes sampled from 2015 to 2018. Figure **(A)** illustrates the total TSI [chl-a] distribution by a dot plot and **(B)** illustrates the same distribution with a box plot (Impd = impoundments; NL = natural lakes; SML = surface mine lakes).

DISCUSSION

State of Indiana Lakes

Many lakes throughout the state of Indiana receive high nutrient loads, and thus are productive aquatic systems. This was expected as agricultural activity is a dominant land use throughout the state, and the subsequent runoff of nutrients — specifically nitrogen and phosphorus — would contribute to increased productivity in lakes.

While some lakes sampled had excessive levels of nitrogen, it appears *qualitatively* that many of the lakes sampled experience high phosphorus loading. Unlike nitrogen, phosphorus is bound in rock and sediment. As a result, phosphorus loading can occur at the water-sediment interface in the presence of anoxic conditions. Increased levels of SRP in the hypolimnion was common throughout the lakes sampled and indicates two interactions: the loading of phosphorus and the presence of thermal stratification. A molar relationship between nitrogen, phosphorus, and carbon — commonly referred to as the Redfield Ratio — is required to *quantitatively* determine if phosphorus is indeed the most common limiting nutrient for Indiana lakes.

Nitrogen and phosphorus are the primary nutrients for plant growth on lake and in the water. As a result, increased nutrient loading can contribute to increased algal growth. Algal communities occur in nearly all lakes and thus the presence of these communities is not necessarily an indication of impairment. However, certain algal groups are a concern due to their ability to produce nuisance blooms that can result in harmful conditions to both human and environmental health. Cyanobacteria (blue-green algae) are of particular concern in Indiana, and were common in many lakes sampled. Specifically, 27 percent of lakes sampled had blue-green communities that accounted for over 90 percent of all algal cells present. Understanding the presence of cyanobacteria cell density in lakes is an important management tool to identify the potential of harmful algal blooms (HABs) that can occur not only in the growing season, but throughout the entire year.

Trophic state is perhaps the most useful measure of the current state of Indiana Lakes, as well as a tool to compare Indiana to other states and regions across the United States. We found that nearly half (47 percent) of Indiana lakes were either eutrophic or hypereutrophic based on TSI [chl-a], indicating high levels of productivity. We did find some deviation in the relationship between the predicted relationship between TSI [chl-a] and TSI [TP]. According to Carlson (1977), chlorophyll-a concentrations can be predicted based on the TP concentration in the lake. However, we found that over half of the actual values were less than the predicted values. Non-algal turbidity is likely driving this deviation. Indiana Lakes are generally more turbid as a result of sediment runoff compared to the lakes that Carlson used in his model. Increased non-algal turbidity would reduce light penetration, decreasing the depth of the euphotic zone, and thus decrease algal photosynthesis. Therefore, by leveraging the known relationship with Carlson TSI values, we can gain additional insight on the function of Indiana lakes.

Spatial Patterns

Aggregating lakes by ecoregion is helpful to identify region differences in lake water quality. Ecoregion 54 (Eastern Corn Belt Plains) and 55 (Central Corn Belt Plains) had higher median values for chlorophyll-a, TP, and TSI [chl-a] compared to Ecoregions 56, 71, and 72. Row crop agriculture is the primary land use with Ecoregions 54 and 55. The relationship between agricultural fertilizers and lake eutrophication is well-established, and the high relevance of agriculture in these ecoregion is likely the cause of increased nutrient and trophic state (Novotny 2003).

Ecoregion 71 and 72 are located in southern Indiana, and have less agricultural activity, more forested land, and are primarily impoundments. Even though reservoirs have larger watersheds and have increased potential for larger nutrient loads, these ecoregions all had lower median values. This finding indicates the importance of land use on lake water quality. Unsurprisingly, ecoregion 71 and 72 had higher median Secchi depth measurements compared to ecoregion 54 and 55.

While we see qualitative differences in our lakes aggregated by ecoregion, further statistical analysis is needed to develop a quantitative comparison. A previous study conducted by Tetra Tech (2008) concluded that there were no significant differences between the geographic regions of Indiana in terms of water quality. However, their analysis instead concluded that there were significant differences between the three dominant lake types in Indiana.

Lake Type Patterns

Limnological characteristics can vary greatly with lake type. Our data included three lake types: natural lakes, impoundments, and surface mine lakes. Impoundments generally had a larger surface area, were shallower, and more productive compared to natural lakes and surface mine lakes. This finding was expected as larger watersheds can contribute higher nutrient loads and shallower lakes have a large portion of the water column in the euphotic zone, contributing to increased productivity.

Natural lakes were the deepest lakes sampled, and had median hypolimentic nutrient samples (e.g. TP, SRP) that were higher than that of impoundments and surface mine lakes. This is likely from the depth of the lake promoting increased thermal stability, causing the hypolimnion to be anoxic longer into the growing season, and promoting the release of sediment-bound phosphorus into the lake.

Surface mine lakes were unique compared to the other lake types. Surface mine lakes had high median alkalinity concentrations and extremely high conductivity values compared to the other lake types. Most surface mine lakes are located in southwestern Indiana which is characterized by limestone geology. As a result, these lakes have higher concentrations of calcium carbonate ($CaCO_3$). High conductivity in surface mine lakes is likely a byproduct of the mining process, where iron-sulfur compounds in mine waste can leach ions out of the soil and into the water column (Gyure et al. 1987). As conductivity is a measure of the ability of water to pass an electrical current, increased concentrations of dissolved ions cause higher conductivities in these lakes.

CONCLUSIONS

Summary conclusions from the 2015 to 2018 lake water quality assessment program include:

- Phosphorus concentrations in many Indiana lakes can be excessive and contribute to eutrophication.
- Internal phosphorus from lake sediments is an important source of phosphorus in many lakes, and is inherently difficult to control.
- High non-algal turbidity in many Indiana lakes results in reduced algal communities otherwise predicted by available phosphorus concentrations.
- Cyanobacteria (blue-green algae) are common in Indiana lakes, and should be monitored on lakes were cell dominance is high.
- Almost half of Indiana lakes assessed were either eutrophic or hypereutropohic. However, 44 percent of lakes were mesotrophic.
- Impoundments were generally the most productive lakes assessed.
- Carlson's Trophic State Index is a useful measure of overall tropic state in Indiana Lakes.
- Our randomized lake selection process — on average — generates data representative of Indiana lakes.

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APPENDICES

Appendix A – Information for Indiana lakes sampled from 2015 to 2018.

Lake Name	County	Lake Type	Year	Surface Area (ha)	Max depth (m)
Atwood	LaGrange	impoundment	2015	7.28	10.1
Bass	Sullivan	Surface Mine Lake	2015	85.39	16.0
Bass (N.Chain)	St. Joseph	natural lake	2015	35.61	9.6
Bear	Noble	natural lake	2015	55.04	17.2
Big Otter	Steuben	natural lake	2015	27.92	12.2
Big Turkey	LaGrange	natural lake	2015	182.12	20.1
Blackman	LaGrange	natural lake	2015	25.90	16.9
Bobcat	Greene	Surface Mine Lake	2015	2.00	9.0
Boones Pond	Boone	Surface Mine Lake	2015	3.24	8.4
Brush Creek Reservoir	Jennings	impoundment	2015	67.58	7.6
Cagles Mill (Cataract)	Putnam	impoundment	2015	566.58	12.5
Canada	Porter	natural lake	2015	4.05	7.0
Carr	Kosciusko	natural lake	2015	25.90	11.5
Cedar	Lake	natural lake	2015	316.07	4.2
Center	Kosciusko	natural lake	2015	48.56	13.0
Clear (LaPorte)	LaPorte	natural lake	2015	42.90	3.6
Crane	Noble	natural lake	2015	11.33	10.9
Crystal	Greene	Surface Mine Lake	2015	3.24	11.0
Failing	Steuben	natural lake	2015	9.31	12.0
Fish (Lower)	LaPorte	natural lake	2015	54.23	4.7
Fish (Upper)	LaPorte	natural lake	2015	56.25	7.1
Gambill	Sullivan	Surface Mine Lake	2015	4.86	13.0
Geist Reservoir	Marion	impoundment	2015	728.46	7.2
Goldeneye	Kosciusko	impoundment	2015	8.09	4.0
Goodman	Greene	Surface Mine Lake	2015	1.21	7.9
Goose	Kosciusko	natural lake	2015	10.93	12.2
Green	Steuben	natural lake	2015	9.71	10.7
Griffy	Monroe	impoundment	2015	52.61	9.0
Grouse Ridge	Bartholomew	impoundment	2015	8.09	8.6
Hackberry	Sullivan	Surface Mine Lake	2015	2.02	8.3
Hale	Sullivan	Surface Mine Lake	2015	6.07	8.5
Hartz	Starke	natural lake	2015	11.33	10.1
Hindman	Noble	natural lake	2015	5.26	6.0
Hog	LaPorte	natural lake	2015	23.88	16.8
Huntingburg City	Dubois	impoundment	2015	73.25	6.1
James	Kosciusko	natural lake	2015	108.05	19.0
John Hay	Washington	impoundment	2015	84.99	7.9
Kickapoo	Sullivan	impoundment	2015	12.14	11.6
King	Fulton	natural lake	2015	7.69	9.8
Larwill	Whitley	natural lake	2015	4.05	11.2

Lake Name	County	Lake Type	Year	Surface Area (ha)	Max depth (m)
Little Bause	Noble	natural lake	2015	2.83	5.0
Long	Porter	natural lake	2015	26.31	8.6
Loon	Steuben	natural lake	2015	55.85	18.0
Loon	Whitley	natural lake	2015	6.07	29.2
Manitou	Fulton	natural lake	2015	288.55	13.7
Mansfield Reservoir (Hardin)	Parke	impoundment	2015	833.68	18.5
Marsh	Steuben	natural lake	2015	22.66	12.0
Martin	LaGrange	natural lake	2015	10.52	17.5
Mud (Chain of Lakes)	Noble	natural lake	2015	3.24	6.0
Nauvoo	LaGrange	natural lake	2015	15.38	9.0
North Little	Kosciusko	natural lake	2015	4.86	8.5
Oliver	LaGrange	natural lake	2015	150.14	27.0
Oswego	Kosciusko	natural lake	2015	16.59	11.0
Otter	Steuben	natural lake	2015	47.75	9.5
Port Mitchell	Noble	natural lake	2015	6.07	9.9
Prairie Creek Reservoir	Delaware	impoundment	2015	492.12	9.0
Red Pine	Sullivan	Surface Mine Lake	2015	1.62	3.7
Redbud	Sullivan	Surface Mine Lake	2015	1.62	7.0
Ridinger	Kosciusko	natural lake	2015	55.04	12.0
Round	Whitley	natural lake	2015	53.00	19.6
Royer	LaGrange	natural lake	2015	27.92	17.7
Scales	Warrick	Surface Mine Lake	2015	26.71	6.3
Schlamm	Clark	impoundment	2015	285.31	6.9
Shakamak	Sullivan	impoundment	2015	22.66	6.6
Shipshewana	LaGrange	natural lake	2015	81.75	4.7
Shriner	Whitley	natural lake	2015	7.28	22.4
Skunk	Greene	Surface Mine Lake	2015	0.30	5.0
St. Joseph Reservoir	Allen	impoundment	2015	12.14	3.0
Starve Hollow	Jackson	impoundment	2015	58.68	4.3
Summit	Henry	impoundment	2015	329.83	14.9
Sycamore	Greene	Surface Mine Lake	2015	2.83	7.6
T Lake	Sullivan	Surface Mine Lake	2015	2.02	7.6
Todd	Greene	Surface Mine Lake	2015	3.24	10.0
Trimble	Greene	Surface Mine Lake	2015	3.64	3.0
Turtle	Sullivan	Surface Mine Lake	2015	3.24	7.0
Waveland	Montgomery	impoundment	2015	145.69	5.0
Wawasee	Kosciusko	natural lake	2015	1059.50	22.8
Webster	Kosciusko	natural lake	2015	313.24	15.5
White Oak #2	Knox	impoundment	2015	2.83	5.2
Willow	Sullivan	Surface Mine Lake	2015	1.62	9.8
Yellowwood	Brown	impoundment	2015	53.83	8.5

Lake Name	County	Lake Type	Year	Surface Area (ha)	Max depth (m)
Atwood	LaGrange	natural lake	2016	68.80	9.8
Ball	Steuben	natural lake	2016	35.21	19.8
Banning	Kosciusko	natural lake	2016	4.86	4.6
Bartley	Noble	natural lake	2016	13.76	9.3
Bass	Starke	natural lake	2016	544.32	6.7
Bear	Noble	natural lake	2016	55.04	16.7
Beaver Dam	Steuben	natural lake	2016	4.45	7.2
Bixler	Noble	natural lake	2016	47.35	11.6
Brush Creek Reservoir	Jennings	impoundment	2016	67.58	7.6
Cagles Mill (Cataract)	Putnam	impoundment	2016	566.58	11.7
Cedar	Lake	natural lake	2016	316.07	3.9
Celina	Perry	impoundment	2016	66.37	15.5
Chapel pit	Greene	Surface Mine Lake	2016	1.21	5.8
Chrisney	Spencer	impoundment	2016	10.52	4.0
Crane	Noble	natural lake	2016	11.33	10.8
Dallas	LaGrange	natural lake	2016	114.53	30.2
Diamond	Noble	natural lake	2016	42.49	23.2
Eagle Creek Reservoir	Marion	impoundment	2016	611.10	13.1
Elk Creek #9	Washington	impoundment	2016	19.43	6.4
Ferdinand City New	Dubois	impoundment	2016	4.05	4.3
Ferdinand City Old	Dubois	impoundment	2016	6.07	5.5
Fletcher	Fulton	natural lake	2016	18.21	12.0
Freeman	Carroll	impoundment	2016	626.07	10.5
Gage	Steuben	natural lake	2016	132.34	22.0
Gambill	Sullivan	Surface Mine Lake	2016	4.86	12.8
George	Steuben	natural lake	2016	205.99	25.0
George (Hobart)	Lake	impoundment	2016	109.27	2.1
Gilbert	Marshall	natural lake	2016	14.16	8.8
Goldeneye	Kosciusko	impoundment	2016	8.09	4.6
Green Valley	Vigo	impoundment	2016	20.24	4.9
Hackberry	Sullivan	Surface Mine Lake	2016	2.02	9.0
Hamiliton	Steuben	natural lake	2016	324.57	21.3
Hoffman	Kosciusko	natural lake	2016	75.68	9.4
Holem	Marshall	natural lake	2016	12.14	8.7
Hunter	Elkhart	natural lake	2016	40.07	8.5
Knapp	Noble	natural lake	2016	35.61	17.4
Kuhn	Kosciusko	natural lake	2016	47.75	8.1
Lake of the Woods	LaGrange	natural lake	2016	55.04	25.7
Lake of the Woods	Marshall	natural lake	2016	168.36	13.4
Lemon	Monroe	impoundment	2016	667.76	7.6
Long	Porter	natural lake	2016	26.31	9.1
Lower Fry	Sullivan	Surface Mine Lake	2016	1.62	2.1

Lake Name	County	Lake Type	Year	Surface Area (ha)	Max depth (m)
Maxinkuckee	Marshall	natural lake	2016	750.31	27.0
Mayfield	Sullivan	Surface Mine Lake	2016	6.07	7.6
McClures	Kosciusko	natural lake	2016	12.95	8.7
Miller (Chain-O)	Noble	natural lake	2016	4.45	8.8
Molenkramer Reservoir	Ripley	impoundment	2016	37.64	2.1
Monroe (Lower)	Monroe	impoundment	2016	4353.75	
Muncie	Noble	natural lake	2016	19.02	8.2
Nasby Mill Pond	LaGrange	impoundment	2016	14.16	1.4
Nauvoo	LaGrange	natural lake	2016	15.38	7.9
North Twin	LaGrange	natural lake	2016	54.63	12.0
Palestine	Kosciusko	impoundment	2016	93.89	8.2
Prairie Creek Reservoir	Delaware	impoundment	2016	492.12	8.8
Pretty	LaGrange	natural lake	2016	74.46	25.0
Redbud	Sullivan	Surface Mine Lake	2016	1.62	7.0
Rider	Noble	natural lake	2016	2.02	4.9
Robinson	Whitley	natural lake	2016	23.88	14.0
Rothenberger	Kosciusko	natural lake	2016	2.43	14.6
Sawmill	Kosciusko	natural lake	2016	10.93	7.5
Scheister	Clay	Surface Mine Lake	2016	4.13	14.6
Sellers	Kosciusko	natural lake	2016	12.95	6.1
Shaffer	White	impoundment	2016	522.47	5.7
Silver	Steuben	natural lake	2016	96.32	10.5
Simonton	Elkhart	natural lake	2016	114.13	7.3
Skunk	Greene	Surface Mine Lake	2016	0.30	4.3
South Twin	LaGrange	natural lake	2016	46.95	15.5
Springs Valley (Tucker)	Orange	impoundment	2016	57.06	9.1
Spurgeon Hollow	Washington	impoundment	2016	4.86	5.2
Star	Greene	Surface Mine Lake	2016	2.02	7.6
Steinbarger	Noble	natural lake	2016	29.54	11.3
Still	LaGrange	natural lake	2016	12.14	19.3
Story (Lower)	Dekalb	natural lake	2016	31.16	9.1
Story (Upper)	Dekalb	natural lake	2016		8.7
Sullivan	Sullivan	impoundment	2016	205.18	6.1
Tippecanoe	Kosciusko	natural lake	2016	286.12	32.3
University	Monroe	impoundment	2016	3.24	10.3
Upper Long	Noble	natural lake	2016	34.80	14.0
Webster	Kosciusko	natural lake	2016	313.24	14.3
Westler	LaGrange	natural lake	2016	35.61	9.8
Wolf	Lake	natural lake	2016	155.81	4.7
Adams	LaGrange	natural lake	2017	118.58	27.7
Airline	Greene	Surface Mine Lake	2017	10.12	21.0
Atwood	LaGrange	natural lake	2017	68.80	10.0

Lake Name	County	Lake Type	Year	Surface Area (ha)	Max depth (m)
Banning	Kosciusko	natural lake	2017	4.86	4.7
Barton	Steuben	natural lake	2017	38.04	9.1
Bass	Starke	natural lake	2017	544.32	7.0
Benefiel	Sullivan	Surface Mine Lake	2017	24.28	9.1
Big Chapman	Kosciusko	natural lake	2017	167.55	13.0
Big Turkey	LaGrange	natural lake	2017	182.12	19.4
Bischoff Res.	Ripley	impoundment	2017	80.94	6.3
Bowen	Noble	natural lake	2017	12.14	18.2
Brookville	Franklin	impoundment	2017	2128.72	31.4
Cedar	LaGrange	natural lake	2017	48.56	8.8
Chapel Pit	Greene	Surface Mine Lake	2017	1.21	6.0
Chrisney	Spencer	impoundment	2017	10.52	4.3
Clair	Huntington	Surface Mine Lake	2017	17.40	16.0
Crooked	Steuben	natural lake	2017	324.57	18.6
Crooked	Whitley	natural lake	2017	83.37	31.7
Crosley	Jennings	impoundment	2017	5.67	6.1
Dale Reservoir	Spencer	impoundment	2017	13.36	5.8
Deam	Clark	impoundment	2017	78.92	9.5
Dock	Noble	natural lake	2017	6.48	6.7
Eagle	Noble	natural lake	2017	32.78	13.1
Engle	Noble	natural lake	2017	19.43	8.2
Fish	LaGrange	natural lake	2017	40.47	24.8
Fish	Elkhart	natural lake	2017	13.76	8.3
Golden	Steuben	natural lake	2017	48.16	8.5
Goldeneye	Kosciusko	impoundment	2017	8.09	4.8
Griffy	Monroe	impoundment	2017	52.61	9.6
Hale	Sullivan	Surface Mine Lake	2017	6.07	9.1
Hammond	Greene	Surface Mine Lake	2017	2.43	8.0
Hartz	Starke	natural lake	2017	11.33	10.0
Henry	Steuben	natural lake	2017	8.09	6.2
Horshoe	Greene	Surface Mine Lake	2017	10.93	7.3
Hunter	Elkhart	natural lake	2017	40.07	8.8
Jimmerson	Steuben	natural lake	2017	114.53	16.8
John Hay	Washington	impoundment	2017	84.99	5.9
Kiser	Kosciusko	natural lake	2017	3.64	6.0
Latta	Noble	natural lake	2017	17.00	10.4
Lawrence	Marshall	natural lake	2017	27.92	20.0
Little Barbee	Kosciusko	natural lake	2017	27.52	7.1
Long	Porter	natural lake	2017	26.31	8.2
Loomis	Porter	natural lake	2017	25.09	16.7
Loon	Whitley	natural lake	2017	6.07	28.4
Manlove	Fayette	impoundment	2017	6.07	2.9

Lake Name	County	Lake Type	Year	Surface Area (ha)	Max depth (m)
Mansfield Reservoir (Hardin)	Parke	impoundment	2017	833.68	18.0
Mayfield	Sullivan	Surface Mine Lake	2017	6.07	7.9
McClish	Steuben	natural lake	2017	14.16	16.9
Mill Pond	Marshall	natural lake	2017	52.20	5.5
Miller (Chain-O)	Noble	natural lake	2017	4.45	7.3
Mississinewa Reservoir	Miami	impoundment	2017	1286.95	21.6
Molenkramer Res	Ripley	impoundment	2017	37.64	1.8
Mongo Mill Pond	LaGrange	natural lake	2017	29.54	2.5
Nasby Mill Pond	LaGrange	impoundment	2017	14.16	1.5
Oak	Clark	impoundment	2017	0.81	3.5
Otter	Steuben	natural lake	2017	47.75	8.8
Patoka Reservoir	Dubois	impoundment	2017	3593.74	7.3
Pleasant	Steuben	natural lake	2017	171.59	15.0
Price	Kosciusko	natural lake	2017	4.86	13.0
Riddles	St. Joseph	natural lake	2017	31.16	5.8
Rider	Noble	natural lake	2017	2.02	5.4
Robinson	Whitley	natural lake	2017	23.88	15.4
Sawmill	Kosciusko	natural lake	2017	10.93	7.7
Schlamm	Clark	impoundment	2017	7.69	6.6
Simonton	Elkhart	natural lake	2017	114.13	7.3
Snow	Steuben	natural lake	2017	125.46	24.7
Starve Hollow	Jackson	impoundment	2017	58.68	4.8
Steinbarger	Noble	natural lake	2017	29.54	11.9
Story (Upper)	Dekalb	natural lake	2017		8.3
Sylvan	Noble	impoundment	2017	254.96	9.4
Tipsaw	Perry	impoundment	2017	574.00	6.0
Trout	Sullivan	Surface Mine Lake	2017	2.02	6.0
Upper Long	Noble	natural lake	2017	34.80	16.2
Versailles	Ripley	impoundment	2017	93.08	4.2
Waldron	Noble	natural lake	2017	87.42	13.7
Webster	Kosciusko	natural lake	2017	313.24	14.5
West	Sullivan	Surface Mine Lake	2017	39.20	25.0
Westler	LaGrange	natural lake	2017	35.61	10.0
White Pine	Sullivan	Surface Mine Lake	2017	0.81	3.5
Woods (Big Blue #3)	Rush	impoundment	2017	17.81	4.2
Bass	Sullivan	Surface Mine Lake	2018	85.39	15.5
Bass (N. Chain)	St. Joseph	natural lake	2018	35.61	9.5
Baugher	Noble	natural lake	2018	12.95	10.7
Big Chapman	Kosciusko	natural lake	2018	167.55	12.0
Big Fry	Sullivan	Surface Mine Lake	2018	1.82	3.3
Big Long	LaGrange	natural lake	2018	148.12	25.7
Big Otter	Steuben	natural lake	2018	27.92	12.7

Lake Name	County	Lake Type	Year	Surface Area (ha)	Max depth (m)
Bobcat	Greene	Surface Mine Lake	2018	2.00	9.1
Bowen	Noble	natural lake	2018	12.14	18.8
Brokesha	LaGrange	natural lake	2018	14.57	5.7
Cagles Mill (Cataract)	Putnam	impoundment	2018	566.58	10.7
Canada	Porter	natural lake	2018	4.05	6.7
Chapel Pit	Greene	Surface Mine Lake	2018	1.21	6.1
Clear	Greene	Surface Mine Lake	2018	1.21	5.8
Dallas	LaGrange	natural lake	2018	114.53	31.0
Duely	Noble	natural lake	2018	8.50	5.8
Engle	Noble	natural lake	2018	19.43	8.1
Failing "Gentian"	Steuben	natural lake	2018	9.31	10.0
Ferdinand City New	Dubois	impoundment	2018	4.05	4.3
Fish	Steuben	natural lake	2018	23.88	8.1
Fox	Sullivan	Surface Mine Lake	2018		9.1
Fry	Sullivan	Surface Mine Lake	2018	1.62	2.7
George	Steuben	natural lake	2018	205.99	24.9
Golden	Steuben	natural lake	2018	48.16	9.2
Gooseneck	Steuben	natural lake	2018	10.12	10.3
Gordy	Noble	natural lake	2018	12.55	10.6
Goshen Dam Pond	Elkhart	impoundment	2018	57.47	2.6
Hogback	Steuben	natural lake	2018	59.09	7.9
Impoundment No. 26	Sullivan	Surface Mine Lake	2018	19.02	2.8
J.C. Murphy	Newton	impoundment	2018	485.64	3.4
Kings	Fulton	natural lake	2018	7.69	9.5
Knapp	Noble	natural lake	2018	35.61	17.7
Latta	Noble	natural lake	2018	17.00	10.9
Lawrence	Marshall	natural lake	2018	27.92	19.0
Little Bause	Noble	natural lake	2018	2.83	4.8
Little Chapman	Kosciusko	natural lake	2018	48.56	9.2
Little Otter	Steuben	natural lake	2018	13.76	10.5
Little Pike	Kosciusko	natural lake	2018	10.12	3.1
Locust	Sullivan	Surface Mine Lake	2018	2.83	4.8
Loomis	Porter	natural lake	2018	25.09	16.5
Loon	Steuben	natural lake	2018	55.85	5.5
McClish	Steuben	natural lake	2018	14.16	17.0
Middlefork Res.	Wayne	impoundment	2018	112.10	9.7
Mink	Porter	natural lake	2018	14.16	
Mississinewa Res.	Miami	impoundment	2018	1286.95	18.6
Nauvoo	LaGrange	natural lake	2018	15.38	8.3
Pike	Kosciusko	natural lake	2018	82.15	9.9
Pleasant	Steuben	natural lake	2018	171.59	12.8
Port Mitchell	Noble	natural lake	2018	6.07	9.7

Lake Name	County	Lake Type	Year	Surface Area (ha)	Max depth (m)
Potato Cr. (Worster)	St. Joseph	impoundment	2018	132.34	5.4
Prarie Creek Reservoir	Deleware	impoundment	2018	492.12	8.8
Pretty	LaGrange	natural lake	2018	74.46	25.1
Prides Creek	Pie	impoundment	2018	36.42	8.3
Redbud	Sullivan	Surface Mine Lake	2018	1.62	
Riddles	St. Joseph	natural lake	2018	31.16	5.6
Robinson	Whitley	natural lake	2018	23.88	15.2
Rothenberger	Kosciusko	natural lake	2018	2.43	8.5
Sand	Noble	natural lake	2018	19.02	15.9
Scales	Warrick	Surface Mine Lake	2018	26.71	5.2
Scheister	Clay	Surface Mine Lake	2018	4.13	14.9
Scott	Greene	Surface Mine Lake	2018	4.86	14.6
Shakamak	Sullivan	impoundment	2018	22.66	6.7
Silver	Steuben	natural lake	2018	96.32	9.1
Skunk	Greene	Surface Mine Lake	2018	0.30	4.5
Spencer	Sullivan	Surface Mine Lake	2018	2.43	5.5
Starve Hollow	Jackson	impoundment	2018	58.68	4.9
Steinbarger	Noble	natural lake	2018	29.54	12.0
Stump Jumper	Clay	Surface Mine Lake	2018	2.39	9.1
Syl-Van	Steuben	natural lake	2018	9.71	11.0
Syracuse	Kosciusko	natural lake	2018	228.25	10.1
Tamarack	LaPorte	natural lake	2018	8.09	1.5
Thomas	Marshall	natural lake	2018	6.48	13.7
Tippecanoe	Kosciusko	natural lake	2018	286.12	37.0
Twin Pitts, East	Pike	Surface Mine Lake	2018	12.55	5.0
Twin Pitts, West	Pike	Surface Mine Lake	2018	7.28	2.7
University	Monroe	impoundment	2018	3.24	10.4
Upper Long	Noble	natural lake	2018	34.80	16.3
Versailles	Ripley	impoundment	2018	93.08	4.9
Waveland	Montgomery	impoundment	2018	145.69	6.0
Webster	Kosciusko	natural lake	2018	313.24	15.0
Woods (Big Blue #3)	Rush	impoundment	2018	17.81	4.3

Appendix B – Trophic state indices for all lakes sampled from 2015 to 2018.

Lake Name	County	Year	TSI [SD]	TSI [Chl-a]	TSI [TP]
Atwood	LaGrange	2015	52	46	46
Bass	Sullivan	2015	39	40	49
Bass (N.Chain)	St. Joseph	2015	49	43	54
Bear	Noble	2015	57	62	61
Big Otter	Steuben	2015	53	52	48
Big Turkey	LaGrange	2015	51	50	46
Blackman	LaGrange	2015	49	42	51
Bobcat	Greene	2015	46	40	47
Boones Pond	Boone	2015	44	33	48
Brush Creek Reservoir	Jennings	2015	67		65
Cagles Mill (Cataract)	Putnam	2015	67	64	
Canada	Porter	2015	55	54	51
Carr	Kosciusko	2015	67	69	44
Cedar	Lake	2015	83	77	74
Center	Kosciusko	2015	46	47	55
Clear (LaPorte)	LaPorte	2015	60	51	57
Crane	Noble	2015	56	60	68
Crystal	Greene	2015	52		59
Failing	Steuben	2015	47	42	44
Fish (Lower)	LaPorte	2015	62	51	51
Fish (Upper)	LaPorte	2015	57	58	56
Gambill	Sullivan	2015	29	33	41
Geist Reservoir	Marion	2015	60	61	64
Goldeneye	Kosciusko	2015	49	50	77
Goodman	Greene	2015	44	38	37
Goose	Kosciusko	2015	45	42	41
Green	Steuben	2015	56	35	42
Griffy	Monroe	2015	36	33	37
Grouse Ridge	Bartholomew	2015	55	55	51
Hackberry	Sullivan	2015	42	51	57
Hale	Sullivan	2015	43	44	60
Hartz	Starke	2015	56	53	53
Hindman	Noble	2015	52	57	55
Hog	LaPorte	2015	47	45	44
Huntingburg City	Dubois	2015	67		58

Lake Name	County	Year	TSI [SD]	TSI [Chl-a]	TSI [TP]
James	Kosciusko	2015		53	57
John Hay	Washington	2015	45		57
Kickapoo	Sullivan	2015	38		52
King	Fulton	2015	73	70	72
Larwill	Whitley	2015	62	75	78
Little Bause	Noble	2015	50	77	65
Long	Porter	2015	49	47	51
Loon	Steuben	2015	34	51	52
Loon	Whitley	2015	59	73	63
Manitou	Fulton	2015	73	61	
Mansfield Reservoir (Hardin)	Parke	2015	63	65	
Marsh	Steuben	2015	50	49	47
Martin	LaGrange	2015	55	60	65
Mud (Chain of Lakes)	Noble	2015	59	70	59
Nauvoo	LaGrange	2015	62	58	61
North Little	Kosciusko	2015	55	54	66
Oliver	LaGrange	2015	52	48	54
Oswego	Kosciusko	2015	51	43	58
Otter	Steuben	2015	50	49	54
Port Mitchell	Noble	2015	59	69	65
Prairie Creek Reservoir	Delaware	2015	57	59	71
Red Pine	Sullivan	2015	52	64	67
Redbud	Sullivan	2015	53	49	54
Ridinger	Kosciusko	2015	70	65	57
Round	Whitley	2015	54	57	52
Royer	LaGrange	2015	63	62	54
Scales	Warrick	2015	63		59
Schlamm	Clark	2015	59		54
Shakamak	Sullivan	2015			65
Shipshewana	LaGrange	2015	77	70	75
Shriner	Whitley	2015	47	57	57
Skunk	Greene	2015	49	45	54
St. Joseph Reservoir	Allen	2015	75	65	78
Starve Hollow	Jackson	2015	63		69
Summit	Henry	2015	34	35	

Lake Name	County	Year	TSI [SD]	TSI [Chl-a]	TSI [TP]
Sycamore	Greene	2015	60	45	37
T Lake	Sullivan	2015	47	39	49
Todd	Greene	2015	35	35	37
Trimble	Greene	2015	54	46	47
Turtle	Sullivan	2015	42	35	47
Waveland	Montgomery	2015	77	75	
Wawasee	Kosciusko	2015	47	40	53
Webster	Kosciusko	2015	52	43	58
White Oak #2	Knox	2015	65		65
Willow	Sullivan	2015	42		44
Yellowwood	Brown	2015	47	41	53
Atwood	LaGrange	2016	53	40	47
Ball	Steuben	2016	61	56	40
Banning	Kosciusko	2016	52	54	53
Bartley	Noble	2016	60	63	57
Bass	Starke	2016	83	71	70
Bear	Noble	2016	52	57	58
Beaver Dam	Steuben	2016	46	42	51
Bixler	Noble	2016	45	48	49
Brush Creek Reservoir	Jennings	2016	63	64	56
Cagles Mill (Cataract)	Putnam	2016	73	71	60
Cedar	Lake	2016	87	71	79
Celina	Perry	2016	43	34	42
Chapel pit	Greene	2016	45	40	49
Chrisney	Spencer	2016	56	39	50
Crane	Noble	2016	66	65	62
Dallas	LaGrange	2016	59	48	48
Diamond	Noble	2016	52	50	41
Eagle Creek Reservoir	Marion	2016	57	59	57
Elk Creek #9	Washington	2016	44	46	47
Ferdinand City New	Dubois	2016	73		82
Ferdinand City Old	Dubois	2016	53	61	53
Fletcher	Fulton	2016	48	47	47
Freeman	Carroll	2016	60	64	63
Gage	Steuben	2016	43	30	36

Lake Name	County	Year	TSI [SD]	TSI [Chl-a]	TSI [TP]
Gambill	Sullivan	2016	29	27	44
George	Steuben	2016	32	33	40
George (Hobart)	Lake	2016	69	70	75
Gilbert	Marshall	2016	64	62	58
Goldeneye	Kosciusko	2016	49	47	47
Green Valley	Vigo	2016	69	70	69
Hackberry	Sullivan	2016	37	39	40
Hamiliton	Steuben	2016	45	44	46
Hoffman	Kosciusko	2016	55	52	53
Holem	Marshall	2016	47	44	49
Hunter	Elkhart	2016	44	43	52
Knapp	Noble	2016	50	44	44
Kuhn	Kosciusko	2016	44	39	45
Lake of the Woods	LaGrange	2016	41	41	54
Lake of the Woods	Marshall	2016	49	55	42
Lemon	Monroe	2016	70	68	57
Long	Porter	2016	49	47	53
Lower Fry	Sullivan	2016	52	52	44
Maxinkuckee	Marshall	2016	58	41	40
Mayfield	Sullivan	2016	36	34	32
McClures	Kosciusko	2016	67	69	65
Miller (Chain-O)	Noble	2016	52	56	56
Molenkramer Reservoir	Ripley	2016	77	76	83
Monroe (Lower)	Monroe	2016		49	20
Muncie	Noble	2016	64	70	66
Nasby Mill Pond	LaGrange	2016	54	30	51
Nauvoo	LaGrange	2016	52	50	47
North Twin	LaGrange	2016	47	40	32
Palestine	Kosciusko	2016	66	69	74
Prairie Creek Reservoir	Delaware	2016	57	56	48
Pretty	LaGrange	2016	40	36	36
Redbud	Sullivan	2016	41	38	40
Rider	Noble	2016	54	54	49
Robinson	Whitley	2016	59	55	62
Rothenberger	Kosciusko	2016	41	43	45

Lake Name	County	Year	TSI [SD]	TSI [Chl-a]	TSI [TP]
Sawmill	Kosciusko	2016	63	60	58
Scheister	Clay	2016	38	39	40
Sellers	Kosciusko	2016	67	70	71
Shaffer	White	2016	62	64	66
Silver	Steuben	2016	42	39	44
Simonton	Elkhart	2016	52	49	40
Skunk	Greene	2016	49	50	49
South Twin	LaGrange	2016	52	39	32
Springs Valley (Tucker)	Orange	2016	41	40	30
Spurgeon Hollow	Washington	2016	55	55	54
Star	Greene	2016	42	38	41
Steinbarger	Noble	2016	58	57	46
Still	LaGrange	2016	56	48	45
Story (Lower)	Dekalb	2016	44	42	43
Story (Upper)	Dekalb	2016	53	52	44
Sullivan	Sullivan	2016	72	72	66
Tippecanoe	Kosciusko	2016	53	46	47
University	Monroe	2016	59	58	58
Upper Long	Noble	2016	52	49	54
Webster	Kosciusko	2016	56	56	58
Westler	LaGrange	2016	61	55	49
Wolf	Lake	2016	61	65	65
Adams	LaGrange	2017	49	47	39
Airline	Greene	2017	33	22	14
Atwood	LaGrange	2017	47	46	32
Banning	Kosciusko	2017	52		57
Barton	Steuben	2017	50	40	47
Bass	Starke	2017	83	76	72
Benefiel	Sullivan	2017	34		14
Big Chapman	Kosciusko	2017	51	49	43
Big Turkey	LaGrange	2017	47	53	46
Bischoff Res.	Ripley	2017	67	63	68
Bowen	Noble	2017	50	46	58
Brookville	Franklin	2017	46	52	44
Cedar	LaGrange	2017	42	40	46

Lake Name	County	Year	TSI [SD]	TSI [Chl-a]	TSI [TP]
Chapel Pit	Greene	2017	51	49	41
Chrisney	Spencer	2017	46	32	30
Clair	Huntington	2017	62	37	69
Crooked	Steuben	2017	49	37	47
Crooked	Whitley	2017	39	39	55
Crosley	Jennings	2017	59	58	63
Dale Reservoir	Spencer	2017	70	69	70
Deam	Clark	2017	51	28	47
Dock	Noble	2017	60	61	66
Eagle	Noble	2017	45	27	50
Engle	Noble	2017	47	48	49
Fish	LaGrange	2017	73	65	57
Fish	Elkhart	2017	57		67
Golden	Steuben	2017	18	54	54
Goldeneye	Kosciusko	2017	46	41	54
Griffy	Monroe	2017	40	35	46
Hale	Sullivan	2017	40	28	20
Hammond	Greene	2017	35	34	40
Hartz	Starke	2017	46	50	46
Henry	Steuben	2017	49	49	61
Horshoe	Greene	2017	42	40	44
Hunter	Elkhart	2017	48		32
Jimmerson	Steuben	2017	48	43	56
John Hay	Washington	2017	40	37	51
Kiser	Kosciusko	2017	47	47	53
Latta	Noble	2017	55	42	40
Lawrence	Marshall	2017	45	41	47
Little Barbee	Kosciusko	2017	59		54
Long	Porter	2017	47	43	48
Loomis	Porter	2017	53	43	97
Loon	Whitley	2017	62	65	62
Manlove	Fayette	2017	73	66	80
Mansfield Reservoir (Hardin)	Parke	2017	63	50	54
Mayfield	Sullivan	2017	38	35	42
McClish	Steuben	2017	49	33	40

Lake Name	County	Year	TSI [SD]	TSI [Chl-a]	TSI [TP]
Mill Pond	Marshall	2017	53	49	51
Miller (Chain-O)	Noble	2017	59	61	66
Mississinewa Reservoir	Miami	2017	59	60	62
Molenkramer Res	Ripley	2017	77	62	80
Mongo Mill Pond	LaGrange	2017	57	44	68
Nasby Mill Pond	LaGrange	2017	56	63	60
Oak	Clark	2017	65	58	59
Otter	Steuben	2017	54	49	52
Patoka Reservoir	Dubois	2017	57	37	24
Pleasant	Steuben	2017	52	49	55
Price	Kosciusko	2017	44	32	45
Riddles	St. Joseph	2017	67	67	71
Rider	Noble	2017	52	55	44
Robinson	Whitley	2017	67	71	64
Sawmill	Kosciusko	2017	59	62	57
Schlamm	Clark	2017	55	45	54
Simonton	Elkhart	2017	52		39
Snow	Steuben	2017	47	46	51
Starve Hollow	Jackson	2017	56	51	56
Steinbarger	Noble	2017	59	61	67
Story (Upper)	Dekalb	2017	52	57	57
Sylvan	Noble	2017	57	58	61
Tipsaw	Perry	2017	56	48	47
Trout	Sullivan	2017	52	52	57
Upper Long	Noble	2017	59	41	85
Versailles	Ripley	2017	77	62	74
Waldron	Noble	2017	59	65	64
Webster	Kosciusko	2017	49	54	55
West	Sullivan	2017	60	43	52
Westler	LaGrange	2017	46	50	60
White Pine	Sullivan	2017	44	38	54
Woods (Big Blue #3)	Rush	2017	70	63	64
Bass	Sullivan	2018	40	37	
Bass (N. Chain)	St. Joseph	2018	46	40	82
Baugher	Noble	2018	62	65	66

Lake Name	County	Year	TSI [SD]	TSI [Chl-a]	TSI [TP]
Big Chapman	Kosciusko	2018	50	47	53
Big Fry	Sullivan	2018	60	65	44
Big Long	LaGrange	2018	42	44	49
Big Otter	Steuben	2018	46	47	51
Bobcat	Greene	2018	52	44	48
Bowen	Noble	2018	67	72	40
Brokesha	LaGrange	2018	43	48	40
Cagles Mill (Cataract)	Putnam	2018	62	65	52
Canada	Porter	2018	33	50	
Chapel Pit	Greene	2018	48	42	77
Clear	Greene	2018	44	46	49
Dallas	LaGrange	2018	54	45	46
Duely	Noble	2018	49	56	43
Engle	Noble	2018	50	51	59
Failing "Gentian"	Steuben	2018	44	35	45
Ferdinand City New	Dubois	2018	69	74	60
Fish	Steuben	2018	57	68	51
Fox	Sullivan	2018	59	51	52
Fry	Sullivan	2018	49	48	39
George	Steuben	2018	38	44	61
Golden	Steuben	2018	60	58	66
Gooseneck	Steuben	2018	44	35	49
Gordy	Noble	2018	43	47	
Goshen Dam Pond	Elkhart	2018	63	42	51
Hogback	Steuben	2018	57	58	70
Impoundment No. 26	Sullivan	2018	67	69	56
J.C. Murphy	Newton	2018	67	70	43
Kings	Fulton	2018	57	56	53
Knapp	Noble	2018	49	51	63
Latta	Noble	2018	57	45	74
Lawrence	Marshall	2018	43	37	72
Little Bause	Noble	2018	42	40	51
Little Chapman	Kosciusko	2018	57	63	63
Little Otter	Steuben	2018	49	52	67
Little Pike	Kosciusko	2018	63	67	45

Lake Name	County	Year	TSI [SD]	TSI [Chl-a]	TSI [TP]
Locust	Sullivan	2018	43	44	64
Loomis	Porter	2018	51	52	80
Loon	Steuben	2018	51	48	45
McClish	Steuben	2018	43	41	66
Middlefork Res.	Wayne	2018	70	63	57
Mink	Porter	2018			55
Mississinewa Res.	Miami	2018	57	53	78
Nauvoo	LaGrange	2018	56	58	44
Pike	Kosciusko	2018	62	68	65
Pleasant	Steuben	2018	50	43	47
Port Mitchell	Noble	2018	55	57	50
Potato Cr. (Worster)	St. Joseph	2018	65	63	51
Prarie Creek Reservoir	Deleware	2018	57	61	57
Pretty	LaGrange	2018	39	41	51
Prides Creek	Pie	2018	57	57	44
Redbud	Sullivan	2018		44	47
Riddles	St. Joseph	2018	64	69	62
Robinson	Whitley	2018	65		58
Rothenberger	Kosciusko	2018	49	53	54
Sand	Noble	2018	54	62	65
Scales	Warrick	2018	55	59	69
Scheister	Clay	2018	37	42	54
Scott	Greene	2018	39	35	58
Shakamak	Sullivan	2018	60	62	45
Silver	Steuben	2018	49	46	68
Skunk	Greene	2018	48	46	49
Spencer	Sullivan	2018	47	46	53
Starve Hollow	Jackson	2018	60	63	74
Steinbarger	Noble	2018	66	71	46
Stump Jumper	Clay	2018	43	50	48
Syl-Van	Steuben	2018	46	43	55
Syracuse	Kosciusko	2018	47	50	56
Tamarack	LaPorte	2018	46	76	51
Thomas	Marshall	2018	56	55	49
Tippecanoe	Kosciusko	2018	47	48	43

Lake Name	County	Year	TSI [SD]	TSI [Chl-a]	TSI [TP]
Twin Pitts, East	Pike	2018	42	35	55
Twin Pitts, West	Pike	2018	49	42	58
University	Monroe	2018	42	43	65
Upper Long	Noble	2018	57	50	54
Versailles	Ripley	2018	73	72	73
Waveland	Montgomery	2018	75	79	60
Webster	Kosciusko	2018	56	59	51
Woods (Big Blue #3)	Rush	2018	72	74	68