National Lakes Assessment Overview **for Indiana**

Melissa Laney and Sarah Powers

2012 results and a decade

Summer 2017 offered Indiana an adventuresome season of lake sampling. With an expanded team, we explored many new lakes with the National Lakes Assessment (NLA). Indiana lake monitoring and water quality assessments have been largely conducted through the Indiana Clean Lakes Program (InCLP), which 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 (www.clp.indiana.edu). While these programs mirror each other in many areas, the NLA opened the lake exploration into a wider range of lakes. Here we share some results and trends of the past three NLA surveys, which fall in line with InCLP monitoring efforts.

We're not just corn in Indiana! We are rich with lakes of various forms. The last glacial retreat 10,000 to 12,000 years ago peppered northern Indiana with kettle lakes. We also have hundreds of reservoirs large and small, including eight U.S. Army Corps of Engineers (USACE) reservoirs. A legacy of strip mining for coal in southwestern Indiana has contributed to our lake resources with a large unique population of coal mine lakes. While the InCLP only monitors public freshwater bodies, the NLA opens our survey efforts to include all waters of the state that make the cut. While we didn't have the challenges of many crews packing in all supplies for a multiday journey, we did get to backpack in for one adventuresome day trip!

In order to capture enough lakes for a separate state-wide survey, Indiana participated in the individual state intensification survey where we sampled 52 lakes in each assessment (Figure 1).

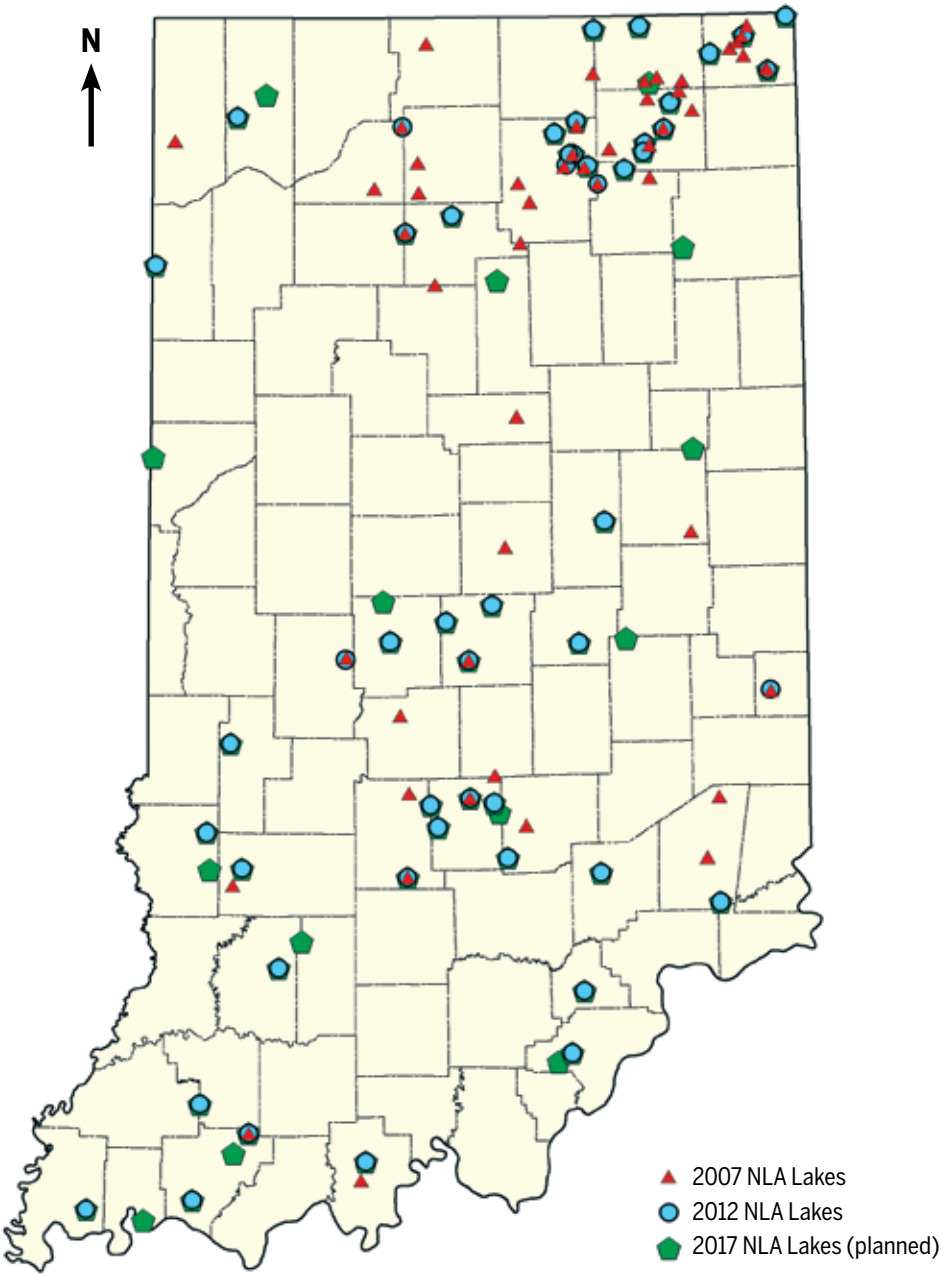

Figure 1. Lakes sampled in the 2007, 2012, and 2017 NLA. The top third of the state is dominated by kettle lakes. Of the remaining man-made lakes that dominate the southern region, the coal mine lakes in the southwest make up a significant subpopulation.

While the NLAs analyze a wide range of parameters, we are primarily narrowing the reporting and trends to trophic status, phosphorus, near-shore habitat and some biological parameters (Table 1).

With the trophic state as an indication of a lake's nutritional level or biological productivity, a trophic state index (TSI) aids in the evaluation of water quality data that is complex and variable. The Carlson TSI represents the standardized trophic status of a lake that can be compared in different years or can be compared to other lakes. In addition to TSI trends, we share results for total phosphorus, an essential plant nutrient that most often controls aquatic plant (algae and macrophyte) growth in freshwater. We also illustrate estimates of algal biomass with chlorophyll-*a*, and specific cyanobacteria results. Lakeshore habitat is often not included in many lake monitoring programs, and the NLA gives us all an opportunity to evaluate and share the impact at the lake's edge. Much of the 2017 data are not available due to ongoing sample analysis; therefore, we primarily report on changes from 2007 and 2012 (see Powers and Laney 2017, for the full state report). Where available, we have included the 2017 results.

Trophic status trends

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, allowing one parameter to predict the value of the other parameters. Indiana typically deviates from this relationship due to the predominant agricultural land use throughout the state (62 percent). The TSI [chl-a] shows the largest change in the eutrophic state, increasing this classification from 26 percent to 40 percent in 2007 and 2012, respectively (Figure 2). Lakes in the "most disturbed," or hypereutrophic category only slightly decreased. The in situ Secchi depth results are one variable that we could pull together immediately and track over the three assessments (Figure 3). In each survey round, the percent of lakes in the "most disturbed" category increased. While there is a slight oscillation for eutrophic lakes between the three surveys, the overall trend is that Indiana lakes have increased in the collective eutrophic-hypereutrophic rankings from 58 percent to 61 percent to 78 percent, respectively (Figure 4).

Table 1. National Lake Assessment Categories and Parameters (Bolded Parameters are Summarized in this Article).

Biological	Recreational	Chemical	Physical
• Sediment diatoms • Phytoplankton (algae) • Zooplankton • Benthic macros • **Algal density (chlorophyll-a)** • Invasive species	• Pathogens • **Algal toxin** • **Algal cell counts (Cyanobacteria)** • **Algal density (chlorophyll-*a*)**	• **Nutrients (phosphorus** & nitrogen) • Water column profile (dissolved oxygen, temp, pH, turbidity, acid neutralizing capacity, salinity) • Sediment mercury	• **Lakeshore habitat cover and structure** • **Shallow water habitat cover and structure** • **Lakeshore human disturbance**

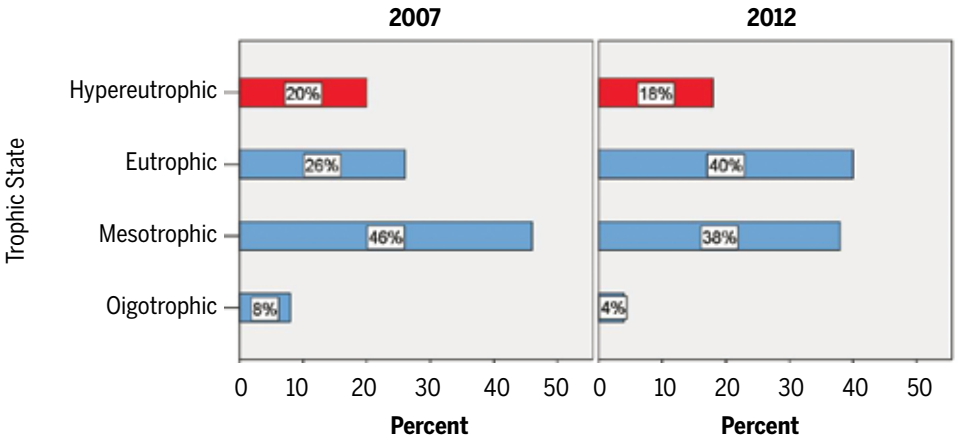

*Figure 2. Trophic state classifications for Indiana lakes during the 2007 and 2012 surveys, based on chlorophyll-*a.

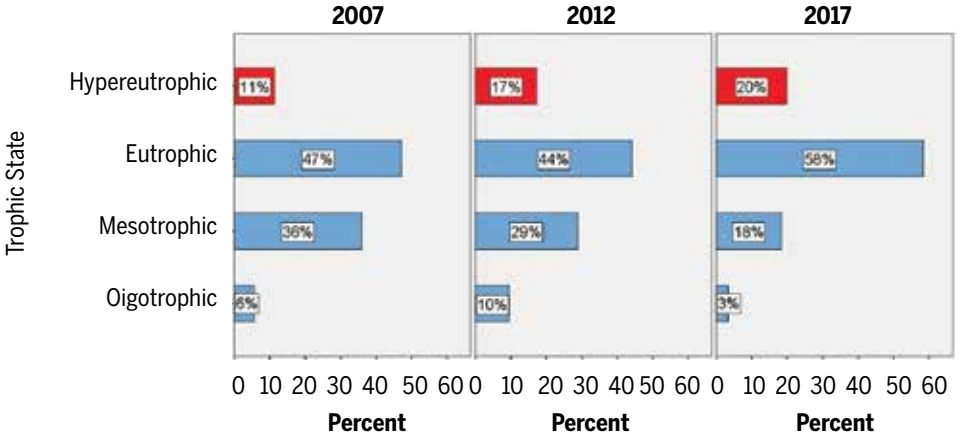

Figure 3. Trophic state classifications for Indiana lakes during the 2007, 2012, and 2017 surveys, based on Secchi depth.

Physical habitat condition

Most elements of our state monitoring program parallel those of the NLA, but that similarity stops after the index site or water column assessment. In addition to building our water quality statewide survey, the NLA offers us the opportunity to evaluate the lake shoreline habitat (Figure 5). This is a critical piece of missing information. All developable

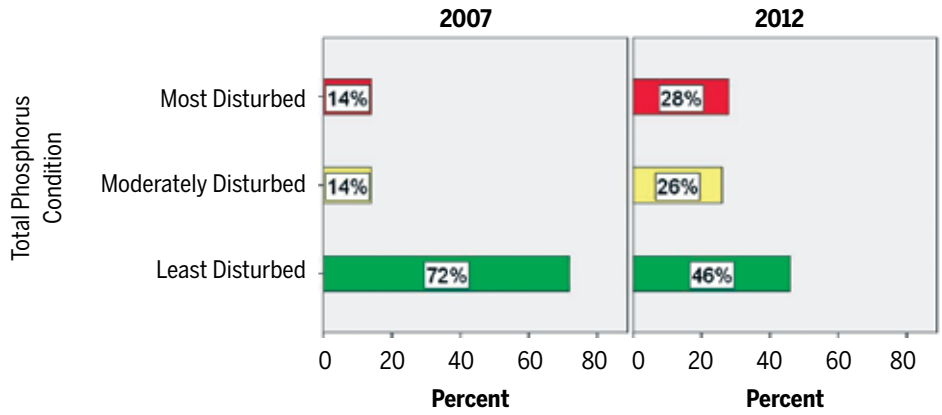

Figure 4. Percent of lakes in indicator categories for total phosphorus concentration of developed benchmarks from NLA 2012 analysis.

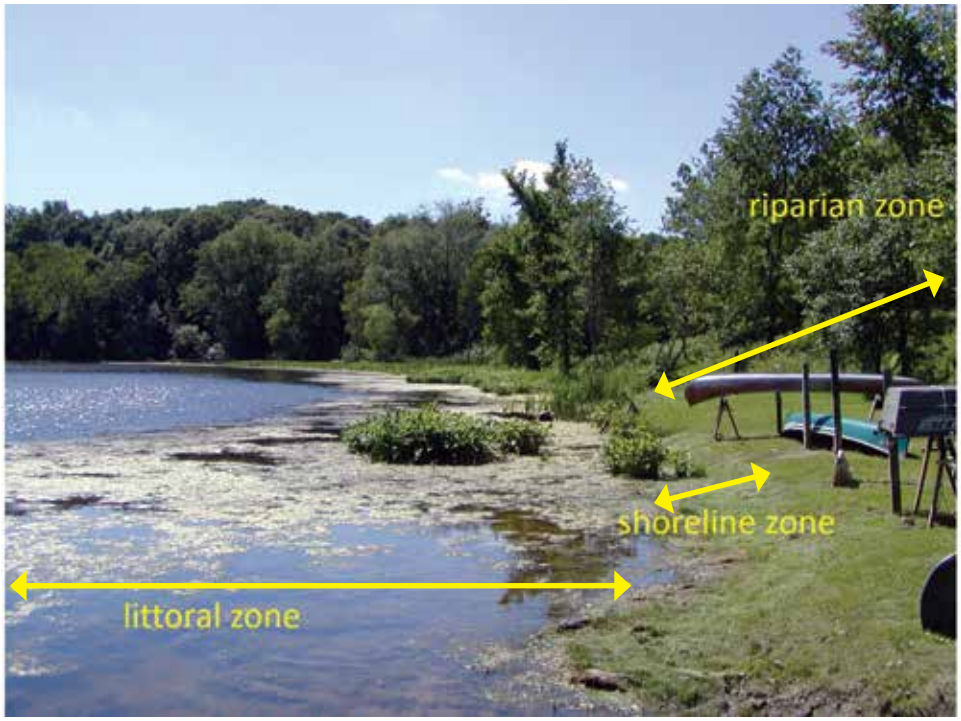

Figure 5. Riparian buffer and littoral edge habitat.

lake shoreline in Indiana has been developed and continually undergoing chronic pressures of lake enthusiasts and residential upgrades. This habitat that frames the lake's edge is an indicator of biological health of the ecosystem. Many of Indiana's lake shorelines have lost most natural features and have been converted to sea walls or other unnatural revetments. Like seawalls giving the lake a bad haircut, many have pier pressures as well. While docks and piers offer fish structure, prolonged and high capacity recreation that accompanies these structures undermines the biological integrity of these diverse habitats.

Seven lake physical habitat field dimensions we evaluated include (Kaufmann et al. 2014a): (1) water depth and surface characteristics, (2) substrate size and type, (3) aquatic macrophyte cover and structure, (4) littoral cover for biota, (5) riparian vegetation cover and structure, (6) near-shore anthropogenic disturbances, and (7) bank characteristics. Of the many variables, we share the composite indices ranking near-shore physical habitat.

Aside from the riparian vegetation condition of the 2012 survey, one-third of Indiana lakes fall in the "most disturbed" category for near-shore habitat (Figures 6-9). One would expect to see each terrestrial edge layer of canopy, understory, and groundcover for Indiana lakes, which resulted in an encouraging 66 percent of lakes in the "least disturbed" ranking. Those most disturbed shallow water habitats are often a result of heavy residential shoreline alterations with seawall revetments, targeted macrophyte management, and near constant high-energy waves. This is characteristic of many popular recreational waters, especially in our northern natural lakes. The morphometry of our many steep-sloped reservoirs also does not support wide bands of shallow water habitat. Therefore, much of the naturally occurring cover elements for fish and macroinvertebrates is deficient and influencing the habitat complexity.

Recreational condition

Indiana lakes are used for a variety of activities, but one of the most prevalent is fulfilling the joys of the many lake enthusiasts with recreation! Algal toxin indicators threaten the recreation capacity of our waters, including impacts to humans, pets and wildlife.

The World Health Organization (WHO) chlorophyll-*a* literature benchmarks act as a proxy for algal toxin exposure risk. Indiana lakes of the 2012 survey, fortunately only reported 10 percent in the most disturbed or higher likelihood of exposure to algal toxins (Figure 10). From 2007 to 2012, there is a slight increase in lakes in the moderately disturbed condition class of 30 percent to 44 percent or at a moderate level of risk, respectively. The most disturbed condition class or high level of risk increase by 2 percent from 2007 to 2012

The WHO has recommendations for cyanobacteria cell counts that can also be used as an indication for exposure to algal toxins. Using this indicator, the WHO cyanobacteria risk increased six-fold from 2007 to 2012 (Figure 11). This is a significant shift compared to the chlorophyll-*a* condition, which only increased by 2 percent. Our InCLP results mirror the NLA data set with a significant proportion of surveyed lakes becoming dominated by cyanobacteria, especially by the peak of the growing season. Many lakes will become > 95 percent cyanobacteria-dominated.

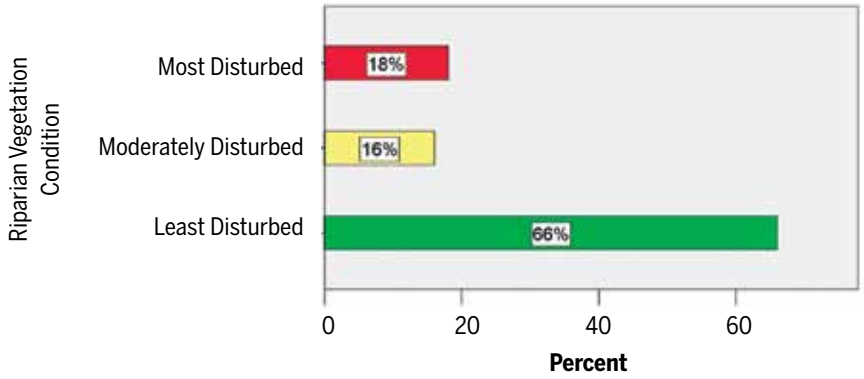

Figure 6. 2012 NLA Riparian Vegetation Condition for Indiana lakes. Riparian buffer vegetation was evaluated for all three forest layers: canopy, understory, ground cover.

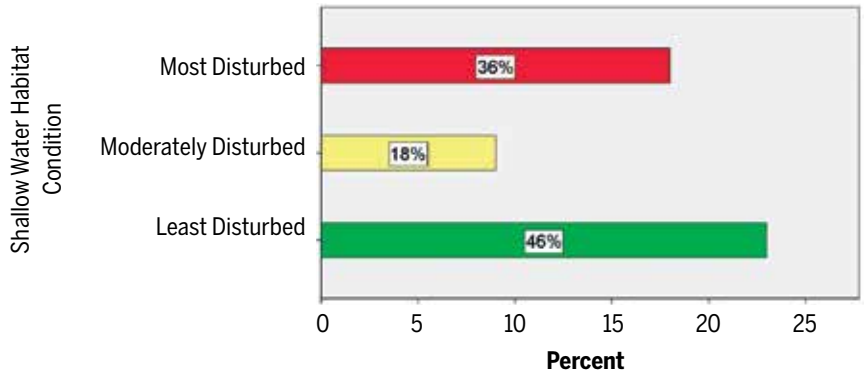

Figure 7. 2012 NLA Shallow Water Habitat Condition for Indiana lakes. Littoral habitat was evaluated for many parameters including rock ledges, brush, snags, and human structures.

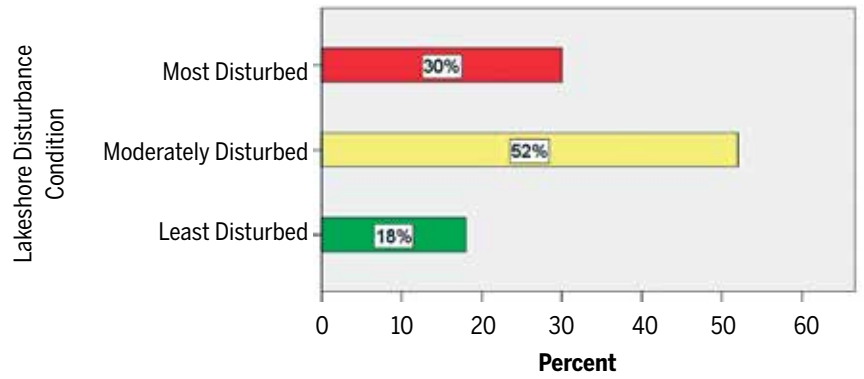

Figure 8. 2012 NLA Lakeshore Disturbance Condition for Indiana lakes. Some examples of shoreline human disturbance include buildings, roads, row crop, lawns, and revetments.

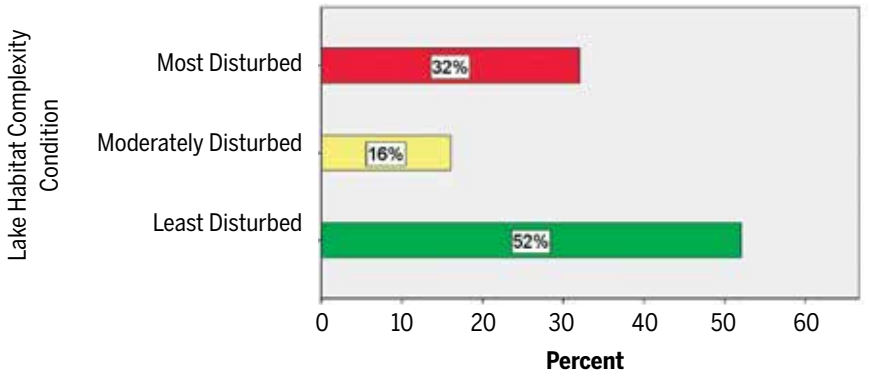

Figure 9. 2012 NLA Lake Habitat Complexity for Indiana lakes. This condition averages together the other composite indices including riparian and littoral complexity, and human disturbance.

Ecoregion and land use

When we say that "lakes are a reflection of their watershed," we refer to not only land use activities within the watershed that may influence lake characteristic, but also soil types, land slope, natural vegetation, climate, and other factors that define the ecological region or *ecoregion*. Omernik and Gallant (1988) defined ecoregions in the Midwest 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. The three ecoregions present in Indiana are show in Figure 12, and include:

Upper Midwest (UMW) is a region of mixed wood plains characterized by a mosaic of agriculture, forest, wetlands, and glacial lakes. The region is characterized as moderately rich in nutrients. Dairy operations, livestock farming, cropland agriculture and urban development make up this area.

Temperate Plains (TPL) was once made up of forest and prairie and is now predominately agriculture cropland and urban development. The lakes in this region are all reservoirs or mine pits. The area is characterized by higher nutrients as a result of agriculture production of primarily corn and soybeans.

Southern Appalachians (SAP) is a broad and disjointed region of irregular plains and low hills of primarily oak-hickory forest and forested wetlands. Much of the region is also used for farmlands (pasture, livestock, and crops) as well as timber, quarry, and coal mine operations. There is moderate urbanization and many lakes are on state and federal properties.

When clumping the surveyed lakes by ecoregions for trophic state, the results show a substantial increase in eutrophication for all three ecoregions (Figure 13). The 2007 Southern Appalachian lakes were dominated by mesotrophic characteristics. The 2012 results showed a significant shift with 50 percent of the lakes falling in the eutrophic or hypereutrophic state. And notably, lakes previously rated

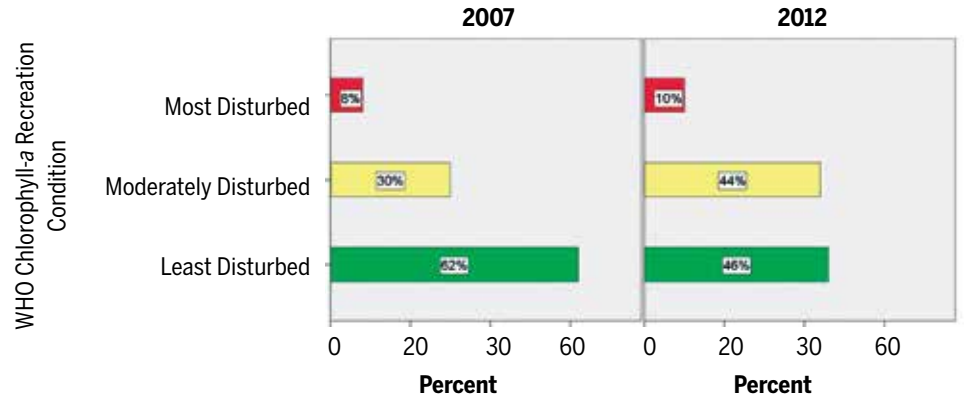

Figure 10. Recreation condition based on WHO chlorophyll-a benchmarks.

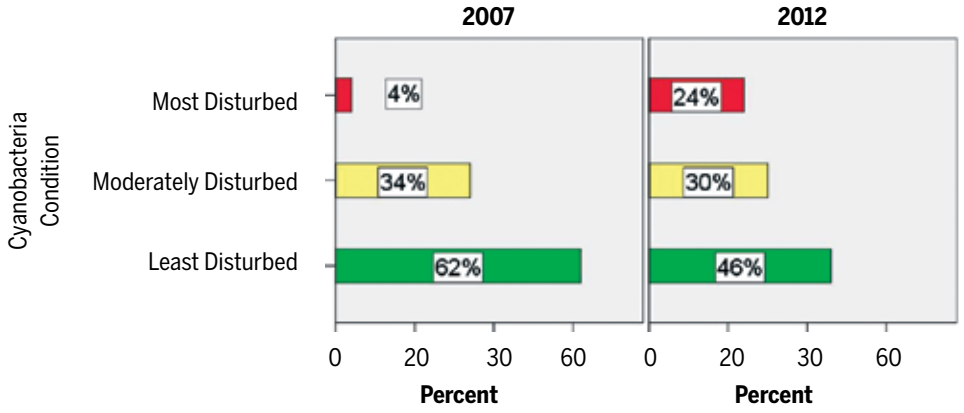

Figure 11. Recreation condition based on cyanobacteria cell counts.

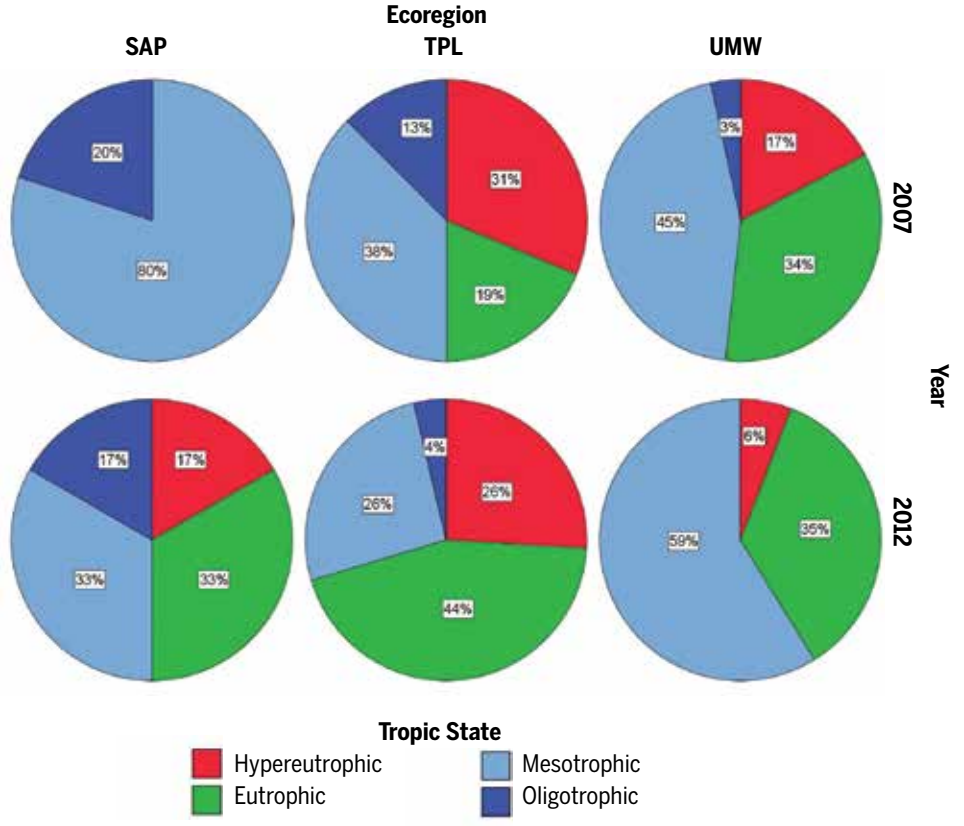

Figure 12. Distribution map of 2012 lakes within the three ecoregions covering Indiana.

as oligotrophic in the Upper Midwest lakes shifted to another category in 2012; however, the number of highly biologically productive (hypereutrophic) lakes in this region decreased between the two assessment rounds.

Indicators and stressors

Looking across ecoregions can show regional changes in indicators. Indicators are broken down into the four primary categories of stressors, including chemical, human use, physical, and biological conditions showing the percent of lakes in the most disturbed condition within each ecoregion (Figure 14). For example, it is easy to see that most lakes in all ecoregions have atrazine present in the water yet only lakes in the Temperate Plains had lakes with atrazine above the 4 ppb USEPA threshold set for recreation (four percent of the 2012 lakes).

The visual representation shows the relative level of disturbance in each ecoregion. Looking across ecoregions in a complex diagram like this can also highlight which ecoregion shows the greatest amount of disturbance. Overall, the Upper Midwest ecoregion has the greatest level of disturbance across lakes, which is slightly unexpected as we typically think of our natural lakes being more pristine overall, but it is important to remember that each indicator is looked at based of the expected result for the ecoregion.

It's been a wonderful opportunity for Indiana to participate in these NLA surveys. While our InCLP monitoring goals mirror those of the NLA (determining state ecological integrity, trophic status, and trends) this opens up our analysis for regional and national comparisons. The additional NLA parameters, such as near-shore habitat and cyanotoxins, expand our monitoring capacity. This will continue to build our state collaboration and articulate the value in such programs. It has been an adventuresome decade of sampling (Figure 15).

References

Kaufmann P.R., R.M. Hughes, T.R. Whittier, S.A. Bryce and S.G. Paulsen (2014a). Relevance of lake physical habitat assessment indices to fish and riparian birds. *Lake Reservoir Manage.* 30:177-191.

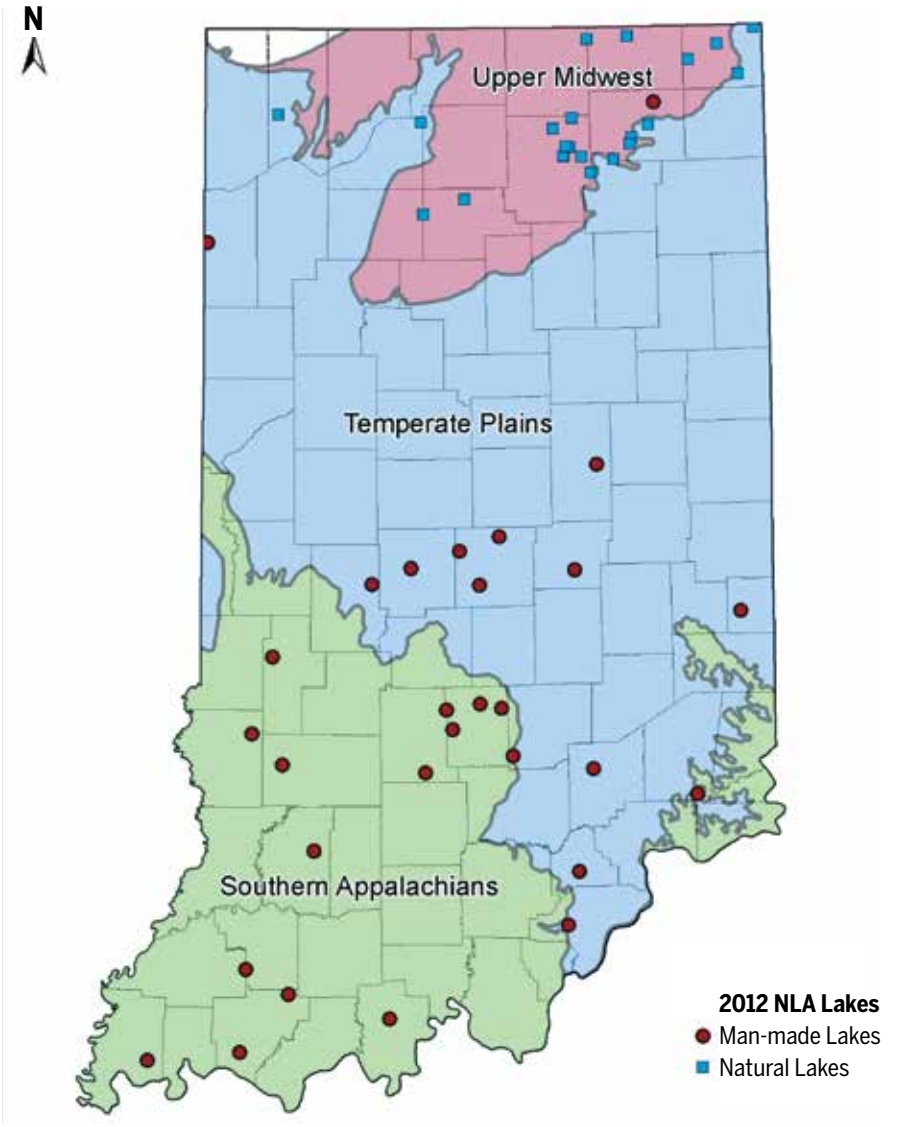

Figure 13. Trophic state trends for surveyed lakes within these ecoregions from 2007 to 2012

Omernik, J.M. and A.L. Gallant. 1988. Ecoregions of the Upper Midwest. EPA/600/3-88/037. U.S. Environmental Protection Agency, Environmental Research laboratory, Corvallis, Oregon.

Powers, S.R. and M.A. Laney. 2017. 2012 Indiana National Lakes Assessment Indiana Intensification Survey – 2017. Prepared for the Indiana Department of Environmental Management, Office of Water Quality. Indianapolis, IN. 41pp. School of Public & Environmental Affairs, Indiana University, Bloomington, IN.

Acknowledgments

Funding and support was provided in part by the Indiana Department of Environmental Management, Watershed Assessment and Planning Branch, Office of Water Quality. This work could not have been completed without the dedication and enthusiasm of many field technicians including the 2017 crew: Karina Cardella, Thomas Miller, Rowan Mitton, Courtney Mobilian, Bruna Oliveria, Joao Palma Chacon, and Cory Shumate.

Melissa Laney is the director of the Indiana Clean Lakes Program (InCLP). She has coordinated the three NLA surveys alongside the ongoing InCLP. She is a Senior Lecturer at School of Public and Environmental Affairs (SPEA). She is the former Region 5 NALMS director. Together, Melissa and Sarah Powers have completed various lake and watershed diagnostic studies throughout Indiana.

Sarah Powers is a lab manager and volunteer coordinator with the Indiana Clean Lakes Program through the Indiana University's SPEA. She is an executive board member of the Indiana Lakes Management Society (ILMS). She is also an adjunct faculty member at SPEA, teaching environmental science and various field and laboratory techniques courses.

Next Issue – *LakeLine* Fall 2018:

The fall issue of *LakeLine* will include articles on lake and watershed management projects to protect, enhance and restore water quality.

LakeLine Winter 2018:

The winter issue of *LakeLine* will focus on highlighting case studies of lake and watershed projects which did not originally go as planned, for one or multiple reasons. If you have a compelling "lake lesson" you'd like to share, please consider submitting an article that highlights the project, including an evaluation of why the project did not originally go as planned (funding, planning, insufficient methodology, permitting, etc). Emphasis should be placed on how issues were resolved to achieve targeted outcomes.

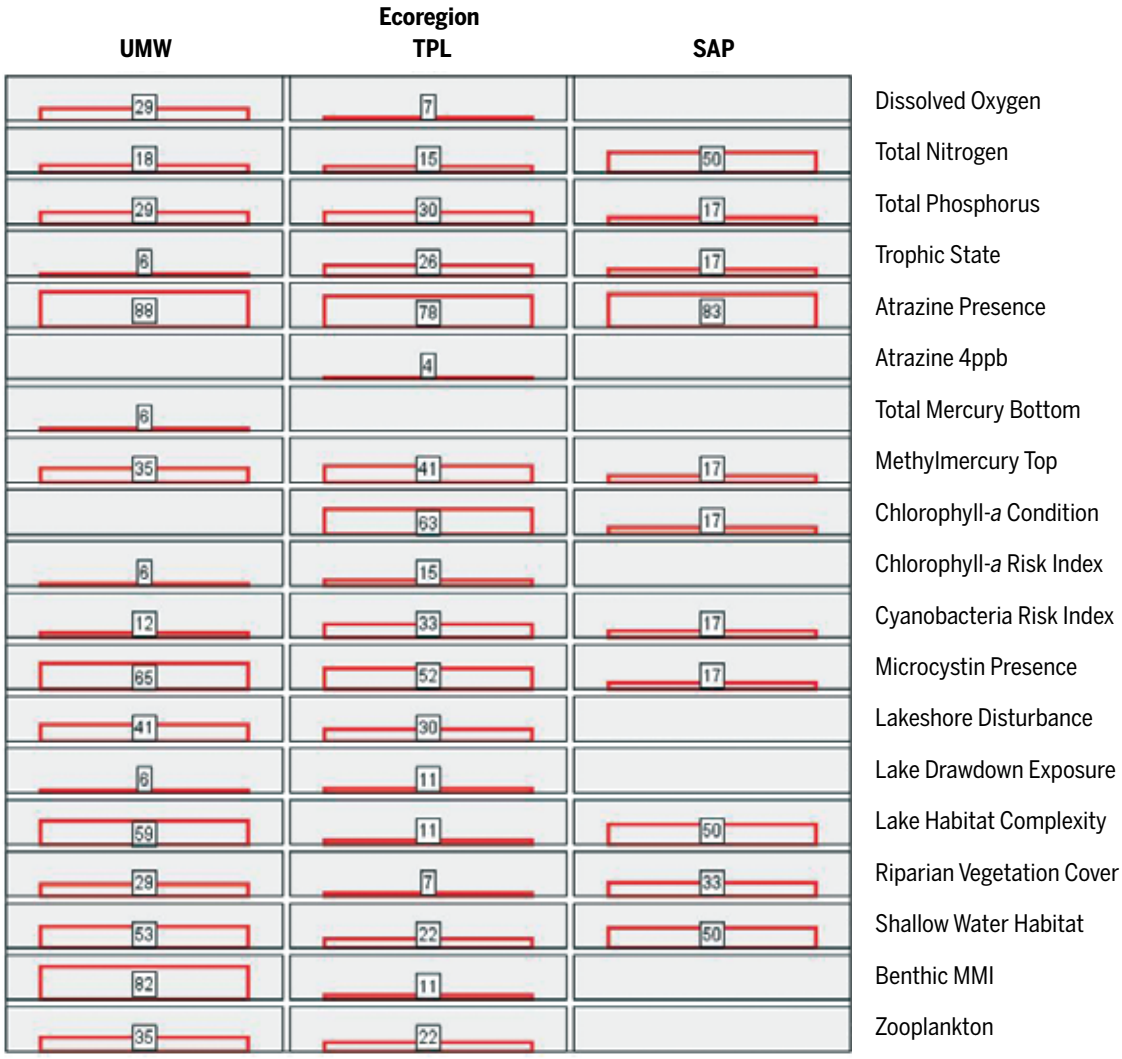

Figure 14. 2012 NLA lakes in the most disturbed category for primary condition indicators broken down by ecoregion.

Figure 15. NLA sampling adventures on Round Lake, IN. The one lucky lake in the 2017 survey requiring backpacks and inflatable boats.