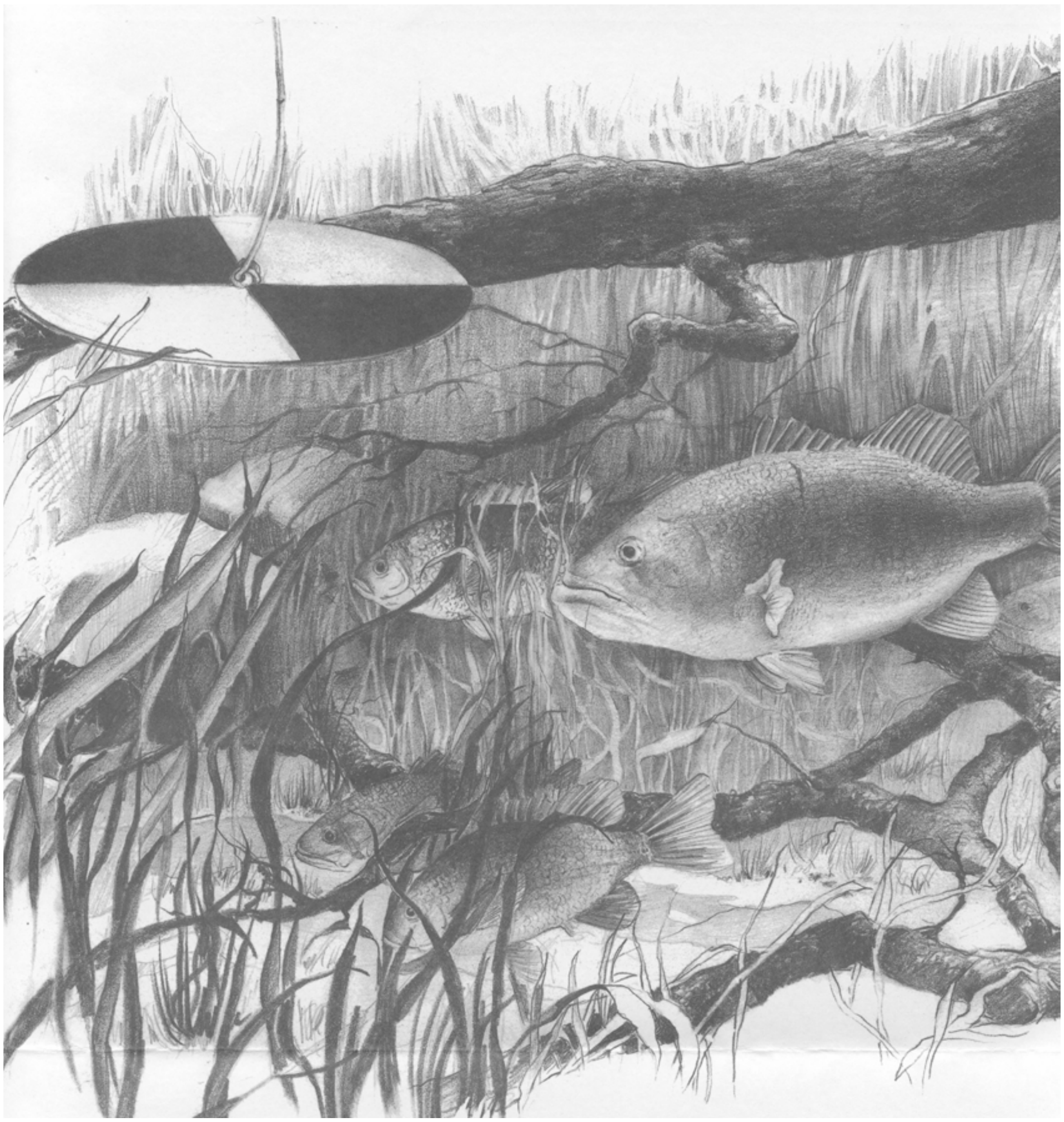
Indiana Volunteer Lake Monitoring Report: 2004-2008



July 2009

Indiana Volunteer Lake Monitoring Report: 2004-2008

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Prepared for:

Indiana Department of Environmental Management
Office of Water Quality
Indianapolis, IN

July 2009

Acknowledgements

The chemical analysis of water samples is a labor-intensive process. The total phosphorus and chlorophyll *a* results in this report would not have been possible were it not for the capable help and skills of many SPEA graduate research assistants who conducted the analyses. Keeping the Volunteer Program running smoothly would be impossible without the services of our Volunteer Coordinators: Lisa Fasher, Rachel Price, Laura Montgrain, Amanda Watson and Matthew Robinson. Moira Rojas provided GIS graphics assistance.

Funds for this program were provided by a Section 319 Lake Water Quality Assessment Grants from the U.S. Environmental Protection Agency. Ms. Carol Newhouse and Laura Bieberich of the Indiana Department of Environmental Management were the Project Officers.

Finally, to all the volunteers – **THANK YOU**! Your hard work and dedication contribute greatly to the understanding and sound management of Indiana's lakes.

2004-2008 Volunteers by County

BROWN COUNTY

Herbert Clark	*Cordry Lake*
Quin Hetherington	*Cordry Lake*
Sarah Sauter	*Yellowwood Lake*
Buzz Settles	*Sweetwater Lake*

CASS COUNTY

Ron/Alice Huffman	*Perry Lake*

DELAWARE COUNTY

Dave Conwell	*Prairie Creek Reservoir*

DUBOIS-ORANGE

Doug Hall	*Patoka Lake*

ELKHART COUNTY

Larry Lehman	*Indiana Lake*
Dave Simmons	*Heaton Lake*

FRANKLIN COUNTY

Craig Nobbe	*Brookville Reservoir*

FULTON COUNTY

Jerry Caylor	*Nyona Lake*
Dennis Grossnickle	*Manitou Lake*
Robert Kahmark	*Town Lake*
Pete Meyer	*Millark Mill Pond, & Mt. Zion Lake*
Kathy Shavey	*South Mud Lake*

HARRISON

Guy Silva	*Pinestone Lake*

HENRY COUNTY

Richard Hook	*Summit Lake*
Sarah Kistler	*Summit Lake*
Dan Robinson	*Summit Lake*

HUNTINGTON

Bob/Leslie Patterson	*Salamonie Lake*

JOHNSON COUNTY

Tom Hougham	*Lamb Lake*

KOSCIUSKO COUNTY

Luther Allen	*Webster Lake*
Don Arnold	*Waubee Lake*
John Bender	*Diamond Lake*
Daniel Berkey	*Lake Wawasee*
Chuck Brinkman	*Irish Lake*
Sandra Buhrt	*Elizabeth & Rachel lakes*
Butch Johnston	*Waubee Lake*
Jack Carr	*Bonar Lake*
Gary Clayton	*Silver Lake*
Chris Cummins	*Winona Lake*
Michael De St. Jean	*Waubee Lake*
Len Draving	*Big & Little Chapman lakes*
Ray O. Deahl	*Lake Wawasee*
Don Hagan	*Kuhn & Big Barbee lakes*
Lauren Hall	*Oswego Lake*

Kathy Hiatt	*Banning, Little Barbee, Sawmill lakes*
Ronald Hill	*Sechrist Lake*
Jill Jordan	*Ridinger Lake*
Holly LaSalle	*James, Oswego, & Tippecanoe lakes*
Ken/Tina Leatherman	*Syracuse Lake*
Jim Metze	*Ridinger Lake*
Don/Dawn Myers	*Lake Webster*
Robert Myers	*Lake Wawasee*
Benjamin Nault	*Pike Lake*
Dave Patterson	*Yellow Creek Lake*
Terry Rouse	*Silver Lake*
Dean Schwalm	*Syracuse Lake*
Becky Schwartz	*James, Oswego, & Tippecanoe lakes*
Elaine Strong-Kokenge	*Little Chapman Lake*
Jeff Thornburg	*James, Oswego, & Tippecanoe lakes*
Gene Topolski	*Big Chapman Lake*
Troy Truley	*Center Lake*

LAGRANGE COUNTY

Bob Christen	*Witmer Lake*
James Barkey	*Dallas Lake*
Jack Dold	*Pretty Lake*
Gordon Huston	*Westler Lake*
Joe Kraft	*Adams Lake*
Jim Lewis	*Adams Lake*
Tom Mackin	*Lake of the Woods*
Bob Mayer	*Olin, Oliver & Martin lakes*
Pat McClellan	*Little Turkey Lake*
Howard Pratt	*Big Long Lake*
Jeff & Julie Rohm	*Dallas Lake*
Herb Ulery	*Stone Lake*
Eugene Worden	*Big Turkey Lake*

LAKE COUNTY

Ron Bedwell	*Holiday Lake & Lake on the Green*
Frank Brongiel	*Cedar Lake*

LAPORTE COUNTY

Jon Dittmar	*Lower Fish Lake*

MARSHALL COUNTY

Louise Anella	*Myers Lake*
Joe Coury	*Pretty Lake*
Peter Gyerko	*Holem Lake*
Bill Harris	*Lost Lake*
Tina Hissong	*Lake Maxinkuckee*
Dixie Kunze	*Cook Lake*
Rocky Papandria	*Moon Lake*
Andrew Plaia	*Millpond Lake*
Joseph Skelton	*Lake of the Woods & Galbraith Lake*
Jerry Wall	*Cook Lake*
Louis Wenino	*Pretty Lake*

MONROE COUNTY

Paula Hedin	*Griffy Lake*
Aunna Huber	*Lake Lemon*
Scott McWhorter	*Lake Lemon*
Coleman Smith	*Lake Lemon*
Charles/Carol Wise	*Lake Monroe (Lower)*
Michael Wilson	*Griffy Lake*

MONTGOMERY COUNTY

Robert Ginger	*Lake Holiday*

MORGAN COUNTY

John Winters	*Ole Swimming Hole Lake*

NOBLE COUNTY

Drew Bobay	*Diamond Lake*
Jean Cook	*Little Long Lake*
Chuck Farris	*Big & Little Crooked Lakes*
Kathy Hiatt	*Smalley Lake*
Lauren Liebing	*Sylvan Lake*
Mike Martin	*Big Lake*
Steve Merrill	*Long & Sand lakes*
Nick Stanger	*Knapp Lake*
Ben Tipton	*Upper Long Lake*
Colin Tipton	*Upper Long Lake*
Dean Wilcox	*Skinner Lake*

OWEN COUNTY

Ruth Bubiel	*Amazon Lake*
Drew Schrader	*Locust Lake*

PORTER COUNTY

Karl Bauer	*Flint Lake*
Ron Bedwell	*Big Bass Lake*
Paul Borkowski	*Big Bass Lake*
Katie Carlton	*Flint Lake*
Michael De St. Jean	*Deep Lake & Round Lake*
Bill Kappa	*Louise Lake*
Mike Min	*Louise Lake*
Robert Minarich	*Flint Lake*

PORTER-LAPORTE COUNTY

Paul/Joy Kamradt	*Clear Lake*

PUTNAM COUNTY

Bob Ginger	*Rocky Fork Lake*
Don Steward	*Heritage Lake*

ST. JOSEPH COUNTY

Michael Squint	*Tawny Lake*

STARKE COUNTY

Tom Camire	*Koontz Lake*

STEUBEN COUNTY

Jim Aikman	*Hogback Lake*
Ron Beach	*Lake Gage*
James Clary	*Lake James*
Joe Geiger, Jr.	*Barton Lake*
Dan Hoagland	*Clear Lake*
Andrew Hosey	*Crooked Lake*
Allen Lefevre	*Lake Gage*
Michael Manee	*Big & Little Otter lakes*
Paul Marki	*McClish Lake*
Mike Marturello	*Snow Lake*
Paul Oakes	*Ball Lake*
Joe Peck	*Silver Lake*
Dick Smith	*Silver Lake*
Jim/Roxanne Thompson	*Otter (West) Lake*
James/Pam Weber	*Syl-van Lake*
John Williamson	*West Otter Lake*

WABASH COUNTY

C.J. Steiner	*Lukens Lake*

WHITLEY COUNTY

Judy Ausderan	*Big Cedar Lake*
Dave Byers	*Shriner Lake*
Chuck Farris	*Little Crooked Lake*
David/Denise Heckman	*Goose Lake*
Chuck Lewton	*Little Cedar Lake*
Nate Lothamer	*Big Cedar Lake*
Rick Miller	*Loon Lake*
Jeanne Rethlake	*Old Lake*

CONTENTS

DESCRIPTION OF PROGRAM

The Indiana Volunteer Lake Monitoring Program was created in 1989 as a component of the Indiana Clean Lakes Program (CLP) administered through the Indiana Department of Environmental Management (IDEM). Indiana University's School of Public and Environmental Affairs (SPEA) implements the program through a grant from IDEM. The Indiana Clean Lakes Program is a comprehensive, statewide public lake management program with five components: public information and education, technical assistance, volunteer lake monitoring, lake water quality assessment, and coordination with other state and federal lake programs

The Volunteer Lake Monitoring Program component of the Clean Lakes Program was created to accomplish four main objectives:

1. Collect water quality data that will contribute to the understanding of how Indiana lakes function;
2. Monitor water quality changes to provide an early warning for problems that may be occurring in lakes;
3. Encourage citizen involvement in the protection and management of their lakes;
4. Provide the means whereby Indiana citizens can learn more about lake ecology and management.

All volunteers in the Program take Secchi disk transparency measurements on their lakes. The Secchi disk is one of the oldest and most basic tools used by limnologists. Secchi disks are used as an indicator of water quality by measuring the transparency of water (Figure 1). Transparency is affected by the amount of suspended materials (algae and sediments) in the water. Excessive amounts of either algae or sediments in the water can be an indication of eutrophication. Sediments may be introduced to lakes via erosion from construction sites, agricultural lands, and river banks. Shallow lakes are especially susceptible to sediment resuspension from motor boats, personal watercraft, or strong winds. Color observations are also made with the Secchi disk to differentiate between these two factors.

A subset of volunteers also collects water samples for total phosphorus and chlorophyll *a* analyses through our Expanded Program. Phosphorus is the primary limiting nutrient required for growth by algae and aquatic plants; therefore most lake management programs measure phosphorus concentrations. Chlorophyll *a* is the primary green pigment in algae and is a direct measure of algal production.

Dissolved oxygen and temperature meters are also available to volunteers throughout the state. Dissolved oxygen enters water via two pathways: diffusion into water from the atmosphere and production by algae and aquatic plants as a by-product of photosynthesis. Oxygen, in turn, is consumed by the respiration of fish and other oxygen-breathing aquatic organisms and by bacterial decomposition processes. The quantity and distribution of dissolved oxygen in lakes helps determine the importance of these processes, and defines where fish and other aquatic life may survive. Lake zones with extremely low concentrations of dissolved oxygen may not support aquatic life and may instead promote chemical conditions whereby nutrients are released into the water from sediment storage. Temperature also has an effect on what aquatic organisms can live in certain areas of a lake.

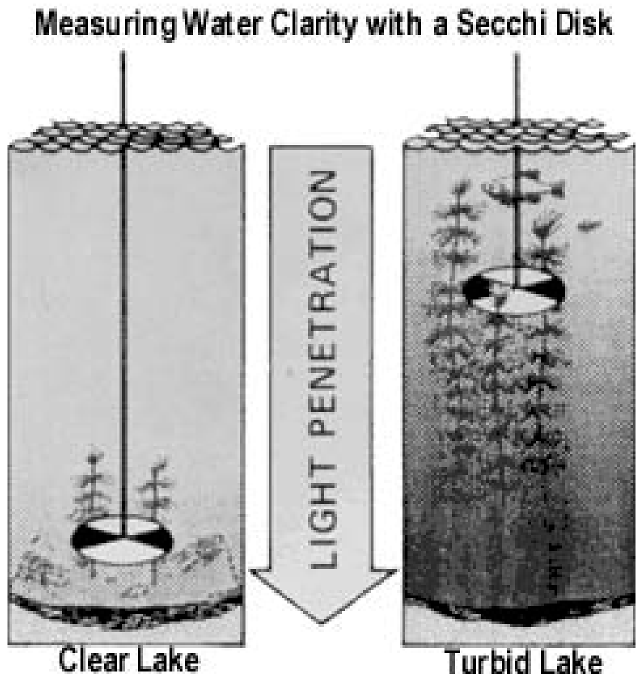


Figure 1. Secchi disk and water quality.

In 2008 volunteers began taking lake level readings from lake elevation staff gages. This cooperative effort with the DNR Division of Water is expanding as the DNR adds more gages to lakes. In response to a survey question, volunteers on 45 lakes without gages stated that they would like to measure lake levels if a gage was installed on their lake. to help support the Department of Natural Resources. In 2008 after the start of the program, 6 volunteer monitors turned in 23 lake level readings. With the support of the DNR we hope to increase this number over time.

MATERIALS AND METHODS

All volunteers are given a training manual, postage paid data cards, and a Secchi disk with a calibrated measuring tape. Secchi disks are painted and assembled by CLP staff at SPEA.

Volunteers need access to a boat once every two weeks. Secchi disk measurements are taken on sunny, calm days between the hours of 10:00 a.m. and 4:00 p.m. Measurements are taken at the same site each time, generally over the deepest part of the lake. In addition to the Secchi depth measurement, volunteers also assign a color to the water. Volunteers choose from a list of: Clear/Blue, Blue/Green, Green, Brown, or Green/Brown. They choose a color that best matches the color of the lake water. Volunteers also evaluate the recreational potential and physical appearance of the lake. Volunteers submit these data to SPEA via pre-paid postage cards or they can enter their data electronically on the CLP website: http://www.indiana.edu/~clp/.

Volunteers are able to use one of eight temperature and dissolved oxygen meters that can be checked out from SPEA or local soil and water conservation district offices in northern Indiana. Both temperature and dissolved oxygen change with the seasons. Volunteers are encouraged to take several profile measurements of their lake, ideally once per month.

Volunteers participating in the Expanded Program collect samples for chlorophyll *a* and total phosphorus at the same location as their Secchi disk measurement. Expanded Program samples are collected once a month during the summer, typically May through August.

The Expanded Program volunteers are given a kit, assembled by CLP staff, including a PVC 2-meter integrated water column sampler, filters, tweezers, a filtering apparatus, a hand-held vacuum pump, a pitcher to transfer collected water, sample bottles, a five gallon bucket for equipment storage, a Styrofoam mailer, prepaid express mail tags, and an expanded program manual. Phosphorus water samples are poured into 125 ml polyethylene bottles and frozen. To collect chlorophyll *a*, a known quantity of lake water is filtered through a glass-fiber filter (Whatman GF-F), which traps the algae. Filters are folded, placed in a 30 ml opaque bottle, and frozen. Once two months of samples are collected, they are shipped overnight to the SPEA lab in Bloomington for analysis by CLP staff.

VOLUNTEER RECRUITMENT

Volunteers are recruited via direct solicitations to county lake associations, statewide news releases, local newspaper articles, announcements in the quarterly *Water Column* newsletter, word of mouth, and information booths at the annual Indiana Lake Management Conference. New volunteers are trained around the state at individual or group training sessions with CLP staff.

Citizens are critical to the success of the Indiana Volunteer Lake Monitoring Program. Their participation allows IDEM to monitor long term lake water quality and to gather data on many more lakes than would be possible without this program. While volunteers come from a wide variety of backgrounds and have varying interests, they all recognize the importance of their lakes as a valuable ecological and recreational asset, and share an interest in protecting or improving its water quality. Many volunteers are actively involved in lake or conservation associations, and participate in lake management decisions. By participating in the Indiana Volunteer Lake Monitoring Program, volunteers become better stewards and spokespersons for their lakes.

Volunteers are important partners in monitoring Indiana lakes. Volunteer monitoring data provides information for volunteers, lake organizations, the Indiana Department of Environmental Management IDEM), the Indiana Department of Natural Resources (IDNR) and others interested in obtaining lake information. IDEM has used volunteer monitoring data in: a) reporting on the status of Indiana's surface waters in the bi-annual Clean Water Act Section 305(b) reports to U.S. EPA, b) development of nutrient criteria for Indiana waterbodies, and c) in identifying impaired waterbodies under the Clean Water Act Section 303(d) list.

Program Growth

The Volunteer Monitoring Program began in 1989 with 41 volunteers taking measurements on 51 lakes. From 2004 to 2008, 2643 observations were made on 126 lakes in Indiana. From 2004 to 2008 35 new volunteers were trained to monitor their lakes. The expanded volunteer monitoring program has also grown in the past 5 years from 39 expanded lakes in 2004 to 42 lakes in 2008. The total number of lakes sampled and observations made in the Volunteer Monitoring Program since its inception are listed in Table 1.

TABLE 1. Summary of lakes monitored with total annual observations.

	Secchi Disk Program		Expanded Program	
Year	Lakes Monitored	Total Observations	Lakes Monitored	Total Observations
1989	51	370	n/a	n/a
1990	73	535	n/a	n/a
1991	74	523	n/a	n/a
1992	85	537	30	90
1993	75	514	31	95
1994	75	677	28	116
1995	85	644	27	130
1996	81	563	27	100
1997	91	668	31	92
1998	87	548	31	111
1999	90	537	31	104
2000	104	618	34	120
2001	84	583	39	132
2002	93	569	41	136
2003	91	611	40	124
2004	94	590	39	132
2005	95	589	40	146
2006	83	514	45	157
2007	91	536	42	149
2008	81	414	37	131

THE LAKES

A variety of attempts have been made to classify lakes. Lakes can be classified based on how they were formed, physical characteristics (depth, surface area, etc.), and where they are located (ecoregion).

Lake Formation

Hutchinson (1957) classified lakes based on how they were formed. Most lakes in Indiana were formed by glacial activity, solution, river channel migration, or by human activity (damming).

The majority of lakes sampled by the Volunteer Monitoring Program are natural lakes located in northern Indiana (Figure 2). Most of Indiana's natural lakes were formed by glacial activity 10,000 to 14,000 years ago. These glacial lakes are mainly "ice block" or kettle lakes, formed by the large blocks of ice deposited in the glacial outwash plain. In the southern portion of Indiana, where limestone is prevalent, lakes were formed in basins caused by the solution of limestone. River channel migration also forms lakes. As a river shifts course, the former channel becomes cut off from the new active channel and can form oxbow lakes. Finally, impoundments have been created by human activity through all parts of Indiana, including farm ponds, millponds, quarry holes, and reservoirs. Ninety-three of the monitored lakes were natural lakes and thirty-three were impoundments.

Physical Characteristics

Lakes can also be classified based on their physical characteristics such as surface area, depth, and watershed area. Monitored lakes varied greatly in surface area and depth. Lake Monroe in Monroe County and Patoka Reservoir in Dubois and Orange County had the largest surface areas of lakes in the program, 10,750 acres (4,350 hectares) and 8,880 acres (2,590 hectares) respectively. Lake Wawasee in Kosciusko County and Lake Maxinkuckee in Marshall County were the largest natural lakes in the program with surface areas of 2,617 acres (1,059 hectares) and 1,853 acres (750 hectares) respectively. Conversely, Deep Lake in Porter County and Little Cedar Lake in Whitley County had the smallest surface areas, 6.9 acres (3 hectares) and 10 acres (4 hectares) respectively. Twenty-nine lakes have a surface area less than 25 hectares, thirty-three lakes are between 26-50 hectares, twenty lakes are between 51-100 hectares, twenty-seven lakes are between 101-500 hectares, two lakes are between 501-1000 hectares, and five lakes are greater than 1,000 hectares (Figure 3).

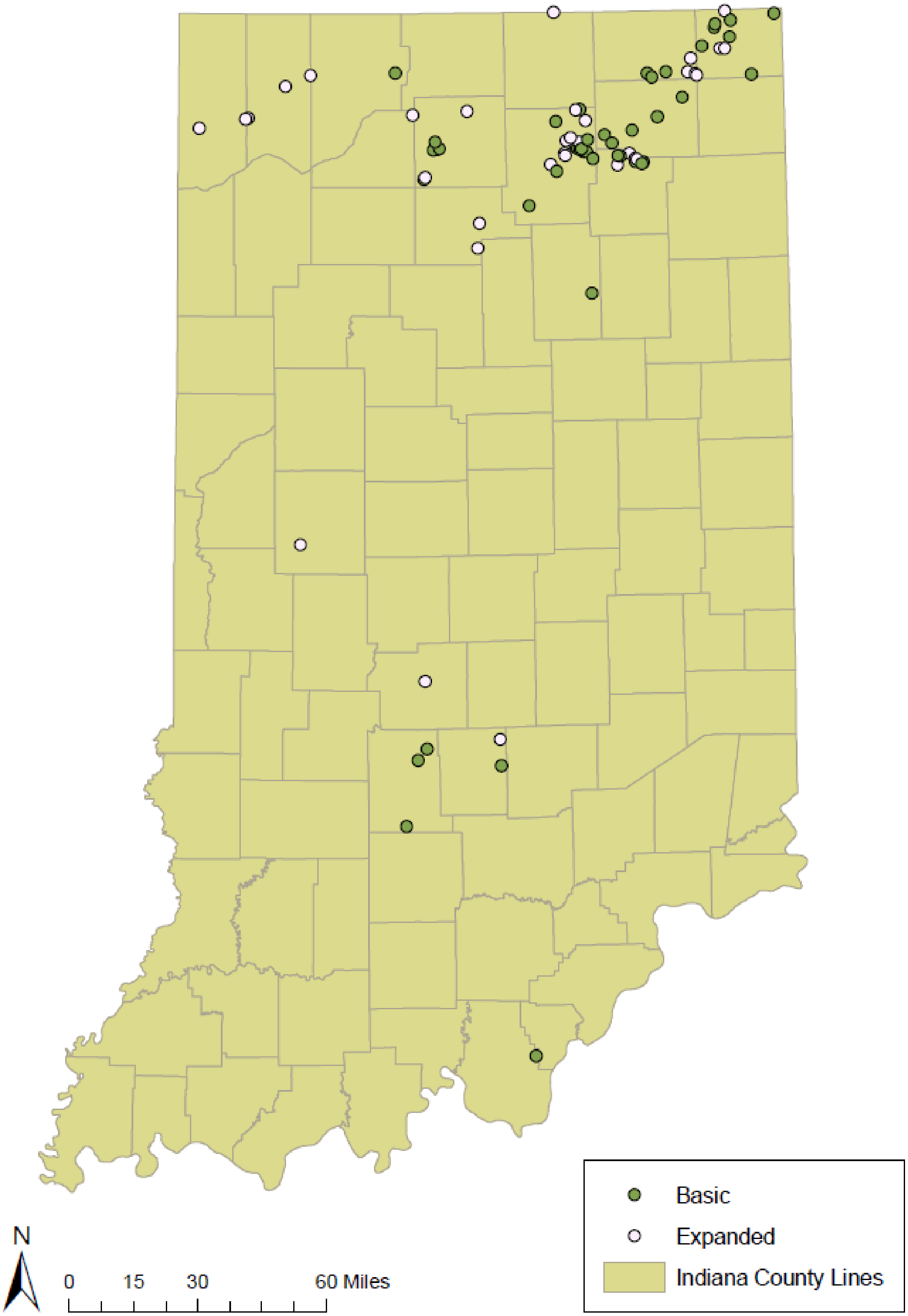


Figure 2. Location of basic and expanded volunteer-monitored lakes, 2004-2008.

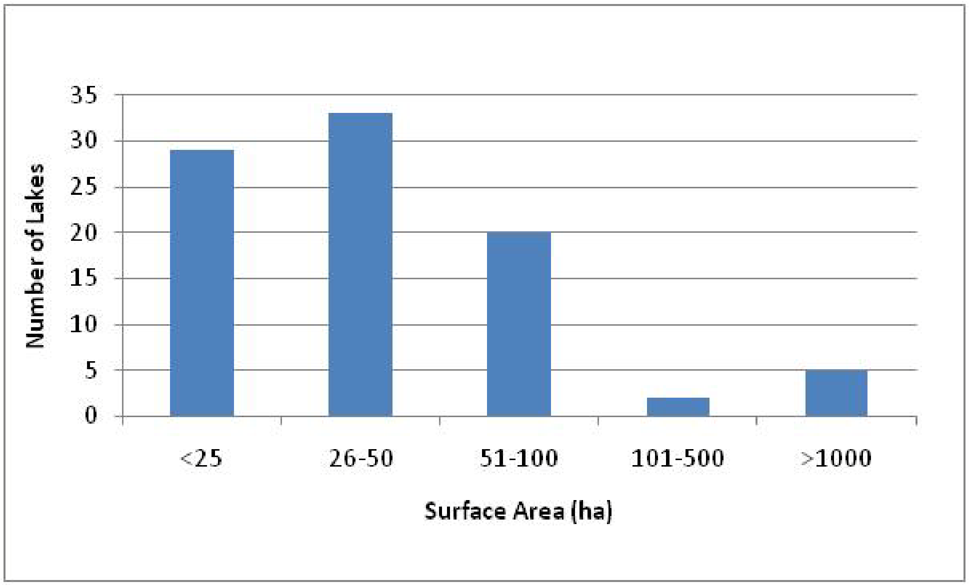


Figure 3. Size distribution of lakes in the Volunteer Lake Monitoring Program.

The deepest monitored lake was Lake Tippecanoe in Kosciusko County at 123 feet, while Lost Lake in Marshall County was the shallowest natural lake at 4 feet. Ten of the monitored lakes were less than 20 feet deep, forty-four lakes were between 21-40 feet, twenty-eight lakes were between 41-60 feet, sixteen were between 61-80 feet, thirteen were between 81-100 feet, and four were greater than 100 feet (Figure 4).

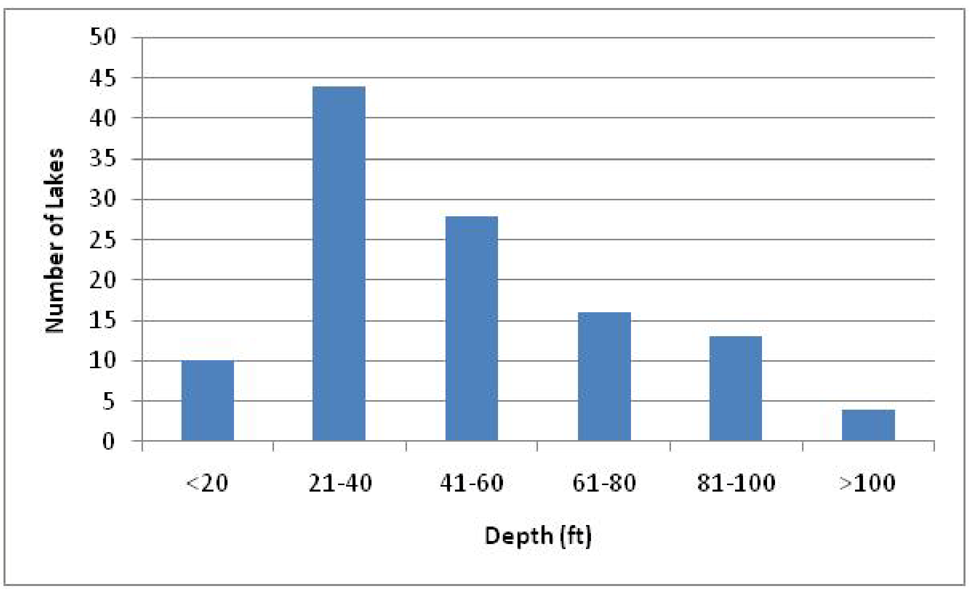


Figure 4. Depth distribution of lakes in the Volunteer Lake Monitoring Program.

Monitored lakes also varied in the size of the watershed. Salamonie Reservoir in Wabash County has the largest watershed, 355,687 acres (144,003 hectares). Banning Lake has the smallest watershed, 306 acres (124 hectares). Thirteen lakes had a watershed area less than 500 hectares, twenty-two watersheds were between 501-2000 hectares, seventeen watersheds were between 2001-5000 hectares, eleven watersheds were between 5001-10,000 hectares, and twenty watersheds were greater than 10,000 hectares (Figure 5).

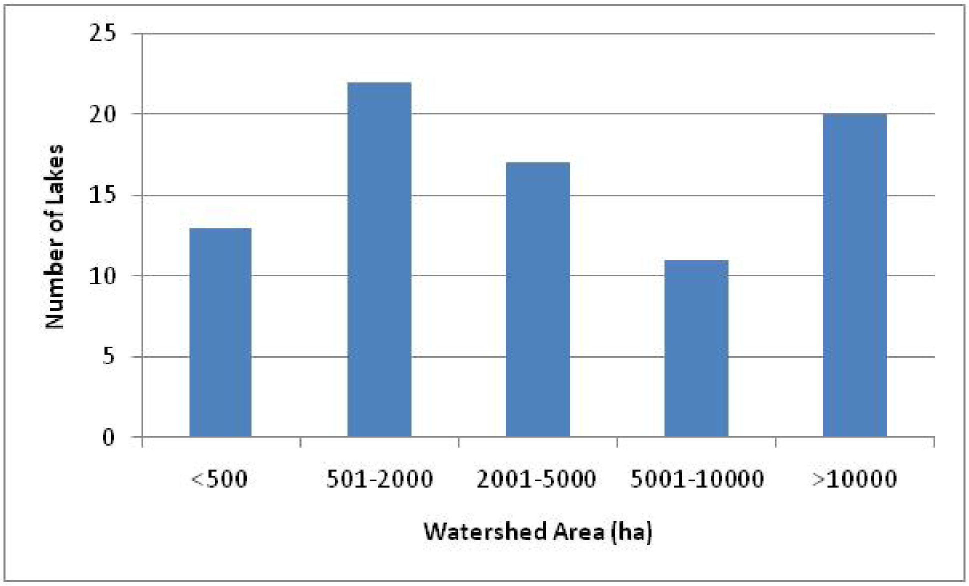


Figure 5. Watershed area distribution for lakes in the Volunteer Lake Monitoring Program.

Ecoregions

Ecoregions were delineated in the late 1980's (Omernik, 1987) to provide a geographic framework for more efficient management of ecosystems and their components. This concept recognizes that land features such as bedrock geology, topography, soil type, vegetation, land use and human impacts interact to form specific ecological regions or ecoregions. The relative importance of individual factors and the complexity with which these factors interact varies from one ecoregion to another.

Indiana is a state composed of many different land types. The northern portion of the state is relatively flat, while the southern portion of the state is hilly. Land use ranges from row crop agriculture in the northern and central portion of the state to large areas of forest in the south to coal mines in the southwest. The use of ecoregions can help explain the differences between these different land types. Overall, six ecoregions are located within the state of Indiana (Figure 6). Five of these contain lakes sampled in the Volunteer Monitoring Program during the 2000 sampling season. Characteristics of Level III ecoregions within Indiana, as described by Omernik and Gallant (1988) are described in Figures 7, 8, 9, 10, 11, and 12.

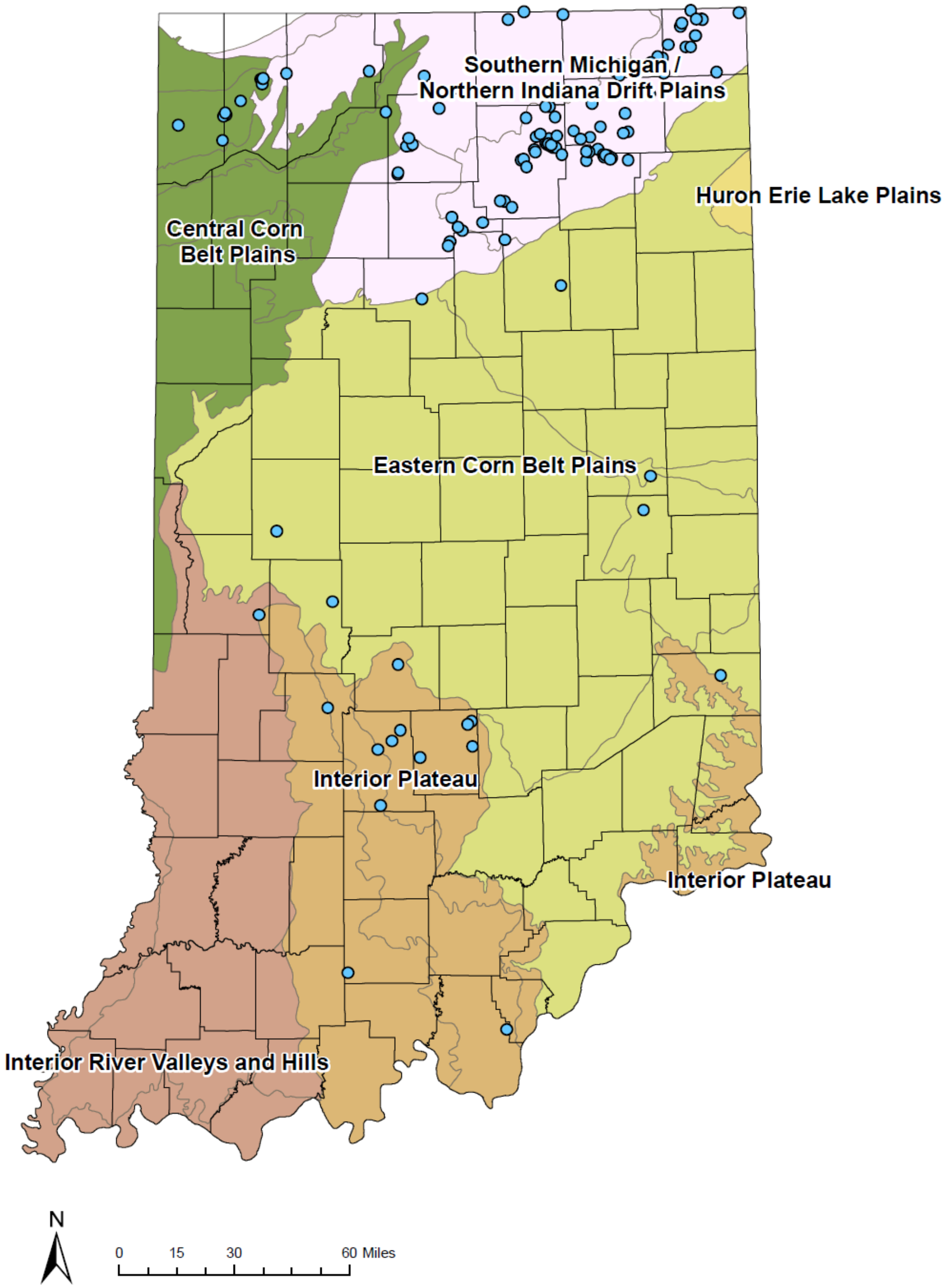
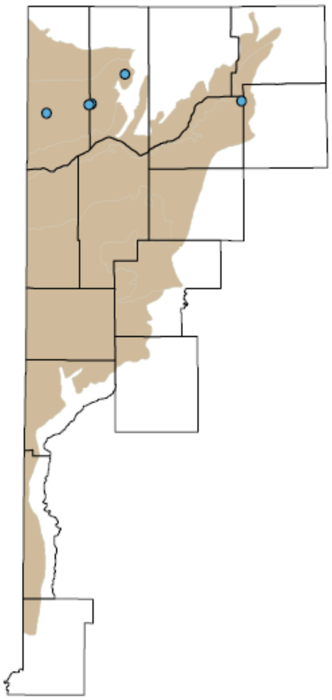


Figure 6. Volunteer Lakes by Level III Ecoregions in Indiana. After: Omernik and Gallant (1988)



54 – Central Corn Belt Plains Ecoregion The Central Corn Belt Plains ecoregion consists of a dissected glacial till plain mantled with loess. Historically, this region was mostly low relief and soils originally developed in tall-grass prairie and oak/hickory forests. Today, almost all of this ecoregion is cultivated for feed crops (corn, soybeans, feed grains and some forage) for livestock. Only 5% of the land remains in woodland. Non-point source pollution in the Central Corn Belt Plains is derived from crop and livestock production.

Number of Lakes in Program During 2004-2008: 9
Maximum Surface Area: 780 acres
Maximum Depth: 71 feet
Median Secchi Disk Transparency: 6 feet
Number of Expanded Lakes: 5
Median Total Phosphorus Concentration: 50.3μg/L
Median Chlorophyll a Concentration: 11.45 μg/L

Figure 7. Lakes monitored in 2008 within Ecoregion 54.

55 – Eastern Corn Belt Plains Ecoregion

The Eastern Corn Belt Plains ecoregion is a gently rolling glacial till plain broken by moraines and outwash plains. It supports a diverse hardwood forest and approximately 75% is currently is in cropland, primarily corn and soybeans. This ecoregion has few natural lakes or reservoirs.

Number of Lakes in Program During 2004-2008: 9
Maximum Surface Area: 2128 acres
Maximum Depth: 100 feet
Median Secchi Disk Transparency: 4 feet
Number of Expanded Lakes: 4
Median Total Phosphorus Concentration: 33.29 μg/L
Median Chlorophyll a Concentration: 3.18 μg/L

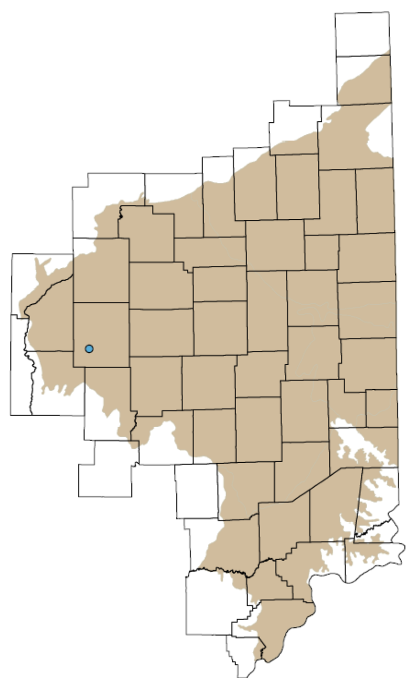


Figure 8. Lakes monitored in 2008 within Ecoregion 55.

56 – Southern Michigan/Northern Indiana Drift Plains Ecoregion

This 25,800 square-mile ecoregion includes a broad, nearly flat to rolling glaciated plain, deeply mantled by glacial till and outwash, sandy and gravelly beach ridges and flats, belts of morainal hills, and boggy kettle depressions. Land is managed for cropland, livestock, forest and woodland, and urban use. Approximately 25% of the region is urbanized. Lakes are common in some areas; however many depressions are filled with peat deposits or dark mineral soils.

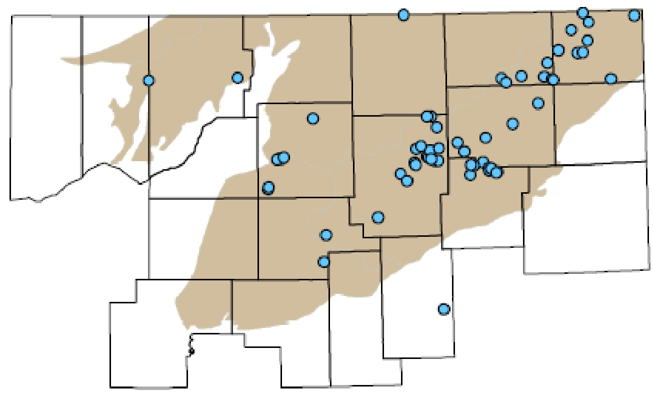


Figure 9. Lake monitored in 2008 within Ecoregion 56.

Number of Lakes in Program During 2004-2008: 92
Maximum Surface Area: 2617 acres
Maximum Depth: 123 feet
Median Secchi Disk Transparency: 5.8 feet
Number of Expanded Lakes: 36
Median Total Phosphorus Concentration: 34.38 μg/L
Median Chlorophyll a Concentration: 2.10 μg/L

57 – Huron/Erie Lake Plains Ecoregion

This ecoregion consists of a broad, nearly level lake plain crossed by beach ridges and low moraines. Most of the area was originally covered by forested wetlands. Local relief is generally only a few feet. The ecoregion covers 11,000 square miles of Indiana, Ohio and Michigan. Cash crop farming is the primary land use in the Huron/Erie lake Plain and soils are often poorly drained. Approximately one-tenth of the region is urbanized. There are few lakes or reservoirs in this ecoregion.

Number of Lakes in Program during 2004-2008: 0

Figure 10. No lakes were monitored within Ecoregion 57 during 2008

71 – Interior Plateau Ecoregion

The Interior Plateau includes a till plain of low topographic relief formed from Illinoisan glacial drift materials, rolling to moderately dissected basin terrain, and rolling to deeply dissected plateaus. Layers of limestone, sandstone, siltstone and shale underlie much of this region. Acreage in this ecoregion is managed for cropland, livestock, pasture, woodland and forest. There are numerous quarries and some coal surface mines; natural lakes are few.

Number of Lakes in Program During 2004-2008: 10
Maximum Surface Area: 10,754 acres
Maximum Depth: 110 feet
Median Secchi Disk Transparency: 3.1 feet
Number of Expanded Lakes: 5
Median Total Phosphorus Concentration: 18.59 µg/L
Median Chlorophyll a Concentration: 1.27 µg/L

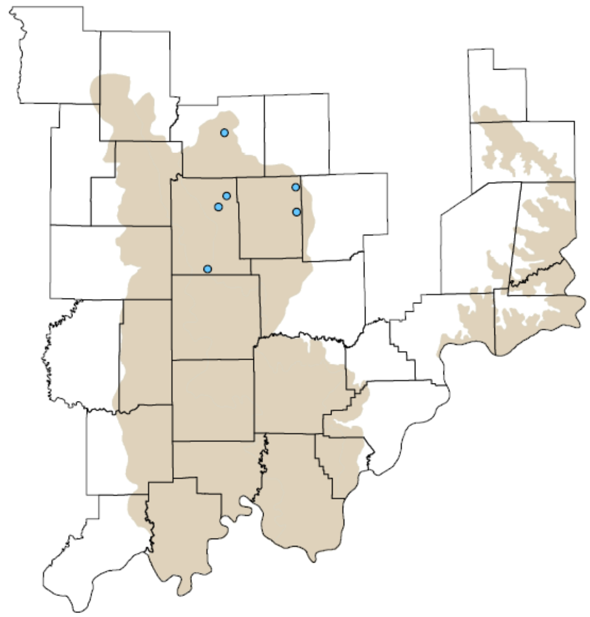


Figure 11. Lakes monitored in 2008 within Ecoregion 71.

72 – Interior River Valleys and Hills Ecoregion

The Interior River Valley and Hills is comprised of a dissected glacial till plain, rolling narrow ridge tops, and hilly to steep ridge slopes and valley sides. Land uses are varied: cropland, livestock, pasture, timber and coal surface mines. About one-third of the region is forested, primarily in oak and hickory. Lakes, reservoirs and numerous ponds are scattered throughout the ecoregion. The greatest land use impacts on stream water quality in the region result from crop and livestock production and surface mining.

Number of Lakes in Program During 2004-2008: 0

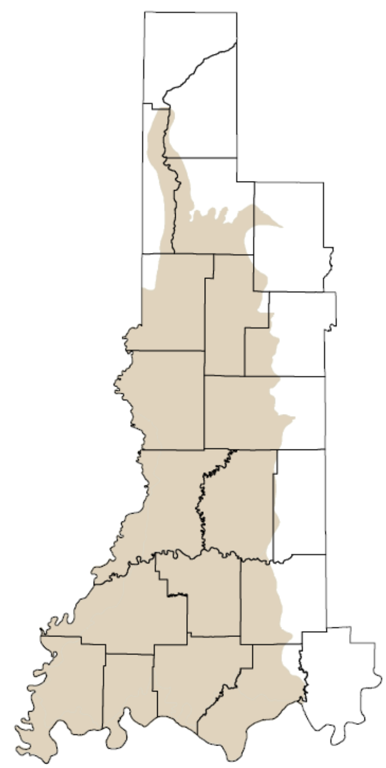


Figure 12. No lakes were monitored in Ecoregion 72 during 2008.

CARLSON'S TROPHIC STATE INDEX

The large amount of water quality data collected by the Volunteer Lake Monitoring Program can be confusing to evaluate. In order to analyze all of the data collected it is helpful to use a trophic state index (TSI). A TSI condenses large amounts of water quality data into a single, numerical index. Different values of the index are assigned to different concentrations or values of water quality parameters.

The most widely used and accepted TSI, called the Carlson TSI, was developed by Bob Carlson (1977). Carlson found statistically significant relationships between summertime total phosphorus, chlorophyll *a*, and Secchi disk transparency for numerous lakes. He then developed mathematical equations to describe the relationships between these three parameters, which are then the basis for the Carlson TSI. Using this method a TSI score can be generated by just one of the three measurements. Carlson TSI values range from 0 to 100. Each increase of 10 TSI points (10, 20, 30, etc.) represents a doubling in algal biomass. Data for one parameter can also be used to predict the value of another.

The Carlson TSI is divided into four main lake productivity categories: *oligotrophic* (least productive), *mesotrophic* (moderately productive), *eutrophic* (very productive), and *hypereutrophic* (extremely productive). The productivity of a lake can therefore be assessed with ease using the TSI score for one or more parameters (Figure 13). Mesotrophic lakes, for example, generally have a good balance between water quality and algae/fish production. Eutrophic lakes have less desirable water quality and an overabundance of algae or fish.

Using the Carlson TSI index, a lake with a mean July/August Secchi disk depth of 7 feet would have a TSI score of 49 points (located in line with the 7 feet) (Figure 13). This lake would be in the mesotrophic productivity category. It would also be expected to have a chlorophyll *a* concentration of 7 µg/L and a total phosphorus concentration of 25 µg/L based on the relationships between these parameters.

The Carlson TSI does not apply to all lakes. The relationship between transparency, chlorophyll *a*, and total phosphorus can vary based on factors not observed in Carlson's study lakes. High concentrations of suspended sediments will cause a decrease in transparency from the predicted value based on total phosphorus and chlorophyll *a* concentrations. Heavy predation of algae by zooplankton will cause chlorophyll *a* values to decrease from the expected levels based on total phosphorus concentrations.

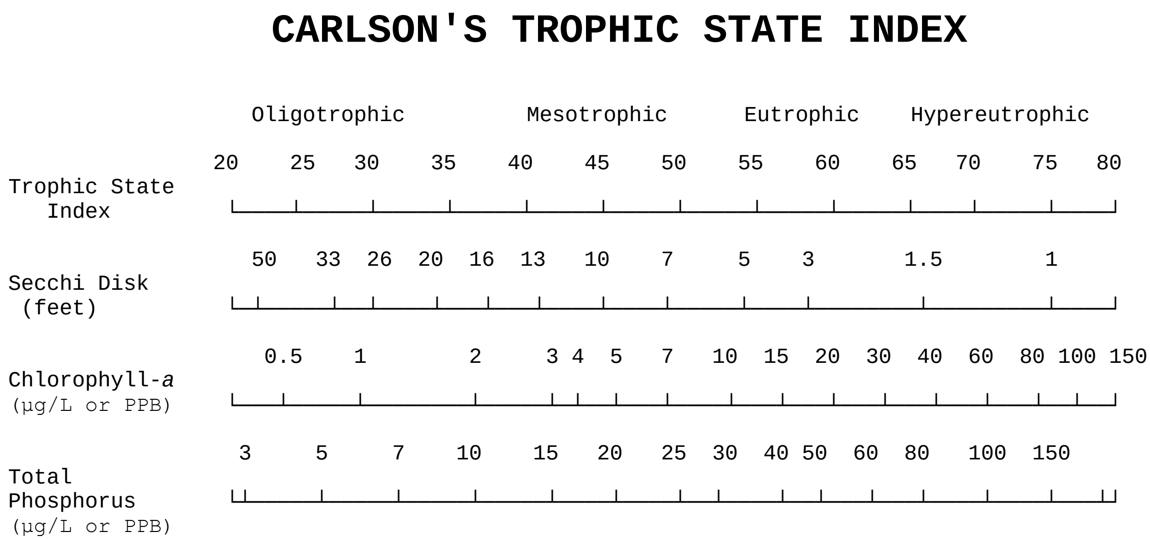


Figure 13. Carlson's index is the most widely-used TSI in the world.

TRANSPARENCY RESULTS

Secchi disk transparency results for all lakes by category can be seen in Figure 14. Tables 2, 3, 4, 5, 6, and 7 in APPENDIX A summarize the mean July/August Secchi disk transparency for each lake from 2004-2008. The July/August measurements are used for year-to-year comparisons for consistency and because this period represents the "worst-case" conditions of many lakes due to warm weather, lake stratification, algal blooms and heavy recreational use. Cordry Lake in Brown County had the highest mean summertime Secchi disk transparency, 22.4 feet for the period of 2004-2008. Sweetwater Lake in Brown County had the second highest mean, 22.2 feet. Pike Lake in Kosciusko County had the lowest mean summertime transparency of 0.3 feet.

Volunteers also receive a summary table each year with the annual minimum, maximum, and July/August mean Secchi depth measurements and the Carlson's TSI index value based on the July/August mean for each lake. The deepest Secchi depth in 2008, 26.4 feet, was recorded at Ridinger Lake in Kosciusko County. This measurement was the first measurement taken in the season towards the end of June. The other two measurements taken on this lake in 2008 were considerably lower. The shallowest Secchi depth transparency in 2008 was recorded at Lake Lemon in Monroe County at 0.1 feet. The deepest July/August mean values for 2008 were found at Crooked Lake in Noble County at 18.0 feet and Big Long Lake in Lagrange County at 17.0 feet. The shallowest July/August mean values for 2008 were found at Big Bass Lake in Porter County (1.1 feet) and Lake Monroe in Monroe County (2.4 feet).

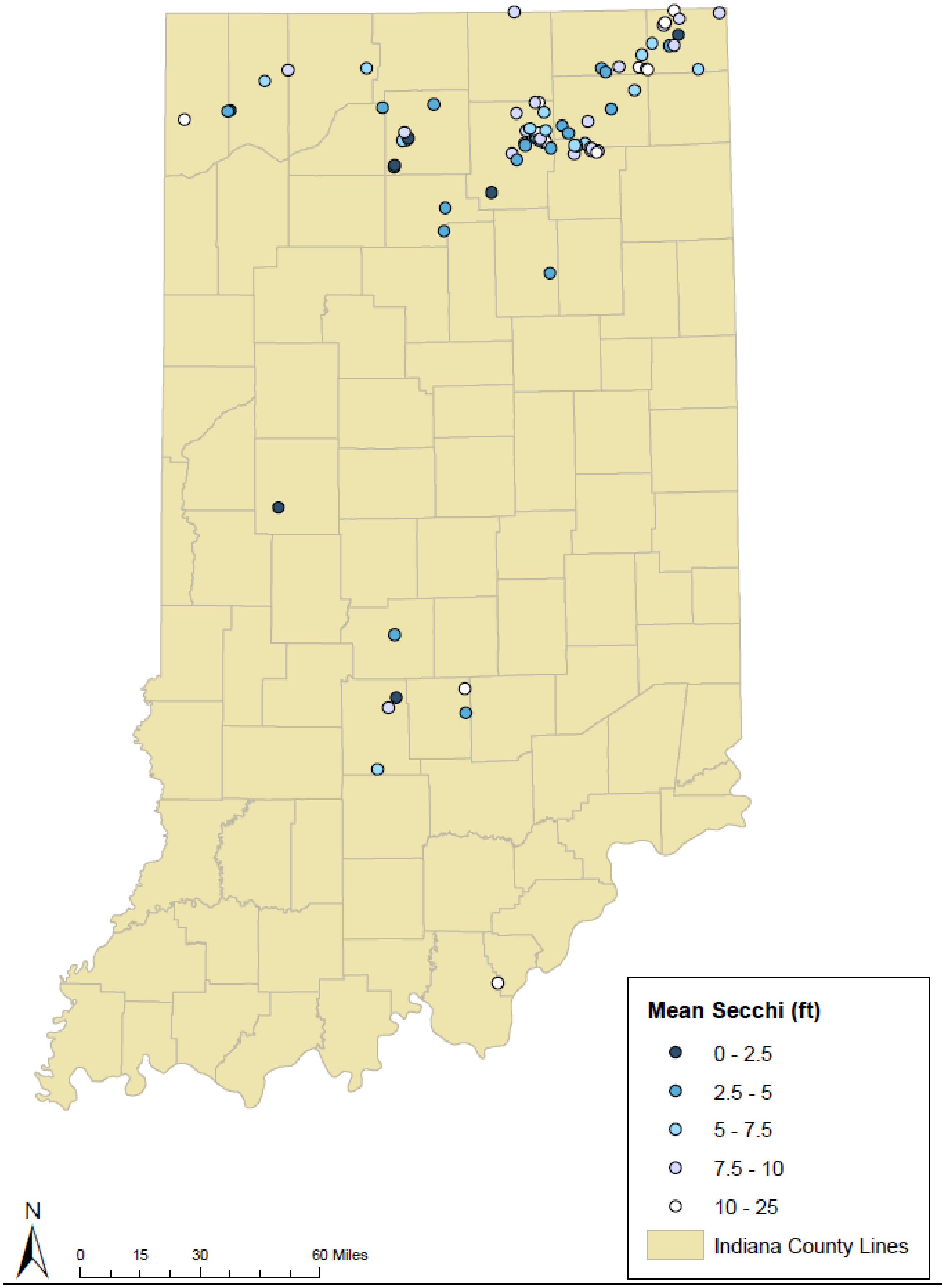


Figure 14. Secchi disk transparency July/August mean results for 2008.

Factors Affecting Lake Transparency

Anything that increases the amount of suspended material in the water affects the Secchi disk transparency. Decreased water transparency is generally related to either an increase in sediment or algae in the water column. Sediment enters the water column as a result of runoff from the landscape or is resuspended from the lake bed. Algal growth is directly related to nutrient enrichment of a lake. Therefore increases in nitrogen or phosphorus in the water leads to more algal growth and a decrease in transparency. The basin morphometry, basin type, watershed size, ecoregion, and time of week when sampled can all influence transparency.

Basin Morphometry

The physical characteristics of a lake (known as *morphometry*) influence many lake processes. Shallow lakes tend to be more productive than deeper lakes because, on average, a greater percentage of total lake volume within shallow lakes has enough light to grow algae. Shallow lakes also have a greater sediment area to water volume ratio. Sediment resuspension from wind mixing and turbulence caused by boats and personal watercraft are more prevalent in shallow lakes and can lead to a decrease in transparency. Data from 2004-2008 seems to support this premise. As the maximum depth of a lake increases, the median summertime Secchi depth transparency also increases (Figure 15). For example, in our data set, lakes having a maximum depth less than 20 feet had the lowest median summertime Secchi depth transparency, 3.1 feet. Lakes having a maximum depth greater than 100 feet had the highest median Secchi depth transparency, 14.2 feet.

Basin Type

Impoundments typically have lower Secchi depth transparencies than natural lakes due to their elongate shape (longer wind fetch), and larger watersheds; resulting in greater water and sediment runoff. Indiana impoundments tend to have lower maximum lake depths than do natural lakes. These conditions are observed in Indiana as impoundments have a median transparency of 3.1 feet, while natural lakes have a transparency of 5.7 feet (Figure 16).

Watershed Size

As watershed size increases it is expected that Secchi depth transparency will decrease. An increase in watershed size means that more land area drains into a lake and this can result in more sediment delivery to the lake and more turbulent-causing water flow. Along with sediment, a larger watershed size also leads to more nutrients entering the lake, which can stimulate algal growth thereby decreasing transparency further. Data from the Volunteer Lake Monitoring Program supports these relationships (Figure 17). The highest median Secchi depth transparency (8.8 feet) occurred for lakes with a watershed area of less than 500 hectares and the lowest median Secchi depth transparencies occurred in the larger watersheds. The median values for those watersheds over 2000 hectares was 4 to 5 feet.

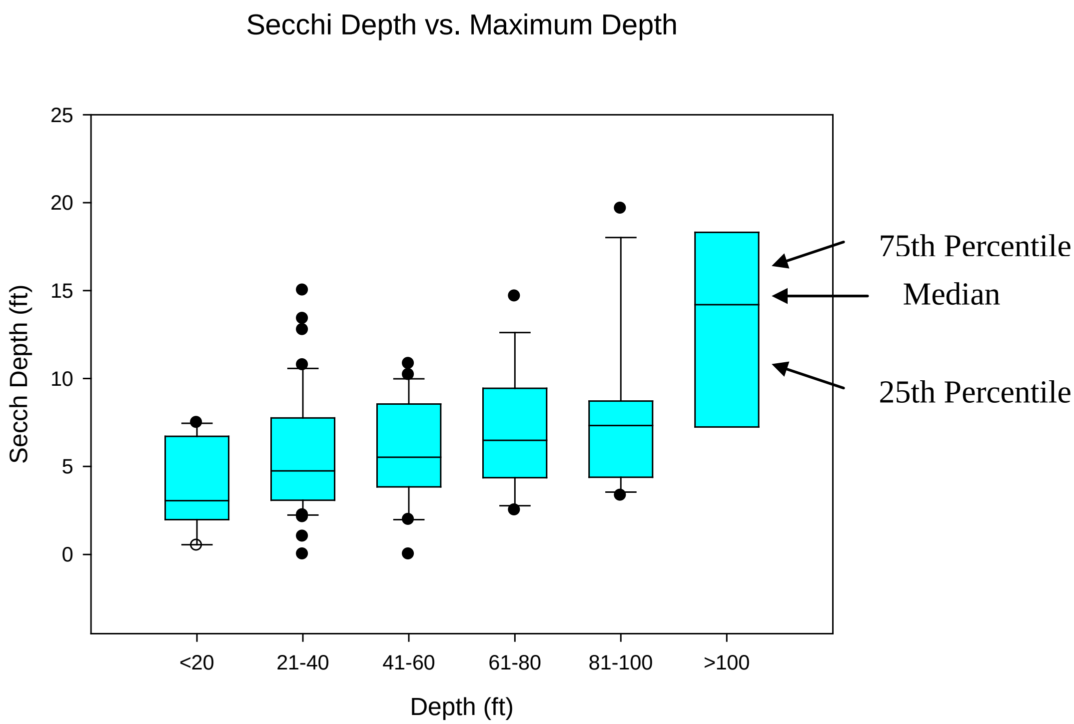


Figure 15. Mean summertime transparency distribution vs. maximum lake depth.

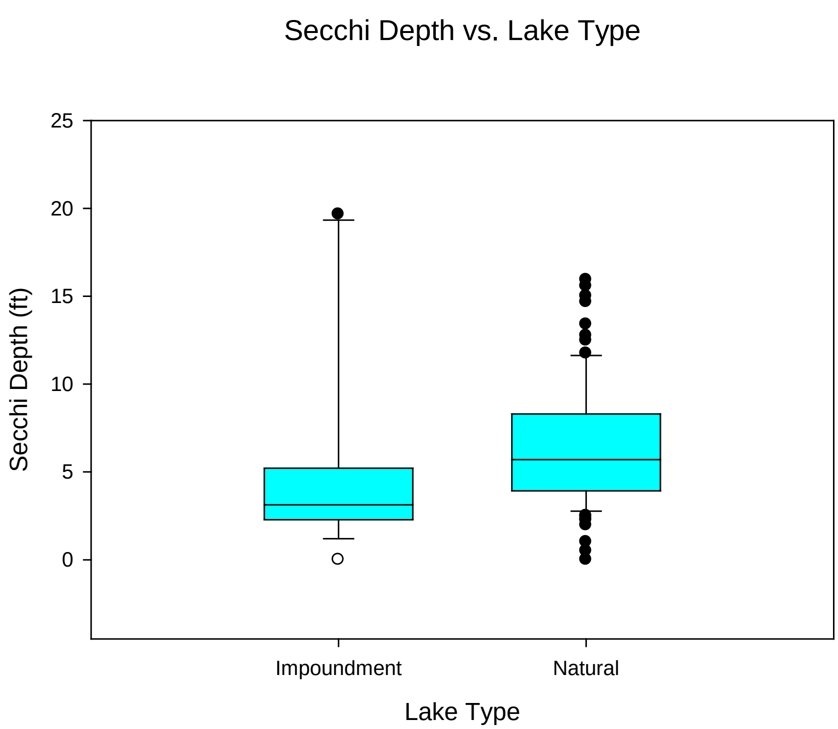


Figure 16. Mean summertime transparency distribution of natural lakes vs. impoundments.

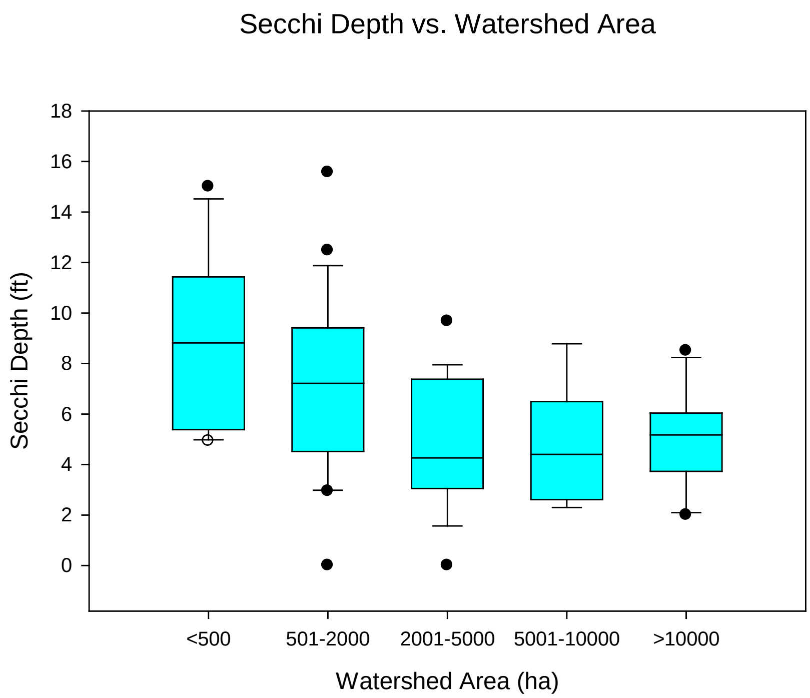


Figure 17. Mean summertime transparency distribution vs. watershed size.

Ecoregion

Median summertime Secchi disk transparency varied greatly among the ecoregions of Indiana (Figure 18). Lakes within the Southern Michigan/Northern Indiana Drift Plains (Ecoregion 55) had the lowest median summertime transparency of 0.5 foot.

The Central Corn Belt (Ecoregion 54) lakes had the highest median summertime transparency at 5.8 feet. This region has a limited number of shallow lakes that are subject to resuspension of sediments. The majority of land in this region is cultivated for feed crops (corn, soybeans, feed grains), leading to increased nutrient and sediment inputs to these lakes.

Lakes in the Southern Michigan/Northern Indiana Drift Plains (Ecoregion 56) had the second highest median summertime Secchi disk transparency, 5.8 feet. This ecoregion contains the majority of the natural, glacial lakes in Indiana and the highest number of volunteer-monitored lakes in our program (92). Transparency is expected to be higher in these lakes because they are natural lakes and are deeper than other lakes.

The Eastern Corn Belt (Ecoregion 55) lakes also have large amounts of cropland (75%) within their watersheds. This influences the lakes of that region leading to the lowest median transparency, 4 feet.

The Interior Plateau (Ecoregion 71) had a median summertime transparency of 4.4 feet. All of the lakes monitored by volunteers in this ecoregion are impoundments. These would be

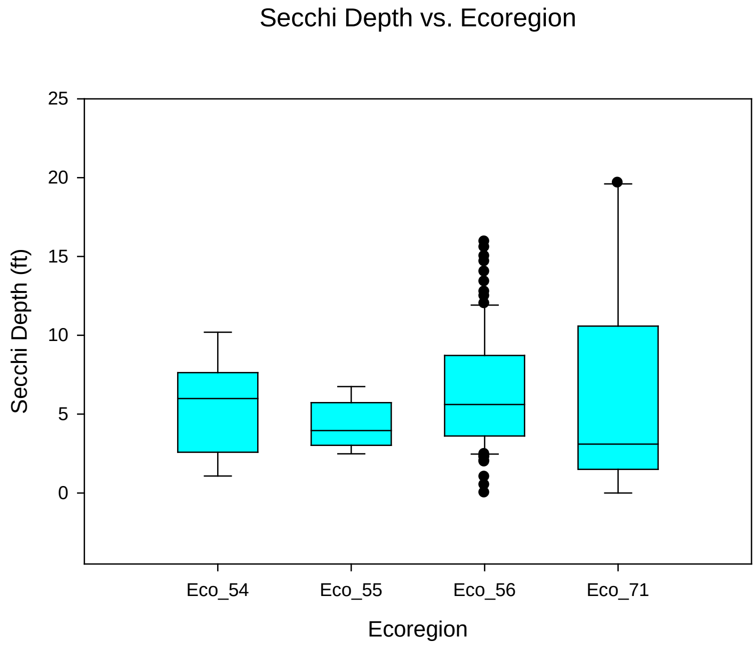


Figure 18. Distribution of median summertime transparency of monitored lakes (2004-2008) among ecoregions.

expected to have lower transparencies because they are impoundments, but these lakes include those located within Hoosier National Forest and in several Indiana State Parks and Forests. The largely forested watersheds provide more protection for the lakes by reducing soil erosion and nutrient loss.

Time of the Week

Recreational use of lakes has a large impact on transparency measurements. Boats and personal watercraft disturb bottom sediments causing them to be resuspended, resulting in reduced transparency. Transparency measurements taken on weekends or holidays are expected to be lower than transparencies recorded during the week due to increased boat traffic.

Time of the week data were analyzed for transparencies from 2004-2008. The mean weekday summertime transparency was 7.7 feet and the mean weekend transparency was 7.6 feet (Figure 19). These results do not show a relationship based on recreational use.

We postulated that boating activity would be higher on Indiana lakes during the weekends. There may not, however, be a significant difference between weekday and weekend boating activity on average. Without boating use data, it is impossible to draw conclusions from the volunteer transparency data.

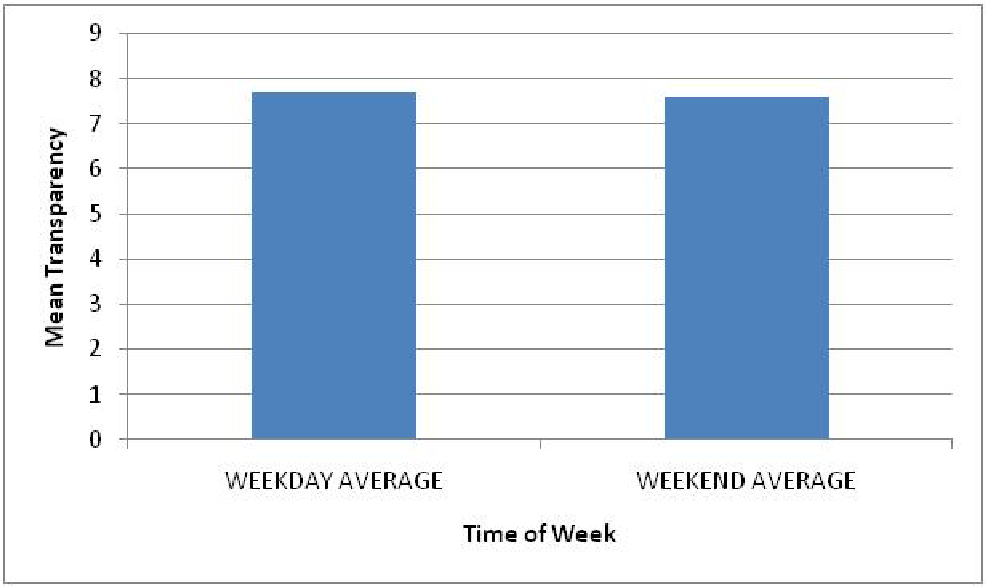


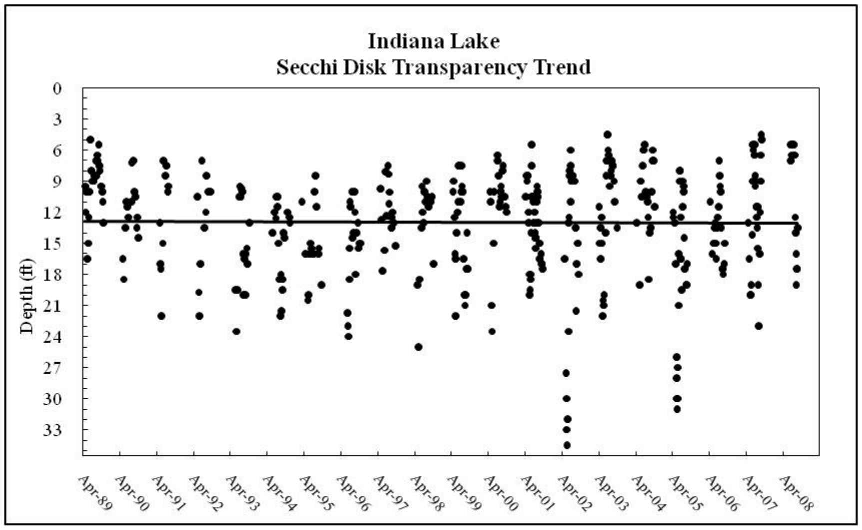
Figure 19. Comparison of mean summertime transparency based on time of week.

Long-Term Trends

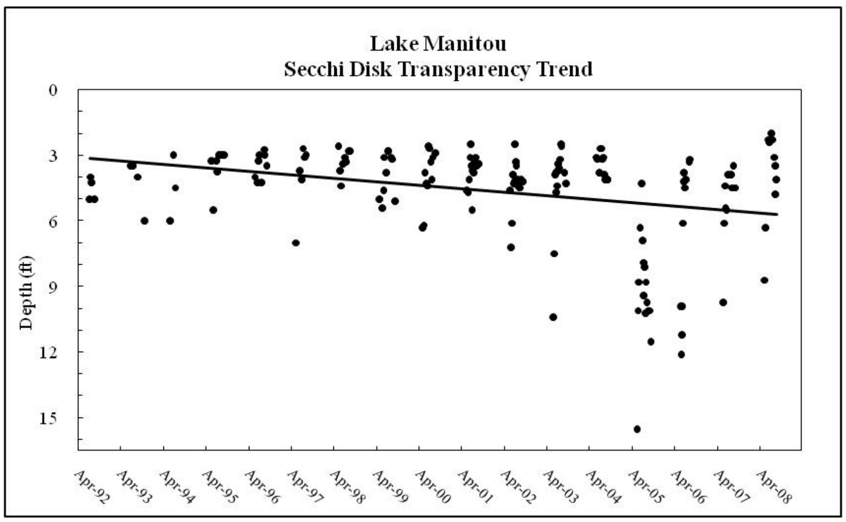
One of the main objectives of the Volunteer Lake Monitoring Program is to obtain long-term data on Indiana lakes to assess trends in water quality. Each year volunteers receive a graph of all the measurements taken over the previous 10 years. A computer software program is used to fit a trend-line to the points. This trend line gives information on how the lake has changed over time. The graph is displayed with the lake surface at the top and increasing depth down the vertical axis. Therefore, a downward sloping line indicates increasing transparency (Figure 20). An upward sloping line indicates decreasing transparency. A line that appears to be horizontal indicates that transparency has not changed much throughout the sampling period (Figure 20).

Caution should be used when analyzing this trend data because it has not been normalized. As a result, trend lines might not be indicative of a true trend in the condition of the lake. Factors that may cause the trend line to not reflect a true trend include the number of samples taken during a sampling season, the distribution of those samples, and the time period within the season that the samples were taken. If a majority of samples are taken during periods that typically have higher transparency, such as early spring or late fall, and samples are not taken during July and August, when transparency is usually low, average transparency will be overstated (Figure 21).

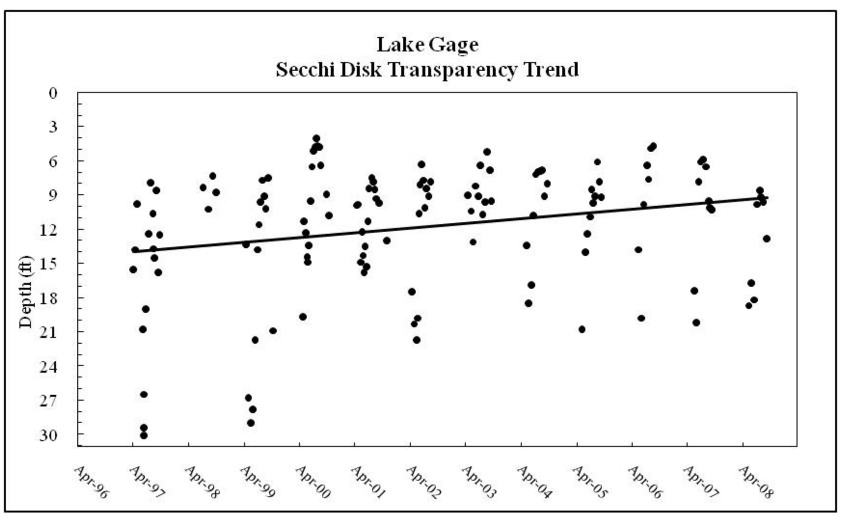
Conversely if the majority of samples were taken during July and August and none were taken during the spring and fall, average transparency will be underestimated. Variation in when samples are taken between years can also affect the trends seen in the data. If samples were taken during the spring and fall early in the program and samples were then taken in July and August in more recent years it would appear that transparency was worsening when that may not be the case. Likewise if samples were taken in July and August in the first years of participation in the program and then were taken only in the spring and fall in more recent years it would appear that transparency was improving when that may not be accurate.



A trend line showing virtually no change in Secchi disk transparency.



A trend line showing improving Secchi disk transparency.



A trend line showing decreasing Secchi disk transparency.

Figure 20. Long-term transparency trends.

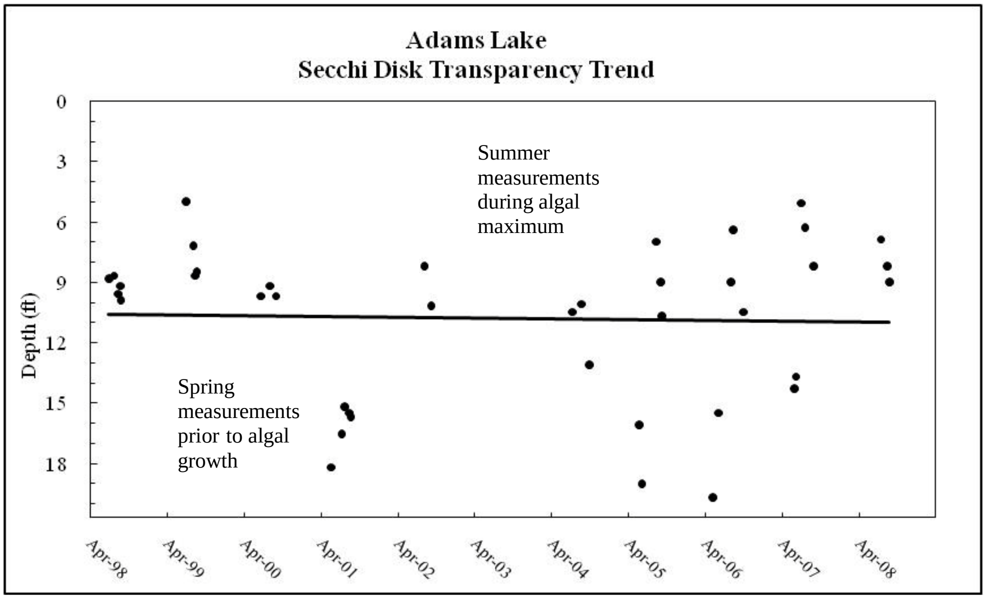


Figure 21. Seasonal variation in Secchi disk transparency.

When we visually inspected the trend plots made for volunteers in 2008, there were 30 lakes with long-term trends suggesting improving transparency, 24 lakes with a visual trend of decreasing transparency, and 26 lakes with little or no change in transparency.
Variation in lake conditions and Secchi disk transparency may simply occur as a result of events that span long time periods or as a result of non-seasonal events. Some of these could be:

1. Major watershed changes that may occur in one year, but not others, for example, clear cutting or large construction projects.
2. Periodic clearing of regulated drains. For example, this has been a problem at Lake of the Woods in Marshall County.
3. Localized storms, droughts or other variable weather events.
4. Major lake events that occur only once every few years, for example, weed treatments or channel dredging.
5. A change in data collection methods. For example, a schedule change may force a volunteer to sample on weekends when boat traffic is heavy, or many readings in one year may occur after storm events.

Trophic State Index Analysis

Carlson's TSI is a useful tool to classify and analyze lake data. Between 2004 - 2008 the majority of lakes sampled in the Volunteer Lake Monitoring Program were mesotrophic (48%) or eutrophic (33%) (Figure 22). On average about 5% of lakes were hypereutrophic, with more hypereutrophic lakes in 2004 and fewer hypereutrophic lakes in all other sample years. The percentage of hypereutrophic lakes have decreased from 2004-2008 by about 5%. In 2008, 38% of lakes were eutrophic, 55% were mesotrophic, 4% were hypereutrophic, and 1% was oligotrophic.

Observation of long-term trends in TSI values can be a more reliable method of comparison as TSI values are calculated using the July/August means thereby removing seasonal variations. The decrease in the amount of hypereutrophic lakes may indicate an improving trend in lake water quality. A lake's trophic status can however, vary yearly, but long-term data indicates that for many lakes the trophic state is very stable.

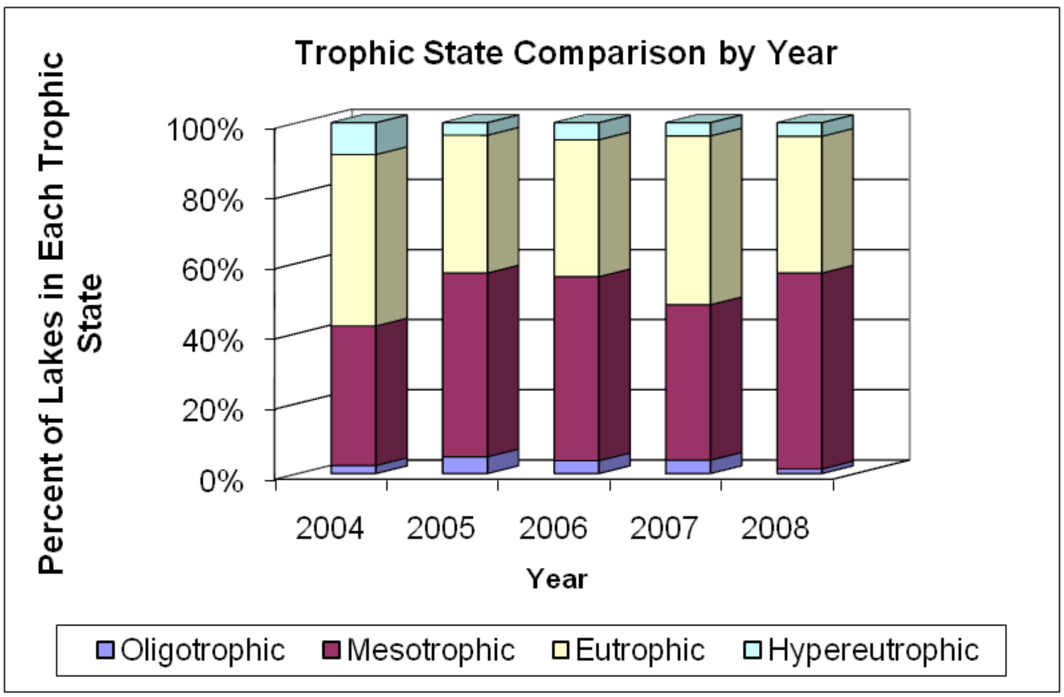


Figure 22. Annual distribution of volunteer monitored lakes among trophic classes, 2004-2008.

PHYSICAL APPEARANCE & RECREATION POTENTIAL RESULTS

Volunteers' judgments on the physical appearance and recreation potential of a lake can add to information gained through transparency measurements. Hoyer, Brown and Canfield (2004) found significant relationships between lake users perceptions of physical condition of water and associated lake trophic state water chemistry variables. They also found a relationship between recreational or aesthetic value and trophic state.

Physical Appearance

Volunteers are asked to rate the physical appearance of their lake each time they measure transparency. Volunteers rate the lake's physical appearance using the following categories:

1. Crystal Clear
2. Some Algae
3. Definite Algae
4. High Algae
5. Severe Algae

A rating of 1 or 2 indicates enhanced physical appearance. Decreasing transparency generally leads to values of 3, 4, or 5 for physical appearance because sediment and algae that reduce transparency also cause the appearance of the lake to be less desirable. In general, lower transparency is correlated with higher algal levels and therefore more impaired physical appearance.

User perceptions of water quality vary among ecoregions. Smeltzer and Heiskary (1990) found that expectations of lake users also vary by region. Users in regions of Minnesota and Vermont develop different water quality expectations based upon regional water quality. Areas where mesotrophic lakes predominate generate higher expectations than regions where eutrophic or hypereutrophic lakes predominate.

Citizen perceptions of 'crystal clear' lakes showed the greatest differences among ecoregions (Figure 23). For example, a transparency of 5.8 feet in the Eastern Corn Belt (Region 55) received a rating of crystal clear, while the same transparency in all other regions is rated as definite algae or worse. What appears to be excellent transparency to volunteers in this ecoregion is considered poor transparency in all other ecoregions. Lake users in the Interior Plateau (Region 71) had the highest perception of their lakes compared to other regions. Lakes in this region have primarily forested watersheds, which leads to reduced sediment and nutrient inputs. Differences among ecoregions decrease as water quality worsens. Citizen perceptions of 'definite algae', 'high algae', and 'severe algae' correspond to similar transparency values (Figure 23).

Physical Apperance by Ecoregion

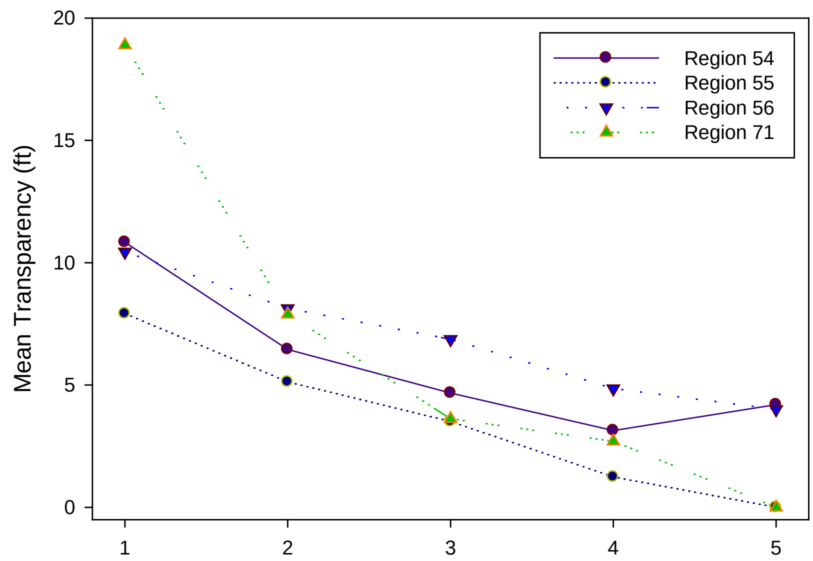


Figure 23. Mean transparency for each physical appearance category by ecoregion.

Recreation Potential

Recreation potential is also rated each time a transparency measurement is taken. Volunteers rate recreation potential based on the following five categories;

1. Beautiful – no impairment
2. Minor Aesthetic Problems
3. Swimming Impaired
4. No Swimming
5. No Recreation

Recreation potential was correlated with transparency but not to the same degree as physical appearance. Additional factors relating to recreation potential such as leaf litter, bacteria, or water temperature do not influence transparency. In addition, some lakes do not allow swimming or have limited recreation, which can cause the recreation to be rated as no swimming or recreation.

Recreational potential varies with ecoregions similarly to physical appearance. A transparency of 6 feet in the Eastern Corn Belt (Region 55) is classified as 'beautiful-no impairment', while the same transparency in other regions is classified as 'minor aesthetic problems' (Figure 24).

Recreational Potential by Ecoregion

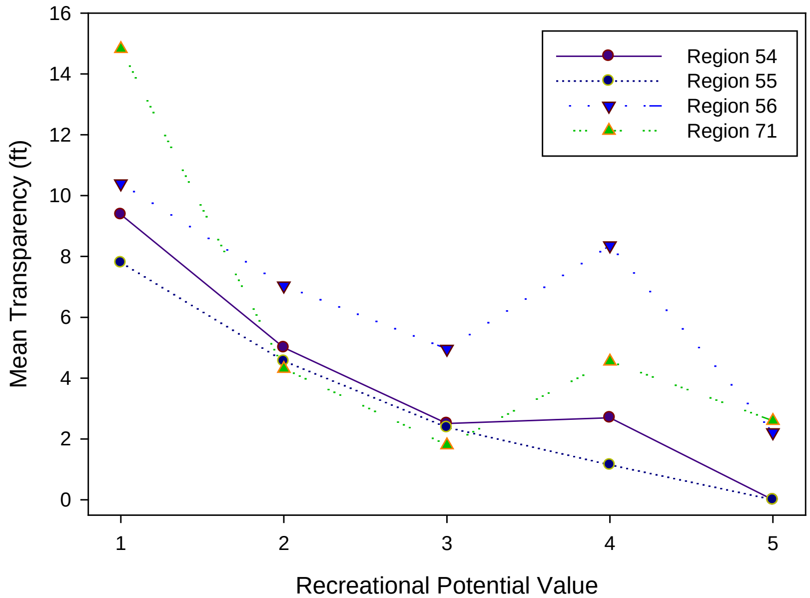


Figure 24. Mean transparency for each recreational potential category by ecoregion.

COLOR RESULTS

Water color can be used as an additional indicator of lake health and it can also be used to provide insight into what is causing decreases in transparency. Sediment and algae influence the color of a body of water. Sediments tint the water towards brown colors and algae tend to cause the water to be various shades of green.

Color measurements are taken each time a Secchi disk transparency is taken. Volunteers use a color chart developed by the Illinois EPA that attempts to assign different colors to varying levels of chlorophyll *a* and suspended sediments in the water. Exact correlations between color and the amounts of chlorophyll *a* and suspended sediment have yet to be determined.

In general, lakes with a greenish tint to the water (colors 1-10) had deeper Secchi disk transparencies than lakes with a more brownish tint to the water (colors 11-19) (Figure 25). Lakes with the greenish tint have less non-algal turbidity allowing light to penetrate deeper and increasing transparency. Color #7 had the highest mean transparency, 7.5 feet, and was also one of the lightest colors on the chart. Color #14 and #13 had the lowest mean transparencies, 4.3 feet and 5.4 feet respectively. This was not expected because it was thought that darker colors such as #5, #16, or # 19 would have lower transparencies. Colors #13 and #14 may be produced by yellow-brown algae that have carotene as a primary pigment or they may be produced by a combination of high levels of suspended sediments and algae which would explain the low transparency measurements for these lakes.

Examination of water color with the color chart is not as straight forward as an earlier method where volunteers were asked to choose between five different colors: clear/blue, blue/green, green, brown, or green/brown. Data from the color chart is also difficult to interpret and has not provided many meaningful relationships between water color and transparency. Therefore, in 2005 volunteers returned to the previous system of choosing one of the five colors listed above. This system has provided more useful results as well as made the process of determining water color more straight forward for volunteers.

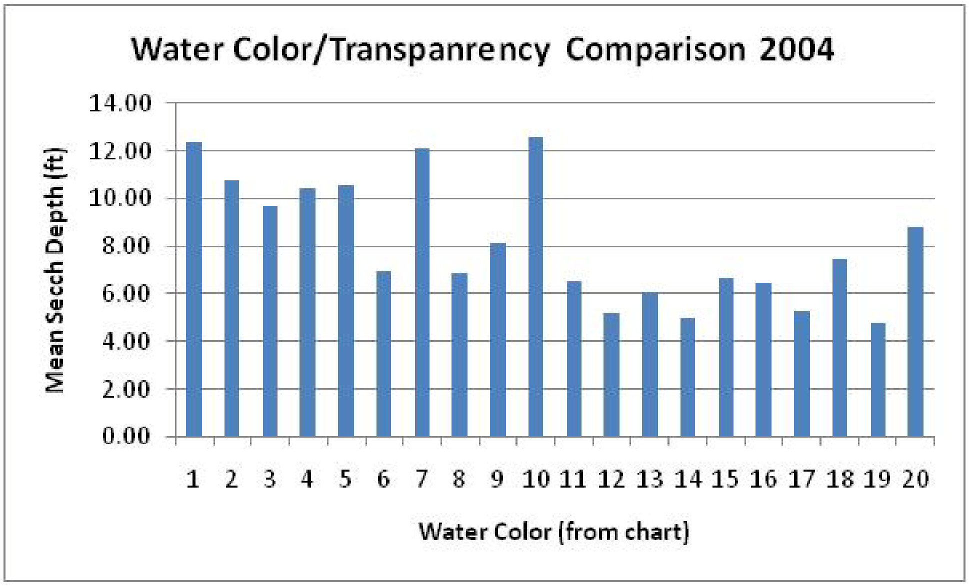


Figure 25. Mean Secchi disk transparency (2004) compared to water color number from the color chart.

The simplified water color system displays a clearer relationship to distinct trends of color choices in comparison to lake transparency (Figure 26). Lakes for which volunteers chose "clear/blue" tend to have the highest transparency with a mean Secchi depth transparency of 13.4 feet. "Blue/Green" had the second highest transparency with a mean of 9.6 feet. The water color choices of "Green," "Brown," and "Green/Brown" had the lowest mean Secchi depth with transparencies of 7.4, 6.0, and 6.5 feet respectively.

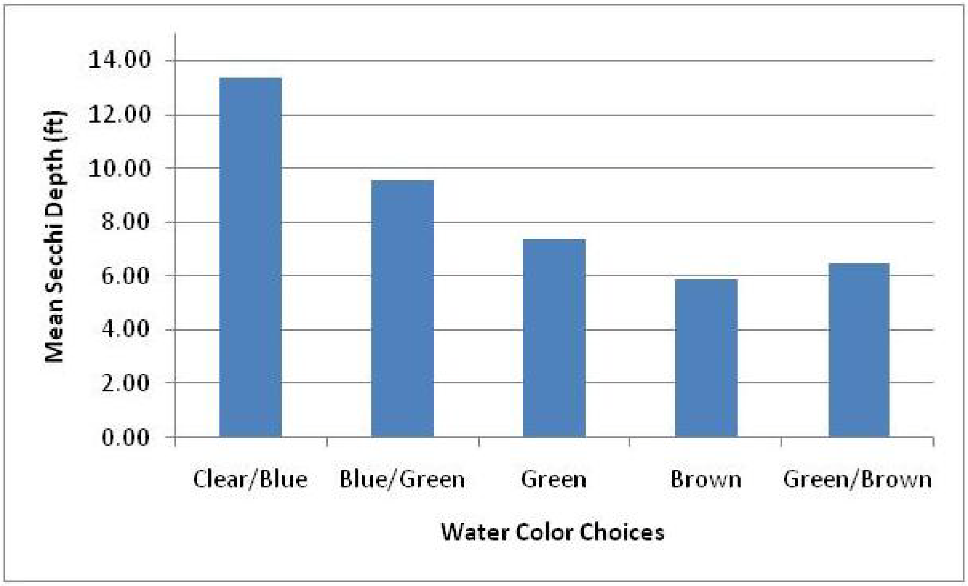


Fig 26. Mean summertime Secchi disk transparency (2008) compared to water color.

TEMPERATURE AND DISSOLVED OXYGEN RESULTS

Volunteers are able to check out temperature and dissolved oxygen meters from the School of Public and Environmental Affairs in Bloomington, and Soil and Water Conservation District offices in Fulton, Kosciusko, LaGrange, Marshall, Noble, Porter, and Steuben Counties. Volunteer monitor use of the dissolved oxygen meters has been minimal in the past few years due to older meters needing replacement.

From 2005-2008, 51 temperature and dissolved oxygen profiles were made on 7 different lakes. These temperature and dissolved oxygen profiles can yield very useful information and can indicate:

1. if the lake is thermally stratified or mixing (unstratified)
2. if stratified, the depth of the hypolimnion
3. the position of the metalimnion
4. how much of the lake has sufficient oxygen for fish
5. if the hypolimnion has no oxygen
6. the potential for nutrient release from the bottom sediments

Additional temperature and dissolved oxygen meters are being placed in more areas in an attempt to increase use.

All of the older meters operated poorly and were replaced following the 2008 season. The older meters caused a decline in the use, but with the new meters being delivered for the 2009 samplings season. This should cause an increase in temperature and dissolved oxygen monitoring. The plan to continue the effort to increase dissolved oxygen monitoring should help to boost program growth. The information that the dissolved oxygen and temperature profile of the lake displays is vital to understanding the lake ecosystem.

The data displayed in Figures 27 and 28 illustrates the changes in the temperature and dissolved oxygen profile experienced by one lake during the 2008 summer season. Little Long Lake in Noble County was strongly stratified from June to September according to the profiles. The strong temperature barrier does not allow the lake to mix completely (Figure 27). This temperature difference allows for the dissolved oxygen profile to follow the same pattern. The temperature change does not allow oxygen from the top layer of the lake to mix into the bottom creating hypoxic conditions (Figure 28). With the next monitoring season we hope to see an influx of data on temperature and dissolved oxygen.

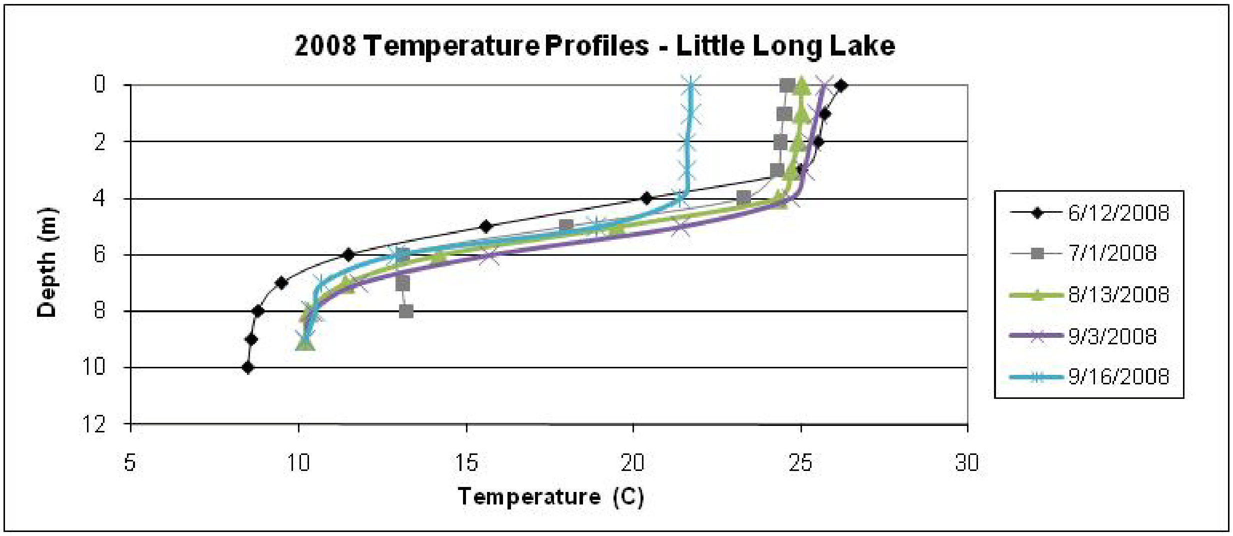


Figure 27. Temperature profile of Little Long Lake from June through September of 2008.

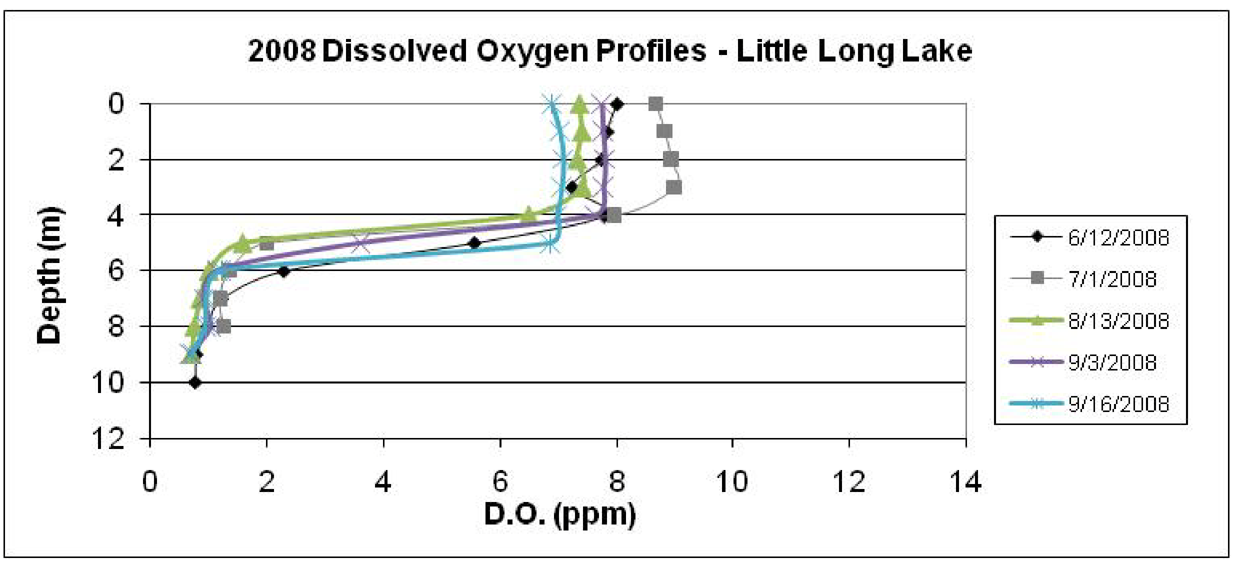


Figure 28. Dissolved oxygen profile of Little Long Lake from June through September of 2008.

EXPANDED PROGRAM RESULTS

In 2008, expanded volunteers collected 119 total phosphorus and chlorophyll *a* samples on 37 lakes. The locations of the expanded program lakes are shown in Figure 2. Most of the expanded lakes are located in the northeast corner of the state.

Variation in size and depth of the expanded lakes is similar to the variation in all lakes in the program. Figures 29 and 30 show the size and depth distributions of lakes in the expanded monitoring program, respectively. Little Crooked Lake in Whitley County had the smallest surface area, 6.1 ha and is one five expanded lakes less than 25 ha in size. Lake Wawasee in Kosciusko County, 1060 ha, was the largest lake sampled and one of only two lakes that had a surface area greater than 500 ha. The majority of expanded program lakes (40) had surface areas between 26 and 500 ha. Cedar Lake in Lake County was the shallowest lake in the expanded program, 14.1 feet. Tippecanoe Lake in Kosciusko County, 123 feet, was the deepest lake. Twenty-one of the 49 lakes sampled between 2004 and 2008 were between 21 and 40 feet deep. Four lakes were greater than 100 feet deep, while only two were less than 20 feet deep. The remaining lakes were distributed fairly evenly among the remaining classifications; 41-60 feet, 61-80 feet, and 81-100 feet.

Tables 8, 9, 10, 11, 12, 13 in APPENDIX B contain the minimum, maximum, and July/August mean values for total phosphorus and chlorophyll *a* from 2004, 2005, 2006, 2007, and 2008, respectively.

Big Bass Lake in Porter County (207 μg/L) and Cedar Lake in Lake County (152 μg/L) had the highest mean total phosphorus concentrations from 2004-2008 and were the only lakes having concentrations greater than 100 μg/L. Yellowwood Lake in Brown County and Griffy Lake in Monroe County had the lowest mean total phosphorus concentrations, 10 μg/L and 11.7 μg/L, respectively.

Cedar Lake in Lake County had the highest mean chlorophyll *a* concentration of 65.9 μg/L, over the 2004-2008 sampling period. Cedar Lake and Big Bass Lake in Porter County (43.0 μg/L) were the only lakes with mean chlorophyll *a* concentrations greater than 25 μg/L. Five lakes had chlorophyll *a* concentrations less than 1 μg/L; Myers Lake in Marshall County (0.06 μg/L), McClish Lake in Steuben County (0.36 μg/L), Gage Lake in Steuben County (0.67 μg/L), Cordry Lake in Brown County (0.77 μg/L), and Indiana Lake in Elkhart County (0.98 μg/L).

The data from the expanded program agree with expected relationships between total phosphorus and chlorophyll *a*. Figure 31 shows that as total phosphorus increases chlorophyll *a* also increases in response. Another relationship seen in the expanded program data is that as chlorophyll *a* increases, Secchi disk transparency decreases logarithmically (Figure 32). More chlorophyll *a* indicates increases algal biomass which interferes with light penetration and decreases transparency. Secchi disk transparency also decreases exponentially as total phosphorus increases (Figure 33).

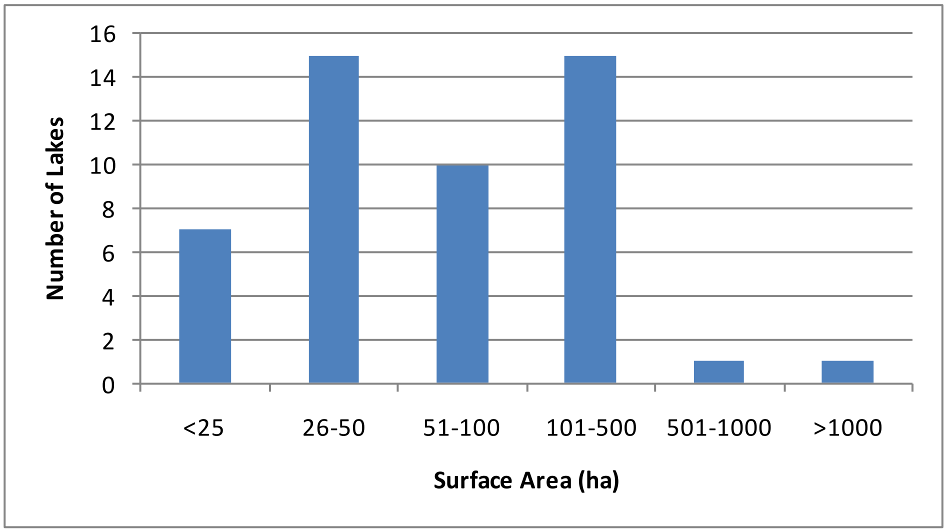


Figure 29. Size distribution of lakes in the Expanded Volunteer Monitoring Program 2004-2008.

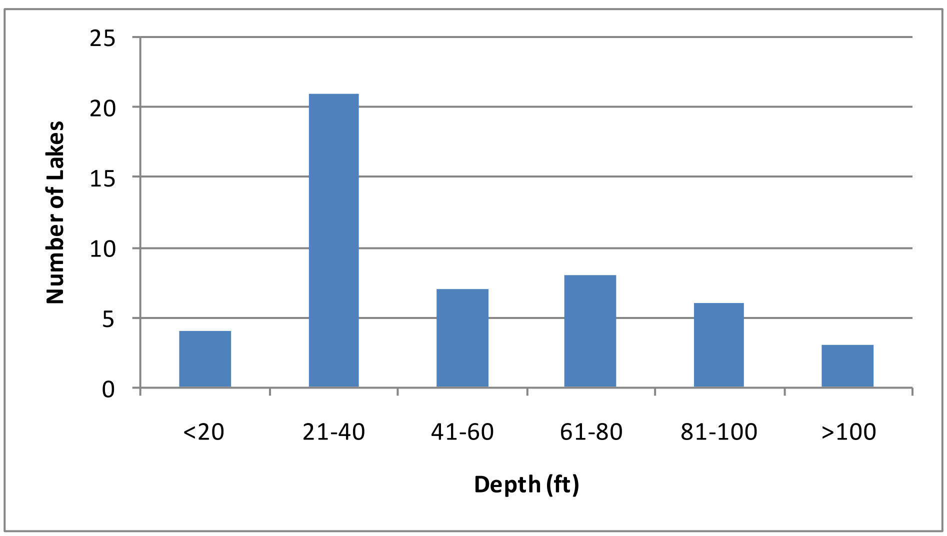


Figure 30. Depth distribution of lakes in the Expanded Volunteer Monitoring Program 2004-2008.

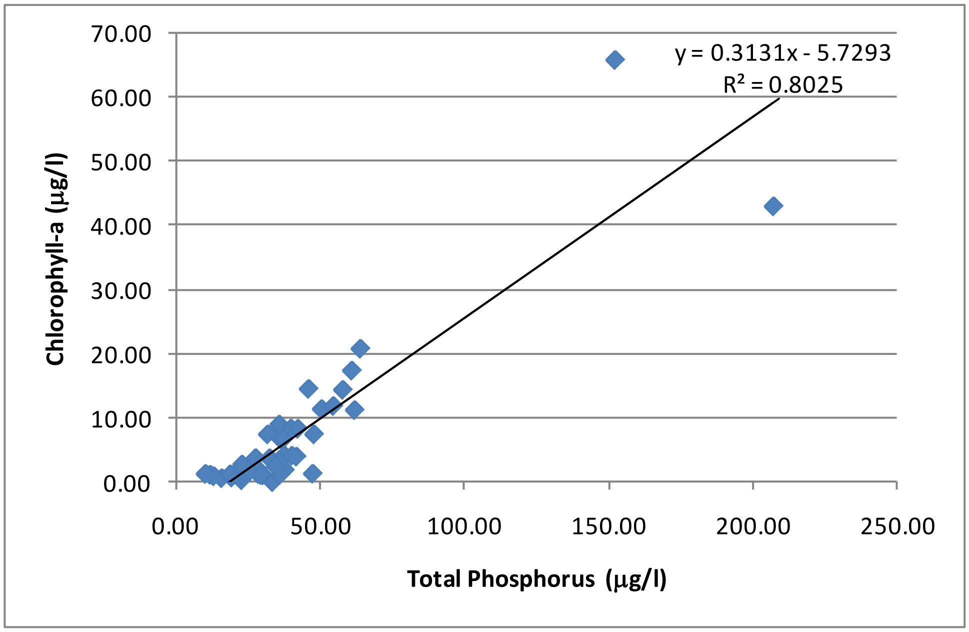


Figure 31. Relationship between total phosphorus and chlorophyll *a* in lakes monitored by volunteers.

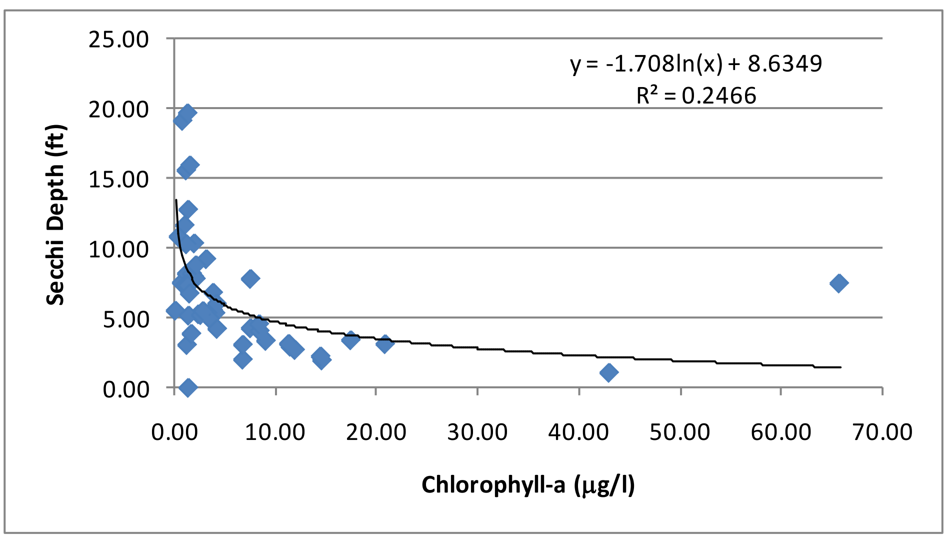


Figure 32. Relationship between transparency and chlorophyll *a*.

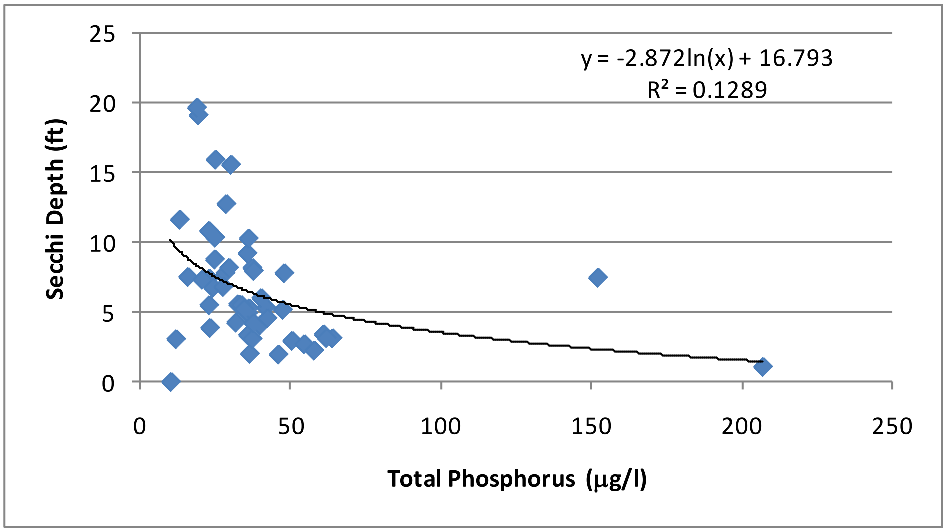


Figure 33. Relationship between transparency and total phosphorus.

Factors Affecting Phosphorus and Chlorophyll *a* Concentrations

Many factors influence total phosphorus concentrations, which subsequently affect chlorophyll *a* concentrations. Phosphorus concentrations are affected by both external and internal factors. Watershed land use is one factor that can be used as a predictor of water quality. Watersheds in which agriculture predominates will generally have higher phosphorus loads. Watersheds comprised mostly of forests will generally have lower phosphorus loads; therefore the phosphorus concentration in the lake will be lower. Human activities that remove vegetation from land, such as row crop agriculture and construction practices, can increase runoff and nutrient additions to lakes. Other human activities that add phosphorus to lakes include: gardening, fertilizing lawns, some industrial activities, and improperly functioning septic systems or wastewater treatment plants. Once phosphorus enters the lake the dissolved portion is utilized by algae and rooted vegetation, the suspended portion settles to the lake bottom. Shallower lakes are more prone to wind resuspension of sediments, thereby resuspending phosphorus as well, making it available for algal production. Other internal factors that influence phosphorus concentrations include sediment disturbance due to recreational use, surface area and the maximum depth.

Chlorophyll concentrations in lakes are influenced by factors that affect algae growth including: phosphorus availability, light intensity and penetration, water temperature, and algal predation. An increase in total phosphorus, with all other factors held constant, will often cause an increase in algae and result in an increase in chlorophyll *a*. Factors that increase turbidity such as heavy runoff or boating may cause chlorophyll *a* concentrations to remain low even when total phosphorus increases because the increased turbidity decreases light availability.

Characteristics of lakes such as basin morphometry, watershed size, and ecoregion can be used to obtain information about these relationships in Indiana's lakes. Basin morphometry can determine the importance of resuspension of sediments and the availability of light in lakes.

Watershed size can give information about the amount of nutrients and sediment expected to come from the landscape. Ecoregion can give some information about land use and human impacts on lakes.

Basin Morphometry

Total phosphorus concentrations are often greater in shallow lakes because bottom sediments, rich in phosphorus, may be resuspended into the water by motorboats or wind activity. Shallow lakes also have less water volume per unit surface area, meaning there is less dilution of phosphorus. The lake with a maximum depth less than 20 feet had the highest median total phosphorus concentration, 94 µg/L, while lakes with a maximum depth greater than 100 feet had the lowest median total phosphorus concentrations, 23 µg/L (Figure 34).

Chlorophyll *a* concentrations mirrored the total phosphorus concentrations based on maximum depth (Figure 35). Median chlorophyll *a* concentrations were highest in lakes less than 20 feet deep (24.9 µg/L) and lowest in lakes greater than 81 feet deep (1.3 µg/L). Higher concentrations of phosphorus in shallow lakes contribute to greater algal production, but another important factor contributing to increased chlorophyll *a* in shallow lakes is that more of the water column has sufficient light penetration to support algal photosynthesis. Deep lakes, on the other hand, have larger volumes of water that are too dark to support photosynthesis.

The surface area of monitored lakes had little effect on total phosphorus or chlorophyll *a* concentrations (Figures 36 and 37). The median concentrations varied little between different surface areas.

Watershed Size

It is expected that lakes with a larger watershed would have higher concentrations of total phosphorus because of the increase in the amount of runoff from larger watersheds. Median total phosphorus concentration was highest in lakes with a watershed greater than 10,000 hectares (37.0 µg/L) and lowest in lakes with a watershed less than 5,001-10,000 hectares (26.0 µg/L) (Figure 38). The 5,001-10,000 hectare watershed was less representative that the other groups though, with only 2 lakes of this size being samples

We would expect chlorophyll *a* to follow this pattern. The median chlorophyll *a* concentration was highest in lakes with a watershed greater than 5,001 hectares (2.95 µg/L) but was lowest in lakes with a watershed area of less than 500 hectares (1.92 µg/L) (Figure 39).

Ecoregion

Total phosphorus concentrations are expected to vary with ecoregion because land use and land type vary among them. Ecoregion 54 (Central Corn Belt) had the highest median total phosphorus concentration, 50.3 µg/L (Figure 40). All lakes in the Central Corn Belt region, however, were shallow and hence may be affected by resuspension. Lakes in this region are also surrounded by agriculture which may increase nutrient runoff. The lowest

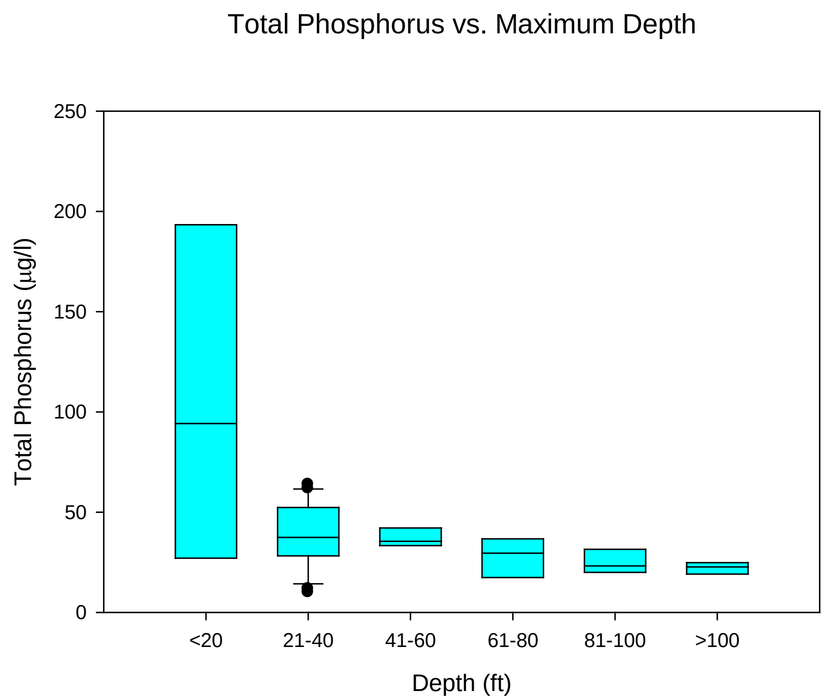


Figure 34. Distribution of mean total phosphorus concentrations (2004-2008) by depth.

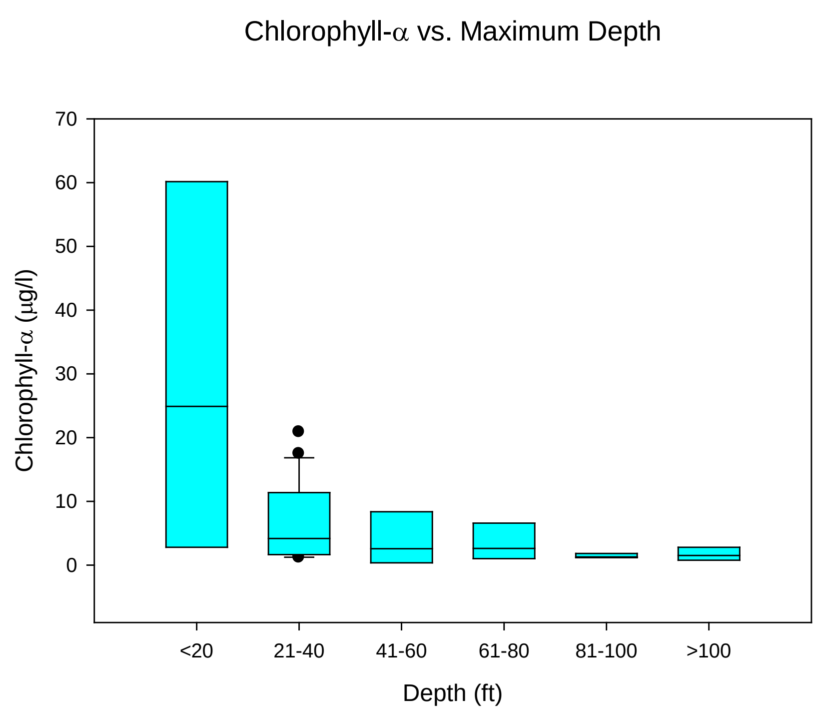


Figure 35. Distribution of mean chlorophyll *a* concentrations (2004-2008) by depth.

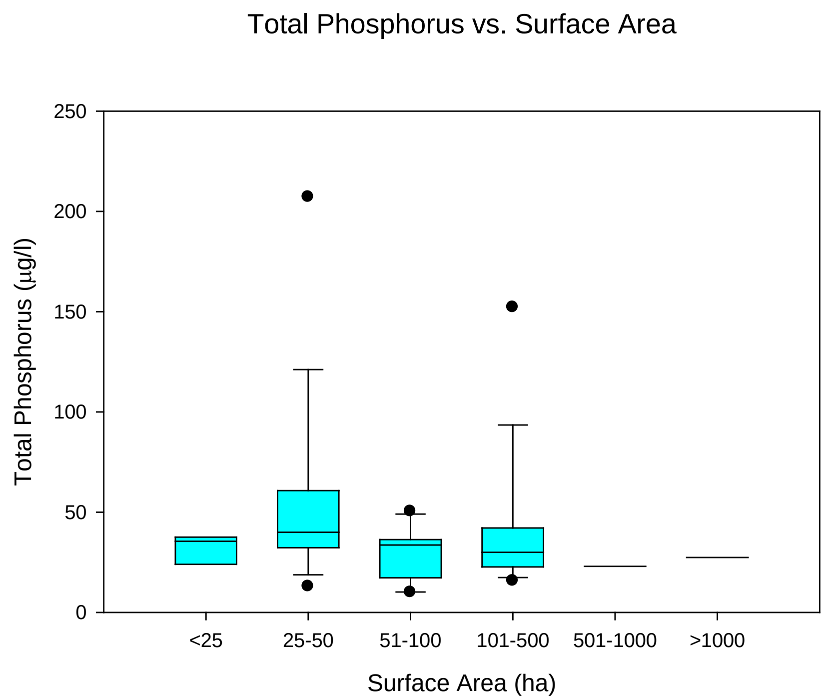


Figure 36. Distribution of mean total phosphorus concentrations (2004-2008) by basin size.

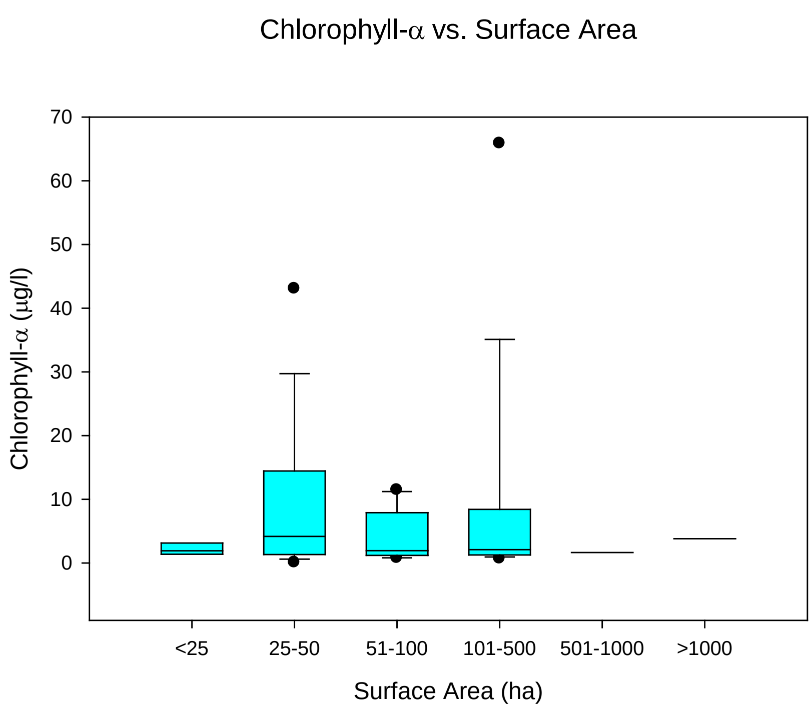


Figure 37. Distribution of mean chlorophyll *a* concentrations (2004-2008) by basin size.

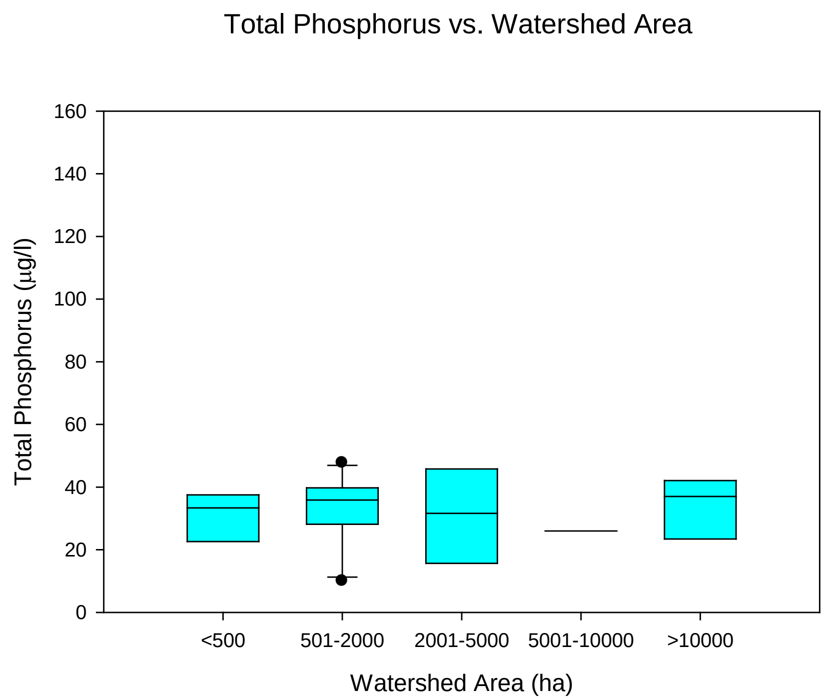


Figure 38. Distribution of mean total phosphorus concentrations (2004-2008) by watershed size.

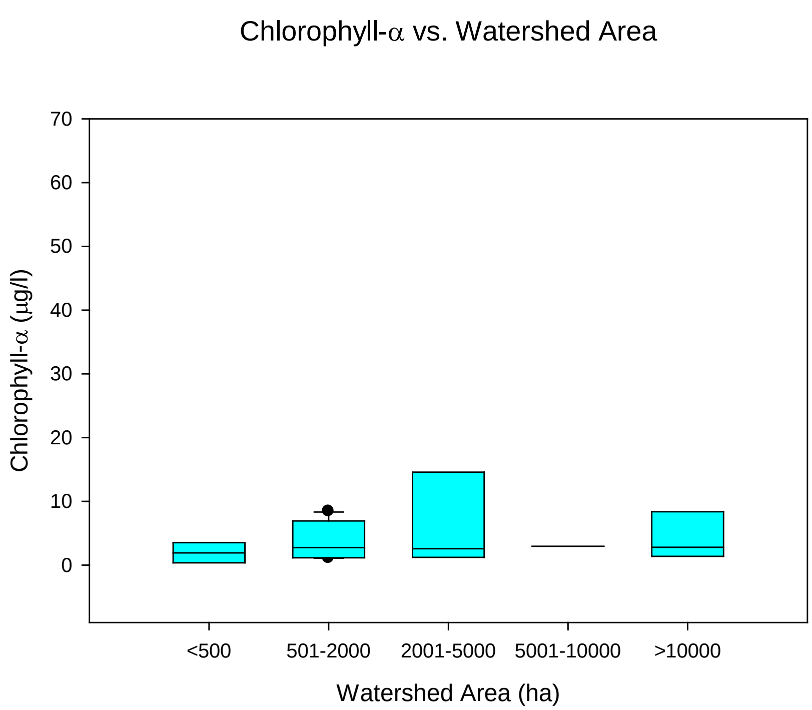


Figure 39. Distribution of mean chlorophyll *a* concentrations (2004-2008) by watershed size.

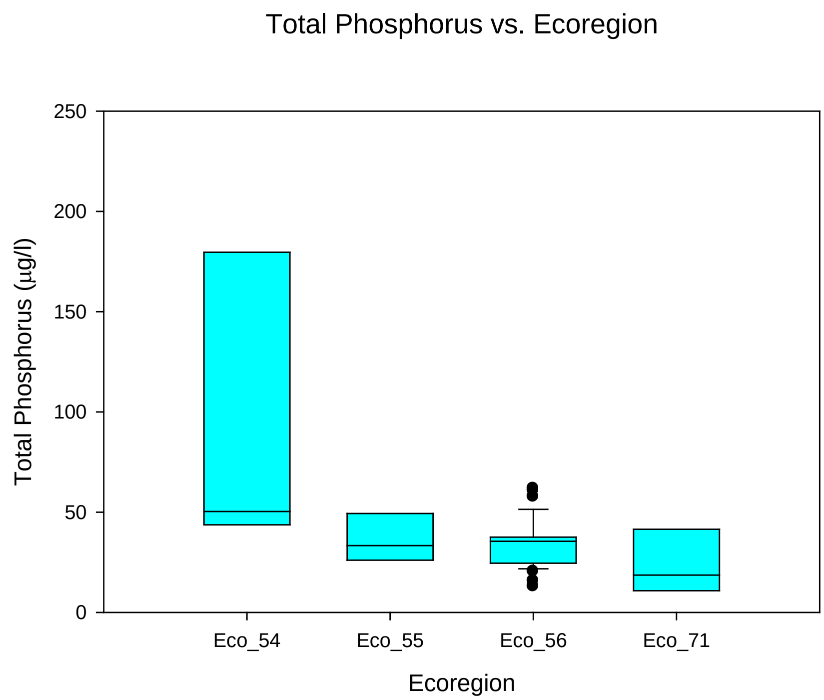


Figure 40. Distribution of mean total phosphorus concentrations (2004-2008) based on ecoregion.

median total phosphorus concentration, 13.4 µg/L, occurred in Ecoregion 71 (Interior Plateau). Ecoregion 56 (Southern Michigan/Northern Indiana Drift Plains) had the second highest median total phosphorus, 35.4 µg/L and the highest number of lakes sampled with 35. This region is also predominately agricultural. Lakes in this region, however, are relatively deep so sediment resuspension is less of an issue.

Chlorophyll *a* concentrations also vary with ecoregion in a manner similar to total phosphorus as expected (Figure 41). Ecoregion 54 (Central Corn Belt) had the highest median chlorophyll *a* concentration, 11.45 µg/L. The next highest was 3.18 µg/L in Ecoregion 55 (Eastern Corn Belt Plains). The lowest median chlorophyll *a* concentration, 1.27 µg/L, was in Ecoregion 71.

Long-Term Trends

Twenty-two lakes have ten or more years of total phosphorus and chlorophyll *a* results. Tables 8-13 in Appendix B show the minimum, maximum, and summertime mean concentrations of total phosphorus and chlorophyll *a* for 2004-2008.

Many of the factors that affect transparency over the long-term also influence total phosphorus and chlorophyll *a* concentrations. Major changes in the watershed, such as large construction projects, changes in agricultural practices or clear cutting can impact a lake in one year but not in others. Localized storms, lake treatments, or even changes in collection times can all affect annual concentrations.

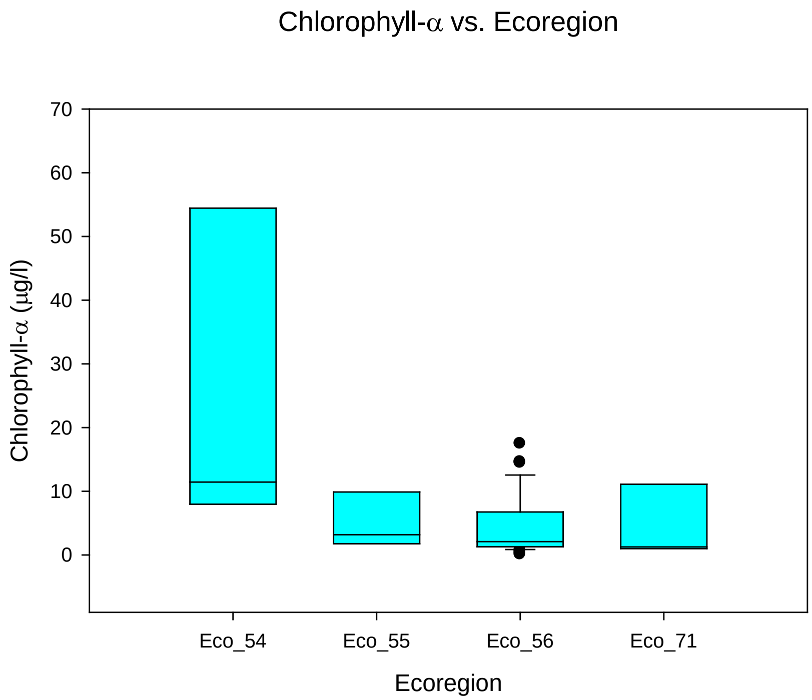


Figure 41. Distribution of mean chlorophyll *a* concentrations (2004-2008) based on ecoregion.

QUESTIONNAIRE RESULTS

Each year volunteers receive a brief questionnaire following the sampling season. These surveys provide feedback on the program, and information on the problems being experienced on monitored lakes.

From 2004 to 2008 volunteers were asked to indicate the biggest problems affecting their use and enjoyment of their lake. In most years, excessive weeds were identified as the greatest threat to lakes, affecting 45% of respondents in 2004. Algal blooms were the second greatest problem with lakes in 2008 with 40% of respondents reporting issues. The major issues that volunteers complain of are also large waterfowl population, silt, Jet Ski traffic, low water levels, and boat traffic. The chart below displays what percentage of the respondents from each year complained of a particular issue (Figure 43).

In 2006 the volunteer survey was altered for a season to see if there would be a better way of understanding how being involved in the program affects the monitors themselves 60 volunteers responded. This survey asked the volunteers more specific question towards changes in their beliefs and how they would be affected if the program was no longer continued. The survey also asked if and how they have used the data that they have collected. Many of the volunteers reported using it to present to their lake associations. Volunteers were also asked if the volunteer

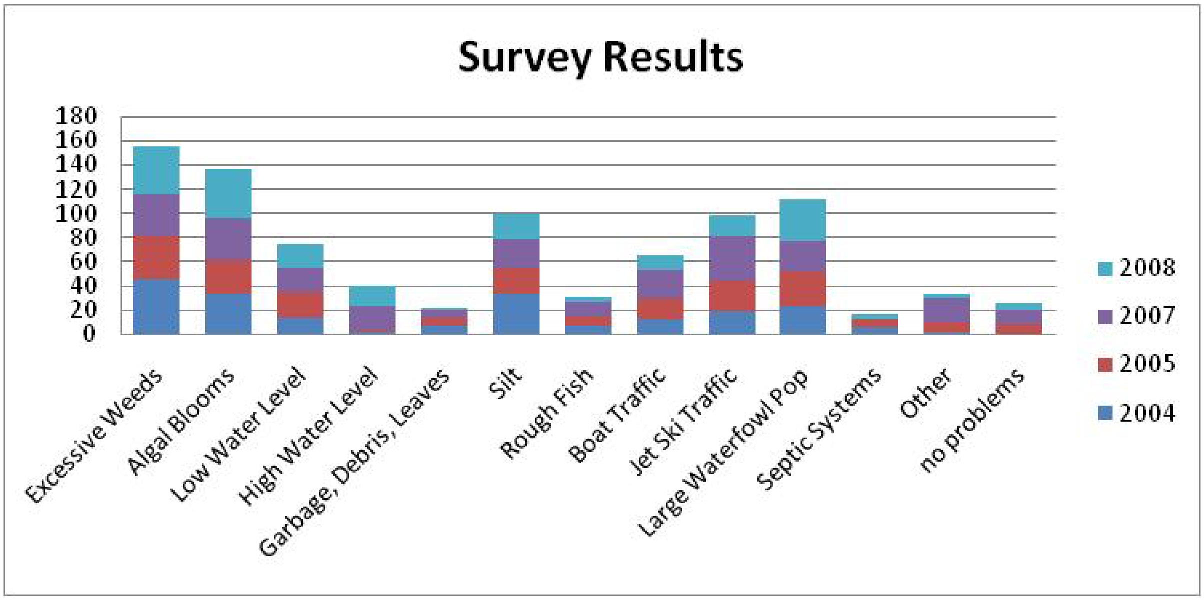


Figure 42. 2004-2008 survey results reporting common issues with monitored lakes.

monitoring program has increased their ecological understanding and 33% reported that they strongly agree and 60.9% agree (Fig. 40). When asked if they hope the program continues for many more years 70% strongly agree and 28% agree (Fig. 41). This survey demonstrated the feelings of the volunteers and how much they value the volunteer monitoring program. The more frequently used survey allow for continuous comparison of what the volunteer monitors feel are the biggest issues with the lakes. These very different processes have allowed us to understand two perspectives that motivate the volunteer monitors.

CONCLUSIONS

The past five years of volunteer lake monitoring data in Indiana have been vital to providing information on Indiana's lakes. The information collected by volunteer monitors is vital to the new Indiana State Standards being developed. The data that is collected through the volunteer program will help to set standards for the future so further control and knowledge of our lake ecosystems can be developed. The program continues to provide datasets needed to monitor long-term trends in water quality. The program has also continued to grow and educate the users of Indiana's lakes. The efforts of the volunteers that have donated their time to the Volunteer Lake Monitoring Program are much appreciated. They are vital to this program and we look forward to continued work with them in the future and the further success of the program.

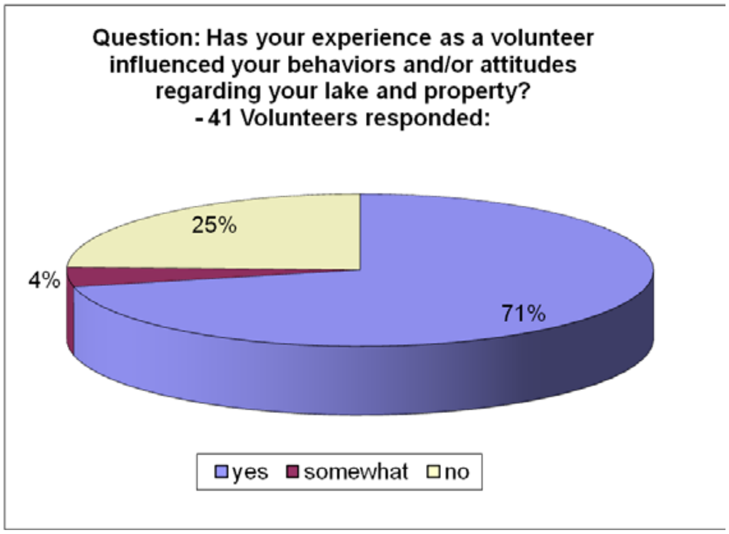
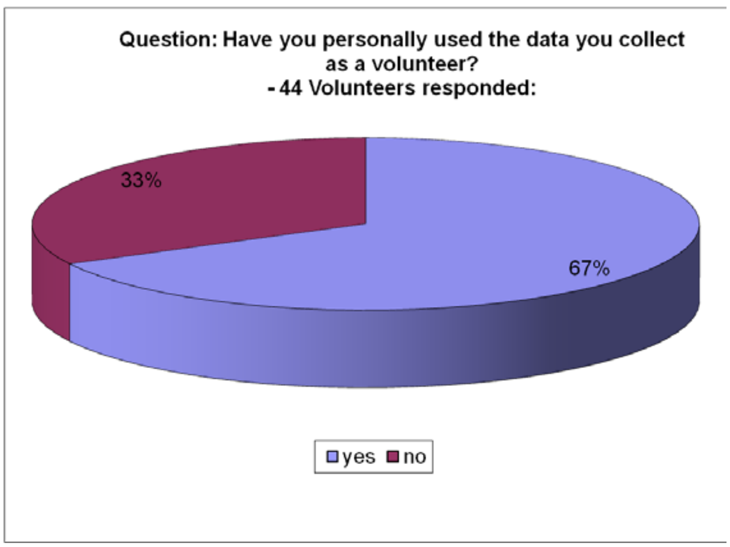
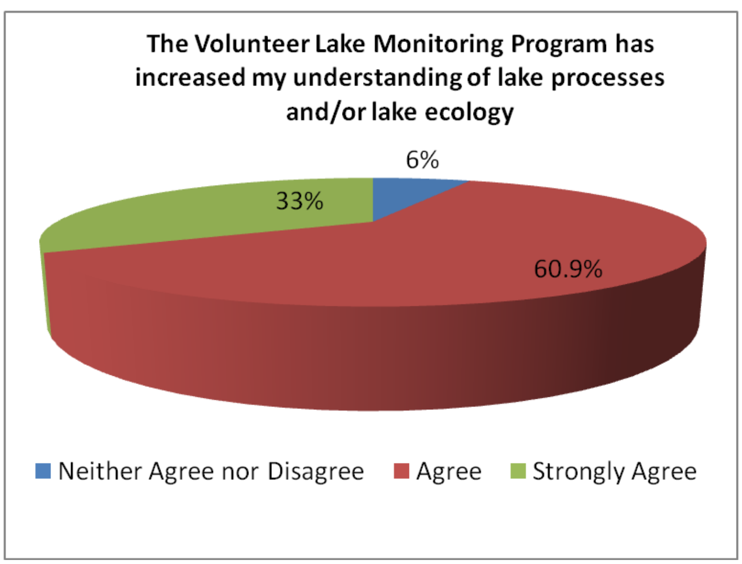


Figure 43. Survey results.





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Appendix A:

Secchi Disk Transparency Summaries for Lakes by Year for 2004-2008

Table 2. Secchi Disk Transparency Summary Data for 2004

Lake Name	County	Yearly Min. (feet)	Yearly Max. (feet)	July-Aug Mean (feet)	Carlson's TSI	# Obs.
Adams	LaGrange	10.1	13.1	10.3	44	3
Amazon	Owen	0.1	5.7	*	n/a	2
Ball	Steuben	2.8	3.3	3.3	60	2
Barton	Steuben	10.9	12.4	11.8	42	3
Bass	Porter	1.9	2.0	1.9	68	4
Big	Noble	2.6	6.7	3.8	58	6
Big Barbee	Kosciusko	5.2	7.2	5.2	53	4
Big Cedar	Whitley	12.0	14.0	12.5	41	6
Big Chapman	Kosciusko	8.2	11.0	8.5	46	5
Big Long	LaGrange	12.3	24.4	13.8	39	10
Boner	Kosciusko	9.2	13.3	9.2	45	6
Brookville	Franklin	9.0	10.0	*	n/a	3
Cedar	Lake	6.0	16.0	9.8	44	3
Center	Kosciusko	3.7	8.6	5.4	53	5
Clear	Steuben	13.0	13.0	13.0	40	1
Clear	Porter/Laporte	8.7	12.5	10.9	43	10
Cook	Marshall	3.6	7.0	5.2	53	6
Cordry	Brown	19.2	25.0	22.4	32	11
Crooked	Steuben	6.1	10.1	6.1	51	3
Crooked	Noble	17.0	19.5	17.0	36	4
Dallas	Lagrange	4.0	11.0	5.0	54	4
Diamond	Kosciusko	2.1	2.6	2.3	65	3
Diamond	Noble	6.0	11.5	9.3	45	4
Elizabeth	Kosciusko	13.3	22.7	14.9	38	9
Flint	Porter	5.4	9.8	9.3	45	3
Gage	Steuben	6.8	18.5	7.0	49	10
Galbraith	Marshall	1.8	6.3	3.6	58	5
Goose	Whitley	1.6	6.0	3.9	58	4
Griffy	Monroe	9.2	12.4	9.2	45	4
Heaton	Elkhart	5.3	9.8	6.3	51	4
Heritage	Putnam	3.8	4.2	4.0	57	7
Hogback	Steuben	3.0	5.0	3.5	59	13
Holem	Marshall	3.0	11.0	4.8	55	12
Holiday	Montgomery	2.4	4.2	2.7	63	16
Holiday	Lake	2.8	3.5	2.9	62	4
Indiana	Elkhart	5.5	19.0	11.3	42	22
James	Kosciusko	2.8	7.1	4.0	57	8
James	Steuben	6.2	16.4	9.3	45	14
Koontz	Starke	3.0	6.5	3.9	57	14

Kuhn	Kosciusko	9.0	14.2	13.8	39	4
Lake of the Woods	Lagrange	4.2	9.8	7.5	48	5
Lake of the Woods	Marshall	1.9	4.7	1.9	68	6
Lamb	Johnson	3.3	9.8	6.8	49	8
Lemon	Monroe	1.4	5.4	1.5	71	7
Little Chapman	Kosciusko	1.7	6.5	2.5	64	4
Little Crooked	Whitley	3.0	3.0	3.0	61	4
Little Long	Noble	2.7	7.5	3.5	59	11
Little Turkey	Lagrange	3.2	9.3	3.7	58	4
Long	Noble	3.6	7.3	4.2	57	6
Lost	Marshall	3.6	3.9	3.7	58	6
Lower Fish	LaPorte	3.6	8.1	5.1	54	4
Manitou	Fulton	2.7	4.1	3.3	60	12
Martin	LaGrange	5.8	16.8	10.5	43	10
McClish	Steuben	7.5	18.0	9.7	44	4
Millark Mill Pond	Fulton	1.0	3.0	2.8	62	8
Millpond	Marshall	5.1	6.1	6.1	51	2
Monroe (LOWER)	Monroe	4.0	5.0	*	n/a	2
Mt. Zion	Fulton	0.9	2.1	1.6	70	8
Myers	Marshall	7.8	20.2	9.0	46	8
Nyona	Fulton	2.6	3.6	2.8	62	4
Ole Swimming Hole	Morgan	1.5	4.0	3.4	60	11
Olin	LaGrange	6.5	23.2	7.5	48	10
Oliver	LaGrange	6.6	17.4	7.7	48	10
Oswego	Kosciusko	4.0	9.3	4.6	55	7
Perry	Cass	2.2	2.8	2.5	64	2
Pike	Kosciusko	1.6	2.4	1.7	69	6
Prairie Creek Res	Delaware	3.7	3.9	3.8	58	2
Pretty	LaGrange	13.6	14.5	14.5	39	3
Pretty	Marshall	10.8	18.0	13.2	40	4
Rachel	Kosciusko	4.9	12.9	8.4	46	9
Ridinger	Kosciusko	2.1	2.5	2.1	67	2
Sand	Noble	4.1	5.4	*	n/a	2
Shriner	Whitley	14.6	19.6	17.1	36	8
Silver	Kosciusko	2.6	4.7	3.9	58	7
Silver	Steuben	8.5	11.0	9.4	45	6
Skinner	Noble	2.9	8.3	3.1	61	7
Snow	Steuben	7.5	14.0	9.8	44	8
South Mud	Fulton	1.6	3.7	1.9	68	4
Summit	Henry	4.9	4.9	4.9	54	1
Sweetwater	Brown	16.3	37.3	19.9	34	11
Syracuse	Kosciusko	8.0	10.3	9.1	45	2
Tawny	St. Joseph	10.3	17.4	14.1	39	9

Tippecanoe	Kosciusko	4.3	12.0	5.9	52	8
Town	Fulton	0.4	0.7	0.5	87	14
Upper Long	Noble	5.3	8.0	6.3	51	7
Waubee	Kosciusko	9.0	13.1	9.8	44	9
Wawasee	Kosciusko	6.8	13.6	6.8	49	8
Webster	Kosciusko	3.8	14.7	5.7	52	7
West Otter	Steuben	5.6	6.3	6.3	51	2
Westler	LaGrange	5.0	8.0	5.0	54	4
Winona	Kosciusko	5.3	8.1	5.5	53	7
Witmer	LaGrange	3.7	7.5	4.7	55	3
Yellowwood	Brown	10.0	10.0	*	n/a	1
TOTALS	2004 Minimum	0.1	0.7	0.5	32	1
* data not available	2004 Maximum	19.2	37.3	22.4	87	22
	2004 Average	5.7	10.1	6.9	52	6

Table 3. Secchi Disk Transparency Summary Data for 2005

Lake Name	County Name	Yearly Min (feet)	Yearly Max (feet)	Jul-Aug Mean (feet)	Carlson's TSI	# of Obs.
Adams	LaGrange	7	19	7.00	49	5
Ball	Steuben	5.7	5.7	*	n/a	1
Barton	Steuben	12.4	19	12.90	40	5
Big	Noble	3	5.8	5.04	54	5
Big Barbee	Kosciusko	5.8	9.2	6.15	51	7
Big Cedar	Whitley	16	17.2	*	n/a	2
Big Long	LaGrange	12.8	18.1	15.52	38	12
Big Otter	Steuben	6.1	6.1	*	n/a	1
Big Turkey	LaGrange	2.6	8	3.53	59	4
Bonar	Kosciusko	8	11.9	8.00	47	2
Brookville	Franklin	7.3	14.25	*	n/a	2
Cedar	Lake	0.8	12	12.00	41	3
Center	Kosciusko	4.2	6.4	4.40	56	7
Clear	Porter-LaPorte	8.8	14.8	10.46	43	7
Clear	Steuben	16	18	16.00	37	2
Cook	Marshall	5.3	12.2	5.64	52	8
Cordry	Brown	15.9	23.6	20.02	34	6
Crooked	Noble	17	20	18.44	35	4
Crooked	Steuben	4.6	12.9	7.05	49	4
Dallas	LaGrange	4.7	10	4.70	55	4
Deep	Porter	5.3	5.9	5.53	52	3
Diamond	Kosciusko	3.4	4.3	3.55	59	5
Diamond	Noble	5.5	12	5.83	52	5
East	Johnson	7.2	7.2	7.20	49	2
Eli	Johnson	4.3	4.3	4.30	56	1
Elizabeth	Kosciusko	12	23.3	17.95	36	6
Flint	Porter	7.6	16	8.18	47	4
Gage	Steuben	6.1	20.8	8.70	46	10
Galbraith	Marshall	1.2	6.4	3.78	58	6
Goose	Whitley	2	8.8	8.80	46	4
Griffy	Monroe	8.4	8.4	*	n/a	1
Heaton	Elkhart	8.8	9.7	9.40	45	3
Hogback	Steuben	3	4.5	3.00	61	3
Holem	Marshall	6.9	11.7	9.34	45	19
Holiday	Montgomery	2.3	3.8	2.71	63	13
Indiana	Elkhart	8	31	13.72	39	30
James	Steuben	7.6	34.6	8.86	46	9
Koontz	Starke	3	6.5	4.60	55	17
Kuhn	Kosciusko	6.6	15.4	8.20	47	6

Lake of the Woods	LaGrange	3.33	6	3.41	59	6
Lake of the Woods	Marshall	3	5.9	3.42	59	4
Lamb	Johnson	4.3	10.2	6.73	50	16
Lemon	Monroe	1.1	4.5	1.68	70	13
Little Chapman	Kosciusko	1.5	2	1.65	70	7
Little Crooked	Whitley	5	12	11.49	42	4
Little Long	Noble	3.3	9.9	5.32	53	12
Little Otter	Freemont	7.5	8.5	*	n/a	1
Little Otter	Steuben	8.1	8.1	*	n/a	2
Little Turkey	LaGrange	3.3	7.5	4.56	55	4
Long	Noble	4	15	6.52	50	7
Loon	Noble	4.5	7.9	5.25	53	6
Lost	Marshall	2.2	2.7	2.44	64	2
Louise	Porter	3.8	14	5.99	51	13
Lower Fish	LaPorte	5.9	11	8.34	47	4
Lukens	Wabash	7.1	9.2	8.55	46	6
Manitou	Fulton	4.3	15.5	8.82	46	15
Martin	LaGrange	8	16.9	10.89	43	10
Maxinkuckee	Marshall	7.2	14.7	8.21	47	4
McClish	Steuben	6.17	9.2	7.24	49	4
Mill Pond	Marshall	5.5	6.7	5.79	52	3
Millark Mill Pond	Fulton	1.7	3.2	3.05	61	9
Monroe (LOWER)	Monroe	3	3	*	n/a	1
Moon	St. Joseph	2.3	3.75	3.50	59	3
Mt. Zion	Fulton	0	3.3	2.93	62	9
Myers	Marshall	7.3	13.7	7.40	48	3
Nyona	Fulton	2.9	3.4	2.90	n/a	3
Ole Swimming Hole	Morgan	0.7	6.5	3.38	60	16
Olin	LaGrange	7.1	20.4	7.92	47	10
Oliver	LaGrange	7	19.8	8.59	46	10
Pike	Kosciusko	0.3	0.3	0.30	94	1
Pinestone	Harrison	5	12	7.97	47	8
Pretty	LaGrange	15.5	15.5	15.50	38	1
Pretty	Marshall	10	17.6	13.45	40	4
Rachel	Kosciusko	5.9	12.1	7.65	48	6
Rocky Fork	Putnam	2.7	6.2	5.04	54	4
Round	Porter	8.9	9.2	9.07	45	3
Salamonie	Wabash	1.9	3.3	2.61	63	14
Shriner	Whitley	16.2	20.6	20.40	34	5
Silver	Steuben	9.4	14.6	9.89	44	5
Skinner	Noble	3.9	12	3.90	58	4
Snow	Steuben	7.9	9.5	8.55	46	6
Summit	Henry	4.05	9.1	4.75	55	9

Sweetwater	Brown	16	24.6	21.40	33	11
Syl-Van	Steuben	21	21	*	n/a	1
Syracuse	Kosciusko	7.3	10.7	8.54	46	5
Tawny	St. Joseph	8.4	15.9	13.43	40	9
Upper Long Lake	Noble	5.5	9.5	7.52	48	9
Waubee	Kosciusko	8.4	25.3	10.82	43	7
Wauhob	Porter	9.4	11.5	10.20	44	4
Wawasee	Kosciusko	5.5	18	6.07	51	13
Webster	Kosciusko	7.7	19.5	8.99	45	4
Westler	LaGrange	3.5	4.5	3.74	58	3
Winona	Kosciusko	8.5	11.7	8.99	45	4
Witmer	LaGrange	4	13	6.00	51	3
Yellowwood	Brown	9.6	9.6	*	n/a	1
*** Data not Available**	2005 Minimum	0.0	0.3	0.3	33.0	1.0
	2005 Maximum	21.0	34.6	21.4	94.5	30.0
	2005 Average	6.4	11.7	7.8	50.0	6.2

Table 4. Secchi Disk Transparency Summary Data for 2006

Lake Name	County	Yearly Min (feet)	Yearly Max (feet)	July/Aug Mean (feet)	Carlson's TSI	# of Obs.
Adams	LaGrange	6.4	19.7	9.34	45	5
Ball	Steuben	3.9	8.8	3.90	58	3
Barton	Steuben	8.4	11.4	9.66	44	4
Big	Noble	2.6	10.2	3.28	60	9
Big Barbee	Kosciusko	3.9	6.6	4.92	54	5
Big Bass	Porter	1	1.8	1.10	76	4
Big Cedar	Whitley	15.8	19.8	17.96	36	4
Big Chapman	Kosciusko	3.5	8	6.59	50	7
Big Long	LaGrange	13.9	21.7	15.14	38	10
Big Otter	Steuben	6.6	11.8	7.36	48	3
Bonar	Kosciusko	9.8	15.2	9.80	44	3
Brookville	Franklin	10	22	10.00	44	2
Cedar	Lake	1.1	12	1.17	75	4
Center	Kosciusko	3	4	3.76	58	6
Clear	Porter-LaPorte	6.8	14.9	13.14	40	6
Clear	Steuben	10	10	10.00	44	1
Cook	Marshall	4.9	7.3	6.45	50	5
Cordry	Brown	17.4	25.8	19.79	34	11
Crooked	Noble	11	15	15.00	38	4
Crooked	Steuben	6.3	8.9	8.22	47	3
Dallas	LaGrange	2.8	6.5	4.27	56	3
Diamond	Noble	9	11	9.62	44	5
Elizabeth	Kosciusko	14.2	19	14.73	38	6
Flint	Porter	9	14.7	9.00	45	3
Gage	Steuben	4.7	19.8	5.79	52	7
Goose	Whitley	2	18	4.04	57	8
Heaton	Elkhart	6.6	8.6	6.60	50	3
Hogback	Steuben	3	4.5	3.62	59	4
Holem	Marshall	3.5	11.2	9.70	44	18
Holiday	Montgomery	2	3.8	2.46	64	9
Holiday	Lake	4.1	7.9	4.30	56	4
Indiana	Elkhart	7	18	11.91	41	22
Irish	Kosciusko	6.6	14	6.60	50	3
James	Kosciusko	3.1	6.8	3.97	57	12
James	Steuben	6.9	29.7	11.57	42	10
Koontz	Starke	3.3	7.5	3.99	57	17
Kuhn	Kosciusko	8.6	11.8	9.68	44	5
Lake of the Woods	LaGrange	3.3	10.4	6.41	50	4
Lake on the Green	Porter	1.7	2.9	2.22	66	2

Lamb	Johnson	0.7	6.5	5.79	52	15
Lemon	Monroe	1.5	6.7	2.62	63	15
Little Cedar	Whitley	7	12.5	7.46	48	5
Little Chapman	Kosciusko	0.2	5.5	2.98	61	11
Little Crooked	Whitley	3	9	9.00	45	4
Little Long	Noble	2.9	8.6	5.57	52	9
Little Otter	Steuben	9	11.8	9.10	45	3
Little Turkey	LaGrange	3	9.6	3.00	61	3
Long	Noble	3.8	3.8	*	n/a	1
Loon	Noble	1.8	5.9	3.92	57	6
Lower Fish	LaPorte	5.2	7.3	7.30	48	2
Manitou	Fulton	3.2	12.1	3.74	58	11
Martin	LaGrange	3.7	10.8	7.04	49	5
McClish	Steuben	16.4	18.9	18.60	35	3
Millpond	Marshall	4.75	8.7	6.06	51	7
Monroe (Lower)	Monroe	4	6	4.00	57	2
Myers	Marshall	10.8	19.2	11.24	42	4
Nyona	Fulton	3.5	3.5	3.50	59	1
Old	Whitley	6	12	9.66	44	4
Ole Swimming Hole	Morgan	2.3	5	3.28	60	14
Olin	LaGrange	5.6	9.2	7.28	49	5
Oliver	LaGrange	6.1	8	6.71	50	5
Oswego	Kosciusko	3.1	11	4.47	56	12
Patoka	Dubois-Orange	4.6	7.5	5.44	53	10
Pinestone	Harrison	3.5	8.5	8.50	46	3
Pretty	Marshall	15	17.5	16.20	37	5
Rachel	Kosciusko	6.9	8.4	8.00	47	6
Rocky Fork	Putnam	5.6	8.5	6.00	51	3
Salamonie	Wabash	2.1	3.1	2.53	64	6
Shriner	Whitley	12.1	20	17.14	36	7
Silver	Kosciusko	2.3	2.6	2.40	65	3
Silver	Steuben	10.4	11.4	10.40	43	4
Skinner	Noble	2	3.6	2.68	63	2
Snow	Steuben	7.2	16.9	8.75	46	10
South Mud	Fulton	2.4	2.8	2.63	63	3
Summit	Henry	4.3	6.5	5.63	52	7
Sweetwater	Brown	17.5	21.4	18.80	35	11
Syracuse	Kosciusko	9.5	15.3	10.03	44	4
Tippecanoe	Kosciusko	3.1	11.9	4.68	55	12
Upper Long	Noble	4	9	6.46	50	11
Waubee	Kosciusko	8.6	11.2	8.80	46	4
Wawasee	Kosciusko	9	19.6	9.00	45	2
Webster	Kosciusko	6.3	18.8	7.24	49	7

Westler	LaGrange	4	6	4.47	56	3
*** No Data**	**Totals**	**n/a**	**n/a**	**n/a**	**n/a**	**514**
	2006 Minimum	0.2	1.8	1.1	34	1
	2006 Maximum	17.5	29.7	19.8	76	22
	2006 Average	6.0	11.1	7.5	51	6

Table 5. Secchi Disk Transparency Summary Data for 2007.

Lake Name	County	Yearly Min (feet)	Yearly Max (feet)	July/Aug Mean (feet)	Carlson's TSI	# of Obs.
Adams	Lagrange	5.1	14.3	5.67	52	5
Ball	Steuben	2.1	8.9	*	n/a	4
Barton	Steuben	10	16.1	16.10	37	3
Big	Noble	2.5	5.1	4.18	57	8
Big Barbee	Kosciusko	4.6	6.9	5.63	52	3
Big Bass	Porter	1.2	1.9	1.25	74	5
Big Cedar	Whitley	13.8	16.5	16.50	37	3
Big Chapman	Kosciusko	5.6	12.2	8.99	45	7
Big Long	LaGrange	14.9	24.2	16.37	37	8
Big Otter	Fremont	7.6	8.4	*	n/a	2
Blue	Miami	9	9	*	n/a	1
Bonar	Kosciusko	7.2	12.5	12.50	41	3
Cedar	Lake	0.9	15	3.00	61	4
Center	Kosciusko	2.6	4.3	3.16	61	5
Clear	Porter-LaPorte	6.7	11.3	8.83	46	4
Clear	Steuben	14	15.5	14.00	39	2
Cook	Marshall	5.06	7.05	5.38	53	5
Cordry	Brown	17.3	20	18.54	35	7
Crooked	Noble	9	22	11.22	42	4
Crooked	Steuben	6.2	22.1	8.60	46	4
Dallas	LaGrange	3.7	3.9	3.75	58	3
Diamond	Noble	8	14.1	11.00	43	4
Elizabeth	Kosciusko	10.6	23.8	11.14	42	4
Fish	Lake	1.5	1.5	*	n/a	1
Flint	Porter	6	13.35	6.00	51	3
Gage	Steuben	5.9	20.2	6.87	49	9
Galbraith	Marshall	4.1	4.1	*	n/a	1
Goose	Whitley	2.5	10	*	n/a	2
Griffy	Monroe	10.1	10.1	*	n/a	1
Heaton	Elkhart	5.4	8.2	7.41	48	4
High	Noble	5.7	5.7	5.70	52	1
Hogback	Steuben	3	5.2	3.00	61	4
Holem	Marshall	3.5	10.2	9.08	45	14
Holiday	Lake	3.7	8.1	3.94	57	4
Holiday	Montgomery	2.4	3.8	3.23	60	8
Indiana	Elkhart	4.5	23	11.49	42	32
Irish	Kosciusko	6.5	16	6.60	50	4
James	Kosciusko	3.7	7.8	5.25	53	14
James	Steuben	7.7	33.4	11.40	42	7

Koontz	Starke	3.6	8	4.24	56	15
Kuhn	Kosciusko	9.2	14.6	9.78	44	4
Lake of the Woods	LaGrange	4.2	9.5	4.20	56	3
Lake of the Woods	Marshall	1.6	3.55	1.74	69	5
Lamb	Johnson	3.5	9.5	6.52	50	16
Lemon	Brown	1.6	6.4	2.37	65	17
Little Cedar	Whitley	7.5	9.8	8.26	47	9
Little Chapman	Kosciusko	4	5.4	4.27	56	13
Little Crooked	Whitley	3.6	8	6.93	49	4
Little Long	Noble	3.1	8	3.10	61	4
Little Otter	Steuben	7.6	8.6	*	n/a	2
Little Turkey	LaGrange	2.4	10	3.36	60	4
Long	Noble	5.1	5.1	5.10	54	1
Loon	Whitley	3.1	6.4	5.25	53	5
Lower Fish	LaPorte	4.9	7	4.90	54	3
Manitou	Fulton	3.5	9.7	3.93	57	10
Martin	LaGrange	5.4	14.6	8.45	46	9
McClish	Steuben	5.5	12.8	7.70	48	4
Millpond	Marshall	2.7	6.7	5.25	53	10
Monroe (LOWER)	Monroe	4	7	4.00	57	2
Myers	Marshall	12.5	17	*	n/a	3
Nyona	Fulton	2.8	3.9	3.90	58	3
Old	Whitley	4	8	5.66	52	4
Ole Swimming Hole	Morgan	2.1	3.8	2.71	63	11
Olin	LaGrange	5.9	10.3	6.95	49	9
Oliver	LaGrange	6.1	9.4	6.35	50	9
Oswego	Kosciusko	3	8.2	4.10	57	14
Patoka	Dubois-Orange	4.9	8.6	5.39	53	4
Pinestone	Harrison	5.6	16	7.53	48	7
Pretty	Marshall	13.3	16.8	14.95	38	4
Pretty	LaGrange	14.6	14.6	*	n/a	1
Rachel	Kosciusko	8.7	11.7	9.80	44	4
Rocky Fork	Putnam	5	11	9.20	45	7
Salamonie	Wabash	1.6	3.3	2.61	63	13
Shriner	Whitley	16.9	20.8	18.65	35	6
Silver	Steuben	10	13	*	n/a	3
Skinner	Noble	2.5	4.8	3.88	58	5
Snow	Steuben	6.6	12.2	7.40	48	6
Stone	LaGrange	15	16	15.00	38	3
Summit	Henry	4	6.3	5.56	52	4
Sweetwater	Brown	16	26.5	22.18	32	10
Syl-van	Steuben	8	8	*	n/a	1
Syracuse	Kosciusko	7.5	20	7.65	48	4

Tawny	St. Joseph	8.6	9.8	9.29	45	4
Tippecanoe	Kosciusko	3	9.8	4.36	56	15
Upper Long	Noble	6	10	6.34	51	11
Waubee	Kosciusko	6	26	10.25	44	6
Wawasee	Kosciusko	5.5	22	5.98	51	4
Webster	Kosciusko	7.5	14	10.37	43	7
West Otter	Steuben	5.5	7	5.70	52	3
Winona	Kosciusko	6	6	6.00	51	1
Witmer	LaGrange	4	16.5	4.34	56	3
*** No Data**	**Totals**	**n/a**	**n/a**	**n/a**	**n/a**	**536**
	2007 Minimum	0.9	1.5	1.2	32	1
	2007Maximum	17.3	33.4	22.2	74	32
	2007 Average	6.1	11.4	7.4	50	6

Table 6. Secchi Disk Transparency Summary Data for 2008.

Lake Name	County	Yearly Min (feet)	Yearly Max (feet)	July/Aug Mean (feet)	Carlson's TSI	# of Obs.
Adams	Lagrange	6.9	9	8.0	47	3
Ball	Steuben	2.6	10.3	7.2	49	4
Banning	Kosciusko	3.9	6.8	5.1	54	3
Barton	Steuben	11.4	14.2	13.3	40	4
Big	Noble	4.5	5.4	5.0	54	6
Big Barbee	Kosciusko	4.6	6.2	5.3	53	4
Big Bass	Porter	1.1	1.2	1.1	76	3
Big Chapman	Kosciusko	5.1	16.25	7.1	49	9
Big Long	LaGrange	14.7	19.2	17.0	36	5
Bonar	Kosciusko	8	14.3	14.3	39	3
Cedar	Lake	10	15	11.4	42	3
Center	Kosciusko	8.7	14.2	10.0	44	6
Clear	Steuben	8	18	9.3	45	4
Clear	Porter-Laporte	6.3	11	8.3	47	3
Cook	Marshall	4.6	5.2	4.9	54	3
Cordry	Brown	12.3	19.8	14.8	38	7
Crooked	Steuben	14.6	14.6	0.0	n/a	1
Crooked	Noble	14	19	18.0	35	4
Dallas	LaGrange	2.7	4.2	3.1	61	3
Elizabeth	Kosciusko	9	15.3	11.4	42	4
Flint	Porter	5.9	9.5	6.5	50	4
Gage	Steuben	8.6	18.7	9.3	45	8
Galbraith	Marshall	2.4	3.7	2.7	63	4
Goose	Whitley	1.5	15	7.9	47	7
Hogback	Steuben	3.4	5	3.7	58	5
Holem	Marshall	6.1	9	8.4	46	6
Holiday	Lake	3.6	7.7	3.6	59	3
Holiday	Montgomery	2.1	2.9	2.5	64	5
Indiana	Elkhart	5.5	19	9.8	44	15
Irish	Kosciusko	5	14.5	6.5	50	5
James	Kosciusko	6	10.8	7.5	48	4
James	Steuben	7.1	16.2	11.0	43	10
Knapp	Noble	3.6	12.9	3.8	58	7
Koontz	Starke	3.2	8.2	4.1	57	13
Kuhn	Kosciusko	8.3	13.2	11.0	43	5
Lake of the Woods	Lagrange	4.2	13	4.8	n/a	4
Lake of the Woods	Marshall	1.7	4.3	2.7	63	5
Lamb	Johnson	0.7	5.7	3.3	60	15
Lemon	Monroe	0.1	3.9	2.4	65	12

Little Barbee	Kosciusko	3	4.1	4.1	57	3
Little Cedar	Whitley	7.3	11.2	9.3	45	6
Little Chapman	Kosciusko	3.4	6.5	4.0	57	8
Little Crooked	Whitley	6	11	9.4	45	4
Little Long	Noble	3.2	12.3	5.8	52	9
Little Turkey	LaGrange	6.5	6.5	6.5	50	1
Locust	Owen	5.4	11.2	7.7	48	8
Loon	Whitley	2.5	6.9	4.1	57	6
Lost	Marshall	3	3.7	3.3	60	2
Lower Fish	LaPorte	6.5	7.7	7.0	49	4
Manitou	Fulton	2	8.7	3.0	61	11
Maxinkuckee	Marshall			0.0		0
McClish	Steuben	9.8	12.6	10.9	43	3
Millpond	Marshall	4.8	6.3	6.0	51	6
Monroe (LOWER)	Monroe	6.5	6.5	6.5	50	1
Myers	Marshall	11.2	11.2	0.0		1
Nyona	Fulton	3.9	4.2	3.9	57	4
Old	Whitley	5	8.6	7.0	49	3
Ole Swimming Hole	Morgan	2.6	3.7	2.9	62	7
Oswego	Kosciusko	6.3	9	7.5	48	4
Pinestone	Harrison	9.8	16.5	11.2	42	5
Pretty	Marshall	8.8	12	9.2	45	5
Rachel	Kosciusko	10.5	13	11.5	42	4
Ridinger	Kosciusko	2.1	26.4	2.6	64	3
Salamonie	Wabash	2.5	3.8	2.8	62	9
Sawmill	Kosciusko	4.2	6.7	5.5	53	3
Sechrist	Kosciusko	7	18.3	9.1	45	5
Shriner	Whitley	14.5	18.5	17.1	36	8
Silver	Steuben	9.5	10.2	9.8	44	3
Skinner	Noble	3.2	4.2	3.5	59	5
Smalley	Noble	2.4	3.2	2.8	62	2
Snow	Steuben	7	9.5	8.3	47	6
Sweetwater	Brown	13.8	23.5	16.0	37	8
Syl-Van	Steuben	9.9	13.6	13.3	40	5
Syracuse	Kosciusko	7.8	10.5	8.3	47	4
Tawny	St. Joseph	9	15.2	11.1	42	4
Tippecanoe	Kosciusko	5	10.1	7.1	49	4
Upper Long	Noble	5	9.9	8.5	46	14
Waubee	Kosciusko	8.7	18.4	8.7	46	3
Wawasee	Kosciusko	6	11	6.7	50	3
Webster	Kosciusko	5.5	9	7.3	48	5
West Otter	Steuben	4.8	7.6	6.0	51	3

Winona	Kosciusko	4.2	9	4.2	56	4
Witmer	Lagrange	4.2	6.2	4.2	56	2
Yellow Creek	Kosciusko	2.5	11.4	2.5	64	5
*** No Data**	**Totals**	**n/a**	**n/a**	**n/a**	**n/a**	**432**
	2008 Minimum	0.1	1.2	0.0	35.5	0
	2008 Maximum	14.7	26.4	18.0	75.7	15
	2008 Average	6.0	10.6	7.0	50.5	5

Appendix B:

Chlorophyll *a* and Total Phosphorus Summaries for Lakes by Year for 2004-2008

Table 7. Chlorophyll *a* and Total Phosphorus Summary Data 2004

Lake Name	County	Chlorophyll *a* Min (ug/L)	Chlorophyll *a* Max (ug/L)	Chlorophyll *a* July/Aug Mean (ug/L)	Carlson's Chl-*a* TSI	Total Phosphorus Min (ug/L)	Total Phosphorus Max (ug/L)	Total Phosphorus July/Aug Mean (ug/L)	Carlson's Phos. TSI
Barton	Steuben	0.5	2.8	2.0	44	16.0	51.0	41.0	58
Big	Noble	6.5	23.2	12.3	57	40.0	78.0	43.4	59
Big Bass	Porter	35.8	64.3	51.9	66	135.0	162.0	159.0	72
Big Chapman	Kosciusko	1.6	2.2	1.6	43	21.0	44.0	40.3	58
Big Long	Lagrange	0.5	2.0	1.4	42	10.0	55.0	53.0	61
Cedar	Lake	29.5	188.4	51.1	66	31.7	320.0	262.3	77
Center	Kosciusko	3.3	4.9	4.9	50	12.0	60.0	60.0	62
Clear	Porter-LaPorte	1.7	2.8	2.4	45	21.0	34.0	28.1	55
Cordry	Brown	0.4	0.7	0.6	37	10.0	30.0	27.0	54
Crooked	Noble	1.0	2.4	1.5	42	10.0	120.0	27.0	54
Flint	Porter	1.2	4.4	1.7	43	30.0	41.0	37.3	57
Galbraith	Marshall	11.9	18.6	13.1	57	45.0	63.0	50.2	60
Goose	Whitley	0.6	42.9	5.2	51	41.0	97.0	63.1	63
Griffy	Monroe	1.5	1.7	0.0	n/a	10.0	10.0	0.0	n/a
Holiday	Lake	5.1	18.2	13.8	57	53.0	65.0	58.7	62
Holiday	Montgomery	25.9	28.9	27.3	62	69.0	84.0	83.0	65
Indiana	Elkhart	1.2	1.8	1.2	41	10.0	34.0	24.0	53
Koontz	Starke	5.1	14.1	11.2	56	28.0	79.0	29.5	55
Lake of the Woods	Marshall	10.5	21.9	20.7	60	34.0	61.0	48.1	60
Lake of the Woods	Lagrange	2.4	5.9	2.9	47	21.0	64.0	30.4	55
Little Turkey	Lagrange	0.8	14.5	3.2	47	10.0	47.0	43.4	59
Manitou	Fulton	12.3	15.9	13.2	57	31.0	66.0	34.3	57
Martin	LaGrange	1.0	13.1	1.1	41	37.0	68.0	44.7	59
Maxinkuckee	Marshall	0.3	2.1	0.7	37	25.0	27.0	26.0	54
McClish	Steuben	0.0	0.3	0.1	24	18.0	37.0	25.8	54
Myers	Marshall	*	*	*	*	57.0	60.0	60.0	62
Nyona	Fulton	16.3	59.6	33.7	64	52.0	127.0	85.8	66
Ole Swimming Hole	Morgan	14.5	23.5	17.5	59	65.0	137.0	95.3	67
Olin	LaGrange	1.1	6.3	1.3	41	10.0	34.0	30.3	55
Oliver	LaGrange	0.8	2.6	1.8	43	10.0	34.0	28.5	55
Silver	Kosciusko	7.2	34.8	14.0	58	65.0	249.0	67.0	63
Silver	Steuben	1.5	2.2	1.5	42	26.0	43.0	40.0	58
South Mud	Fulton	9.8	63.8	28.0	62	48.0	83.0	56.3	62
Summit	Henry	4.7	7.2	7.2	53	31.0	38.0	31.0	56

Sweetwater	Brown	0.6	0.9	0.7	37	13.0	18.0	16.4	49
Syracuse	Kosciusko	2.3	2.8	2.5	46	38.0	38.0	38.0	58
Tippecanoe	Kosciusko	2.1	6.3	6.3	52	17.0	23.0	17.0	50
Wawasee	Kosciusko	2.6	4.9	3.8	49	10.0	44.0	42.5	59
West Otter	Steuben	4.2	7.6	4.2	49	40.0	50.0	40.0	58
* No Value	**Totals**								
	2004 Minimum	0.0	0.3	0.0	24	10.0	10.0	0.0	49
	2004 Maximum	35.8	188.4	51.9	66	135.0	320.0	262.3	77
	2004 Average	6.0	19.0	9.7	49	32.1	71.2	51.0	59

Table 8. Chlorophyll *a* and Total Phosphorus Summary Data for 2005

Lake Name	County	Chlorophyll *a* Min (ug/L)	Max (ug/L)	July/Aug Mean (ug/L)	Carlson's Chl-*a* TSI	Total Phosphorus Min (ug/L)	Max (ug/L)	July/Aug Mean (ug/L)	Carlson's Phos. TSI
Barton	Steuben	0.27	1.40	0.97	39	21	42	23.37	53
Big	Noble	6.16	9.93	6.16	52	22	27	22.00	52
Big Bass	Porter	8.53	41.62	9.90	55	177	212	212.00	75
Big Long	LaGrange	0.96	1.25	1.22	41	10	50	14.14	48
Cedar	Lake	46.63	47.39	46.63	66	137	164	137.00	70
Center	Kosciusko	4.54	7.01	4.81	50	34.5	67	42.00	59
Clear	Porter-LaPorte	0.79	3.20	1.59	43	20	40	21.91	52
Cordry	Brown	0.71	1.25	0.73	37	23	36	23.00	53
Crooked	Noble	0.32	1.87	1.46	42	23	46	23.00	53
East	Johnson	0.53	4.67	3.79	49	26	49	32.25	56
Flint	Porter	0.80	3.92	3.79	49	14	45	36.74	57
Gage	Steuben	0.68	1.51	0.82	38	20	40	26.00	54
Galbraith	Marshall	6.54	69.42	12.26	57	35	126	40.56	58
Goose	Whitley	2.67	43.12	2.92	47	27	101	28.93	55
Griffy	Monroe	0.45	4.39	0.45	34	15	42	15.00	48
Hogback	Steuben	6.41	11.48	*	n/a	30	71	*	n/a
Holiday	Lake	4.58	40.05	29.71	63	39	73	73.00	64
Holiday	Montgomery	18.47	27.37	25.37	62	70	85	73.00	64
Holiday	Putnam	11.21	11.21	*	n/a	68	68	*	n/a
Indiana	Elkhart	1.38	1.92	1.39	42	3	26	6.48	40
James	Steuben	1.16	2.54	2.50	46	10	44	14.87	48
Koontz	Starke	5.61	12.95	8.69	54	30	84	31.46	56
Lake of the Woods	LaGrange	2.34	3.39	2.88	47	21	65	21.98	52
Lake of the Woods	Marshall	1.87	13.80	13.09	57	35	85	40.56	58
Little Turkey	LaGrange	3.25	5.17	5.17	51	27	50	28.93	55
Manitou	Fulton	0.06	5.59	0.48	35	20	67	23.24	53
Martin	LaGrange	0.27	2.60	1.55	43	13	39	20.07	51
Maxinkuckee	Marshall	1.94	3.92	2.76	46	26	32	29.93	55
McClish	Steuben	0.04	0.85	0.61	36	24.5	1142	26.19	54
Nyona	Fulton	6.77	13.77	6.77	53	28	57	53.00	61
Ole Swimming Hole	Morgan	19.98	51.73	29.60	63	53	107	60.91	62

Olin	LaGrange	0.27	1.34	1.16	41	3	36	7.14	41
Oliver	LaGrange	0.73	1.74	1.06	40	7	29	12.12	46
Rocky Fork	Putnam	15.22	18.29	1.06	n/a	42	70	42.00	59
Silver	Steuben	0.80	2.78	1.99	44	21	71	23.37	53
Summit	Henry	0.10	2.97	0.54	35	35	35	35.00	57
Sweetwater	Brown	0.40	20.00	4.22	49	1.11	39	5.05	37
Syracuse	Kosciusko	0.80	4.54	2.33	45	23	50	25.38	54
Wawasee	Kosciusko	2.94	6.54	4.65	50	15	47	18.70	51
Yellowwood	Brown	1.05	1.71	1.34	42	10	33	10.00	44
*** No Data**	**Totals**								
	2005 Minimum	0.04	0.85	0.45	34	1.11	26.00	5.05	37
	2005 Maximum	46.63	69.42	46.63	66	177.0	1142.0	212.0	75
	2005 Average	4.71	12.76	6.49	47	31.5	89.8	36.3	54

Table 9. Chlorophyll- *a* and Total Phosphorus Summary Data for 2006.

Lake Name	County	Chlorophyll - *a* Min (ug/L)	Max (ug/L)	July/Aug Mean (ug/L)	Carlson's Chl-*a* TSI	Total Phosphorus Min (ug/L)	Max (ug/L)	July/Aug Mean (ug/L)	Carlson's Phos. TSI
Barton	Steuben	0.6	1.07	1.07	40	16	32	27.13	54
Big	Noble	1.87	6.92	5.30	51	26	31	26.00	54
Big Bass	Porter	0.53	9.08	2.19	45	141	257	228.41	76
Big Chapman	Kosciusko	0.71	1.07	0.84	38	15	25	15.97	49
Big Long	LaGrange	0.09	0.48	0.48	35	29	45	34.06	57
Cedar	Lake	11.21	33.32	13.53	57	27	159	143.00	71
Center	Kosciusko	0.21	7.69	0.81	38	30	59	34.19	57
Clear	Porter-LaPorte	1.07	1.09	1.09	40	18	41	28.64	55
Cordry	Brown	0.25	0.36	0.25	30	7	16	7.00	41
Crooked	Noble	0.05	2.09	0.08	22	23	48	33.94	57
Flint	Porter	0.33	2.16	0.84	38	28	49	35.50	57
Gage	Steuben	0.12	0.67	*	n/a	10	28	11.40	46
Galbraith	Marshall	1.07	4.49	2.19	45	37	76	50.50	61
Goose	Whitley	0.21	43.19	0.89	39	35	70	37.88	58
Hogback	Steuben	0.18	5.47	0.73	37	1.67	122	11.05	45
Holiday	Lake	0.11	3.63	0.63	36	31	43	41.47	59
Holiday	Montgomery	0.53	13.35	2.06	45	41	137	82.76	65
Indiana	Elkhart	0.13	0.51	0.13	26	13	31	13.00	47
James	Kosciusko	0.43	2.78	1.09	40	34	58	45.06	59
James	Steuben	0.61	2.95	0.61	36	20	41	28.64	55
Koontz	Starke	0.11	6.14	0.38	33	42	59	51.09	61
Lake of the Woods	Marshall	2.94	14.2	5.23	51	43	105	45.43	59
Lake of the Woods	LaGrange	0.41	3.51	0.69	37	17	325	22.58	52
Little Chapman	Kosciusko	0.11	1.1	0.35	32	30	37	33.32	56
Little Turkey	LaGrange	0.67	4.38	4.38	50	30	51	51.00	61
Loon	Noble	0.8	2.14	0.97	39	23	23	*	n/a
Manitou	Fulton	0.19	16.34	3.96	49	35	80	65.73	63
Martin	LaGrange	0.73	0.73	0.73	37	10	45	27.66	54
Maxinkuckee	Marshall	0.07	0.38	0.38	33	14	24	24.00	53
McClish	Steuben	0.12	0.12	0.12	25	33	61	33.00	56
Myers	Marshall	0.4	19.68	4.95	50	40	40	40.00	58
Nyona	Fulton	2.35	23.92	3.88	49	31	66	64.00	63

Ole Swimming Hole	Morgan	0.05	0.45	0.06	20	33	86	44.50	59
Olin	LaGrange	0.13	0.87	0.87	39	7	35	31.86	56
Oliver	LaGrange	0.21	1.28	0.33	32	10	27	24.92	53
Oswego	Kosciusko	0.67	5.02	4.41	50	21	163	77.13	65
Rocky Fork	Putnam	4.47	15.76	8.61	54	30	59	30.00	55
Silver	Kosciusko	0.37	0.46	*	n/a	56	74	56.50	62
Silver	Steuben	0.93	0.93	0.93	39	16	32	32.00	56
South Mud	Fulton	0.15	0.45	*	n/a	59	59	59.00	62
Summit	Henry	0.11	0.34	0.12	25	20	37	37.00	57
Sweetwater	Brown	0.11	1.17	0.15	27	10	13	11.40	46
Syracuse	Kosciusko	0.11	2.33	0.11	25	7	48	20.40	51
Tippecanoe	Kosciusko	0.53	1.67	1.52	42	20	35	31.86	56
Wawasee	Kosciusko	0.53	1.67	1.52	42	18	45	37.95	58
*** No Data**	**Totals**								
	2006 Minimum	0.05	0.12	0.06	20	1.67	13	7.00	41
	2006 Maximum	11.21	43.19	13.53	57	141	325	228.41	76
	2006 Average	0.84	5.94	1.89	39	28	67	42.91	57

Table 10. Chlorophyll- *a* and Total Phosphorus Summary Data for 2007.

		Chlorophyll - *a*				Total Phosphorus			
Lake Name	**County**	**Min (ug/L)**	**Max (ug/L)**	**July/Aug Mean (ug/L)**	**Carlson's Chl-*a* TSI**	**Min (ug/L)**	**Max (ug/L)**	**July/Aug Mean (ug/L)**	**Carlson's Phos. TSI**
Barton	Steuben	0.35	6.66	1.68	43	11.5	57	27.55	54
Big	Noble	1.79	17.33	5.57	51	26	56	40.30	58
Big Bass	Porter	16.66	50.06	47.61	66	109	234	208.06	75
Big Chapman	Kosciusko	0.19	4.2	1.71	43	16	36	30.59	55
Big Long	LaGrange	0.36	1.59	0.78	38	16	17	17.00	50
Cedar	Lake	44.86	93.72	87.79	70	59	159.5	104.91	68
Center	Kosciusko	3.27	9.74	7.12	53	26	49	37.65	58
Clear	Porter-LaPorte	1.34	2	1.58	43	16	26	23.00	53
Cordry	Brown	0.39	1.42	0.74	38	10	33	33.00	56
Crooked	Noble	0.39	25.38	2.59	46	10	23	11.40	46
Flint	Porter	1.62	17.05	17.05	59	23	78	78.00	65
Gage	Steuben	0.53	2.64	1.18	41	7	13	9.54	44
Galbraith	Marshall	23.12	23.12	*	n/a	23	23	*	n/a
Goose	Whitley	1.23	12.88	2.01	44	30	50	47.96	60
Griffy	Monroe	1.76	3.18	3.18	47	20	29	20.00	51
Hogback	Steuben	3.85	8.9	4.69	50	36	99	65.25	63
Holiday	Lake	0.94	6.55	6.45	52	27	52	41.42	59
Holiday	Montgomery	9.37	21.08	*	n/a	98	104	*	n/a
Indiana	Elkhart	0.56	2.46	0.73	37	7	13	9.54	44
James	Steuben	0.59	1.84	1.31	41	17	20	18.97	51
James	Kosciusko	2.33	6.64	2.33	45	23	29	29.00	55
Koontz	Starke	3.46	11.92	8.67	54	33	64	38.96	58
Lake of the Woods	Marshall	3.74	22.43	10.04	55	26	54	34.58	57
Little Chapman	Kosciusko	3.43	8.54	4.24	49	36	52	36.00	57
Little Crooked	Whitley	0.84	5.61	1.90	44	20	43	29.33	55
Little Turkey	LaGrange	1.28	6.14	4.59	50	26	33	29.29	55
Manitou	Fulton	2.22	8.65	6.80	53	29	50	47.96	60
Martin	LaGrange	0.8	6.01	5.84	52	23	90	49.30	60
McClish	Steuben	0.24	0.71	0.41	34	10	40	10.00	44
Myers	Marshall	0.95	1.93	*	n/a	29	39	*	n/a

Nyona	Fulton	6.12	10.27	7.67	53	37	60	45.52	59
Ole Swimming Hole	Morgan	12.68	23.1	20.17	60	50	64	64.00	63
Olin	LaGrange	0.27	3.36	1.83	44	7	27	21.42	52
Oliver	LaGrange	0.26	2.05	1.40	42	10	20	16.12	49
Oswego	Kosciusko	1.45	3.97	2.40	46	13	30	17.29	50
Rocky Fork	Putnam	2.31	5.76	*	n/a	29	33	*	n/a
Silver	Steuben	0	4.01	0.74	38	13	40	40.00	58
Sweetwater	Brown	0.43	0.88	0.62	36	7	20	12.65	47
Syl-van	Steuben	4.21	4.21	*	n/a	26	26	*	n/a
Syracuse	Kosciusko	0.58	3	2.71	46	13	23	13.00	47
Tippecanoe	Kosciusko	0.9	2.52	2.01	44	13	23	19.18	51
Wawasee	Kosciusko	1.29	3.99	2.18	45	23	30	23.00	53
*** no data**	**Totals**								
	2007 Minimum	0.00	0.71	0.41	34	7.00	13	9.54	44
	2007 Maximum	44.86	93.72	87.79	70	109	234	208.06	75
	2007 Average	3.88	10.89	7.58	47	26	49	37.86	55

Table 11. Chlorophyll- *a* and Total Phosphorus Summary Data for 2008.

		Chlorophyll - *a*				Total Phosphorus			
Lake Name	County	Min (ug/L)	Max (ug/L)	July/Aug Mean (ug/L)	Carlson's Chl-*a* TSI	Min (ug/L)	Max (ug/L)	July/Aug Mean (ug/L)	Carlson's Phos. TSI
Barton	Steuben	0.6	2.0	0.9	39	13.0	29.0	22.8	53
Big	Noble	7.7	10.9	8.2	54	24.0	29.0	26.4	54
Big Bass	Porter	16.0	115.3	103.6	71	74.0	233.0	228.0	76
Big Chapman	Kosciusko	0.1	5.2	4.2	49	10.0	29.0	25.3	54
Big Long	Lagrange	0.1	2.0	1.8	44	23.0	40.0	31.6	56
Cedar	Lake	48.6	189.0	130.2	73	84.0	153.0	113.4	69
Center	Kosciusko	2.3	4.0	2.5	46	24.0	40.0	34.1	57
Clear	Laporte	1.8	5.2	3.0	47	20.0	24.0	21.9	52
Cordry	Brown	1.2	1.5	1.5	42	10.0	17.0	5.7	39
Crooked	Noble	0.1	1.9	1.9	44	17.0	33.0	28.7	55
Flint	Porter	0.5	21.2	14.1	58	24.0	55.0	50.8	61
Galbraith	Marshall	1.0	36.2	6.1	52	36.0	47.0	39.8	58
Goose	Whitley	5.5	8.8	6.5	52	5.0	53.0	0.1	1
Hogback	Steuben	15.4	70.8	30.7	63	28.0	66.0	66.0	63
Holiday	Lake	4.8	81.4	4.8	50	17.0	47.0	36.9	57
Holiday	Montgomery	1.1	8.0	6.6	52	33.0	79.0	33.0	56
Indiana	Elkhart	1.1	3.5	1.3	42	3.0	13.0	11.4	46
James	Steuben	2.3	22.6	10.8	56	10.0	136.0	54.7	61
James	Kosciusko	1.0	1.6	1.4	42	12.0	35.0	19.3	51
Koontz	Starke	8.2	18.7	13.1	57	30.0	59.0	47.3	60
L of the Woods	Marshall	16.6	34.4	23.9	61	47.0	77.0	60.2	62
L of the Woods	Lagrange	0.8	4.3	2.9	47	23.0	143.0	68.7	64
Little Chapman	Kosciusko	2.3	29.4	15.6	58	38.0	45.0	42.0	59
Little Crooked	Whitley	1.5	12.1	1.9	44	17.0	58.0	45.7	60
Little Turkey	LaGrange	6.9	6.9	6.9	53	36.0	36.0	36.0	57
Manitou	Fulton	2.9	21.9	20.4	60	30.0	45.0	39.1	58
Maxinkuckee	Marshall	0.6	2.3	2.3	45	7.0	12.0	12.0	46
McClish	Steuben	0.3	1.8	0.3	31	10.0	18.0	18.0	50
Nyona	Fulton	6.4	65.6	34.1	64	46.0	56.0	55.5	61
Ole Swim Hole	Morgan	4.2	43.1	33.1	63	20.0	81.0	54.0	61

Oswego	Kosciusko	1.8	8.6	3.9	49	24.0	50.0	36.7	57
Silver	Steuben	1.3	2.5	1.6	43	17.0	66.0	43.7	59
Sweetwater	Brown	0.2	2.2	0.7	37	7.0	125.0	47.4	60
Syracuse	Kosciusko	2.4	8.2	2.8	47	3.0	34.0	26.1	54
Tippecanoe	Kosciusko	2.3	9.3	4.4	50	12.0	73.0	29.6	55
Wawasee	Kosciusko	4.4	10.2	6.8	53	13.0	21.0	14.9	48
*** no data**	**Totals**								
	2008 Minimum	0.1	1.5	0.3	31	3.0	12.0	0.1	1
	2008 Maximum	48.6	189.0	130.2	73	84.0	233.0	228.0	76
	2008 Average	4.8	24.2	14.3	51	23.5	59.9	42.4	55