IOWA DEPARTMENT OF
NATURAL RESOURCES
LEADING IOWANS IN CARING FOR OUR NATURAL RESOURCES
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2014 Lake Water Quality Summary

Iowa's lakes are an incredible water resource. They support excellent fisheries, provide a home to numerous plants and animals, create recreational opportunities for Iowans and tourists, and in some cases, supply Iowans with drinking water. Because our lakes are such an important resource, it is important that we better understand the health of our lakes through routine ambient water quality monitoring.

Monitoring at 138 publically-owned lakes occurs three times each summer, once in early summer (May-June), once in mid-summer (July), and once in late summer (August-September). Lakes are monitored for a number of chemical and biological parameters. Results from monitoring are used to assess and report on water quality in Iowa required as a part of the Clean Water Act, to target individual lakes for restoration activities, build a long-term record to show trends in water quality, and help inform Iowan's about water quality in their lakes.

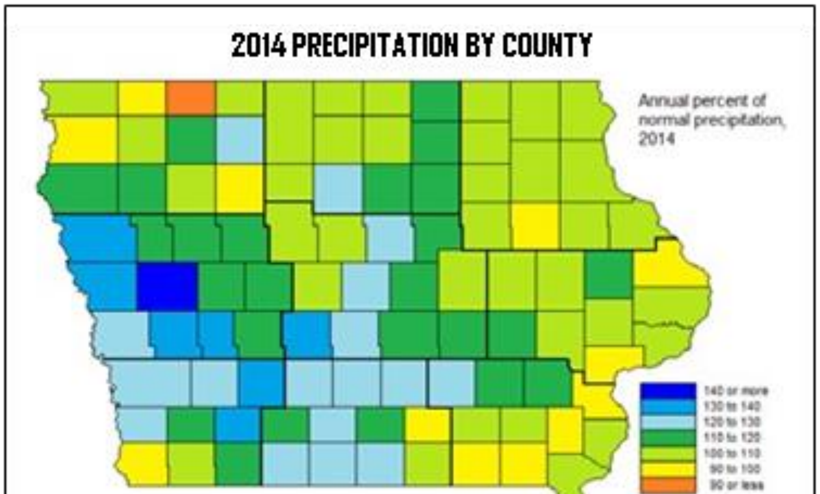

Image from the 2014 IDNR Water Monitoring Summary

2014 was marked by periods of wet and dry weather, which affected conditions at lakes around the state. Drought conditions from 2013 prevailed across most of the state throughout the winter of 2014. Heavy spring rains brought above average rainfall to the western and central parts of the state, which led to flooding throughout much of the state by the end of June (see figure at left). Total annual rainfall was 4.3 inches above average, with peak precipitation occurring in June. Late summer rains also affected Iowa lakes, bringing excess nutrients to the lakes and altering the frequency and intensity of algae blooms. Cooler than average temperatures also affected lake conditions, with February, July, and November ranking among the top ten coldest for those months on record.

Water quality observed at Iowa's lakes was about average in 2014. Average water clarity observed for all 138 lakes monitored was 1.2 meters in 2014, compared to an average for all monitoring from 2000-2014 of 1.1 meters. 42% of all of the lakes monitored has above average water clarity (Secchi depth) in 2014. Changes in average water clarity can be attributed to a number of things, including changes in weather, timing of sampling relative to rainfall or algae bloom formation, or improvements or degradation of overall lake water quality. Concentrations of total phosphorus, the most common limiting nutrient in freshwater systems, were also about average in 2014. The average concentration in 2014 was 119 µg/L, as compared to the 2000-2014 average of 108 µg/L. The majority of Iowa lakes are considered very nutrient rich, or eutrophic. Concentrations greater than 30 µg/L can lead to visible algae blooms in lakes. Of the lakes monitored, 51% had lower than average total phosphorus concentration in 2014. Chlorophyll *a*, a pigment found in algae, was also monitored in 2014. Chlorophyll *a* measurements are frequently used as a proxy for estimating the concentration of algae present in a lake or river. The average concentration of chlorophyll a observed in 2014 was 43 µg/L, as compared to the 2000-2014 average of 40 µg/L. Visible algae blooms can be observed at concentrations as low as 10 µg/L. 48% of the lakes sampled in 2014 had lower than average chlorophyll a concentrations Water quality parameters measured in 2014 are summarized in more detail in Table 1. Descriptions of parameters measured through the Ambient Lake Monitoring program are described on pages 3 & 4.

The frequency and intensity of algae blooms varied widely throughout the summer of 2014. Periods of heavy rainfall in the late spring and early summer pushed high concentrations of nitrogen and phosphorus into Iowa's lakes. These pulses of nutrients have the potential to fuel intense algae blooms under the right conditions. Cyanobacteria, or blue-green algae blooms, are commonly observed in the late summer and thrive in stagnant water, under hot conditions. Thus, while early summer concentrations of nutrients were above average, the frequency and intensity of algae blooms observed in July and August was about average, as rainfall continued to disturb the surface of the water, and lower than average temperatures were observed in July.

Table 1. Water Quality Summary of 138 lakes monitored in Iowa as a part of the Ambient Lake Monitoring Program

Water Quality Parameter	Number of Samples	Minimum Value	Percentiles			Maximum Value
			25th	50th	75th	
Ammonia (µg/L)	401	7	7.1	20	115.7	1544
Chlorophyll a (µg/L)	400	2	13	31	53	417
Dissolved Organic Carbon (mg/L)	401	1	5.1	6	7.8	34
Dissolved Oxygen (mg/L)	401	2.1	7.5	9.3	11.01	24.3
Inorganic Suspended Solids (mg/L)	401	1	1	3	7	149
Nitrate +Nitrite as N (mg/L)	401	0.03	0.03	0.03	0.41	20
Orthophosphate as P (µg/L)	401	3	3	3	34	720
pH	401	7.1	8.14	8.4	8.69	9.9
Phytoplankton Wet Mass (mg/L)	401	0	9.33	29.00	70.25	1436.00
Secchi Depth (m)	401	0.1	0.5	0.8	1.4	9.3
Temperature (˚C)	401	10.3	21.64	23.1	24.54	29.5
Total Kjeldahl Nitrogen (mg/L)	401	0	0.89	1.00	1.86	5.00
Total Phosphorus as P (µg/L)	401	5	50	89	148	887
Total Suspended Solids (mg/L)	401	1	6	11	18	176
Turbidity (NTU)	401	0.3	4.59	10.3	17.78	154.9
Volatile Suspended Solids (mg/L)	401	0	3.5	7	11	126
Zooplankton Dry Mass (mg/L)	401	2	66.96	146.00	288.05	2197.00

µg/L – micrograms per liter (parts per billion)
µmhos/cm – microhoms per centimeter
< - less than detection limit shown

mg/L – milligrams per liter (parts per million)
NTU – Nephelometric Turbidity Units
Raw data available through STORET: http://programs.iowadnr.gov/iastoret/

Note: This summary only includes lakes monitored as a part of the ambient lake monitoring program. Additional lake sites throughout Iowa are also monitored, but are not included in this summary since their sampling frequency, sites, and parameters vary from the fixed network.

Nitrogen – Nitrate + Nitrite as N, Ammonium Nitrogen, and Total Kjeldahl Nitrogen

Nitrogen is an essential nutrient for all plant life, however; too much nitrogen can pollute waters both locally and downstream. Nitrogen is an especially potent pollutant when it reaches the Gulf of Mexico and contributes to hypoxia observed annually. Nitrogen enters our lakes through natural plant decay, fertilizer runoff, manure, industrial waste waters, landfills, and atmospheric gas. Nitrate, the most common form of nitrogen found in Iowa's lakes can cause severe illness or death in infants and domestic animals. Ammonia, in its unionized form, can also be toxic to aquatic wildlife. Relative to other parts of the country, Iowa lakes have very high nitrate concentrations, especially in eco-regions where tile-drained agriculture is the prominent land use, such as the Des Moines Lobe.

Phosphorus – Total Phosphorus and Orthophosphate

Phosphorus is an essential nutrient that plants use during photosynthesis. Phosphorus is generally regarded as the limiting nutrient in fresh waters, but even in low concentrations, phosphorus can cause algae blooms in lakes and rivers. Phosphorus occurs naturally in the earth's crust. Phosphorus is transported to lakes through plant and animal decay, manure, sewage, agricultural fertilizers, and industrial effluents. Total phosphorus concentrations as low as 30µg/L (ppb) can cause visible algae blooms in lakes. Phosphorus frequently attaches to sediment and sinks to the bottom of lakes, where it builds up and reduces its availability to algae. Several chemical and biological processes can release phosphorus back into the water where it can be used by algae. Bottom-feeding fish, such as carp, can stir up sediments, releasing phosphorus into the water column.

Suspended Solids – Total, Fixed, and Volatile Solids (turbidity)

Solids eroded from the land frequently pollute our lakes by reducing water clarity and negatively impacting aquatic life. Soil erosion, algae blooms, and re-suspension of materials are the leading causes for high suspended solids in Iowa lakes. Fixed solids refer to the portion of the suspended solids that is inorganic. Volatile solids are organic and generally are comprised of algae and soil organic matter. Suspended solids in water limit how far light can penetrate in a lake and thus, can limit growth of submerged aquatic plants. Aquatic plants provide excellent structure and shelter for fish and invertebrates.

Phytoplankton and Zooplankton

Phytoplankton, or algae and cyanobacteria, are microscopic plants and animals that photosynthesize in lakes. These organisms form the base for many aquatic food webs. In low densities, certain groups and types of algae serve as excellent food sources for other organisms. When lakes are polluted with high levels of nutrients, such as nitrogen and phosphorus, however; phytoplankton become over-abundant, turning the surface of lakes green, forming dense algal scums and mats, and causing water taste and odor problems. The types of phytoplankton found also shifts with increased pollution, moving from a healthy community that serves as the base of food webs, to blue-green, or cyanobacterial forms. Many species of these blue-green algae produce toxins that can cause skin irritation and illnesses. At high levels, these toxins can also cause tissue damage and death in humans and animals. High phytoplankton biomasses can also contribute to low oxygen and high pH levels in lakes, putting stress on fish and other plants and animals.

Zooplankton are microscopic animals, mainly crustaceans, that feed on phytoplankton in lakes and serve as important sources of food for fish and other aquatic life. Identifying and measuring the diversity and abundance of these organisms in our lakes can help us better understand the overall health of the aquatic ecosystem. Reduced diversity of zooplankton is frequently observed in very nutrient rich, or hypereutrophic, lakes. Some species of zooplankton have also been used as an indicator for good water quality.

Chlorophyll *a*

Chlorophyll *a* is pigment found in most species of algae. It is frequently used as for estimating the amount of algae in lakes and rivers, because manually estimating concentrations of algae (measuring algal biomass) is time consuming and requires extensive knowledge of algae taxonomy. Chlorophyll *a* one of the pigments produced when algae and cyanobacteria photosynthesize. At concentrations of chlorophyll a as low as 10 µg/L, visible "greening" of the water can be observed.

Carlson's Trophic State Index

The Carlson's Trophic State Index (TSI) is an index that was developed to compare different lake water quality values against one another on the same scale. The index uses raw numbers from analyses and converts them on a scale from <30 – 100+. Ranges of index numbers inform the reader about the overall nutrient status and productivity of the lake. While nutrients are important for aquatic life, an overabundance of nutrients can lead to nuisance algae blooms, limit water clarity, and have other negative impacts on the lake. There are 4 classes of lakes that are described within this index. In Iowa, we see 3 of these classes. Classes are described in the table below and the maps (figures 1 and 2) show the trophic state of Iowa's lakes based on 14 years of monitoring for water clarity (Secchi depth) and algae production (chlorophyll a). DNR uses both of these index values to assess water quality in our public lakes under the Clean Water Act.

Lake type:	Description:
Oligotrophic	Oligotrophic lakes have low algae production, or primary productivity, due to low nutrient content. They are often characterized by clear waters with little to no aquatic vegetation. They typically have ample dissolved oxygen and support diverse fisheries and communities of aquatic organisms. These types of lakes are most often found in colder regions of the world with igneous bedrock.
Mesotrophic 	This group of lakes has as intermediate level of algal productivity. Lakes are characterized by relatively clear water and an abundance of submerged plants. These lakes typically support large fish populations, although they may not support very oxygen sensitive fish.
Eutrophic 	The majority of Iowa lakes fall into this category. This group is characterized by high levels of nutrients (especially phosphorus and nitrogen) that cause frequent algae blooms and an abundance of aquatic plants (where light penetrates to the bottom of the lake). Oxygen concentrations in these lake vary with algae production and decomposition, thus, large fisheries can be sustained under the right conditions but are frequently subjected to oxygen stress.
Hypereutrophic 	This class of lakes is characterized by extremely high levels of nutrients that cause frequent algae blooms, usually dominated by blue-green algal species, and very low water clarity (typically less than 3 feet of transparency). These lakes often are pea-soup colored and filled with thick algal scums. They also can have very low oxygen concentrations as algae decompose and sink to the bottom of the lake. As a result, they may not be able to support thriving fisheries or other aquatic life.

Photos courtesy of the Iowa State University Limnology Laboratory. Photos show water clarity with Secchi disc (black and white disc pictured) at 0.2 meters deep.

Lake type:	Chlorophyll a (µg/L):	Total Phosphorus (µg/L):	Secchi Transparency (meters):	Trophic State Index value:
Mesotrophic	2.6 – 20	12 - 24	2 - 4	40 - 50
Eutrophic	21 - 56	25 - 96	0.5 - 2	51 - 70
Hypereutrophic	57 +	97 +	< 0.5	71 +

2014 Relative to Other Years

While 138 lakes are monitored as a part of the Ambient Lake Monitoring program, it is difficult to categorize all of the water quality information for every lake monitored in a short summary. The Table below outlines the 2014 average of several water quality parameters measured at 20 of the most popular lakes in Iowa and shows whether or not the lake's overall water quality was better or worse than average (based on the data collected at each of these lakes) The table also shows whether each lake, on average, has better or worse water quality than the global average for each parameter. Lake popularity (total number of household trips) was determined using the CARD survey data from 2002-2005. Additional information on Iowa's lakes and the can be found at: www.iowadnr.gov/Environment/WaterQualiry/WaterMonitoring/Lakes.aspx.

Lake Name	**Total Phosphorus (µg/L)**	**Nitrate + Nitrite as N (mg/L)**	**Secchi Transparency (m)**	**Total Suspended Solids (mg/L)**	**Chlorophyll *a* (µg/L)**	**Better or worse in 2014***	**Above or below average ****
Saylorville Lake	124	6.80	1.1	6	16.2	Better	Below
West Okoboji Lake	18	<0.12	6.6	<2.1	<3.3	Better	Above
Coralville Reservoir	194	6.18	0.3	28	17.8	Better	Below
Clear Lake	56	<0.12	0.5	26	38.6	Worse	Below
Big Creek Lake	136	5.91	1.5	4	32.3	Worse	Above
East Okoboji Lake	69	0.12	1.9	10	34.4	Worse	Above
Lake Red Rock	160	5.52	0.6	16	9.4	Worse	Below
Big Spirit Lake	37	<0.12	1.6	6	15.2	Better	Above
Lake Macbride	53	0.34	1.4	9	32.4	Better	Above
Rathbun Lake	59	0.67	0.6	15	11.7	Worse	Below
Storm Lake	56	0.20	0.7	17	8.1	Better	Below
Pleasant Creek Lake	40	<0.12	2.3	7	31.2	Worse	Above
Brushy Creek Lake	63	10.62	3.8	3	11.4	Better	Above
George Wyth Lake	41	<0.12	1.3	6	22.7	Worse	Above
Lake Manawa	114	<0.12	0.4	30	82.7	Better	Below
Easter Lake	58	0.14	0.8	10	26.2	Same	Below
Lake Ahquabi	45	<0.12	1.2	5	21.5	Better	Average
Black Hawk Lake	283	0.13	0.9	16	75.9	Worse	Below
Three Mile Lake	49	0.32	0.9	12	22.2	Worse	Above
Lake Geode	28	0.14	2.0	7	22.5	Same	Above

*Majority of 2014 averages were better or worse than the 2000-2014 averages for this lake

** Majority of parameters for 2000-2014 average for these lakes were better or worse than the global averages for all lakes sampled (Global averages for all Iowa lakes sampled as a part of the Ambient Lake Monitoring Program are as follows: total phosphorus concentration: 108 µg/L, average Secchi transparency: 1.2 m, average chlorophyll a concentration: 43 µg/L).

Figure 1. 2014 Average water clarity as measured by Secchi disc.

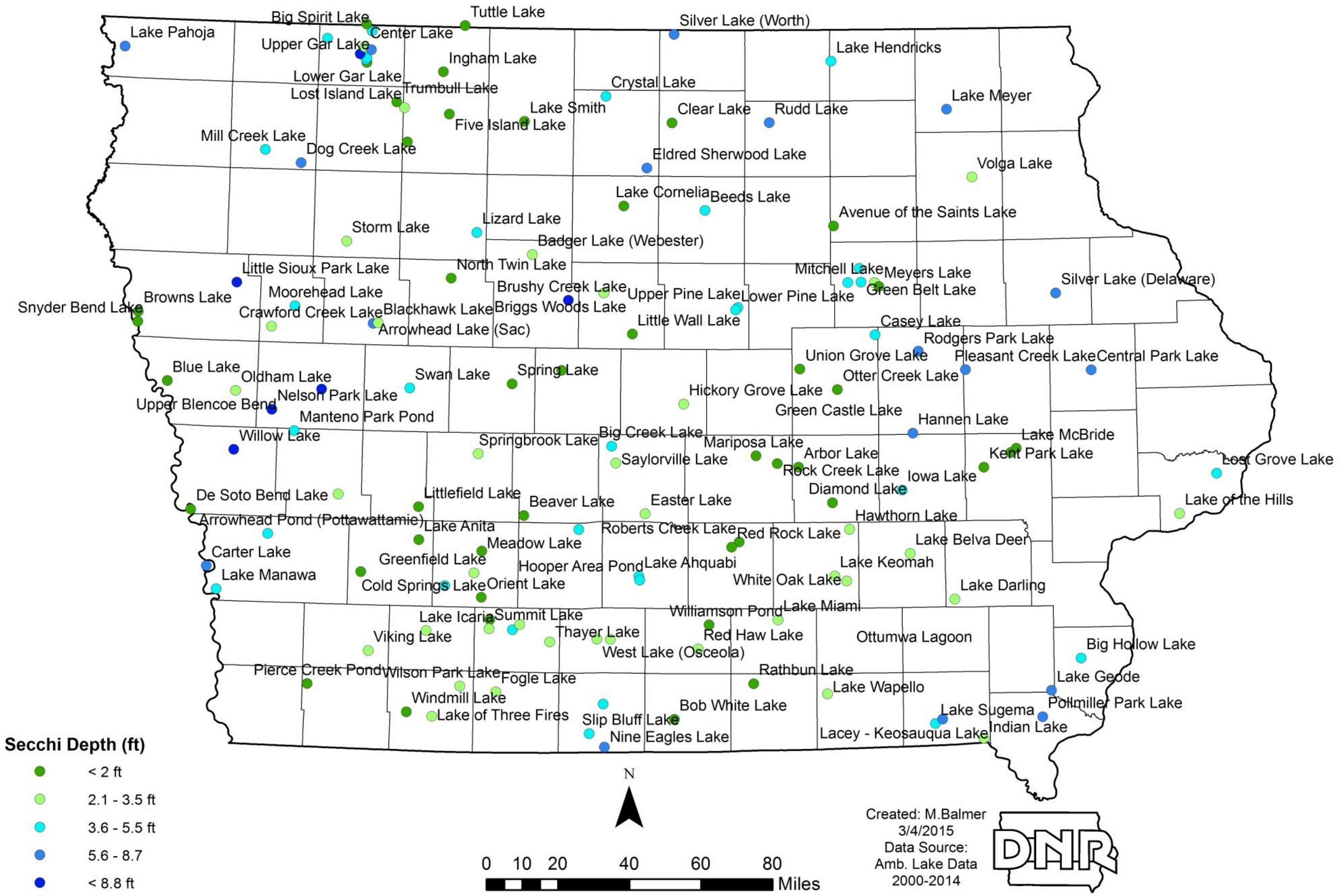

Figure 2. Average concentrations of chlorophyll *a* (an estimate of algae production) in Iowa lakes

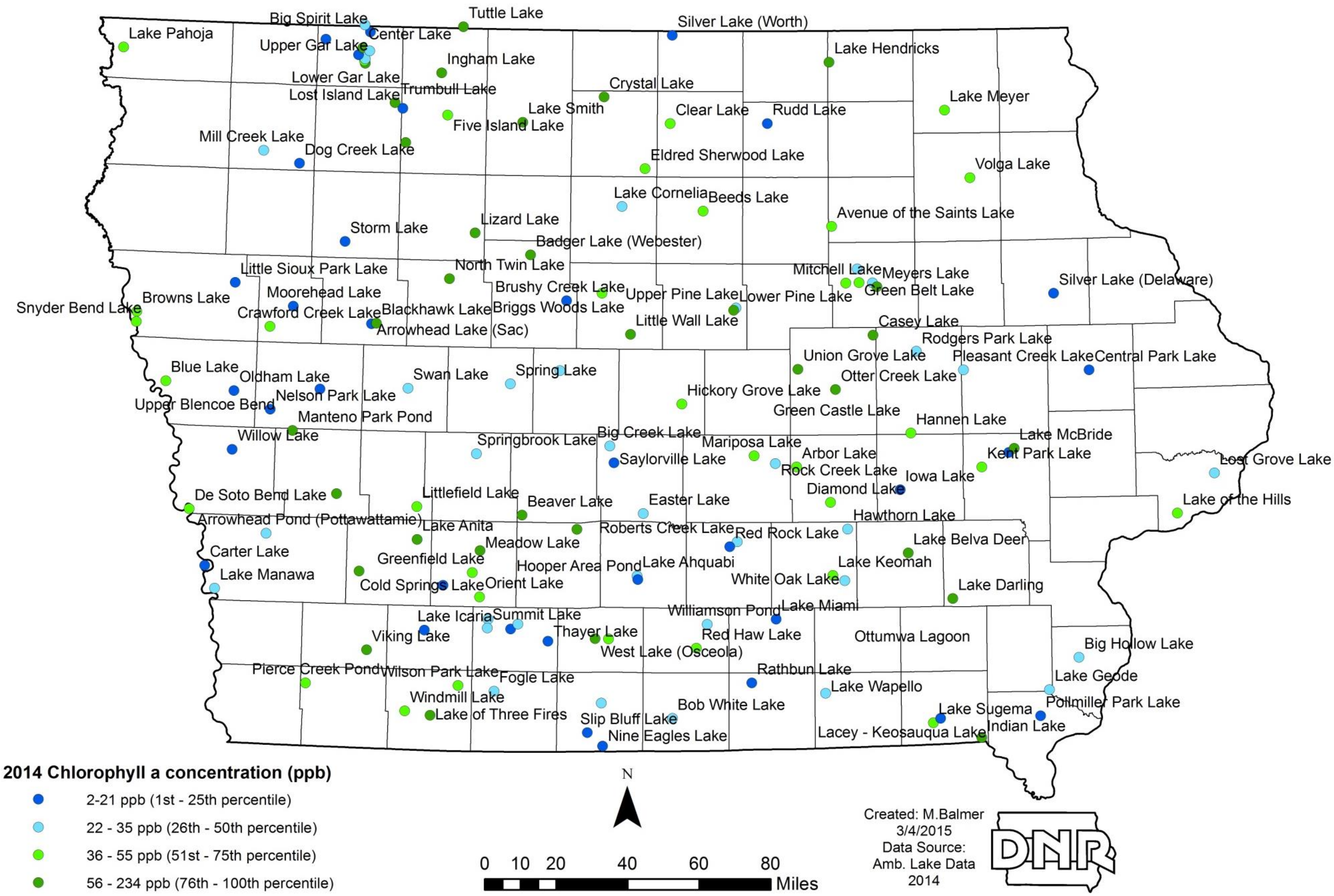

Figure 3. Average 2014 total phosphorus concentrations for Iowa lakes