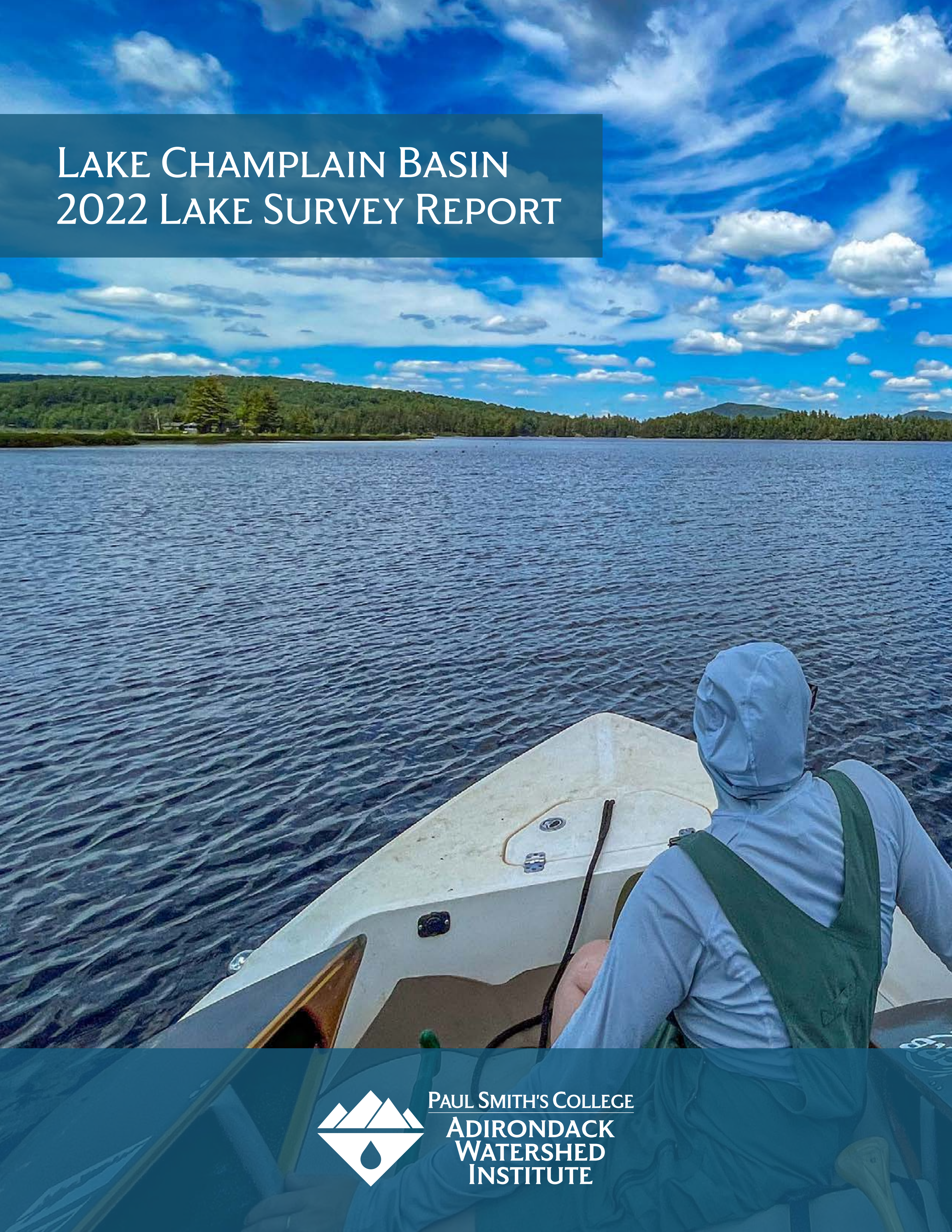
LAKE CHAMPLAIN BASIN 2022 LAKE SURVEY REPORT



PAUL SMITH'S COLLEGE
ADIRONDACK
WATERSHED
INSTITUTE

LAKE CHAMPLAIN BASIN
2022 LAKE SURVEY REPORT

Brendan Wiltse*, Elizabeth Yerger, Lija Treibergs, Joline Hall, Connor Vara, Carli Courville, & Justin Sturtz

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Paul Smith's College Adirondack Watershed Institute
PO Box 265, Paul Smiths, NY

*Corresponding author. Email: bwiltse@paulsmiths.edu, Telephone: 518-327-6460.

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EXECUTIVE SUMMARY

Regular water quality assessment not only helps states meet the requirements of the Clean Water Act, but it is also fundamental to sound management. New York has thousands of water bodies, making regular comprehensive assessment challenging. There are 194 lakes and ponds on the New York side of the Lake Champlain Basin that are part of the Waterbody Inventory (NYS DEC 2016). Of these, 76% (148) have not been assessed in the past 20-years, and 15% (30) are unassessed (ALSC 1986; CSLAP 2019; Laxson et al. 2018; NYS DEC 2016).

Many unassessed or not recently assessed lakes on private land may be impacted by land use and development. Land use and development have changed substantially in the basin over the past 20-years, challenging the utility of several decades-old assessments and likely do not reflect current lake or watershed conditions (Troy et al. 2007). Lack of assessment poses a significant barrier to identifying water quality impairments and implementing actions to address them. Therefore, these lakes would benefit from some level of assessment to prioritize the development of watershed action plans and protect the long-term health of these freshwater resources. Many upland water bodies on the New York side of the basin exist on New York State Forest Preserve land, presumably limiting local stressors from land use and potential management actions. NYS Department of Environmental Conservation staff often relies on water quality data collected more than 30 years ago, as part of the Adirondack Lake Survey, when writing Unit Management Plans that cover these waters (NYS DEC 1999, 2004, 2018, 2019, 2020). Updated assessments of these waters would be informative in understanding recovery from acidification at the scale of individual lakes and the influence of recent climate change on lake chemistry and biology (Areseneau et al. 2016; Waller et al. 2012). Both stressors have direct implications for the recreational use of the water body and their management, as well as the protection of threatened or endangered species.

This report summarizes data collected by the Adirondack Watershed Institute and our partners on lakes within the Lake Champlain Basin during the summer of 2022. A total of 76 lakes were sampled by volunteers and professional staff. Most of the lakes assessed in this report have good water quality, though there are some waterbodies with challenges. Lake Alice and Lake Roxanne have high nutrient concentrations and have higher density of agricultural land use within their watersheds. The Cascade Lakes along Route 73, Lake Colby along Route 86, and Mirror Lake have high concentrations of chloride associated with high density of roads within their watersheds and proximity to state highways. Owl Pond and Gordon Pond have low pH, threatening aquatic life.

The results of this effort provide an important baseline for assessing stressors to our aquatic ecosystems, such as development, road salt, climate change, and the recovery from acid rain. The involvement of volunteers and the additional volunteer recruitment that was supported through this project, helps ensure that more waterbodies within the Lake Champlain Basin are regularly monitored and assessed.

Finally, data from this assessment effort will be used by the project advisory committee overseeing this effort to select three priority waterbodies for the development of watershed action plans. These plans will serve as a model for lake associations and community groups looking to protect and improve water quality in their lakes.

METHODS

Each lake was sampled monthly from either May to September or June to August. The longer sampling period was used for lakes directly supported by the Lake Champlain Basin Program, lakes that are regularly enrolled in the Adirondack Lake Assessment Program were sampled based on volunteer enrollment.

During each sampling visit a 2-meter integrated tube sampler was used to collect a surface water sample for analysis at the Paul Smith's College Adirondack Watershed Institute lab. The tube sampler was field rinsed prior to sample collection and emptied into a 1-L field rinsed mixing bottle. A 250-mL aliquot was sub-sampled in the field for filtration through a 45-µm cellulose membrane filter for chlorophyll-a analysis. A 500-mL subsample was poured into a field rinsed sample bottle and immediately frozen prior to transport to the Paul Smith's College Adirondack Watershed Institute lab. Transparency was measured using a 20-cm Secchi disk.

Samples were analyzed at the Paul Smith's College Adirondack Watershed Institute Lab for pH, specific conductance, dissolved organic carbon, apparent color, chlorophyll-a, total phosphorus, nitrate+nitrite, ammonia, total nitrogen, alkalinity, chloride, calcium, and sodium.

Lakes sampled by Paul Smith's College Adirondack Watershed Institute staff also collected in-situ measurements of temperature, dissolved oxygen, specific conductance, and pH every meter through the water column.

Volunteers and staff monitored lakes for aquatic invasive species following the Adirondack Park Invasive Plan Program protocols.

Right: Adirondack Park Invasive Plant Program Aquatic Invasive Species Coordinator Brian Greene teaching ALAP volunteers how to identify aquatic invasive species.

ANALYTES

Trophic Status

Trophic status is used by limnologists to refer to the overall productivity of a lake. Lake productivity is influenced by nutrient supply, light availability, regional climate, watershed characteristics, and lake morphology. The term cultural eutrophication is often used to describe the process whereby human activities increase lake productivity through an increase in the nutrient supply. This process usually results in unwanted outcomes such as declines in lake aesthetics, increase chance of harmful algal blooms, and fish kills due to elevated bacterial decomposition utilizing all the available oxygen in the water column.

Lakes can be assigned to three main classification categories based on their overall productivity: oligotrophic, mesotrophic, and eutrophic. Oligotrophic lakes have the lowest productivity due to low nutrient content. These lakes are often characterized by clear, highly transparent water, with low phytoplankton biomass. The entire water column is often well oxygenated, making these lakes capable of supporting cold water fish species such as lake trout. Mesotrophic lakes are an intermediate state between oligotrophy and eutrophy. Eutrophic lakes are characterized by high productivity and high nutrient content. As a result, the water column is less clear due to increased phytoplankton production. The greater production of organic matter leads to higher rates of bacterial decomposition at the bottom of the lake. Bacteria utilize oxygen, resulting in a decrease in oxygen availability in the bottom waters during the summer stratified period. This reduction in oxygen is referred to as hypoxic (low oxygen) or anoxic (no oxygen) and is not conducive to supporting cold water fish (Wetzel 2001).

Total Phosphorus

Phosphorus is relatively common in igneous rocks such as those found in the Adirondacks and is also abundant in sediments. The concentration of phosphorus in natural waters is low however, because of the low solubility of these inorganic forms (Wetzel 2001). Phosphorus is also a component of wastewater which is, in turn, a primary source of phosphorus in many waters. Typical concentrations of phosphorus in surface water are a few micrograms per liter. Additions of phosphorus to the aquatic environment enhance algal growth and accelerate eutrophication that leads to depletion of dissolved oxygen (Schindler 1977; Wetzel 2001).

Phosphorus is also added to surface waters from non-point sources such as eroding soils, stormwater, runoff from fertilized fields, lawns, and gardens, and runoff from livestock areas or poorly managed manure pits. Poorly maintained or sited septic systems can also add phosphorus to surface waters. In addition, analyses of water chemistry in Adirondack upland streams shows that streams coming off old growth forest have higher phosphorus concentrations than those flowing off managed forests (Myers et. al, 2007).

Phosphorus plays an important role in biology and is an important nutrient in aquatic ecosystems. Phosphorus is often a limiting nutrient in lakes, meaning that it is a lack of phosphorus that limits aquatic primary production (Schindler 1977). Phosphorus normally enters a lake bound to soil and sediment through overland flow. In developed or urban areas, excess phosphorus can enter a lake due to application of fertilizer or through poor wastewater management. This increase in phosphorus may lead to increased primary production, resulting in aesthetic changes to the lake. If the increase in primary production is large enough, there may be subsequent problems with oxygen depletion because of decomposition. The reduction in oxygen can lead to fish kills and other negative impacts (Carpenter et al. 1998).

Quick Interpretation of Total Phosphorus

Total Phosphorus (µg/L)	Trophic Status
<10	Oligotrophic
10 - 20	Mesotrophic
>20	Eutrophic

Chlorophyll-a

Chlorophyll-*a* is the primary photosynthetic pigment in all photosynthetic organisms including algae and cyanobacteria. The concentration of chlorophyll-*a* is used as an index for algal biomass, or productivity. Nutrient concentrations, light, and water temperature all control algal productivity. Depending on the time of year, these three variables change and can limit algal production. Therefore, we expect to see variability in chlorophyll-*a* throughout the year. Major shifts in chlorophyll-*a* concentration over many years can usually be attributed to changes in nutrients (phosphorus, nitrogen, and silica) (Wetzel 2001).

Quick Interpretation of Chlorophyll-a

Chlorophyll-a (µg/L)	Trophic Status
<2	Oligotrophic
2 - 8	Mesotrophic
>8	Eutrophic

Secchi (Transparency)

Water column transparency is a simple measure of lake productivity. Generally, secchi depth is lower in highly productive eutrophic lakes and higher in less productive oligotrophic lakes. Secchi depth can also be influenced by other water quality parameters that impact clarity, such as dissolved organic carbon, total suspended solids, colloidal minerals, and water color. Therefore, it is valuable to keep other water quality parameters related to lake productivity, such as total phosphorus and chlorophyll-*a*, in mind when looking at changes in transparency. Changes in watershed characteristics, such as the amount of runoff from precipitation or the export of organic matter, can also influence transparency.

Quick Interpretation of Secchi

Transparency (m)	Trophic Status
>5	Oligotrophic
2 - 5	Mesotrophic
<2	Eutrophic

Nitrogen

Nitrogen is present in many forms in the atmosphere, hydrosphere, and biosphere, and is the most common gas in the earth’s atmosphere. The behavior of nitrogen in surface waters is strongly influenced by its vital importance to plant and animal nutrition. Nitrogen occurs in water as nitrite (NO_2^-) or nitrate (NO_3^-) anions, ammonium (NH_4^+) cations, or organic nitrogen. Excessive, or high levels of nitrite are an indicator of organic waste or sewage. Nitrate or ammonium may also be from a pollutant source, but, generally, are introduced at a site far removed from the sample point. This is because nitrate is stable over a range of conditions, but nitrite rapidly volatilizes in oxygenated water. Ammonium is an important nutrient for primary producers, but, at high concentrations, is a dangerous pollutant in lakes and rivers, because the bacterial conversion of NH_4 to NO_3 robs water of oxygen. Generally, nitrogen is not a limiting nutrient in aquatic ecosystems (Schindler 1977).

Nitrogen to Phosphorus Ratio

As the two primary nutrients in aquatic ecosystems, the ratio of nitrogen to phosphorus can influence nutrient limitation and which phytoplankton species are dominant. Increasing occurrence of harmful algal blooms has renewed interest in lake nutrient cycling and how that relates to the occurrence of toxic blooms. The importance of TN:TP to cyanobacterial blooms is debated, but there is evidence that low TN:TP mass ratios favor both nitrogen fixing and non-nitrogen fixing cyanobacteria (Smith 1983). A

TN:TP mass ratio of 22:1 appears to be a threshold under which lakes are more likely to be dominated by N-fixing cyanobacteria (Smith et al. 1985). Laboratory experiments have shown that the non-nitrogen fixing *Microcystis* dominates below ratios of 44:1 (Fujimoto & Sudo 1997). While TN:TP ratios may be an important driver of cyanobacterial blooms, it is important to recognize that other factors are important as well, such as temperature, salinity, NO_3:NH_4 mass ratios, and pH (Liu et al. 2011).

Quick Interpretation of TN:TP Ratio

TN:TP	Status
<22	Higher risk of cyanobacteria blooms

Conductivity

Conductivity—the ability of water to pass an electrical current because of the presence of dissolved ions—is often called the "watchdog" environmental test since it is informative and easy to perform. Calculations of specific conductance standardize conductivity measurements to the temperature of 25 °C for the purposes of comparison. Rain, erosion, snow melt, runoff carrying livestock waste, failing septic systems, and road salt raise conductivity because of the presence of ions such as chloride, phosphate, nitrite etc. Oil spills lower water conductivity. Temperature, shade, sunlight, and sampling depth all affect conductivity. A conductivity probe does not identify the specific ions in a water sample—it simply measures the level of total dissolved solids (TDS) in the water body.

Chloride

The element chlorine can occur in various forms or states of oxidation, but the chloride form (Cl-) is most common in surface waters. There are several natural sources of sodium and chloride, including various rocks that contain sodium- and chlorine-bearing minerals. The most abundant natural mineral form of sodium and chloride is NaCl or Halite, also known as rock salt. Large halite deposits form when ocean water evaporates and mineral deposits are buried, eventually becoming rock.

Chloride is present in most natural waters at very low concentrations, except where surface or groundwater mixes with ocean water. Minimally impacted Adirondack lakes have average chloride and sodium concentrations of 0.2 mg/L and 0.5 mg/L, respectively (Kelting et al. 2012). Another source of chloride is road runoff in regions where rock salt is used as a road deicing agent in winter. New York has one of the highest rock salt application rates per lane mile in the United States (Kelting & Laxson 2010). These application rates are mandated on state roads across the state, regardless of proximity to surface waters.

Quick Interpretation of Chloride

Chloride (mg/L)	Road Salt Influence
<1	None
1 - 9	Low
10 - 39	Moderate
>40	High

pH

pH is an index of the hydrogen ion activity in solution, it is defined as the logarithm of the reciprocal of the concentration of free hydrogen ions in solution. Therefore, high pH values represent lower hydrogen ion concentrations than low pH values, and there is a 10-fold difference in hydrogen ion concentration across a single pH unit. The pH scale extends from 0 to 14, with 7 being neutral. pH values below 7 indicate acidic conditions and pH values greater than 7 indicate alkaline conditions.

Acidity in Adirondack surface waters has two sources: acid deposition (rain, snow, and dry deposition) and organic acids from evergreen needles and other plant matter. Long-term monitoring by the Adirondack Lakes Survey Corporation showed that 25% of lakes in the Adirondacks have a pH of 5.0 or lower and another 25% are vulnerable to springtime acidification

(ALSC, 1990).

Shifts in pH can have major effects on the dominant biological and chemical process present within a lake. Many organisms have narrow pH tolerances, resulting in significant declines in individual health and population numbers if pH values stray outside of their tolerances. Changes in pH also influence the mobility of ions and heavy metals which can result in issues related to nutrient availability and toxicity (Driscoll 1985; Schindler et al. 1985).

Quick Interpretation of pH

pH	Status
<5	Acidic: critically impaired
5.0 - 5.9	Acidic: threatened
6.0 - 6.4	Acidic: acceptable
6.5 - 7.5	Circumneutral: not impaired
>7.5	Alkaline: not impaired

Alkalinity

Alkalinity is a measure of buffering capacity of a waterbody, typically expressed as mg/L of calcium carbonate ($CaCO_3$). The amount of calcium carbonate in a waterbody is primarily related to the bedrock geology of its watershed. Lakes with watersheds underlain by granitic bedrock tend to have low alkalinity due to slow rates of weathering of the bedrock and low amounts of calcium carbonate in the rock. Conversely, lakes underlain by sedimentary rocks such as limestone tend to both weather faster and contain more calcium carbonate. Many lakes in the Adirondacks are underlain by granitic bedrock, and therefore have lower alkalinity.

Quick Interpretation of Alkalinity

Alkalinity (mg/L)	Acid Neutralizing Capacity
0	None
0 - 2	Low
3 - 10	Moderate
11 - 25	Adequate
>25	High

Sulfate

Sulfate is an essential component of lake chemistry as it plays a significant role in various biogeochemical processes that occur within aquatic ecosystems. Sulfate is present in rainwater and enters lakes through atmospheric deposition, and it can also be released from bedrock weathering and human activities such as mining and industrial processes. Sulfate is an electron acceptor in microbial sulfate reduction, which is a critical process in the breakdown of organic matter and the cycling of carbon, sulfur, and nitrogen. Additionally, sulfate can influence the acidity of lakes by forming sulfuric acid through chemical reactions, which can have detrimental effects on aquatic life. Therefore, understanding the sources and dynamics of sulfate in lakes is crucial for the management and conservation of freshwater resources (Wetzel 2001).

Apparent Color

Color is an optical property of water that results from light scattering after absorption of water molecules, dissolved materials, and suspended materials. Blue-green wavelengths are often scattered in alkaline lakes giving them a turquoise appearance, whereas lakes rich in dissolved organic matter scatter longer wavelengths (red and yellow), making them appear brown in color.

The quantification of apparent color in water is done through comparison with standards of a platinum-cobalt solutions via spectroscopy. True color is the color of water after removal of suspended material and apparent color is the color of water without filtration. Color can be used to provide information about the quantify of dissolved organic mater (DOM) in water. Though, caution should be used when using color as a surrogate of DOM because it can behave differently, making it a crude predictor of DOM (Dillon and Molot 1997).

Dissolved Organic Carbon

Dissolved organic carbon (DOC) is the fraction of carbon in a water sample that can pass through filtration. It is an important substance in aquatic ecosystems. It is a source of food for microorganisms and can block or absorb ultraviolet radiation. The source of the carbon can come either from within the lake (autochthonous) or from outside of the lake (allochthonous). Many lakes in the Adirondacks are experiencing increasing DOC, this is thought to be primarily driven by recovery from acid deposition, but may also be a result of climate change (Driscoll et al. 2016). DOC solubility is decreased in soils that are acidic and have a high ionic strength. Therefore, a recovery from acid deposition that increases soil pH will increase DOC solubility. Climate change may also play an important role in increasing DOC. Warmer temperatures accelerate the breakdown of organic material and increased precipitation increases the leaching of DOC from forest soils. Because of the important role DOC plays in attenuating light, increasing DOC in lakes may help cold water fish species by limiting the warming of deeper waters.

Total Calcium

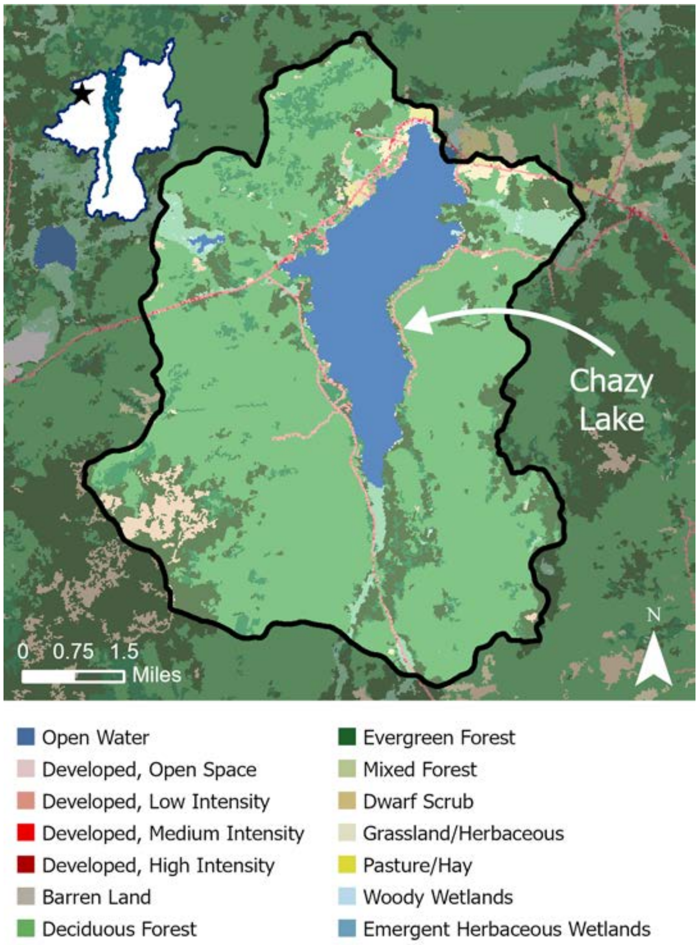
The primary source of calcium in lakes is $CaCO_3$, thus the discussion of calcium is closely tied to that of alkalinity. $CaCO_3$ is not very soluble in water, but in the presence of carbonic acid it is converted to more soluble forms. The primary source of calcium in lakes is from weathering of parent material. Calcium is an important element in biology because it serves a role in the structure and physiology of many organisms. In the Adirondacks, the granitic parent material contains little calcium, and therefore Adirondack lakes tend to be low in calcium. Regionally, lakes are showing calcium declines, in part because of acid deposition. Acid deposition resulted in increased calcium leaching from watershed soils, eventually reducing the pool available for export to lakes (Keller et al. 2001). Concentrations are low enough in some lakes (<2 mg/L) to cause declines in zooplankton that utilize calcium to build their carapace (Jeziorski et al. 2008).

Quick Interpretation of Calcium

Calcium (mg/L)	Status
<2	At Risk

Right: Holcomb Pond viewed from a nearby rock ledge.

CHAZY LAKE



Summary

Trophic Status (Chl-a):	Oligotrophic
Trophic Status (TP):	Oligotrophic
Trophic Status (Secchi):	Oligotrophic
Acidity:	Alkaline: non-impacted
Acid Neutralizing Capacity:	Adequate
Road Salt Influence:	Moderate

Notes: Three sites are sampled on Chazy Lake.

Location

Latitude:	44.7471
Longitude:	-73.8240
County:	Clinton
Town:	Dannemora
Watershed:	Great Chazy River

Lake Characteristics

Surface Area (ha):	746.6
Shoreline Length (km):	20.7
Max Depth (m):	21.9
Mean Depth (m):	15.9
Volume (m^3):	65,399,532
Flushing Rate (times/year):	0.33

Watershed Characteristics

Watershed Area (ha):	5,910.5
Open Water (%):	12.67
Developed, Open Space (%):	1.40
Developed, Low Intensity (%):	0.76
Developed, Medium Intensity (%):	0.15
Developed, High Intensity (%):	0.02
Barren Land (%):	0.07
Deciduous Forest (%):	59.23
Evergreen Forest (%):	13.47
Mixed Forest (%):	5.76
Dwarf Shrub (%):	1.96
Grassland/Herbaceous (%):	0.78
Pasture/Hay (%):	0.36
Cultivated Crops (%):	0.00
Woody Wetlands (%):	3.14
Emergent Herbaceous Wetlands (%):	0.22

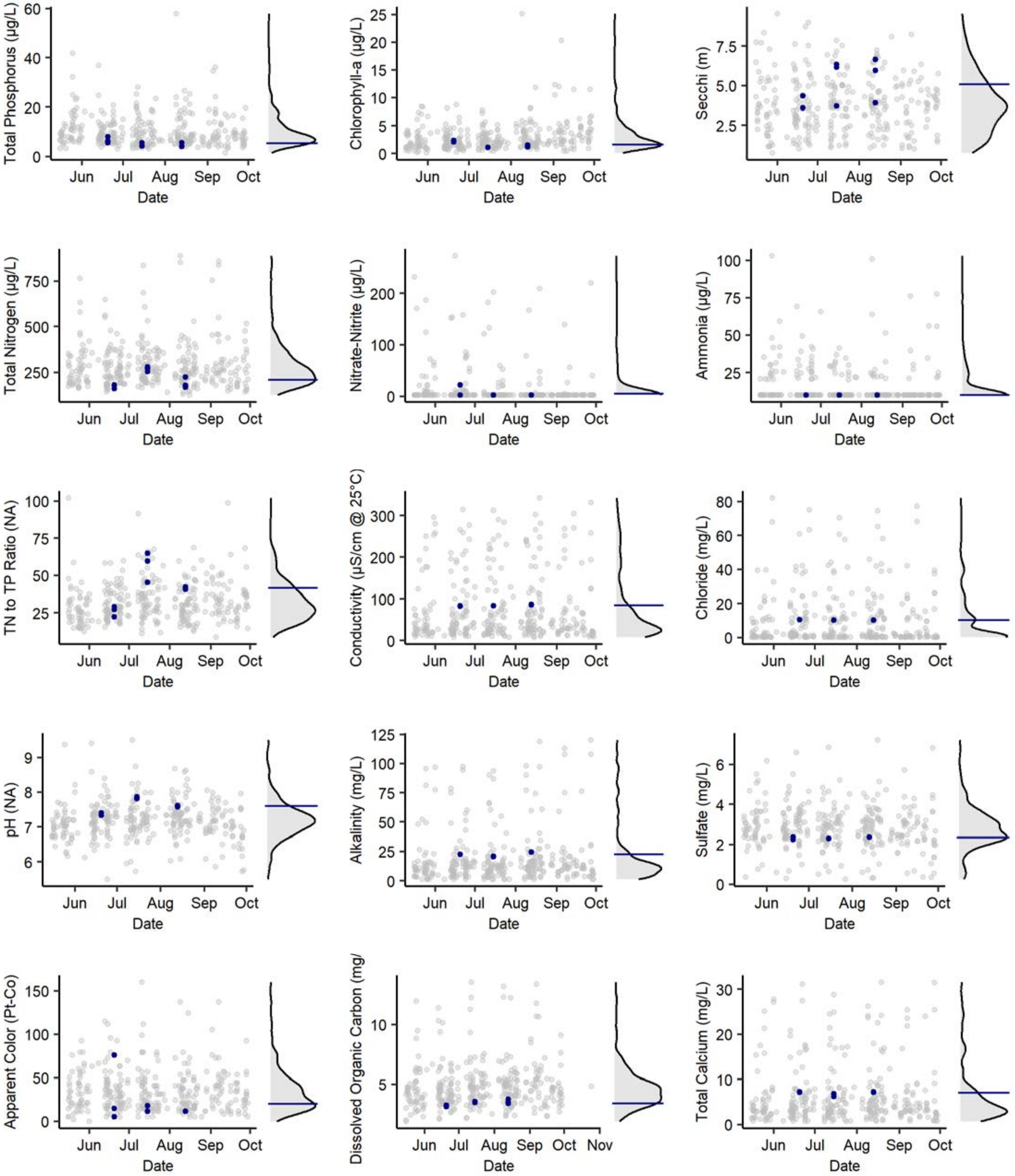
Aquatic Invasive Species Detections

Eurasian watermilfoil:	2006
Chinese mystery snail:	Unknown

Harmful Algal Bloom Reports

None

Gray dots represent all data in the report, blue dots are the samples for the represented lake. The right sub-plot shows the density distribution for all data in gray and the mean for the represented lake as a blue line.



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