New Hampshire Volunteer Lake Assessment Program

2014
Monadnock Region
Regional Report

Gilmore Pond, Jaffrey, NH

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

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New Hampshire
Volunteer Lake Assessment Program
2014 Monadnock Regional Report

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REGIONAL HIGHLIGHTS

- The Monadnock Region consists of those towns in New Hampshire's *Cheshire County*, and western parts of *Hillsborough County.*

- Regional freshwater recreation, including boating, fishing and swimming, in the Monadnock Region generates approximately **$7.5 million dollars in sales, $2.7 million in household income, and 123 jobs annually** (Nordstrom, 2007).

- **A perceived decline in water quality** as measured by water clarity, aesthetic beauty, or overuse could result in approximately **$1.7 million lost revenue, $552,000 in lost household income and 28 lost jobs** (Nordstrom, 2007).

- Regional population is expected to grow by **9,000 people in Cheshire County and 50,000 people in Hillsborough County by 2030**. The majority of growth is estimated to occur in the towns of Keene, Swanzey, Winchester, Rindge, Jaffrey, Peterborough and Hillsborough.

- The Monadnock Region is home to over **20,000 acres** of lakes, river and wetlands. Over **5,000 acres or 30 percent** of water occurs in the towns predicted to experience the heaviest population growth.

- The regional average summer air temperature was 0.7° F above the historical regional average conditions in 2013, as reported in Keene, New Hampshire, yet was 0.4° F below average in 2014. Regional average surface water temperatures were 1.8° F warmer than the historical regional average, as recorded by VLAP, in 2013 and 1.0° F warmer in 2014. Regional average summer precipitation (rainfall) was 2.0 inches above the historical regional average in 2013 and only 0.37 inches above average in 2014.

- The Monadnock region consists of **156 lakes** or great ponds. Regional water quality data is collected at **34 lakes participating in VLAP** while the **remaining 80 percent of lakes are sparsely monitored** through the Lake Trophic Survey Program.

- Regional lakes are classified into three categories that describe the overall health of the lake as oligotrophic, mesotrophic, or eutrophic by the Lake Trophic Survey Program. Thirty-two lakes are oligotrophic, 55 are mesotrophic, 31 are eutrophic, and 38 are un-assessed for trophic classification due to lack of data. Fourteen oligotrophic, 19 mesotrophic, and one eutrophic lake participate in VLAP.

- VLAP lakes are monitored at the deepest point in the lake and at streams entering or exiting the lake. Lakes are monitored monthly during the summer season to establish baseline water quality data and discern long term water quality trends that provide information on overall waterbody health.

- Regional trend analysis performed on historical water quality data found no significant trend for parameters chlorophyll-a, chloride, and total phosphorus. Acid neutralizing capacity (ANC) and epilimnetic pH significantly increased, which indicates improving conditions. Epilimnetic turbidity and conductivity significantly increased and transparency significantly decreased, which indicates declining conditions.

MONADNOCK REGION WATER QUALITY INDICATORS

The following describes the water quality indicator measured through VLAP, the regional trend that was detected and the current status of the indicator. Trends were determined with a non-parametric Mann-Kendall trend test of the annual medians for each parameter.

Exotic Species	Chlorophyll-a	Transparency	Phosphorus	Dissolved Oxygen	pH	Conductivity	Chloride	Turbidity

Indicator	Trend	Description
	N/A	Ten waterbodies in the Monadnock Region are infested with an exotic species, the majority of which have Variable milfoil. The newest infestation of Variable milfoil was discovered at Otter Lake, Greenfield in 2012. The Connecticut River is also infested with Eurasian milfoil, European naiad and Curly-leaf pondweed. Dublin Lake did support a small infestation of variable milfoil, but due to good early detection and rapid response actions, the population was removed.
	↔	No significant regional trend from 1987 - 2014. Regional median is 3.63 mg/m^3 and representative of mesotrophic conditions or average chlorophyll-*a* levels. Lake specific trend analysis indicates one lake with significantly increasing (worsening) chlorophyll-*a*, five lakes with significantly decreasing (improving) chlorophyll-*a* and 20 lakes with stable chlorophyll-*a* trends.
	↓	Significantly decreasing (worsening) regional transparency trend from 1987 - 2014. The regional median transparency is 3.77 meters and representative of mesotrophic or good conditions. Lake specific trend analysis indicates five lakes with decreasing (worsening) transparency, and 21 lakes with stable transparency trends.
	↔	No significant regional trend from 1987 – 2014. Regional median epilimnetic phosphorus is 8 ug/L and representative of oligotrophic/mesotrophic conditions. Lake specific trend analysis indicates four lakes with significantly decreasing (improving) epilimnetic phosphorus and 22 lakes with stable epilimnetic phosphorus trends.
	N/A	Dissolved oxygen levels fluctuate temporally and spatially within a lake system. Ideal levels are between 6.0 and 8.0 mg/L. The average whole water column dissolved oxygen level was 6.8 mg/L, which is sufficient to support aquatic life.
	↑	Significantly increasing (improving) regional epilimnetic pH trend from 1987 - 2014. Regional median epilimnetic pH is 6.37 and within a desirable pH range. However, lake specific trend analysis revealed five lakes with significantly decreasing (worsening) epilimnetic pH, while the remaining 20 lakes had stable trends.
	↑	Significantly increasing (worsening) regional epilimnetic conductivity trend from 1987 - 2014. The regional median epilimnetic conductivity is 38.4 uMhos/cm which is within a low range, however, individual lake conductivity fluctuates widely from approximately 15 to 168 uMhos/cm due to differences in watershed development. Lake specific trend analysis indicates twelve lakes with significantly decreasing (improving) epilimnetic conductivity, 5 lakes with significantly increasing (worsening) epilimnetic conductivity, and 9 lakes with stable epilimnetic conductivity trends.
	↔	No significant regional epilimnetic chloride trend from 2002 - 2014. Regional median epilimnetic chloride is 13 mg/L and much less than acute and chronic chloride standards. Regional epilimnetic chloride levels range from approximately 3 to 42 mg/L. Chloride trend analysis is not conducted on individual lakes.
	↑	Significantly increasing (worsening) regional epilimnetic turbidity trend from 1996 - 2014. Regional median epilimnetic turbidity is 0.73 NTU and is within a good range however median values increased particularly since 2002. Turbidity trend analysis is not conducted on individual lakes. Average epilimnetic turbidity values for individual lakes range from 0.39 NTU to 2.58 NTU.

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INTRODUCTION AND HISTORY

New Hampshire is home to approximately 1,200 lakes and ponds, and thousands of river miles. Protecting our lakes and rivers is critical to sustaining New Hampshire's drinking water resources, aquatic and natural environments, recreational and tourism industries.

The New Hampshire Department of Environmental Services (NHDES) recognizes the importance of these waterbodies in maintaining a healthy ecosystem for our current and future generations. Protecting high-quality waters and restoring those that are impaired requires coordination and partnership between federal, state and local governments, non-profits, regional commissions, lake associations and watershed residents.

To help citizens assess the health of New Hampshire's lakes and ponds, NHDES established the Volunteer Lake Assessment Program (VLAP) in 1985. The program is a volunteer-driven cooperative effort between the State and local governments, lake associations and lake residents. VLAP trains citizen volunteer monitors to collect water quality data at lakes and their associated tributaries on a monthly basis during the summer. VLAP compiles, interprets and reports the data back to state, federal and local governments, lake associations and lake residents.

VLAP volunteer monitors are invaluable stewards for New Hampshire's lakes. Volunteer monitoring allows NHDES to establish a strong set of baseline chemical and biological data, determine long-term water quality trends and identify emerging water quality issues. NHDES acts on these findings through its funding and regulatory programs. Volunteers use this information to educate lake and watershed residents, businesses and local governments on best management practices to keep New Hampshire's lakes and ponds clean. They have been, and will continue to be, a key element in protecting the integrity of New Hampshire's lakes.

PROGRAM OVERVIEW

VLAP is a cooperative program between NHDES and lake residents and associations. Approximately 500 volunteers monitor water quality at 170 lakes throughout New Hampshire through VLAP. Interest in the program has grown drastically in the past ten years as citizens have become more aware of the connections between land use activities and water quality. Volunteer monitors continually collect high-quality data on their local waterbodies and educate watershed residents.

Volunteer monitors are trained by NHDES to use monitoring equipment to collect lake water quality data, survey the surrounding watershed, and sample the streams and rivers that are tributaries to the lake. Each of the participating lakes must be visited by a NHDES biologist on a biennial basis. This visit is a valuable event in which the volunteer monitors have an opportunity to discuss water quality and watershed concerns and receive recommendations on potential remediation activities. Also, the event allows NHDES biologists to perform a field sampling techniques audit to evaluate volunteer monitor's ability to collect quality data, and to collect information on additional water quality parameters as necessary. Volunteers then sample on their own for the remaining summer months.

To further encourage volunteer monitoring, NHDES, established partnerships with the Lake Sunapee Protective Association (LSPA), Colby Sawyer College (CSC) in New London, NH, and Plymouth State

University (PSU) in Plymouth, NH to operate VLAP satellite laboratories. These satellite laboratories serve as a convenient location for volunteers to borrow sampling equipment and deliver water samples for analysis. These strategic locations serve the Dartmouth Lake Sunapee, North Country and White Mountain regions.

The data gathered by the volunteers are reviewed by NHDES quality assurance officers and satellite laboratory managers and imported into NHDES' Environmental Monitoring Database (EMD). During the winter, NHDES biologists review and interpret the water quality data, perform trend analyses, and compile the results into annual reports. The high-quality data gathered through VLAP also helps NHDES to conduct statewide surface water quality assessments. Assessment results are submitted to the Environmental Protection Agency (EPA) by NHDES every two years as a requirement of the Clean Water Act.

Once the volunteer monitors receive the data and the annual report for their lake, NHDES encourages the volunteers to relay that information to their respective associations, organizations, businesses, and local governments. Volunteers are also kept informed of the latest in lake management and water quality issues through an annual newsletter, technical and educational materials, regional workshops, and information on important legislation. In addition, NHDES biologists give presentations at lake association meetings and participate in youth education events. Educational initiatives, such as those mentioned above, allow volunteers to recognize potential water quality or shoreland violations around the lake and report their findings to NHDES.

MONITORING AND PARAMETER SUMMARY

VLAP encourages the collection of comprehensive data sets on key water quality parameters to determine overall health of the system. Lakes and tributaries are sampled several times each year over a period of years. This establishes baseline water quality data and allows for the discernment of long-term water quality trends. These trends depict lake health and provide invaluable information to NHDES' mission to protect New Hampshire's lakes. The sampling efforts of the volunteer monitors supplement the environmental monitoring efforts of NHDES. Only through the assistance of volunteer monitors can such a high volume of sampling be accomplished throughout the state.

NHDES recognizes the importance of collecting data sets that are representative of varying conditions. VLAP has an EPA approved Quality Assurance Project Plan (QAPP). The QAPP identifies specific responsibilities of NHDES and volunteers, sampling rationale, training procedures, data management and quality control. NHDES and volunteers adhere to the QAPP regime to ensure high-quality and representative data sets are collected.

Volunteers collect samples once per month in June, July and August, with some lakes monitored more or less frequently. Samples are collected at approximately the same location each month at each of the deep spot thermal layer, major tributaries (those flowing year round) and seasonal tributaries during spring run-off. The samples are analyzed for a variety of chemical and biological parameters including: pH, ANC, conductivity, chloride, turbidity, total phosphorus and *E. coli* (optional). Additional in-lake data are also collected at the deep spot including lake transparency (with and without a viewscope), chlorophyll-a, phytoplankton, and dissolved oxygen and temperature profiles. Volunteer monitors are also trained to identify and collect samples of suspicious aquatic plants and cyanobacteria.

Environmental outcomes are measured by making comparisons to established New Hampshire averages, medians, ranges of lake water quality and state water quality standards. If analytical results for a particular sampling station frequently exceed state water quality standards, then additional sampling to identify potential pollution sources is necessary. Volunteers often conduct storm event sampling, tributary bracket sampling, and spring run-off sampling to better assess watershed health and provide additional data to guide lake management decisions.

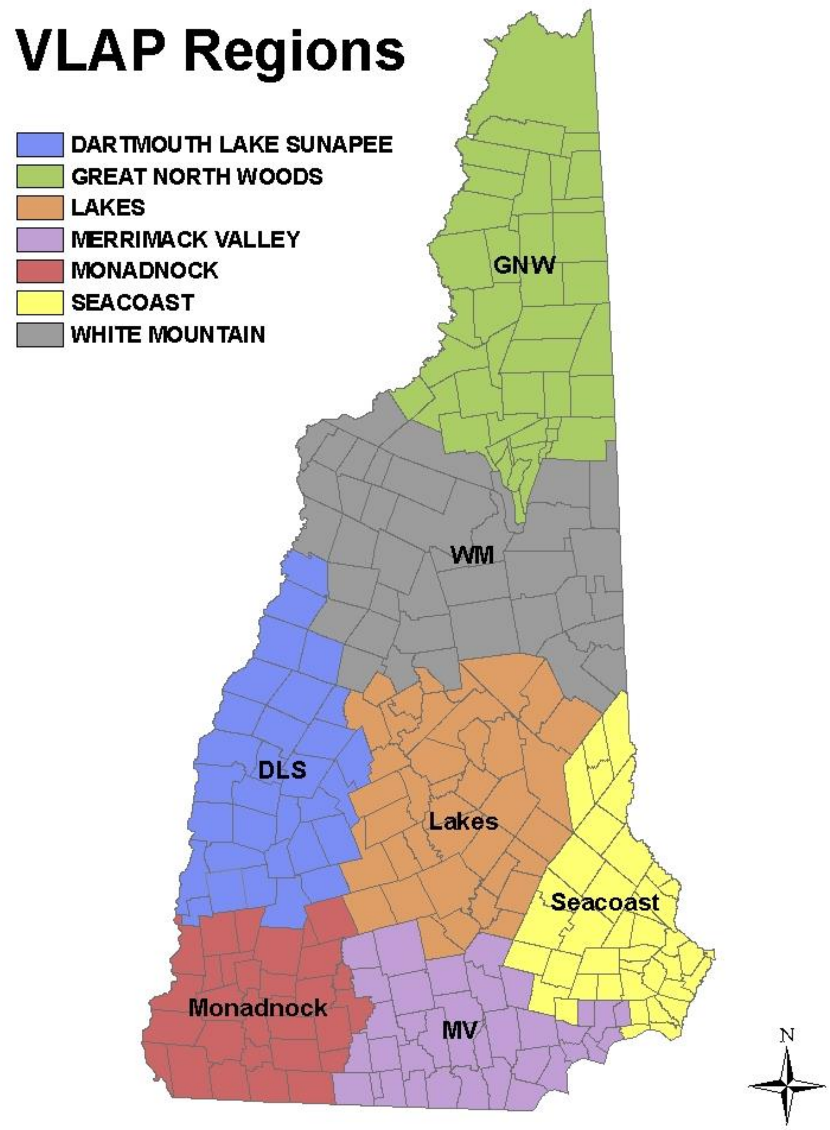
Appendix A includes a summary of each monitoring parameter and Appendix B includes recommended best management practices to remediate pollution sources.

MONADNOCK REGIONAL SUMMARY

The Monadnock Region consists of those towns in New Hampshire's Cheshire County, and western parts of Hillsborough County (Figure 1). Bordering portions of the Connecticut River and Vermont to the west, and the Contoocook River to the east, the area is home to Keene State College in Keene, Mount Monadnock in Jaffrey, and a large variety of lakes and ponds.

Freshwater resources in the Monadnock region provide valuable drinking water and recreational opportunities and play an important role in the regional economy.
Freshwater recreation, including boating, fishing and swimming, in the Monadnock Region generates approximately $7.5 million dollars in sales, $2.7 million in household income, and 123 jobs annually (Nordstrom, 2007). A perceived decline in water quality as measured by water clarity, aesthetic beauty, or overuse could result in approximately $1.7 million lost revenue, $552,000 in lost household income and 28 lost jobs (Nordstrom, 2007).

Figure 1. VLAP Regions



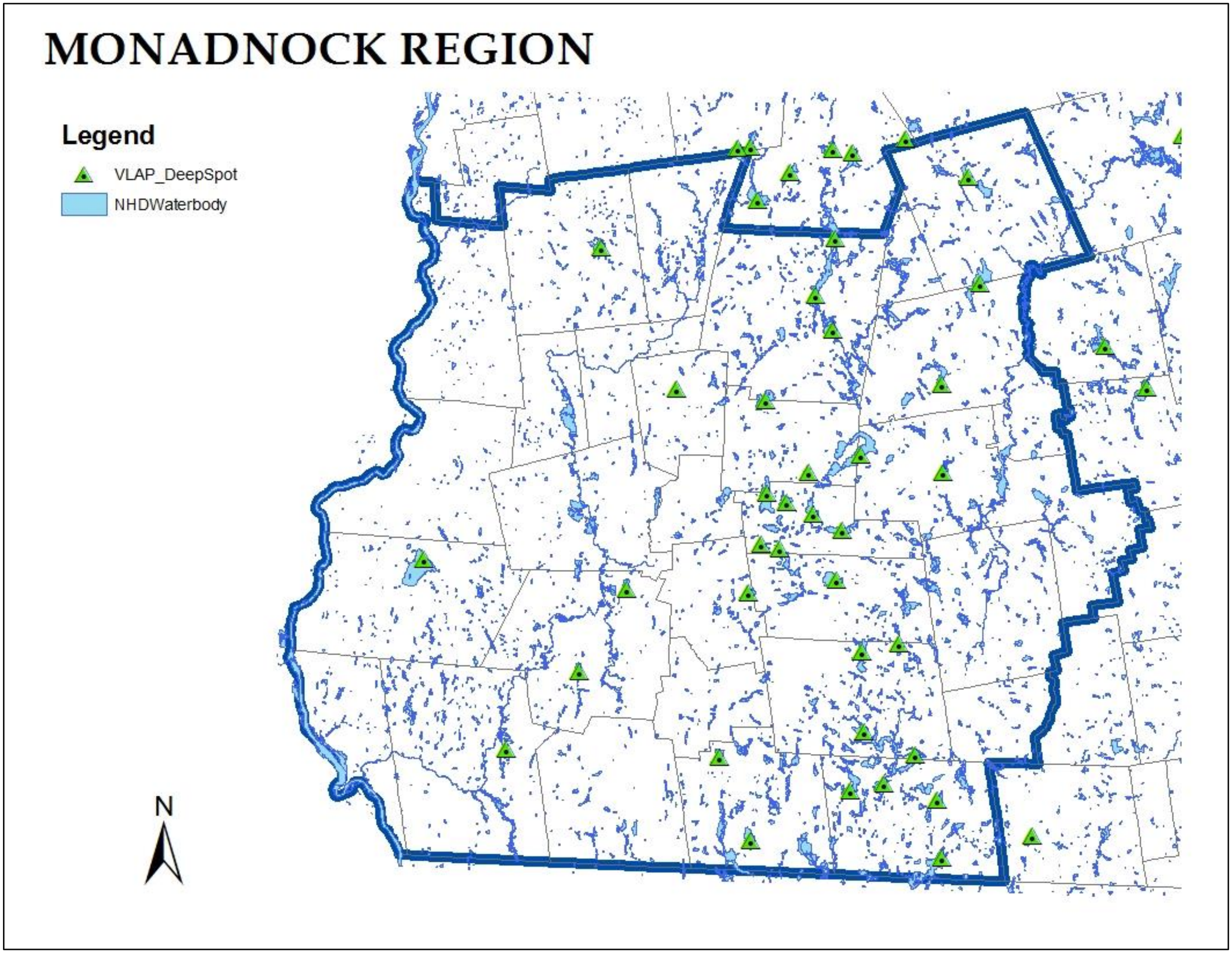
Similarly, a decline in water clarity alone can result in a decrease in New Hampshire lakefront property values. A one meter decrease in water clarity can lead to an average decrease in property values of between 0.9% and 6.0% in New Hampshire (Gibbs, Halstead, Boyle& Huang, 2002). This may negatively impact property tax revenues, especially in a state where there are approximately 64,000 vacation homes concentrated around the Lakes Region (lakes), Seacoast (ocean) and North Country (skiing) (Loder, 2011). According to a 1999 publication of the Society for the Protection of New Hampshire Forests, "The Economic Impact of Open

Space in New Hampshire," vacation homes contribute approximately $286 million to state and local tax revenues (note: open space includes lakes). For a town with a large number of lakefront homes (vacation or residential), a decline in water clarity can cause decreased property values and local tax revenue.

The Monadnock region encompasses the Level 8 Hydrologic Unit Code (HUC) Watersheds of the Connecticut River from Bellows Falls to Vernon Dam, Connecticut-Ashuelot River-Vernon Dam to Millers River, and the Contoocook River. The HUC boundary defines a specific drainage basin of a major river or series of smaller rivers. There are 18 HUC 8 watersheds in New Hampshire. There are seven VLAP regions (Figure 1). The Monadnock Region consists of 34 VLAP lakes as follows. Individual reports for each lake can be found in Appendix E.

Lake Name	**Town**
Warren Lake	Alstead
Gregg Lake	Antrim
Spofford Lake	Chesterfield
Dublin Lake	Dublin
Howe Reservoir	Dublin
Laurel Lake	Fitzwilliam
Rockwood Pond	Fitzwilliam
Norway Pond	Hancock
Chesham Pond	Harrisville
Childs Bog	Harrisville
Harrisville Pond	Harrisville
Russell Reservoir	Harrisville
Silver Lake	Harrisville
Skatutakee Lake	Harrisville
Contention Pond	Hillsborough
Franklin Pierce Lake (Jackman Reservoir)	Hillsborough
Contoocook Lake	Jaffrey
Frost Pond	Jaffrey
Gilmore Pond	Jaffrey
Thorndike Pond	Jaffrey
Stone Pond	Marlborough
Sand Pond	Marlow
Nubanusit Lake	Nelson
Emerson Pond	Rindge
Monomonac Lake	Rindge
Pearly Pond	Rindge
Pool Pond	Rindge
Granite Lake	Stoddard
Highland Lake	Stoddard
Island Pond	Stoddard
Chapman Pond	Sullivan
Swanzey Lake	Swanzey
Wilson Pond	Swanzey
Forest Lake	Winchester

Figure 2. Monadnock Region Lakes



LAND USE AND POPULATION GROWTH

According to the 2010 update of the Society for the Protection of New Hampshire Forests' publication "New Hampshire's Changing Landscape 2010," New Hampshire's population is expected to increase by 180,000 through 2030 (Figure 3). Almost 70 percent of that growth will occur in the Southeastern part of the state, particularly in Merrimack, Hillsborough and Rockingham counties.

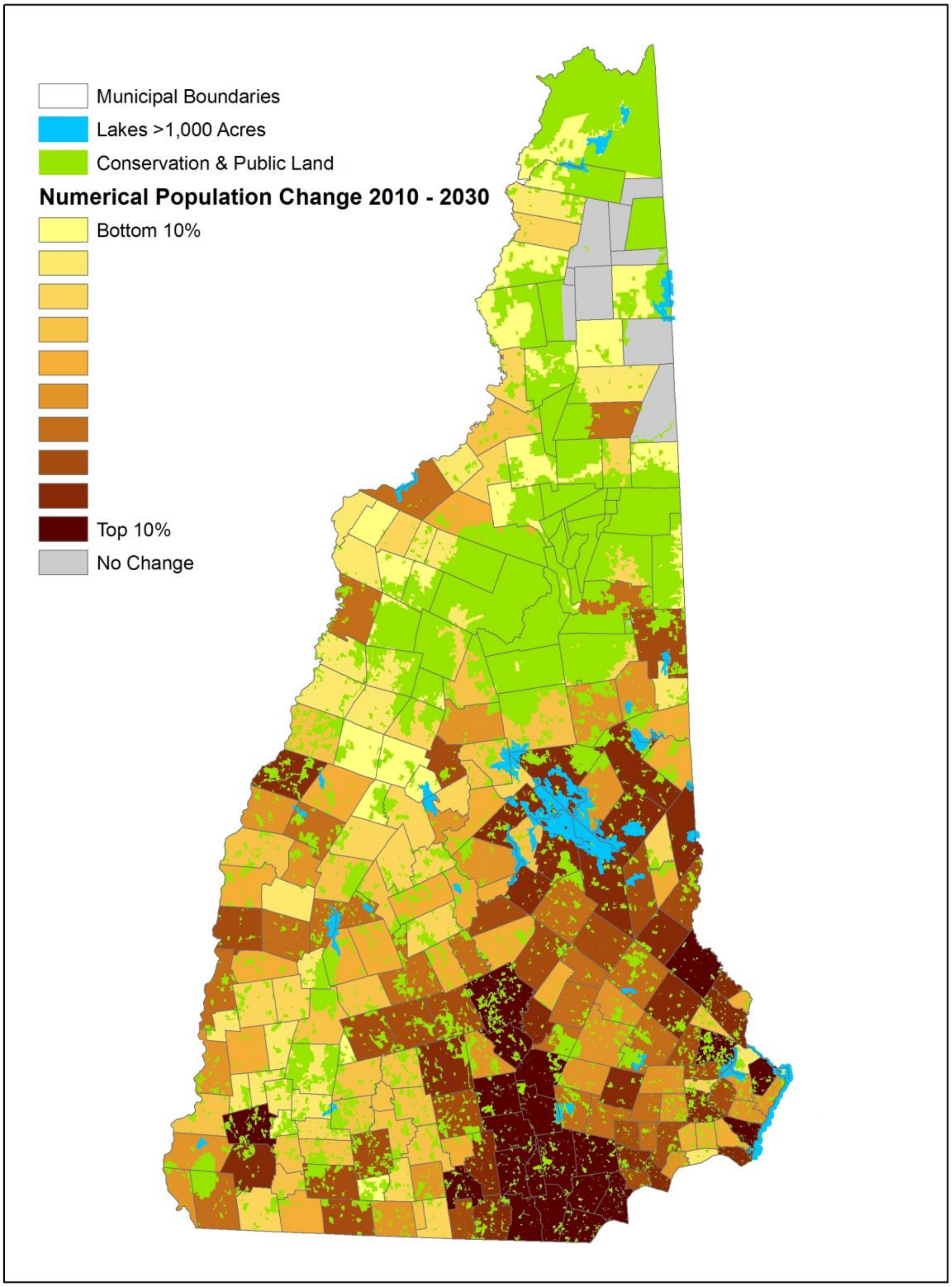
The population is anticipated to grow by approximately 9,000 people in Cheshire County and 50,000 people in Hillsborough County by 2030. The majority of growth is estimated to follow main road corridors and urbanizing areas and is anticipated to be greatest in the towns of Keene, Swanzey, Winchester, Rindge, Jaffrey, Peterborough and Hillsborough.

The Monadnock Region is home to approximately 20,000 acres of water (lakes, river, and wetlands). Eighty percent of this water is located in Cheshire County, and 20% is located in Hillsborough County. Over 5,000 acres of water occurs in the towns predicted to experience the heaviest population growth in these three counties, representing approximately 30% of the total waterbody acreage in the Monadnock region.

Major land use categories in the Monadnock region are forest, developed and agriculture. Population growth and land use change go hand-in-hand. Growing populations necessitate land clearing to accommodate new homes, housing complexes, roadways and commercial businesses. Developed land corresponds to more impervious surfaces such as roadways, driveways and rooftops. It also corresponds to the loss of tree canopy coverage, unstable sediments, wildlife habitat loss and vegetative buffer loss. Consequences of development can negatively affect our waterbodies through increases in stormwater runoff, water temperatures, erosion, turbidity and nutrients, as well as shifts in aquatic life, aquatic plant, algae and cyanobacteria growth.

Population growth in Monadnock region could impact its waterbodies. Efforts should be made to evaluate current land use activities, infrastructure and regional water quality. This information should facilitate a plan to accommodate projected population growth while conserving and protecting valuable land and water resources.

Figure 3. NH Population Growth per Town 2010-2030



EXOTIC SPECIES

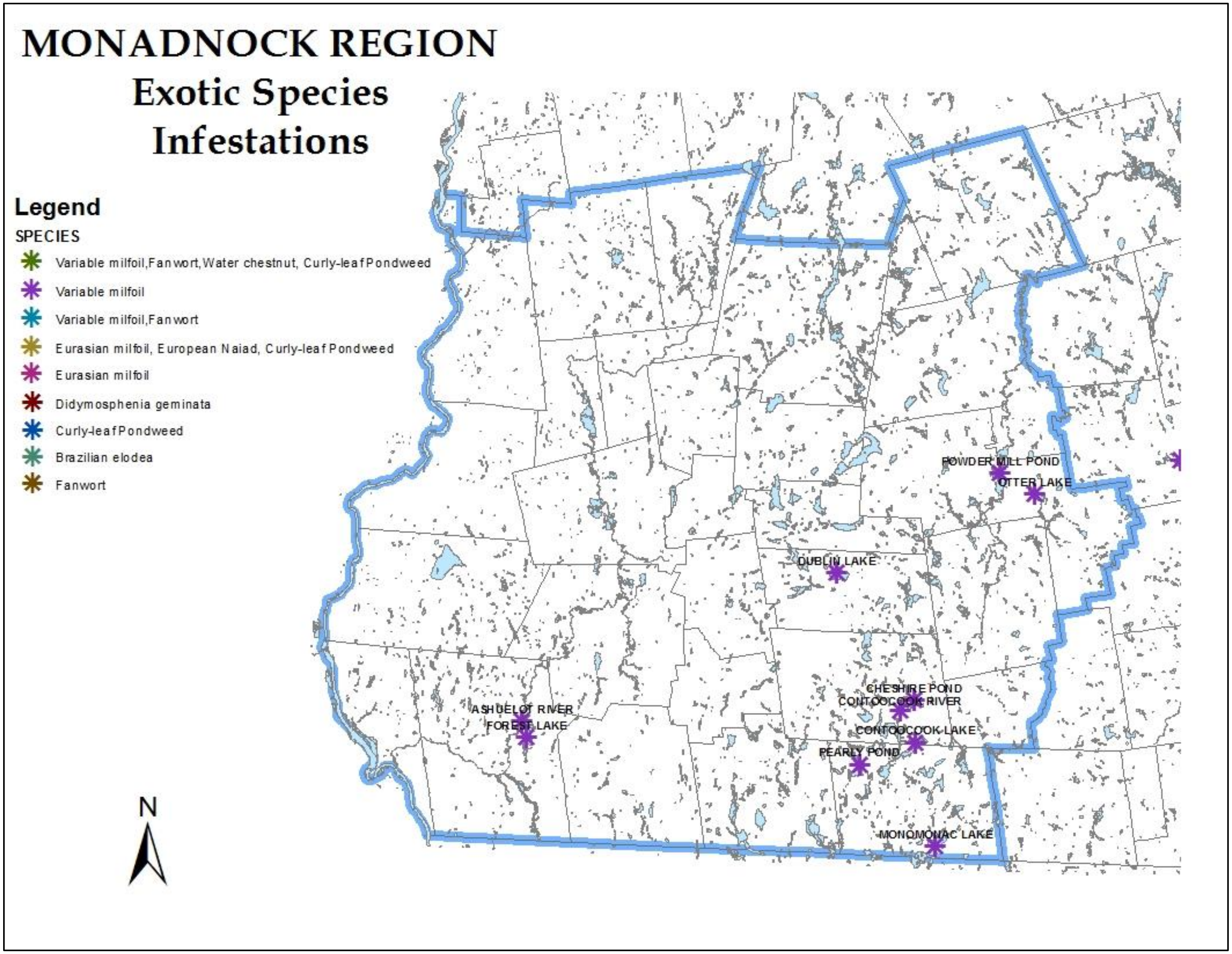
Exotic aquatic nuisance species are those plants and animals not native to New Hampshire's waterbodies, spread quickly through the aquatic environment, negatively affect economic and recreational activities, and can have a detrimental influence on natural habitats, the ecology of the system, and native species. They are a serious threat to the health of New Hampshire's aquatic ecosystems, recreation and tourism industries.

New Hampshire has 106 exotic plant infestations in 85 waterbodies. Those include Variable milfoil, Eurasian milfoil, Brazilian Elodea, Water chestnut, Curly-leaf Pondweed, Fanwort, European Naiad and *Didymo* (Rock Snot). Variable milfoil inhabits the majority of infested waterbodies, and *Didymo*, an invasive alga, has now infested 54 river miles in the North Country. Currently, ten waterbodies in the Monadnock Region are infested with an exotic species (Figure 4). A new infestation of Variable milfoil was discovered at Otter Lake in Greenfield in 2012. The Ashuelot River and Contoocook River have Variable milfoil infestations along with Cheshire Pond, Contoocook Lake, Forest Lake, Monomonac Lake, Pearly Pond and Powder Mill Pond. The Connecticut River is infested with Eurasian milfoil, European naiad and Curly-leaf pondweed. Dublin Lake did support a small infestation of variable milfoil, but due to good early detection and rapid response actions it is invasive species free now.

The unique nature and invasive tendencies of these exotic species heighten the need to prevent new infestations, manage current infestations and engage watershed residents. Public education is integral in preventing further infestations. One program that educates the public and engages watershed residents is the NHDES Weed Watchers Program. The Weed Watchers program has approximately 750 volunteers dedicated to monitoring lakes and ponds for the presence of exotic aquatic plants. Volunteers are trained to survey their lake or pond once a month from May through September. To survey, volunteers slowly boat, or sometimes snorkel, around the perimeter of the waterbody and its islands looking for suspicious aquatic plant species. If a suspicious plant is found, the volunteers send a specimen to NHDES for identification, either in the form of a live specimen, or as a photograph emailed to the Exotic Species Program Coordinator. Upon positive identification, a biologist visits the site to determine the extent of infestation, initiates a rapid response management technique where possible, and formulates a long-term management plan to control the nuisance infestation.

Another program dedicated to public education and engaging watershed residents regarding exotic plant species is the Lake Host™ program, which was developed in 2002 by the non-profit organization New Hampshire Lake Association (NHLA, a.k.a. NH LAKES) and NHDES. The Lake Host™ Program is funded through NHDES and federal grants and provides courtesy boat inspections at boat ramps to prevent invasive species introduction and spread. Since the program was implemented, the number of participating waterbodies, volunteers and number of "saves" (exotic plants discovered) has consistently increased. The program is invaluable in educating boaters, preventing recreational hazards, avoiding property value and aquatic ecosystem decline, addressing aesthetic issues, and saving costly remediation efforts.

Figure 4. Monadnock Region Exotic Aquatic Plant Infestations



GEOMORPHOLOGY AND CLIMATE

Chemical, physical and biological properties of lakes often reflect how they were formed. Lake formation can occur in a variety of ways. In New Hampshire, most lakes were formed during the last ice age as glaciers retreated approximately 12,000 years ago. Lakes are also formed from rivers (oxbow), and are man- and animal-made (e.g., impoundments, dams and beavers). These formations create distinct lake morphology. Included in a lake's morphology are length, width, area, volume, and shape. Lake morphology affects the lake's overall ability to adapt to shifts in climate and land use.

Along with the morphological characteristics of lakes, the bedrock and sediment geology is also important in understanding lake properties. Underlying geological properties can affect the pH and ANC of our surface and groundwater. New Hampshire is typically referred to as the "Granite State" because the bedrock geology consists of variations of igneous rock high in granite content that contributes to a lower capacity to buffer acidic inputs such as acid rain. Metamorphic rocks make up the remainder of bedrock geology and consist of slate, schist, quartzite and carbonate rocks which tend to contribute to a more neutral pH and better buffering capacity.

Climate also drives multiple processes in lake systems. Lakes respond to shifting weather conditions such as sunlight, rainfall, air temperature and wind and wave action in various ways. This variability is reflected in the types and number of biological communities present, and chemical and physical properties of the lake system. It is essential that we understand how these factors influence water quality data collected at individual lake systems. Therefore, volunteers record pertinent weather data, rain and storm event totals, on field data sheets while sampling.

To summarize the Monadnock region climate conditions in 2013, the sampling season experienced slightly warmer air temperatures and above average rainfall based on air and precipitation data recorded in Keene, New Hampshire (Table 1). Average air temperatures in May, June and July were warmer than historical averages, while August was much cooler and September was average. Overall, the 2013 average summer air temperature was 0.7 degrees warmer than the historical average. Surface water temperatures were well above historical averages in June and July and below average in August making the 2013 summer average surface water temperature 1.8 degrees above the historical average. The 2013 monthly rainfall amounts were well above historical averages from May through July and September, and even slightly above average in August resulting in the annual average summer precipitation being 2.03 inches greater than the historical average.

In contrast, the 2014 sampling season was cooler and slightly drier. Average air temperatures in May, June and August were below the historical averages, and July and September saw average air temperatures resulting in the seasonal average being 0.4 degrees cooler than the historical average. Surface water temperatures were slightly above historical averages from June through August making the 2014 summer average surface water temperature 1.0 degree warmer than the historical average. This marks the fifth year in a row where summer average surface temperatures were warmer than the historical average. The 2014 monthly rainfall amounts were above historical averages May through August and well below average in September making the annual summer average precipitation only 0.37 inches greater than the historical average. June and July experienced rainfall amounts that were greater than 1.0 inch above average only to be offset by the drastically dry September which was 2.03 inches below average.

Table 1. Current Year and Historical Average Temperature and Precipitation Data for Monadnock Region

	May	June	July	August	September	Summer
2013 Average Air Temperature (°F)	56.8	65.3	73.9	66.7	59.9	64.5
2014 Average Air Temperature (°F)	55.4	64.6	70.0	65.8	61.0	63.4
Annual Average Air Temperature (°F)	56.0	65.0	70.0	68.0	60.0	63.8
2013 Average Surface Water Temperature (°F)	-------	72.2	79.1	73.3	--------	74.9
2014 Average Surface Water Temperature (°F)	-------	72.0	75.7	74.7	--------	74.1
Annual Average Surface Water Temperature (˚F)		70.1	75.1	74.2		73.1
2013 Precipitation (in.)	5.12	7.28	6.87	3.96	6.69	5.98
2014 Precipitation (in.)	4.53	5.06	6.04	4.21	1.78	4.32
Annual Average Precipitation (in.)	3.93	3.90	4.29	3.81	3.81	3.95

Monitoring and Assessment

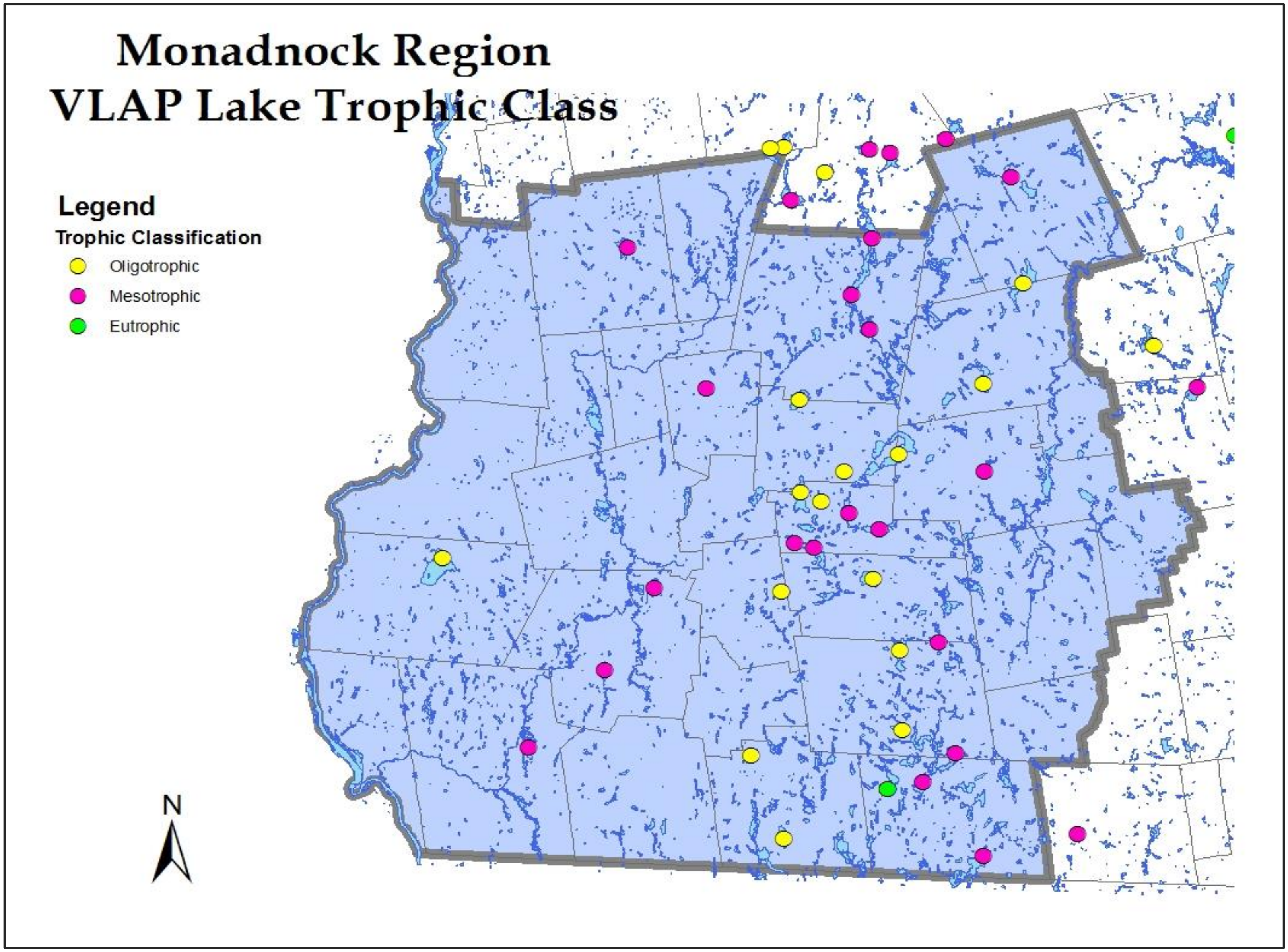
New Hampshire considers a public water to be great ponds or artificial impoundments greater than 10 acres in size, rivers, streams and tidal waters. The Monadnock region consists of 156 lakes, or great ponds, and 34 of those lakes participate in VLAP. These data are critical for informing the local public of lake conditions, but also in making formal national water quality assessments reported to EPA. Data on the remaining 80% of lakes are sparse, being only occasionally sampled through the NHDES Lake Trophic Survey Program.

The NHDES Lake Trophic Survey Program monitors New Hampshire's lakes on a rotating basis, with the goal of conducting a comprehensive lake survey every 10 to 15 years. The surveys compile chemical, biological and morphological data. The data are used to assign a lake trophic class to each waterbody. The trophic class provides an assessment on lake productivity and can provide information on how population growth and human activities may be accelerating the lake aging process, also known as lake eutrophication.

Three trophic classes are used to assess a lake's overall health: oligotrophic, mesotrophic and eutrophic. Oligotrophic lakes have high dissolved oxygen levels (> 5 mg/L), high transparency (> 12 ft. or 3.65 m), low chlorophyll-*a* concentrations (< 4 mg/L), low phosphorus concentrations (< 10 ug/L), and sparse aquatic plant growth. Eutrophic lakes have low levels of dissolved oxygen (< 2 mg/L), low transparency (< 6 ft. or 1.8 m), high chlorophyll-a concentrations (> 15 mg/L), high phosphorus concentrations (> 20 ug/L), and abundant aquatic plant growth. Mesotrophic lakes have characteristics that fall in between those of oligotrophic and eutrophic lakes for the parameters listed.

The trophic class breakdown of Monadnock region lakes is as follows: 32 lakes are oligotrophic, 55 mesotrophic, 31 eutrophic, and 38 are un-assessed for trophic classification due to lack of data. Fourteen oligotrophic, 19 mesotrophic, and one eutrophic lake participate in VLAP (Figure 5). Approximately 55 percent of the Monadnock lakes are classified as oligotrophic and mesotrophic; however, over half of those lakes do not participate in VLAP or a similar monitoring program. As human activities in watersheds accelerate lake aging, it is imperative to keep a close eye on the health of those lakes. Efforts should also be made to gather data on the un-assessed waterbodies. Protecting a lake and preventing lake aging is much more cost-effective than restoring a damaged lake.

Figure 5. Monadnock Region VLAP Lake Trophic Class



VLAP Water Quality Data Interpretation

The Monadnock Region is home to 32 lakes and ponds that participate in VLAP. Volunteer monitors at each lake collect comprehensive data sets at the deepest spot of the lake and from streams entering or exiting the lake. Deep spot sample collection is representative of overall lake quality and is used to establish long-term water quality trends and to provide information into the overall health of the waterbody. Stream sample collection is representative of what flows into the lake from the surrounding watershed. Stream data are used to identify potential watershed pollution problems, such as stormwater inputs, so that remediation actions occur before they negatively impact the overall health of the waterbody.

The following section provides a summary of the VLAP monitoring parameters, long-term water quality trends, and an analysis of the current year and historical data for the VLAP lakes and ponds in the Monadnock region compared with regional and state medians. The deep spot data for the epilimnion, or surface water layer, is compared to the New Hampshire median to provide an understanding of how the quality of a lake deep spot compares to other New Hampshire lake deep spots. Similarly, the epilimnion data are compared to the regional median to provide an understanding of how the quality of your lake deep spot compares with other local lakes. Median values were utilized to represent historical state and regional conditions as the value tends to better represent ‘typical’ conditions while minimizing the effects of ‘extreme’ (i.e., outlier) values. Average annual lake and regional values are then compared to the historical medians.

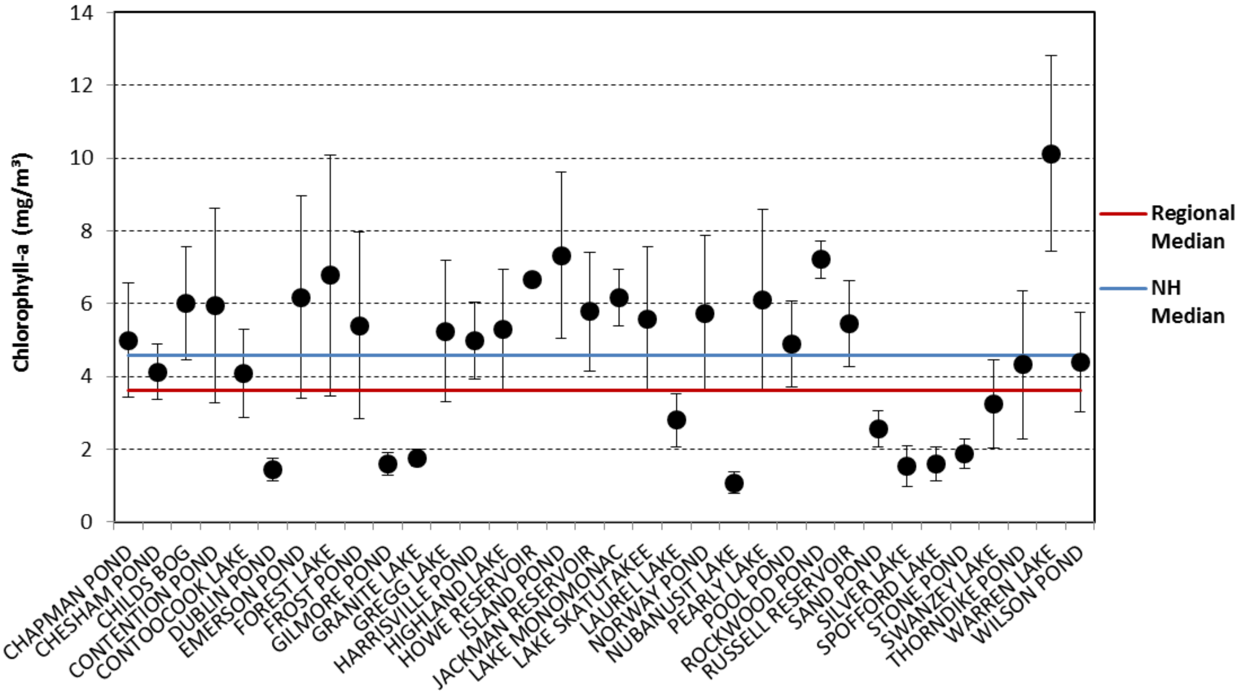
A complete list of monitoring parameters and how to interpret data are included in Appendix A.

Annual and Historical Chlorophyll-*a* Data Analysis

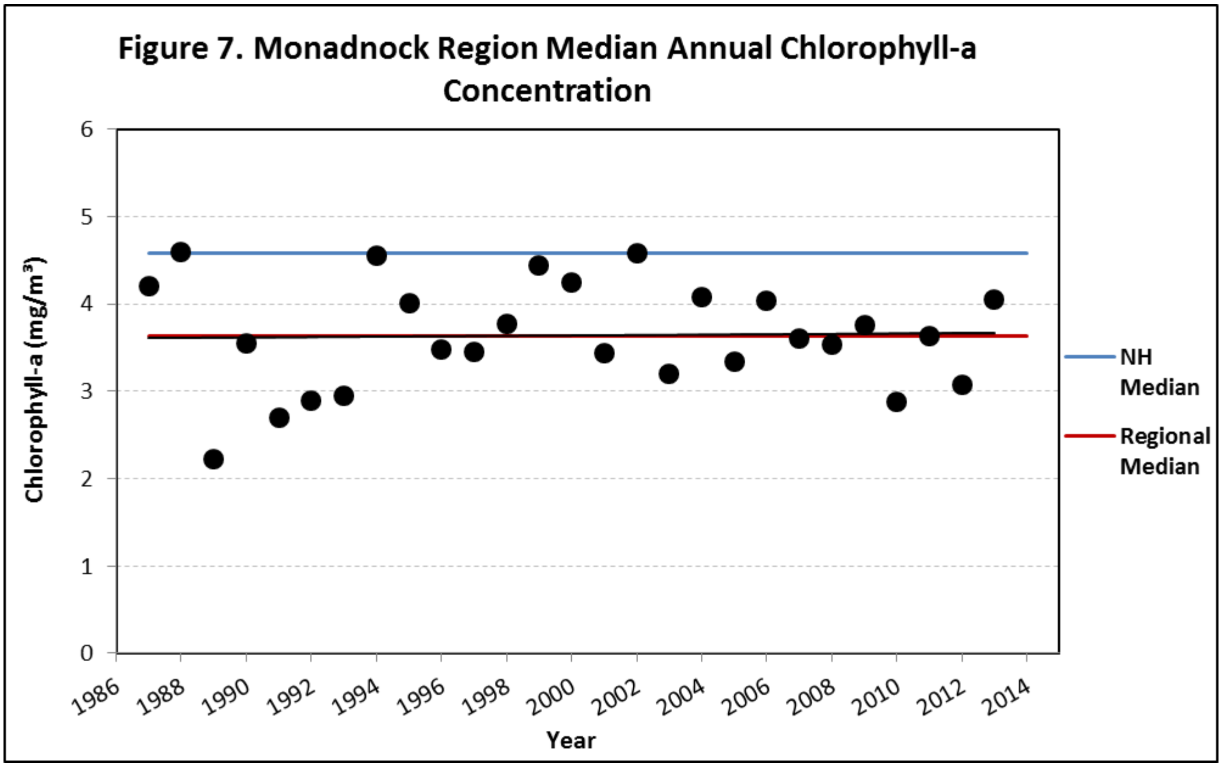
Algae are microscopic plants that are naturally found in the lake ecosystem. Algae, including cyanobacteria, contain chlorophyll-*a*, a pigment used for photosynthesis. The measurement of chlorophyll-*a* in the water gives biologists an estimation of the algal abundance or lake productivity. **The median summer chlorophyll-*a* concentration for New Hampshire's lakes and ponds is 4.58 mg/m3. The median chlorophyll-*a* concentration for the Monadnock region is 3.63 mg/m^3.**

Figure 6 represents the combined 2013 and 2014 average chlorophyll-*a* concentrations for each lake in the Monadnock Region compared with state and regional medians. The average chlorophyll-*a* concentration at 10 lakes is less than the regional median and typically representative of good water quality. Four lakes have average chlorophyll-*a* concentrations between the state and regional medians, and twenty lakes have average chlorophyll-*a* concentrations greater than the state median. Typically, chlorophyll-*a* concentrations that exceed 5.0 mg/m^3 are considered higher than desirable, and this occurred at 17 lakes and is typically representative of eutrophic classification. The remaining lakes, approximately 50%, had chlorophyll-*a* concentrations representative of oligotrophic and mesotrophic classifications.

Figure 6. Average Chlorophyll-a Concentration for Monadnock Region Lakes



The median annual chlorophyll-*a* concentrations for the Monadnock region are represented in Figure 7. Median chlorophyll-*a* concentrations have generally remained between 3.0 and 5.0 mg/m^3 since 1987 and are representative of oligotrophic/mesotrophic conditions, despite the large number of individual lakes with higher than desirable chlorophyll concentrations (Figure 6).



Chlorophyll-*a* Trend Analysis

The regional median chlorophyll-*a* concentration was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A stable trend was detected for the Monadnock Region which is consistent with the majority of state regions (Appendix D: Table D-1).

In addition to the regional trend analysis, Monadnock Region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing or stable over time. Chlorophyll-*a* trends were assessed for approximately 26 deep spots at 25 lakes in the region representing approximately 80% of the Monadnock region VLAP lakes. Table 2 displays lakes that experienced significant chlorophyll-*a* trends. Refer to Appendix D: Table D-5 for the complete list of trend analyses for each individual lake. Chlorophyll-*a* concentrations have significantly decreased (improved) at five deep spots, significantly increased (worsened) at one deep spot, and remained stable at 20 lake deep spots. The stable and improving trends are a positive sign as chlorophyll-*a* concentrations are typically related to phosphorus concentrations. Phosphorus is a nutrient that promotes plant and algal growth in New Hampshire lakes. As phosphorus levels increase in lakes, it will normally cause an increase in algal growth.

Table 2. Significant Chlorophyll-a Trends in Monadnock Region Lakes

Lake Name	Chlorophyll--a	
	Increasing Trend	Decreasing Trend
	p	p
Contoocook Lake		< 0.01
Harrisville Pond		< 0.01
Laurel Lake		< 0.01
Nubanusit Lake		0.01
Pearly Pond		< 0.01
Rockwood Pond	0.02	

Annual and Historical Transparency Data Analysis

Volunteer monitors use the Secchi disk, a 20 cm disk with alternating black and white quadrants, to measure how far a person can see into the water. Transparency, a measure of water clarity, can be affected by algae and sediment in the water, as well as the natural color of the water. Transparency may also be measured using a viewscope, a cylindrical tube, designed to decrease surface water properties that may cause difficulty in viewing the Secchi disk. A comparison of transparency readings collected with and without the use of a viewscope shows that the viewscope typically increases the depth to which the Secchi disk can be seen into the lake, particularly on sunny and windy days. **The median summer transparency for New Hampshire's lakes and ponds is 3.20 meters. The median transparency for the Monadnock region is 3.77 meters.**

Figure 8 represents the combined 2013 and 2014 average transparency for each lake in the Monadnock region compared with state and regional medians. The average transparencies at 16 lakes are less than both the state and regional medians and are typically representative of mesotrophic/eutrophic conditions. Four lakes' transparencies fall in between the state and regional medians and 14 lake transparencies are greater than the regional and state medians, and are typically representative of Oligotrophic/Mesotrophic conditions. It is important to note that data from Nubanusit Lake are collected using only a viewscope which tends to increase transparency depths. Overall lake depth plays an important role when interpreting transparency data. Shallow lakes will typically report lower transparencies than deeper lakes, yet these waterbodies may be quite clear. A better representation would be to look at how transparency changes over time.

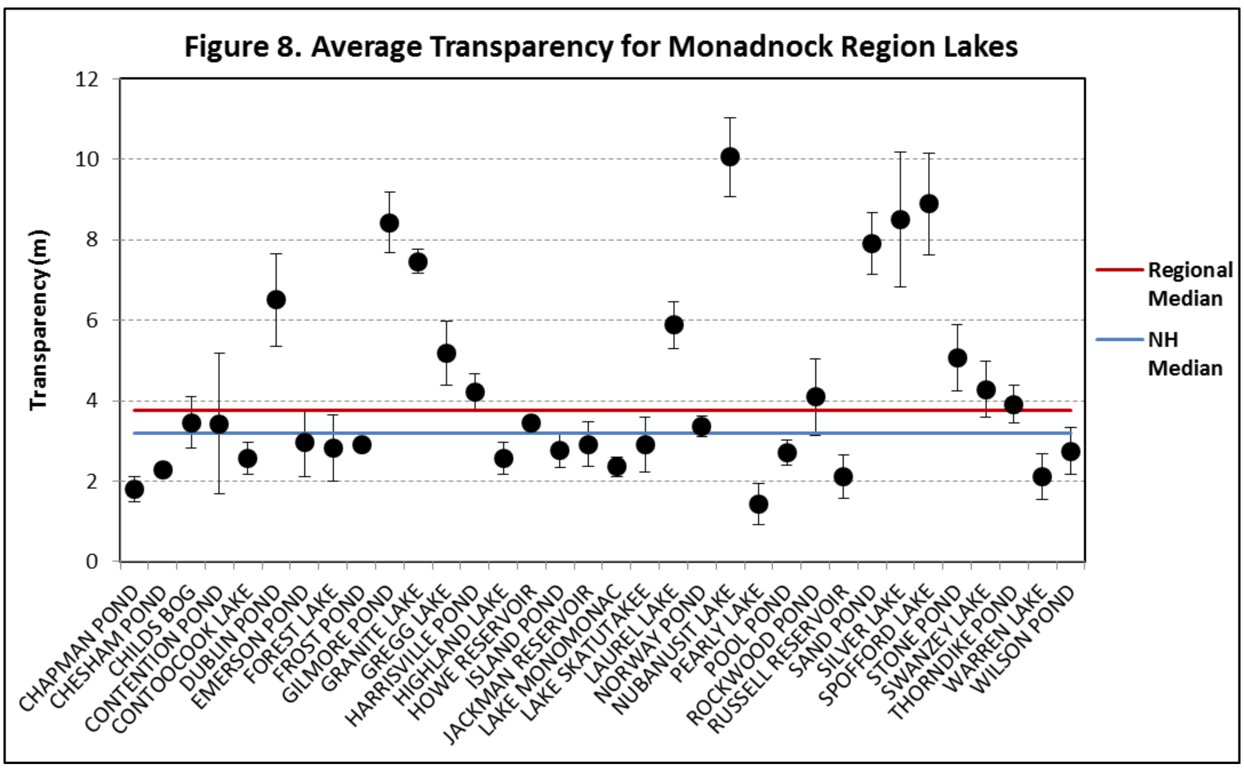
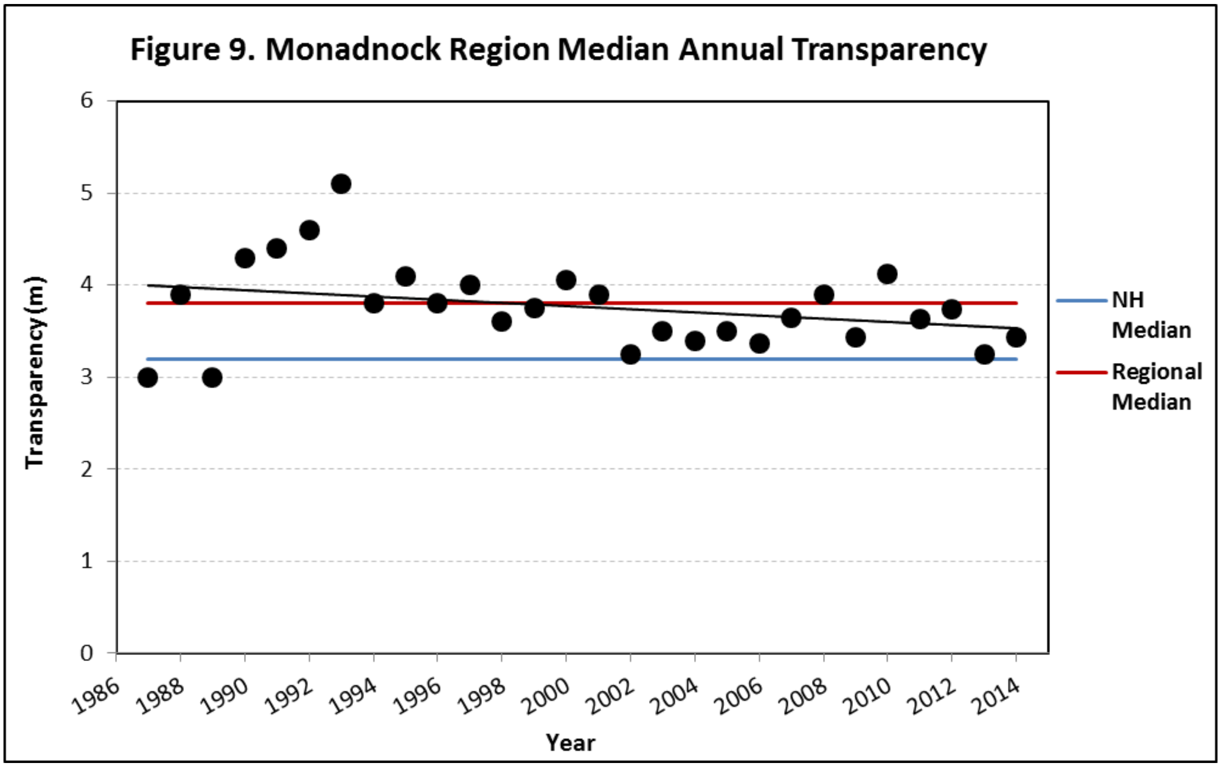


Figure 9 represents the median annual transparency for the Monadnock region. Median transparencies for the region were generally between 3.5 and 5.0 meters between 1987 and 2001. Since then, median transparencies have decreased to between 3.0 and 4.0 meters. It is unclear what has caused the decreased transparency.



Transparency Trend Analyses

The regional median transparency was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly decreasing (worsening) trend was detected for the Monadnock Region which is consistent with all other state regions except for the Lakes Region (Appendix D: Table D-1).

In addition to the regional trend analysis, Monadnock Region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing, or stable over time. Transparency trends were assessed for approximately 26 deep spots at 25 lakes in the region representing approximately 80% of the region's VLAP lakes (Appendix D: Table D-5). Trend analysis revealed five lake deep spots with decreasing (worsening) transparency, and 21 lake deep spots with relatively stable transparency trends (Table 3; Appendix D: Table D-5). The majority of regional lakes have stable lake transparency trends however the region as a whole has experienced a decline in lake transparency (Appendix D: Table D-1; Figure 9).

Transparency, or water clarity, is typically affected by the amount of algae, color and particulate matter within the water column. The stable transparency trends for the region are a positive sign; however transparency at 20% of the lake deep spots is degrading, or getting worse. This cannot be explained by an increase in algal growth (Appendix D: Table D-1). This suggests that the worsening transparency may be explained by an increase in suspended sediments or water color becoming darker. The increased frequency and intensity of storm events has resulted in an increase in stormwater runoff as well as increased flushing of wetland systems. Stormwater runoff can transport exposed and unstable sediments and other debris to lake systems, thus resulting in decreased transparency. Wetland systems are rich in organic acids that add color to the water, making it appear dark. Lake watersheds with extensive wetland systems may experience decreased transparency due to the influx of dark water during storm events. Transparency impacts due to wetland flushing is a natural occurrence, however erosion due to stormwater runoff can be mitigated to reduce sediments and particulate entering lake systems.

Refer to Appendix B for more information on how to manage stormwater runoff.

Table 3. Significant Transparency Trends in Monadnock Region Lakes

Lake Name	Transparency
	Decreasing Trend
	p
Laurel Lake	0.05
Lake Monomonac	0.01
Pool Pond	0.01
Spofford Lake	0.03
Warren Lake	0.01

Annual and Historical Total Phosphorus Data Analysis

Phosphorus is typically the limiting nutrient for vascular plant and algal growth in New Hampshire's lakes and ponds. Excessive phosphorus in a pond can lead to increased plant and algal growth over time. **The median summer epilimnetic (upper layer) total phosphorus concentration of New Hampshire's lakes and ponds is 12 ug/L. The median epilimnetic total phosphorus concentration of the Monadnock Region is 8 ug/L.**

Figure 10 represents the combined 2013 and 2014 average epilimnetic total phosphorus concentration for Monadnock region lakes compared with regional and state medians. The regional median is considerably lower than the state median, and is considered to be representative of oligotrophic conditions. Sixteen lakes have average phosphorus concentrations less than the regional and are representative of oligotrophic conditions. Thirteen lakes have average phosphorus concentrations between the regional and state median and are representative of mesotrophic conditions. While only five lakes experienced average phosphorus concentrations greater than the state median and representative of eutrophic conditions. Pearly Pond in Rindge has historically experienced large amounts of internal and external phosphorus loading resulting in a eutrophic classification. However, due to management activities in the watershed, phosphorus concentrations have decreased in recent years. Overall, regional epilimnetic phosphorus concentrations are relatively low and representative of oligotrophic and mesotrophic conditions.

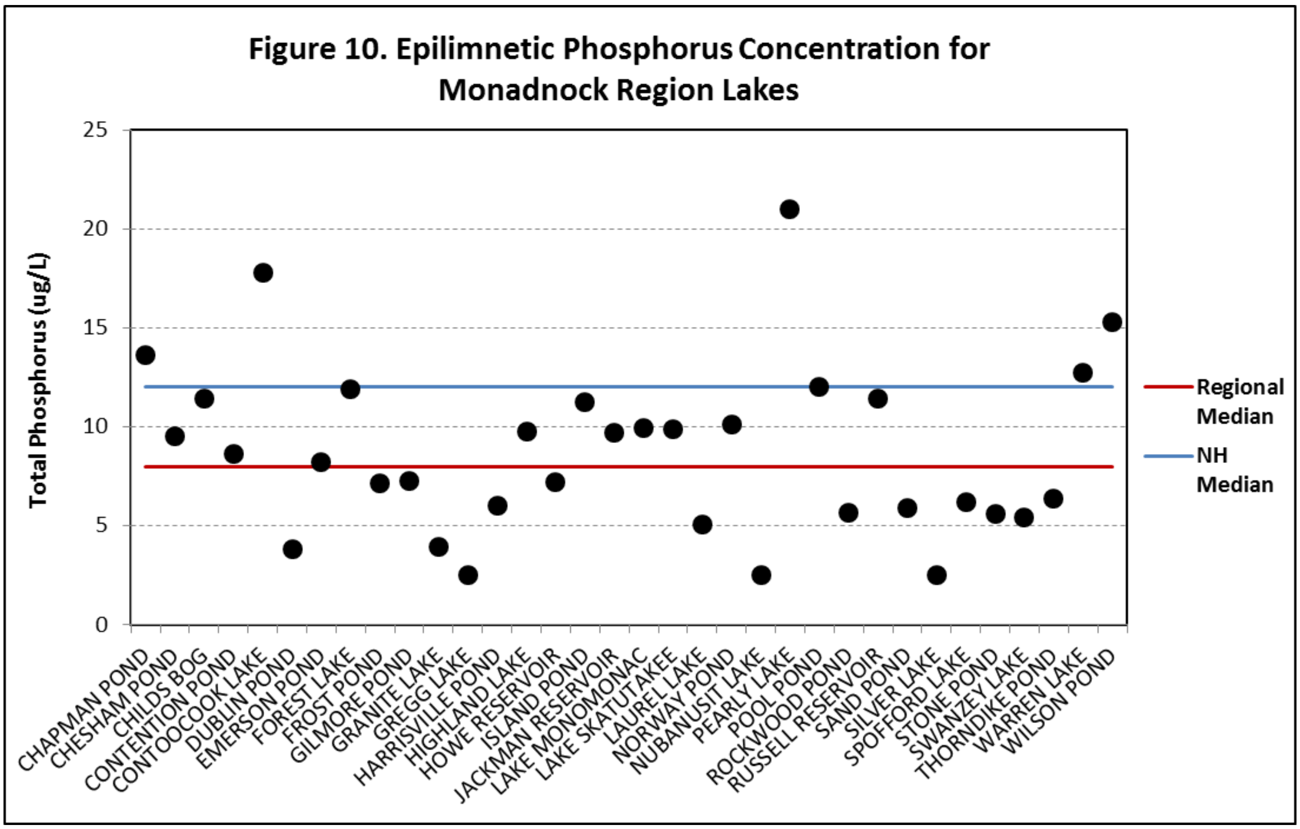
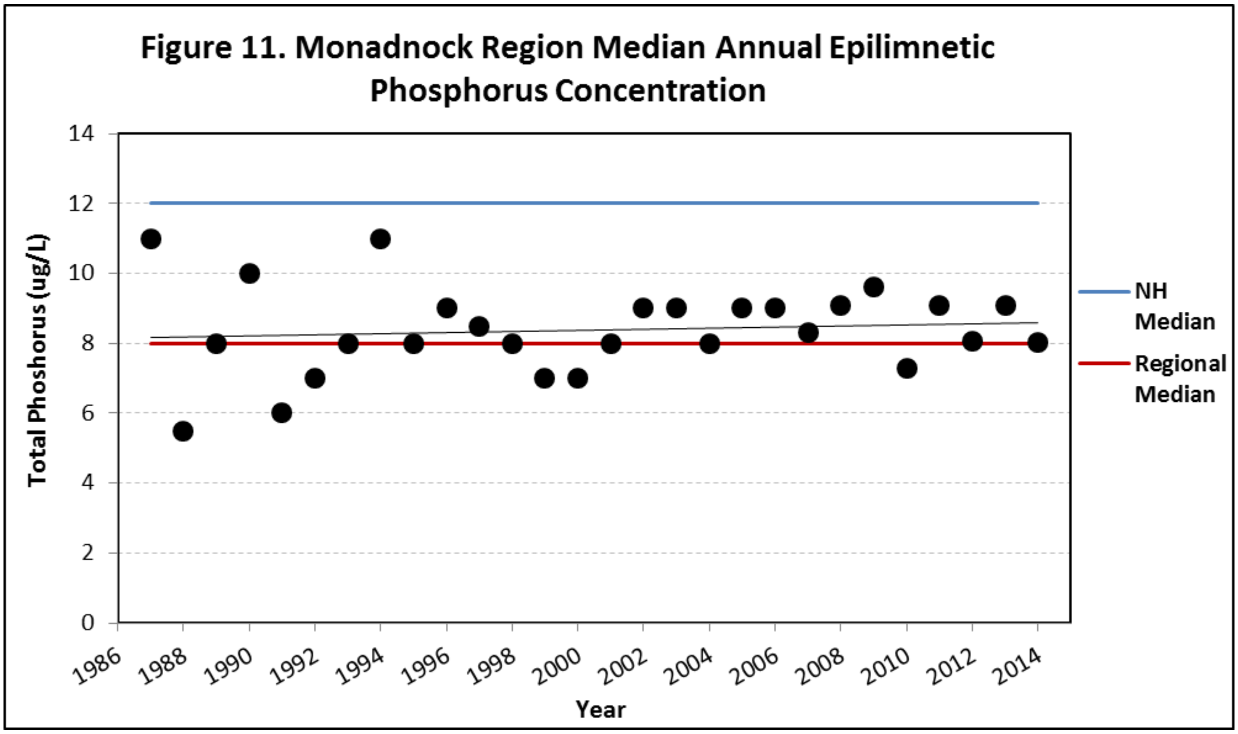


Figure 11 represents the median annual epilimnetic phosphorus concentration for the Monadnock region. Median epilimnetic phosphorus concentrations fluctuated widely between 1987 and 1994, since then median concentrations have generally remained between 6 ug/L and 10 ug/L and are representative of oligotrophic/mesotrophic conditions.



Epilimnetic Phosphorus Trend Analyses

The regional median epilimnetic phosphorus concentration was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A stable trend was detected for the Monadnock Region (Figure 11; Appendix D: Table D-1) which was consistent with the majority of state regions.

In addition to the regional trend analysis, Monadnock Region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing, or stable over time. Epilimnetic phosphorus trends were assessed for approximately 26 deep spots at 25 lakes in the region representing approximately 80% of the region's VLAP lakes (Appendix D: Table D-5). Trend analysis revealed four lake deep spots with significantly decreasing (improving) phosphorus concentrations, while 22 lake deep spots experienced stable epilimnetic phosphorus trends (Table 4; Appendix D: Table D-5). No lake deep spots experienced significant increases in epilimnetic phosphorus which is a great sign.

Increasing epilimnetic phosphorus trends are often a result of phosphorus-enriched stormwater runoff related to increased watershed development. An increase in watershed development often results in an increase in impervious surfaces and unstable sediments. This contributes to an increase in stormwater runoff and sedimentation to rivers and lakes. Efforts should be made to adopt watershed ordinances to limit stormwater runoff and other phosphorus contributions. Watershed residents should be educated on utilizing and installing best management practices to control stormwater runoff from their own properties.

For more information and resources to control phosphorus loading refer to Appendix B.

Table 4. Significant Epilimnetic Total Phosphorus Trends in Monadnock Region lakes

Lake Name	Total Phosphorus (Epilimnion)
	Decreasing Trend
	p
Highland Lake, North	0.05
Highland Lake, South	0.03
Island Pond	< 0.01
Skatutakee Lake	0.03

Dissolved Oxygen Data Analysis

The presence of dissolved oxygen is vital to bottom-dwelling organisms as well as fish and amphibians. If the concentration of dissolved oxygen is low, typically less than 5 mg/L, species intolerant (i.e., sensitive) to this situation, such as trout, will be forced to migrate closer to the surface where there is more dissolved oxygen but the water is generally warmer, and the species may not survive. Temperature and time of day also play a role in the amount of dissolved oxygen in the water column. Water can hold more oxygen at colder temperatures than at warmer temperatures. Therefore, a lake will typically have a higher concentration of dissolved oxygen during the winter, spring, and fall than during the summer. Oxygen concentrations are typically lower overnight than during the day. Plants and algae respire (use oxygen) at night and photosynthesize (produce oxygen) during the day. Dissolved oxygen levels may shift depending on the abundance of aquatic plants and algae in the littoral (near shore) and pelagic (deep water) zones.

Dissolved oxygen and temperature profiles are collected at VLAP lakes on an annual or bi-annual basis. The average dissolved oxygen levels for the Monadnock region is 6.80 mg/L, which is sufficient to support a wide range of aquatic life.

For additional information regarding dissolved oxygen, please refer to Appendix A.

Annual and Historical Deep Spot pH Data Analysis

pH is measured on a logarithmic scale of 0 (acidic) to 14 (basic). pH is important to the survival and reproduction of fish and other aquatic life. A pH below 6.0 typically limits the growth and reproduction of fish. A waterbody is considered impaired for aquatic life when the pH falls below 6.5 or above 8.0. **The median epilimnetic pH for New Hampshire's lakes is 6.60, which indicates that the state surface waters are slightly acidic. The median epilimnetic pH for the Monadnock region is 6.37.**

Figure 12 represents the combined 2013 and 2014 average epilimnetic pH for Monadnock region lakes compared with regional and state medians. The regional median is slightly lower, or more acidic, than the state median and slightly less than the desirable range to support aquatic life. Sixteen lakes have epilimnetic pH values less than the regional median, and in particular, four lakes' pH values are below 6.00, which is considered limiting for certain aquatic organisms. Twelve lakes have pH values between the regional and state median, and six lakes have pH values greater than the state median and within the desirable range 6.5 – 8.0 units. The lowest, most acidic, epilimnetic pH value was 5.64 measured at Chapman Pond in Sullivan whereas; the highest, most basic, pH value was 7.01 measured at Spofford Lake in Chesterfield.

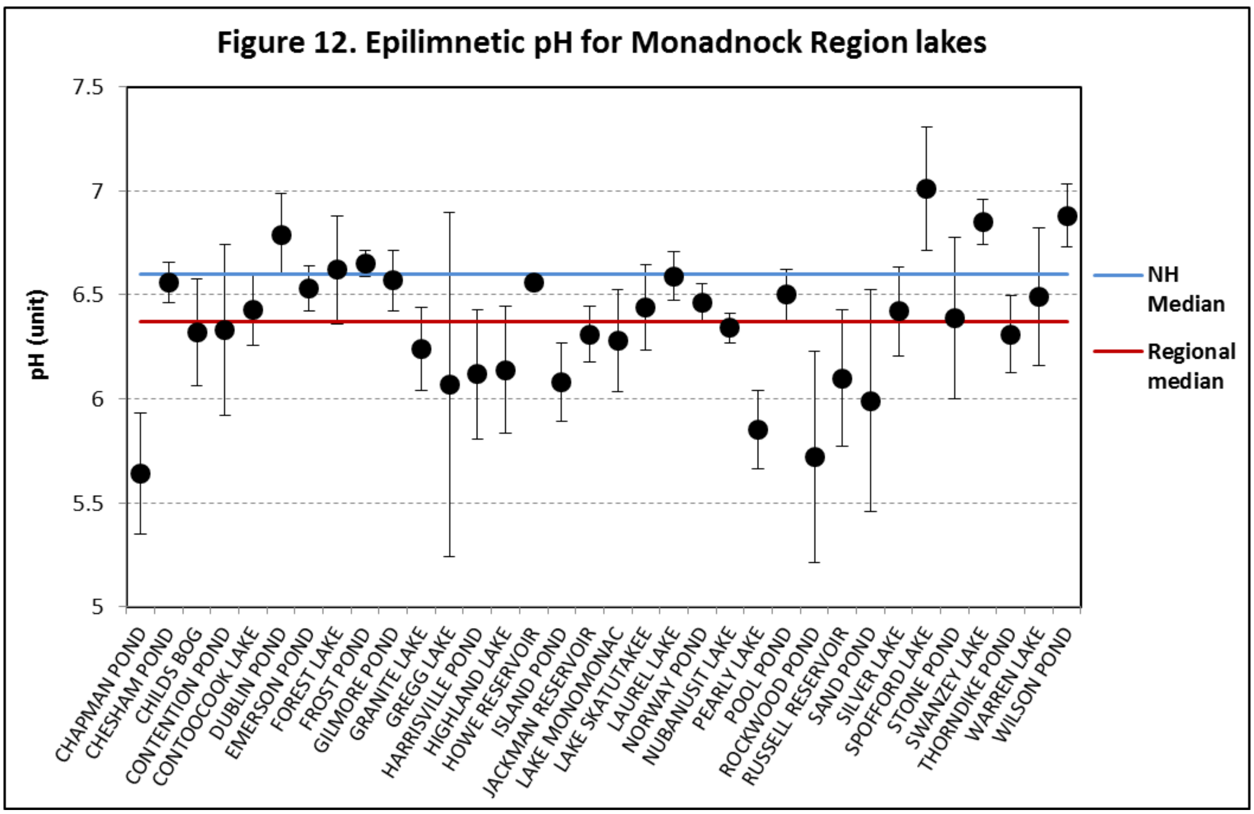
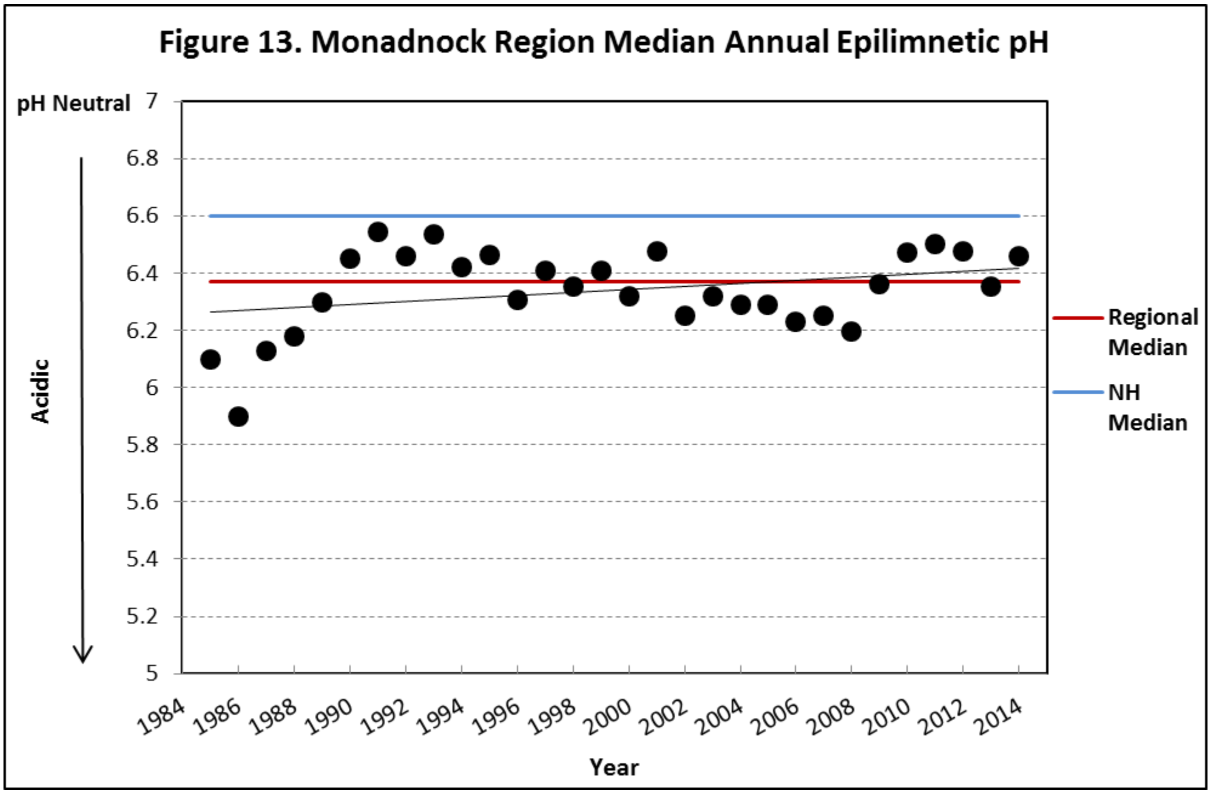


Figure 13 represents the median annual epilimnetic pH value for the Monadnock region compared with the regional and state medians. The median epilimnetic pH has generally remained between 6.20 and 6.60 since 1990. The median epilimnetic pH appeared to decrease from 1990 through 2009 but has rebounded in the past few years and is much improved from the 1980s.



pH Trend Analysis

The regional median epilimnetic pH was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly increasing (improving) epilimnetic pH trend was detected for the region (Figure 13; Appendix D: Table D-1). This is a positive sign and indicator that the region's lakes are slowly recovering for the effects of acid precipitation.

In addition to the regional trend analysis, Monadnock region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing, or stable over time. Epilimnetic pH trends were assessed for approximately 26 deep spots at 25 lakes in the region representing approximates 80% of the region's VLAP lakes. Trend analysis revealed five lake deep spots with significantly decreasing (worsening) epilimnetic pH, and 20 lake deep spots with stable epilimnetic pH levels (Table 3; Appendix D: Table D5).

Variations in pH values between lakes and between different geographical regions may depend on the composition and weathering of underlying bedrock and the lake water chemistry. Another contributing factor to pH is acid deposition received as a result of emissions from power plants and vehicles. This increases levels of atmospheric carbon, nitrogen and sulfur which fall back to the earth in the form of acidic precipitation.

A recent report published by NHDES "Acid Rain Status and Trends New Hampshire Lakes, Ponds and Rainfall" analyzed trends in historical pH, ANC, conductivity, sulfate and nitrate concentrations from three state-wide monitoring programs to determine if the state's lakes and ponds are recovering from the effects of acid rain. The Acid Outlet, Remote Pond and Rooftop Rain programs have been collecting data since the early 1970s and 1980s. Analysis of sulfate, nitrate and pH concentrations of precipitation indicate that pH levels have significantly increased (become less acidic), and sulfate and nitrate concentrations have significantly decreased (improved) since 1972. Analysis of sulfate, nitrate, pH and ANC concentrations of lake water indicate that the majority of lakes sampled have experienced a stable trend or increase (improvement) in pH and ANC as well as a 90% reduction in sulfate and nitrate concentration. This supports significant improvements in local and national air quality as regulations have improved acid rain; however our surface waters reflect a slower rate of recovery.

Table 5. Significant Epilimnetic pH Trends in Monadnock Region Lakes

Lake Name	pH (Epilimnion) Decreasing Trend p
Contoocook Lake	0.01
Forest Lake	0.01
Stone Pond	0.02
Swanzey Lake	0.01
Thorndike Pond	< 0.01

Annual and Historical ANC Data Analysis

ANC measures the buffering capacity of a water body, or its ability to resist changes in pH by neutralizing acidic inputs. These "buffers" are typically bases such as bicarbonate and carbonate. Geology can play an important part in a water body's buffering capacity. Lakes located in areas with predominantly limestone (calcium carbonate), sedimentary rocks and carbonate-rich soils often have a higher ANC, while lakes located in areas with predominantly granite and carbon-poor soils often have a lower ANC. The higher the ANC, the more readily a waterbody can resist change in pH. **The median ANC value for New Hampshire's lakes and ponds is 4.8 mg/L, and the median ANC value for the Monadnock region is 2.1 mg/L, which indicates that many lakes and ponds in the region are *moderately to extremely vulnerable* to acidic inputs.**

Figure 14 represents the combined 2013 and 2014 average ANC for individual lakes in the Monadnock region compared with state and regional medians. Ten lakes have ANC values less than the regional median and are extremely vulnerable to acidic inputs. Nineteen lakes have ANC values between the state and regional medians and are moderately vulnerable to acidic inputs, and five lakes have ANC values greater than the state median and still within the moderately vulnerable category. The lowest ANC value measured in 2014 was 0.55 mg/L at Rockwood Pond in Fitzwilliam, and the highest ANC value was 9.03 mg/L at Spofford Lake in Chesterfield.

Figure 14. Average ANC for Monadnock Region Lakes

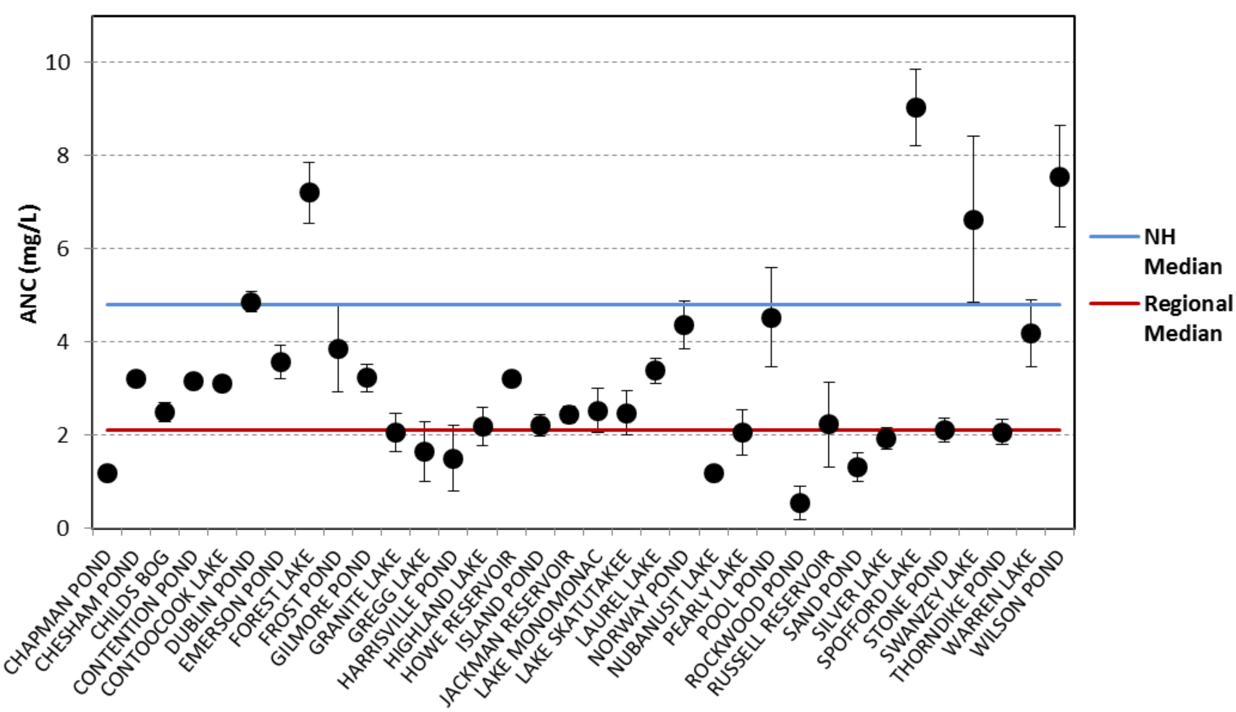
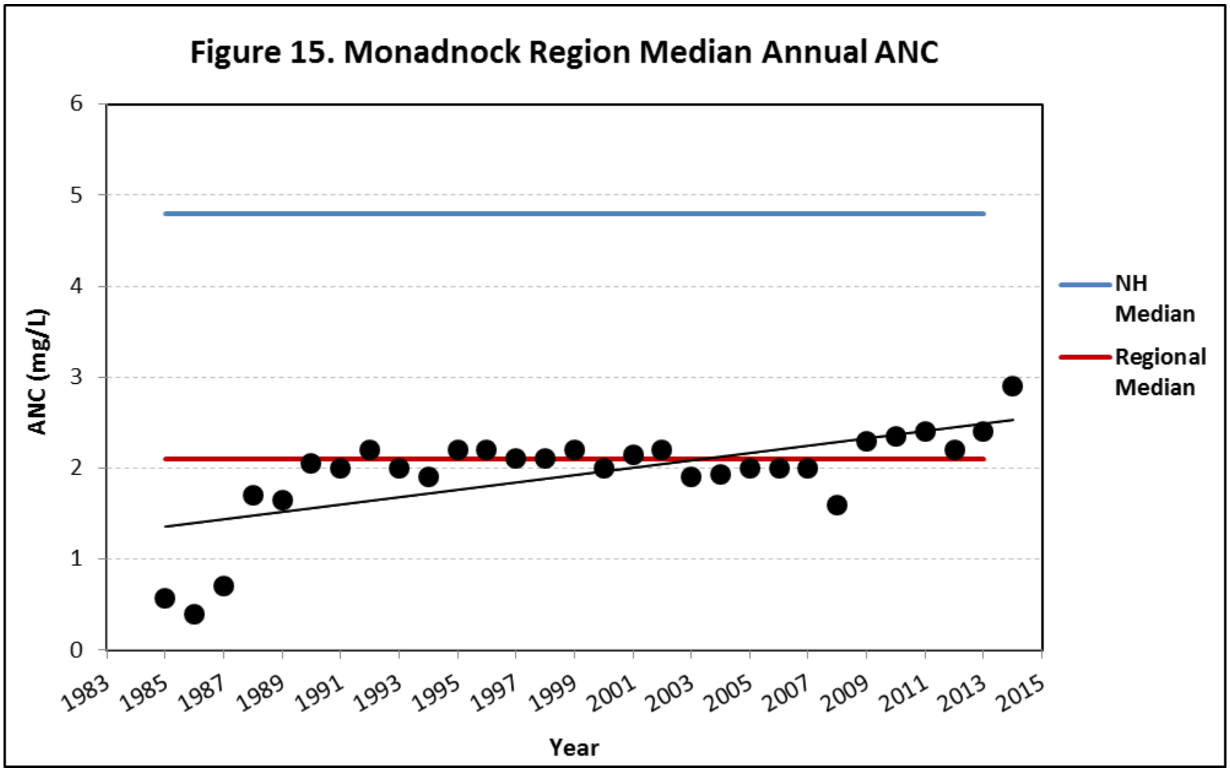


Figure 15 represents the median annual ANC for the Monadnock region. The median ANC generally remained between 1.5 and 2.2 mg/L from 1990 through 2014. Since then, the median ANC has improved slightly to greater than 2.2 mg/L and the 2014 median ANC was the highest (best) regional median measured since monitoring began.



Acid Neutralizing Capacity Trend Analysis

The regional median ANC was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly increasing trend was detected for the Monadnock Region (Appendix D: Table D-1; Figure 15) which is a sign of improvement. This further supports the NHDES "Acid Rain Status and Trends New Hampshire Lakes, Ponds and Rainfall" report.

Annual and Historical Deep Spot Conductivity Data Analysis

Conductivity is the numerical expression of the ability of water to carry an electric current, which is determined by the number of negatively charged ions from metals, salts and minerals in the water column. The soft waters of New Hampshire have traditionally low conductivity values, generally less than 50 uMhos/cm. However, specific categories of good and bad levels cannot be constructed for conductivity because variations in watershed geology can result in natural fluctuations. **The median conductivity value for New Hampshire's lakes and ponds is 40.0 uMhos/cm. The median epilimnetic conductivity value for the Mondanock region is 38.7 uMhos/cm.**

Figure 16 represents the combined 2013 and 2014 average epilimnetic conductiivty for Monadnock region lakes compared with state and regional medians. The regional median is approximately equal to the state median. Eighteen lakes have epilimnetic conductivity values less than the state and regional medians, and 16 have epilimnetic conductivity values greater than the state median. Conductivity values fluctuate widely among the region's lakes. The lowest average epilimnetic conductivity value of 15.0 uMhos/cm was measured at Nubanusit Lake in Nelson whereas the highest value of 166.7 uMhos/cm was measured at Pool Pond in Rindge. Nubanusit Lake experiences low developmental pressures, whereas Pool Pond is located next to a major New Hampshire roadway.

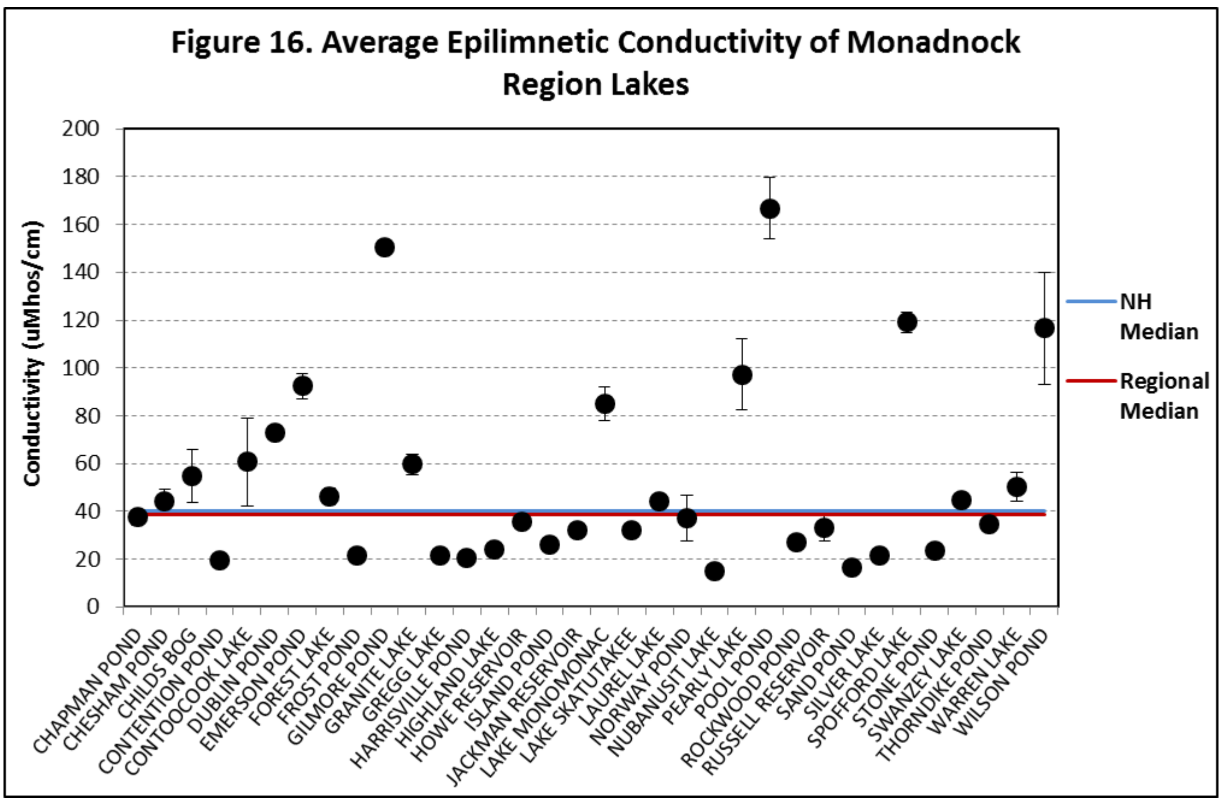
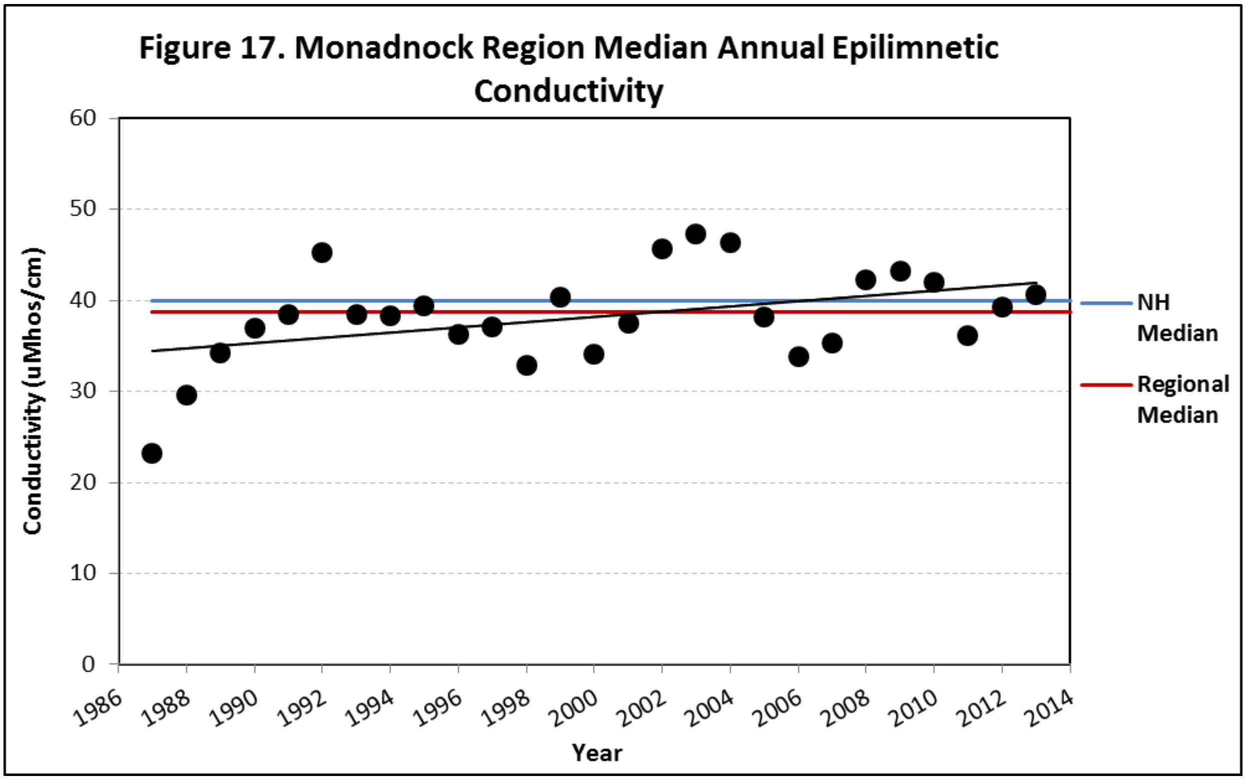


Figure 17 represents the median annual epilimnetic conductivity for the Monadnock region compared with regional and state medians. Median epilimnetic conductivity has generally remained between 30.0 and 50.0 uMhos/cm and is within a good range. The 2014 median epilimnetic conductivity at Monadnock lakes was 40.1 uMhos/cm, which is equal to the state median.



Historical Conductivity Trend Analysis

The regional median epilimnetic conductivity was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly increasing (worsening) epilimnetic conductivity trend was detected for the Monadnock Region which is consistent the majority of state regions (Appendix D: Table D-1).

In addition to the regional trend analysis, Monadnock region lakes with 10 or more consecutive years of data were subject to linear regression analyses to determine whether water quality trends were significantly increasing, decreasing or stable over time. Epilimnetic conductivity trends were assessed for approximately 26 deep spots at 25 lakes in the region representing approximately 80% of the region's VLAP lakes. Trend analysis revealed 12 lake deep spots with significantly decreasing (improving) epilimnetic conductivity, five deep spots with significantly increasing (worsening) epilimnetic conductivity, and nine lakes with relatively stable epilimnetic conductivity trends (Table 6, Appendix D: Table D-5). The percentage of individual lakes with improving epilimnetic conductivity is in contrast with the significantly worsening regional trend.

Table 6. Significant Epilimnetic Conductivity Trends in Monadnock Region Lakes

Lake Name	Conductivity (Epilimnion)	
	Increasing Trend	Decreasing Trend
	p	p
Forest Lake		< 0.01
Harrisville Pond		< 0.01
Highland Lake, North		0.01
Island Pond		< 0.01
Laurel Lake		< 0.01
Nubanusit Lake		< 0.01
Rockwood Pond		< 0.01
Russell Reservoir		0.03
Sand Pond		< 0.01
Silver Lake		< 0.01
Stone Pond		< 0.01
Warren Lake		0.01
Gilmore Pond	< 0.01	
Lake Monomonac	< 0.01	
Pearly Pond	< 0.01	
Spofford Lake	< 0.01	
Swanzey Lake	< 0.01	

Generally, conductivity values in New Hampshire lakes exceeding **100 uMhos/cm** indicate cultural, meaning human, disturbances. An elevated conductivity trend typically indicates point sources and/or non-point sources of pollution are occurring within the watershed. These sources include failed or marginally functioning septic systems, agricultural runoff, road runoff and groundwater inputs. New development in the watershed can alter runoff patterns and expose new soil and bedrock areas, which could also contribute to increasing conductivity. In addition, natural sources, such as mineral deposits in bedrock, can influence conductivity.

Annual and Historical Deep Spot Chloride Data Analysis

High conductivity values are often due to elevated chloride levels, which are generally associated with road salt and/or septic inputs. The chloride ion (Cl^-) is found naturally in some surface and ground waters and in high concentrations in seawater. The chloride content in New Hampshire lakes is naturally low in surface waters located in remote areas away from habitation. Research has shown that elevated chloride levels can be toxic to freshwater aquatic life. In order to protect freshwater aquatic life in New Hampshire, the state has adopted acute and chronic chloride criteria of 860 and 230 mg/L respectively. **The median chloride value for New Hampshire's lakes is 4 mg/L. The median epilimnetic chloride value for the Monadnock region is 13 mg/L.**

Figure 18 represents the combined 2013 and 2014 average epilimnetic chloride values of Monadnock region lakes compared with state and regional medians. Nine lakes have epilimnetic chloride levels between the state and regional medians, and eight lakes have epilimnetic chloride levels greater than the regional median. The chloride measurement is relatively new for VLAP and is an optional analyte for participating lakes. Lakes that serve as water supplies or where conductivity levels may be influenced by chloride are analyzed annually.

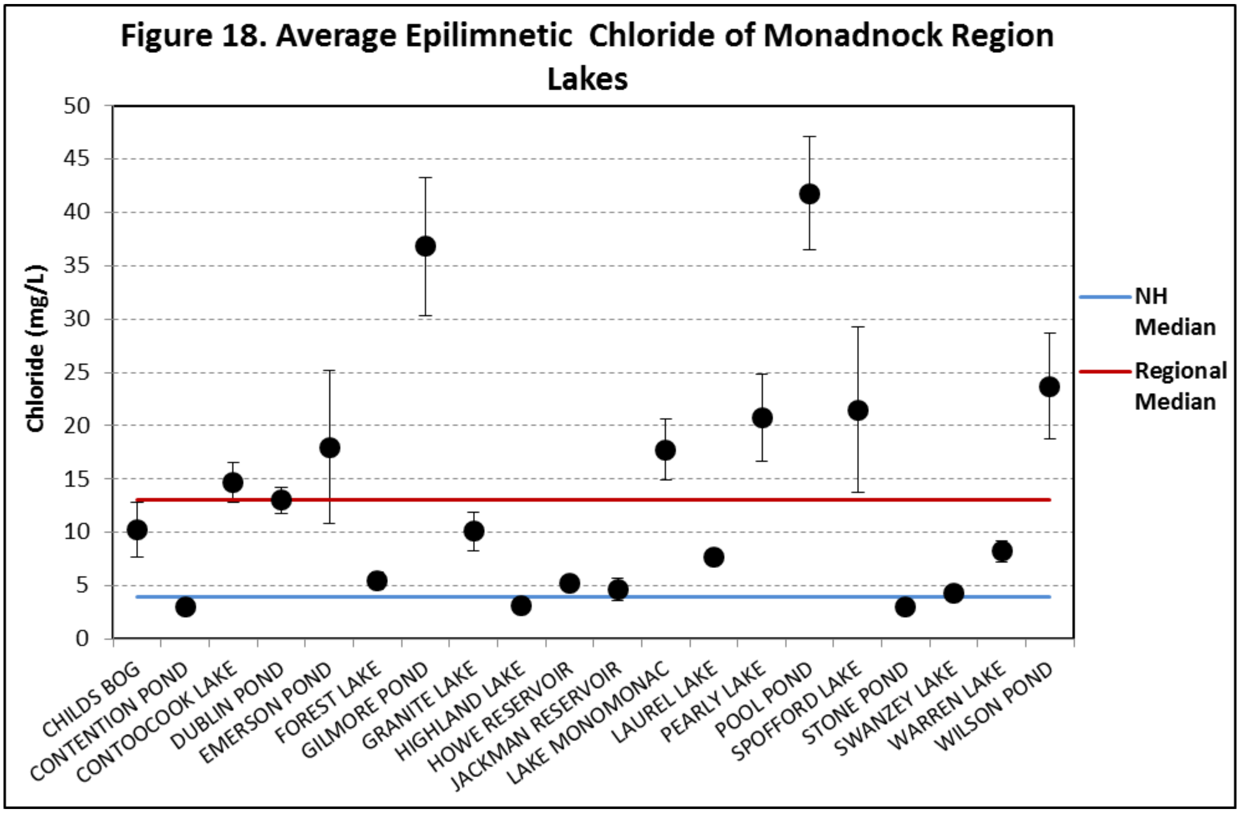
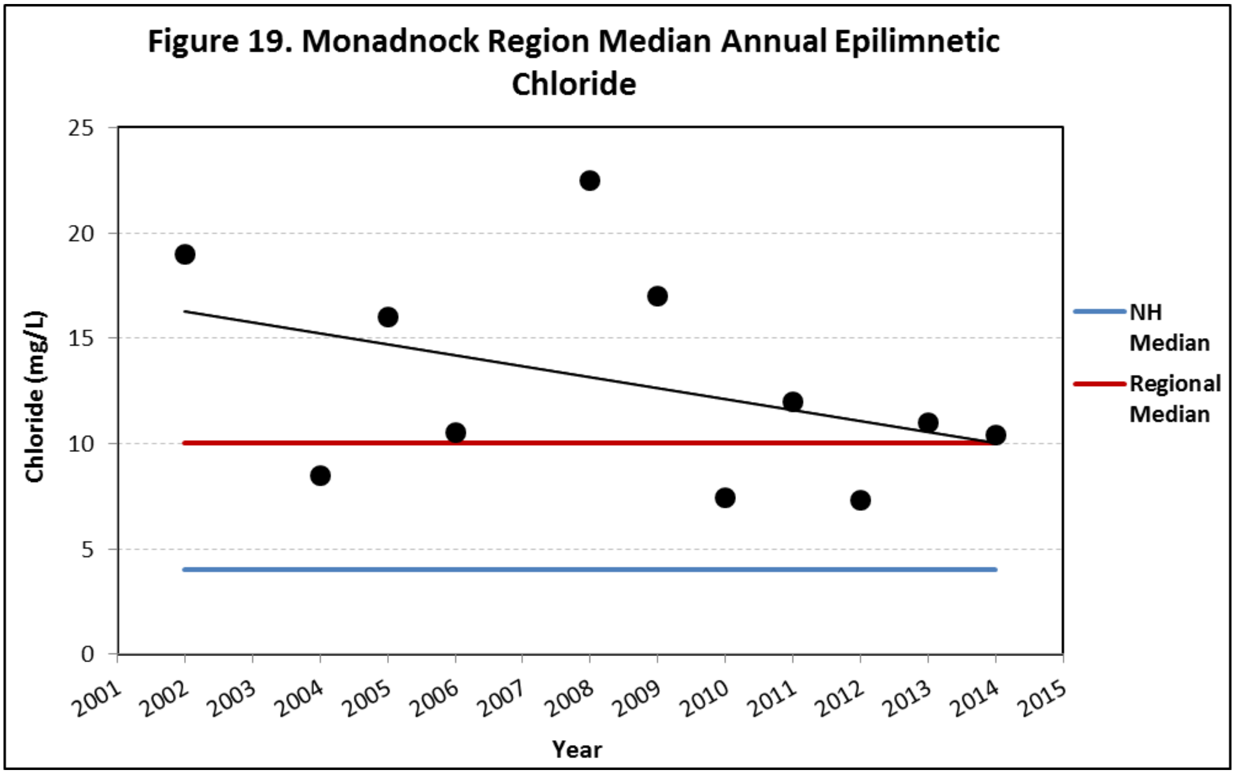


Figure 19 represents median annual epilimnetic chloride levels for the Mondanock region. Median epilimnetic chloride levels generally range between 10 and 20 mg/L and are considered low levels when compared with the acute and chronic chloride standards; however, they are greater than what we would typically measure in undisturbed New Hampshire surface waters.



Historical Chloride Trend Analysis

The regional median epilimnetic chloride was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. No significant trend was detected for the Monadnock Region (Appendix D: Table D-1, Figure 19). This trend is consistent with all regions of the state.

Watershed management efforts to control un-natural sources of conductivity and chloride in waterbodies should employ a combination of best management practices in regards to winter salting practices. State and local governments and private homeowners should evaluate the use of road salt and alternatives to reduce the amount of material applied while maintaining public safety.

For additional information on the relationship between conductivity and chloride, please refer to Appendix A. For additional information on best management practices, please refer to Appendix B.

Annual and Historical Deep Spot Turbidity Data Analysis

Turbidity in the water is caused by suspended matter (such as clay, silt and algae) that causes light to be scattered and absorbed, not transmitted in straight lines through water. Water clarity is strongly influenced by turbidity. **The Class B surface water quality standard for turbidity is no greater than 10 NTUs over the lake background level. The median epilimnetic turbidity for the Monadnock region is 0.73 NTU.**

Figure 20 represents the combined 2013 and 2014 average epilimnetic turbidity for Mondanock region lakes compared with the regional median. Eleven lakes have epilimnetic turbidities that were less than the regional median and considered to be in a low range. Thirteen lakes have epilimnetic turbidities between the regional median and 1.2 NTU and considered to be in an average range, and nine lakes have epilimnetic turbidities greater than 1.2 NTU and were higher than desirable.

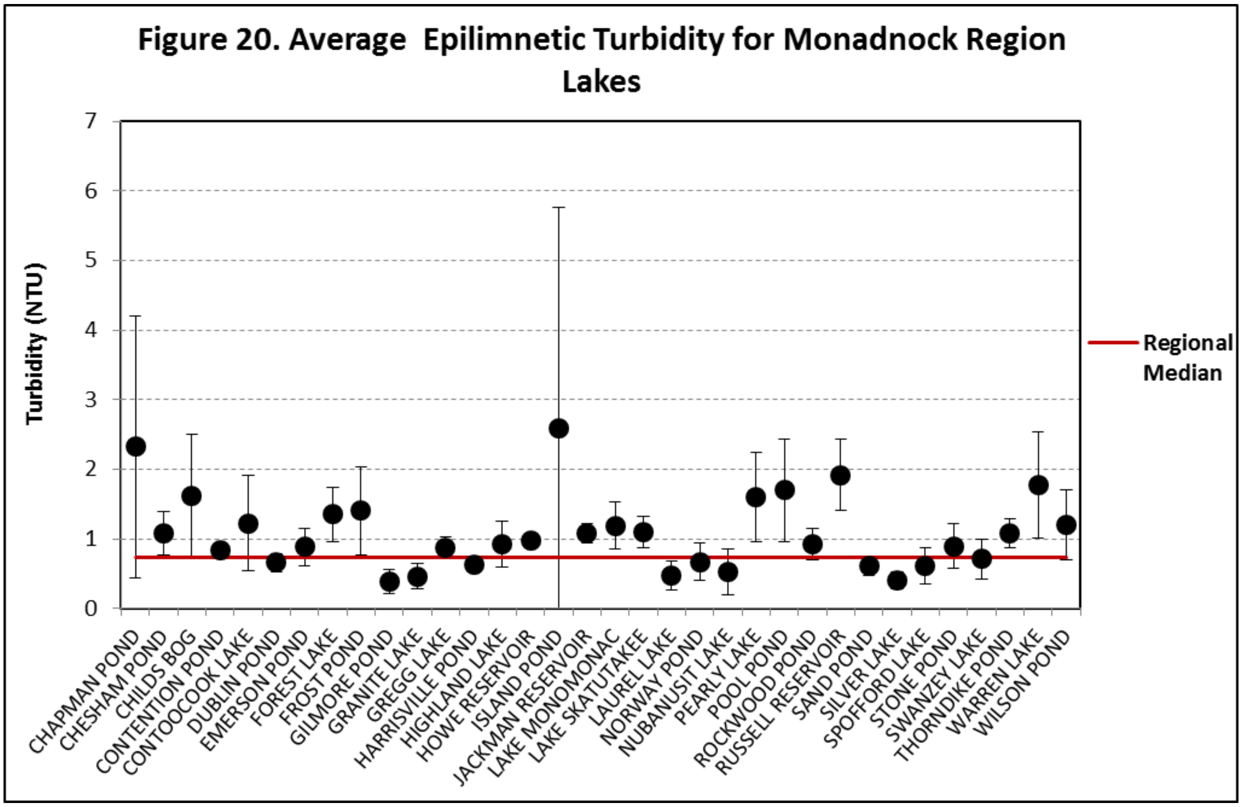
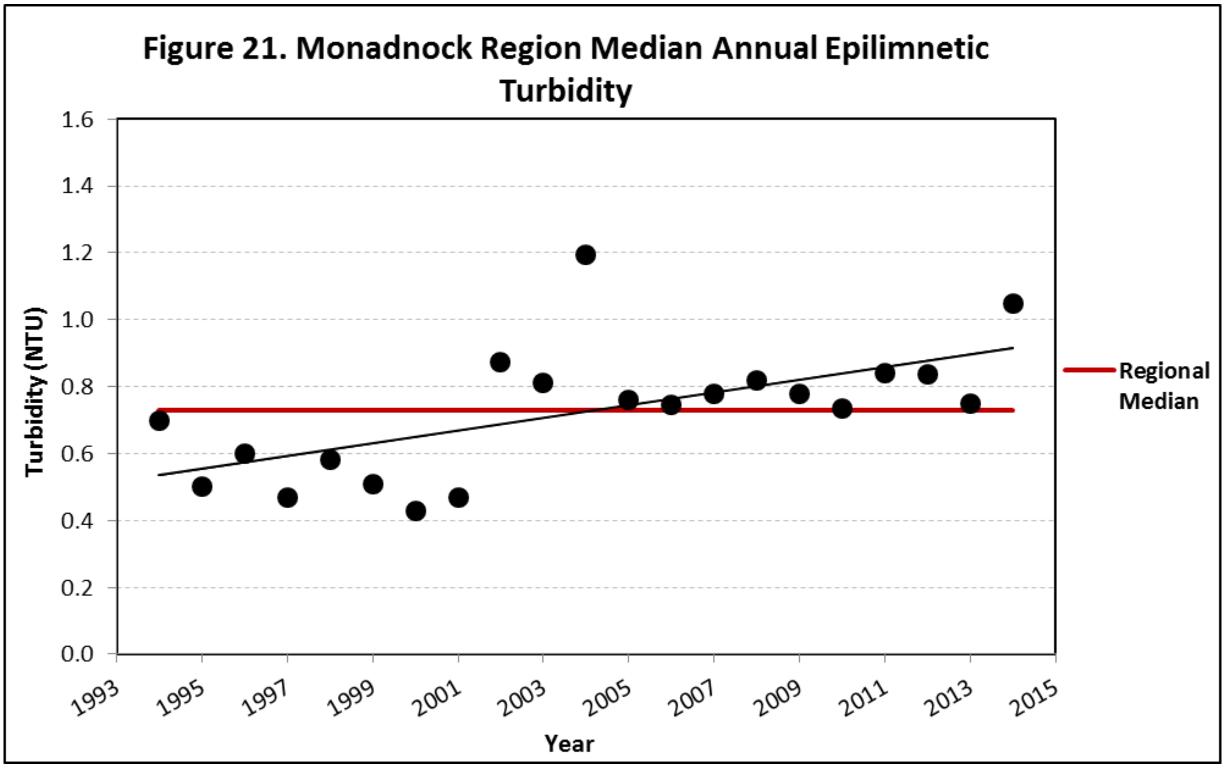


Figure 21 represents the median annual epilimnetic turbidity for the Monadnock region. The 2014 median epilimnetic turbidity was 1.05 NTU, which is slightly greater than the regional median and the highest turbidity measured since 2005. Regional epilimnetic turbidity is typically below 1.0 NTU and is average for most New Hampshire lakes. The increased frequency and intensity of storm events in recent years may be contributing to an increase in stormwater runoff and turbidity in the region's lakes.



Historical Turbidity Trend Analysis

The regional median epilimnetic turbidity was subject to Mann-Kendall non-parametric statistical analyses to determine if a significant regional trend existed using a 95% confidence limit. A significantly increasing (worsening) trend was detected for the Monadnock Region (Appendix D: Table D-1, Figure 21). This trend is consistent with all regions of the state.

Elevated deep spot turbidity levels are typically the result of stormwater runoff, algal or cyanobacteria blooms, and/or disturbance of lake bottom sediments. Stormwater BMPs should be implemented when possible to reduce the amount of suspended sediments and debris transported to surface water. Boating activity in shallow areas should adhere to rules specified by the New Hampshire Marine Patrol in regards to speed and no wake zones. If an algal or cyanobacteria bloom is observed, please contact NHDES immediately.

For additional information on stormwater BMPs, boating, algae and cyanobacteria, a please refer to Appendices A and B.

Reference:

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