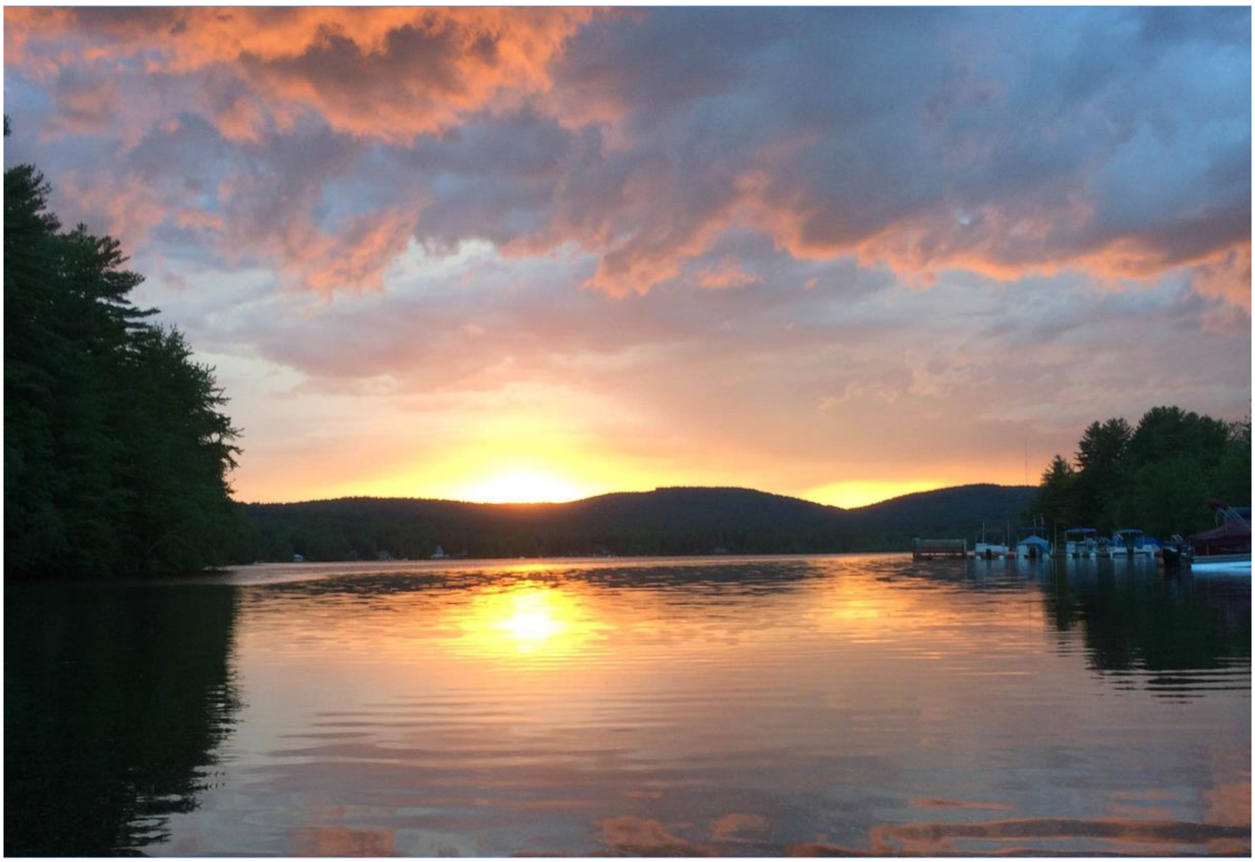
State of New Hampshire Air Quality-2017:

Executive Edition



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Cover photo provided to NHDES by Nick Fontaine 2016: Sunset, New Hampshire

STATE OF NEW HAMPSHIRE
OFFICE OF THE GOVERNOR

CHRISTOPHER T. SUNUNU
Governor

Dear NH Citizens,

It is my pleasure to share with you this report from the New Hampshire Department of Environmental Services (NHDES) detailing the progress we have made together in ensuring that NH's air quality meets federal standards established in the 1990 Clean Air Act. My hope is that this report will inform you about the complex challenges we face and help you to better understand the potential impacts to our health and economy. Understanding that in New Hampshire a strong economy and a clean environment go hand-in-hand, our citizens, businesses, legislature, and government agencies have combined common sense regulation, innovation, and cost-effective strategies to address the threats of poor air quality that could hinder our quality of life, tourism, and manufacturing/industry base.

In the 1990's, because air pollution reduction technology was not widely applied either locally or nationally, the Northeast suffered from poor air quality. Faced with major increases in the number of vehicles traveling our roads, air pollution traveling from large uncontrolled power facilities to our south and west, and our own significant in-state sources of air pollution, our air quality regularly failed to meet federal health-based air quality standards. As a result, we faced significant health care costs, such as increased asthma, heart disease, and premature deaths while also triggering numerous federal requirements that had the potential to impact our economic growth. With our state motto "Live Free or Die" always in mind, we have addressed federal requirements in a cooperative way, such as being the first state to implement a simple electronic motor vehicle emissions test in place of the more costly and time-consuming tailpipe test. We are finding a common-sense cost-effective way to improve our air quality. We also found innovative ways to reduce mercury, lead, and other toxic compounds in our air. We eliminated MtBE while maintaining cleaner-burning gasoline, and required innovative controls on high emitting power generation facilities.

We have worked diligently in cooperation with our upwind neighbors to ensure that they take the necessary steps to prevent transported pollution from negating all of the good work we have done locally. We have enacted reasonable incentives for low pollution renewable power and cost-effective market-based solutions to address greenhouse gases from the energy sector. And while much progress has been made, we occasionally still experience poor to moderate air quality. Ozone and wood smoke continue to provide challenges for us and new threats, such as Perfluorinated compounds (PFCs) have to be investigated and addressed.

I thank NHDES staff, particularly the primary author Dr. Jeff Underhill, for their diligence and dedication working to produce this report and improve our environment. I also appreciate the ongoing dialogue between NHDES, my office and other state agencies, our legislature, and business community to continue our progress.

All in all, I am proud of the progress we have made together, and know we will face new challenges with the same Yankee ingenuity and common sense that make our state such a great place to live and work!

Sincerely,

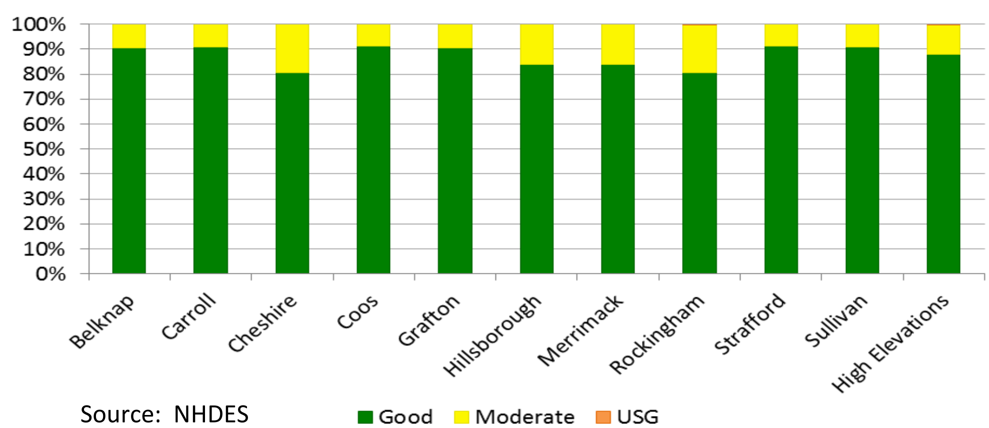
Christopher T. Sununu
Governor

This Executive Edition provides an overview of the report entitled *State of New Hampshire Air Quality–2017: Air Pollution Trends, Effects and Regulation* published by the New Hampshire Department of Environmental Services in January 2018. The reader is referred to this report for additional details and references.

INTRODUCTION

New Hampshire is known for its scenic mountains, lakes and ocean beaches, but like many other states, it also has a history of air pollution problems. The adoption of the federal Clean Air Act (CAA) in the 1970s and a key amendment to it adopted in 1990 led to vast improvements in New Hampshire's air quality and now the majority of the state experiences good air quality most of the year. Despite concerns about pollution control costs, clean air has proven to be consistent with maintaining a strong economy thanks to improvements in employee health and a vibrant environment. The state gross domestic product has remained strong and grown as the air quality improved. This is good news for New Hampshire's residents, tourists and businesses. That being said, there are still days where some communities experience air quality that is unhealthy for sensitive groups (USG), and virtually all counties still experience moderate air pollution levels for 35 to 70 days of the year (
Figure **1**). While this represents a significant improvement since the 1980s, challenges still remain. There are also some days where communities exceed health standards and acid rain still slows the recovery of our waters. The role of climate change is making slow changes in the state, as well.

Figure 1: Annual Air Quality Ratings by County, 2014-2016



AIR POLLUTION AND HEALTH

The connection between air pollution exposure and health impacts is not always obvious. Unless an air pollutant has a strong odor or is present in a high enough concentration to cause an immediate health reaction, the connection between health effects and air pollution exposure often goes unrecognized. For example, exposure to air pollution can trigger or exacerbate existing ailments that may be considered unrelated, such as asthma or tightness in the chest when breathing. The person may blame allergies or a cold for the symptoms.

Repeated exposure to air pollution over time can be the cause of these ailments, yet the connection to air pollution may not be made. Typically, such ailments are treated symptomatically without identifying the actual cause or causes. While air pollution is rarely listed as a cause of death, it might provide a fatal complication to an already compromised individual. According to the Environmental Protection Agency (EPA), air pollution in the United States causes thousands of premature deaths and millions of other health complications every year. Health cost assessment modeling with EPA's Environmental Benefits Mapping and Analysis Program (BenMAP) for small particles and ozone indicates that air pollution still causes over $3 billion per year in health related assessments in New Hampshire, even though the state's air quality is generally good (Table 1). Clearly, there is more work to be done to protect the state's citizens and businesses.

Potential impacts of air pollution on health-related costs:

- Increased acute and chronic bronchitis, asthma attacks, and mortality.
- Increased upper and lower respiratory symptoms.
- Increased emergency room asthma visits and hospital admissions.
- Increased cardiovascular symptoms and illnesses.
- Increased health claims and health risks for all New Hampshire residents.
- Possible decrease in resistance to disease, viruses, and bacterial infection.

Potential impacts of air pollution on business costs, including tourism:

- Increased employee work days lost, and decreased worker wellness and productivity.
- Higher insurance costs due to higher and/or more frequent claims.
- Increased environmental requirements may lead to higher cost for fuels and electricity.
- Reduced crop yields and loss of agricultural business.
- Lost tourism and associated business loss.

Table 1: Modeled Health-Related Valuations by County from Ozone and $PM_{2.5}$ Pollution in New Hampshire

County/Monitor Location	County Population (2014 census estimate)	Annual Ozone (ppb)[a]	Annual $PM_{2.5}$ ($\mu g/m^3$)[a]	N.H. Estimated Total Annual Health Impact Valuations (Millions 2010$)	
				Ozone	*$PM_{2.5}$*
Belknap	60,305	31.0[b]	5.5	$5.5	$120.5
Carroll	47,399	25.3[b]	5.5[b]	$4.3	$94.7
Cheshire	76,115	24.0	8.8	$7.2	$243.4
Coos	31,653	25.3[b]	6.2[b]	$2.8	$71.3
Grafton	89,658	25.3	6.2	$8.3	$202.0
Hillsborough	405,184	31.0[b]	8.4	$40.7	$1,236.9
Merrimack	147,171	31.0	6.2	$14.3	$331.6
Rockingham	300,621	28.9	8.4	$32.1	$917.7
Strafford	125,604	28.9[b]	8.4[b]	$13.0	$383.4
Sullivan	43,103	25.3[b]	6.2[b]	$4.1	$97.1
Mt Washington / Miller State Park	--	37.0	5.4		
State Totals	**1,326,813**	**--**	**--**	**$132**	**$3,699**

[a] *Based on 2013-2015 monitoring data.*

[b] *Nearest representative monitor was used since annual ozone monitoring was not conducted in this county.*

Some air pollution related health impacts in New Hampshire occur in communities with greater exposure to residential wood smoke. Wood is a valuable renewable source of energy and heat in the state, but when not burned efficiently, it produces abundant smoke filled with small particles consisting of hundreds of chemical compounds. Under normal circumstances, burning wood can be an enjoyable and safe experience, however when wood is not burned cleanly and weather conditions stagnate, air pollution can reach unhealthy levels and can become a neighborhood nuisance. The New Hampshire Department of Environmental Services (NHDES) encourages the use of EPA certified wood burning devices installed according to the manufacturer's recommendations. Communities in New Hampshire most prone to wood smoke stagnation include Keene, Henniker, Hillsborough, Laconia, Newport, Swanzey and Winchester.

HEALTH STANDARDS AND ATTAINMENT

The CAA requires EPA to set ambient outdoor air standards for specific pollutants. According to the CAA, such standards should be based upon extensive research and review by experts in the field and be protective of human and environmental health with an adequate margin of safety.

EPA has set National Ambient Air Quality Standards (NAAQS) for the six criteria air pollutants: carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ozone, particulate matter ($PM_{2.5}$ and PM_{10}), and sulfur dioxide (SO_2).[1] Each NAAQS is set for a specific time period of continuous exposure; for instance, the limit may apply to average exposure over a one-hour, eight-hour, 24-hour, or annual period. The number of days over the threshold per year may also be considered. The NAAQS and their corresponding units are included in Table 2.

When an air quality monitor measures a value over the NAAQS threshold, it may be an exceedance of the NAAQS, but not necessarily a violation of the NAAQS. Exceedances are based on short-term measurements. Violations indicate whether an area is subject to nonattainment designation, and are based on a calculated "design value" from measurements over a longer period of time, normally three years. Both exceedances and violation represent unhealthy air quality, however a violation carries a requirement to correct situations that repeat.

To identify a violation of the standard, EPA uses the calculated design value as measured over its designated duration. The form of the design value differs for each pollutant, but it normally does not represent a single maximum. Instead, the design value is based on a statistical pattern within identified health exposure limits. The use of design values, as opposed to single maximum values, helps to prevent basing an area's nonattainment status on a single incident, which may not reflect typical conditions over the long term.

An **exceedance** occurs when a measured concentration exceeds the threshold of the National Ambient Air Quality Standard (NAAQS).

A **violation** occurs when the calculated design value exceeds the NAAQS.

The **design value** is a calculated ambient air concentration that covers a specific duration, normally three years.

amended in 1990.

How the National Ambient Air Quality Standards (NAAQS) are set:
Under the Clean Air Act, the NAAQS are to be reviewed every five years to ensure adequacy of health protection. A review begins with an independent scientific advisory panel that reviews the most recent health science relative to the specific pollutant under review. The Clean Air Scientific Advisory Committee (CASAC) consists of scientists, doctors, researchers and industry specialists and they provide independent advice to the EPA Administrator on the technical bases for EPA's NAAQS. Exposure limit recommendations (often a range) contain an adequate margin of safety. An EPA science panel then reviews the recommendation and forms an EPA internal recommendation for the Administrator to consider. In the final step, the EPA Administrator seeks agreement with the Office of Management and Budget (OMB) which resides within the Executive Office of the President of the United States. After promulgation of the standard, EPA issues a rule to implement the new/revised standard along with steps required to demonstrate compliance. Costs of meeting a health standard are not considered during scientific review for determining safe exposure to a pollutant, however costs are considered when determining how to comply.

Table 2 lists the current primary and secondary NAAQS for each criteria pollutant. The New Hampshire design values for each standard, i.e., the value used to determine whether a violation of the standard has occurred. ***During the 2014 to 2016 period, all NAAQS are being met in New Hampshire, however there are isolated exceedances of the ozone standard as well as 24-hour periods that approach the level of the $PM_{2.5}$ standard in Keene.***

Table 2: 2014-16 Monitoring Design Values in New Hampshire

	Carbon Monoxide		Lead [a]	Nitrogen Dioxide	Ozone	Particulate Matter [b]			Sulfur Dioxide	
	1-Hour	8-Hour	3-Month	1-Hour	8-Hour	Daily $PM_{2.5}$	Annual $PM_{2.5}$	Daily PM_{10}	1-Hour	3-Hour
NAAQS: Units	**35 ppm**	**9 ppm**	**0.15 µg/m³**	**100 ppb**	**70 ppb**	**35 µg/m³**	**12 µg/m³**	**150 µg/m³**	**75 ppb**	**0.5 ppm**
Concord	--	--	--	--	61	--	--	--	7	0.005
Keene	--	--	--	--	61	23	8.0	--	--	--
Laconia	--	--	--	--	58	10	4.5	--	--	--
Lebanon	--	--	--	--	57	15	5.9	--	--	--
Londonderry	0.5	0.4	0.0047	--	65	15	6.6	--	5	0.003
Mt. Washington Base	--	--	--	--	57	--	--	--	--	--
Mt. Washington Summit	--	--	--	--	67	--	--	--	--	--
Nashua	--	--	--	--	63	--	--	--	--	--
Pack Monadnock Summit	0.3	0.3	--	--	68	13	5.8	--	3	0.001
Pembroke	--	--	--	--	--	--	--	--	20	0.012
Portsmouth	--	--	--	--	65	15	6.0	28	23	0.010
Rye	--	--	--	--	67	--	--	--	--	--

-- Denotes no data or insufficient data collected at that site.

[a]EPA rules require lead design values be rounded to the second decimal place for comparison to the standard. However, to be more descriptive of very small values monitored in New Hampshire, lead design values in this table are rounded to the fourth decimal place.

[b]EPA rules define PM_{10} design values as the average number of exceedances per year over three years. However, to show New Hampshire's monitored values relative to the standard, PM_{10} values in this table are the maximum 24-hour averages over three years.

Source: NHDES, 2017

Air pollution standards are normally expressed in concentration units of parts per million (ppm), parts per billion (ppb), or micrograms per cubic meter (µg/m^3). These units reflect the average amount of that pollutant is present in a certain volume of ambient air over a defined period of time (as set by the standard).

While most areas of New Hampshire have attained and continue to meet the NAAQS, this has not always been the case. At various times, EPA has designated certain areas of the state as nonattainment areas. New Hampshire has always met the NAAQS for three of the criteria pollutants: lead, particulate matter, and nitrogen dioxide (NO_2). Portions of the state were previously designated as nonattainment areas for carbon monoxide (CO) and ozone, but the state currently meets the NAAQS for those pollutants as well. In 2016, only one area of the state was designated as nonattainment for any pollutant, the 1-Hour sulfur dioxide (SO_2)(Figure 2). Table 3 summarizes the history of air pollution attainment and nonattainment area designations in New Hampshire.

Table 3: Historical Summary of New Hampshire's Air Quality Area Designations

Pollutant	Area Designations	
	Former Status	Current Status
Carbon Monoxide (CO)	Nonattainment for Manchester and Nashua; attainment for all other areas[a]	Attainment for all areas
Lead (Pb)	Attainment for all areas	Unclassifiable/Attainment for all areas
Nitrogen Dioxide (NO_2)	Attainment for all areas	Unclassifiable/Attainment for all areas
Ozone (O_3)	1-hour NAAQS: Nonattainment for Cheshire, Hillsborough, Merrimack, Rockingham, and Strafford Counties; attainment for all other areas[b] 8-hour NAAQS: Nonattainment for portions of Hillsborough, Merrimack, and Rockingham Counties; attainment for all other areas[c]	Attainment/Unclassifiable for all areas
Particulate Matter (PM)	Attainment for all areas	Attainment for all areas
Sulfur Dioxide (SO_2)	Attainment for all areas	Nonattainment for portions of Hillsborough, Merrimack, and Rockingham Counties; unclassifiable for all other areas[d]

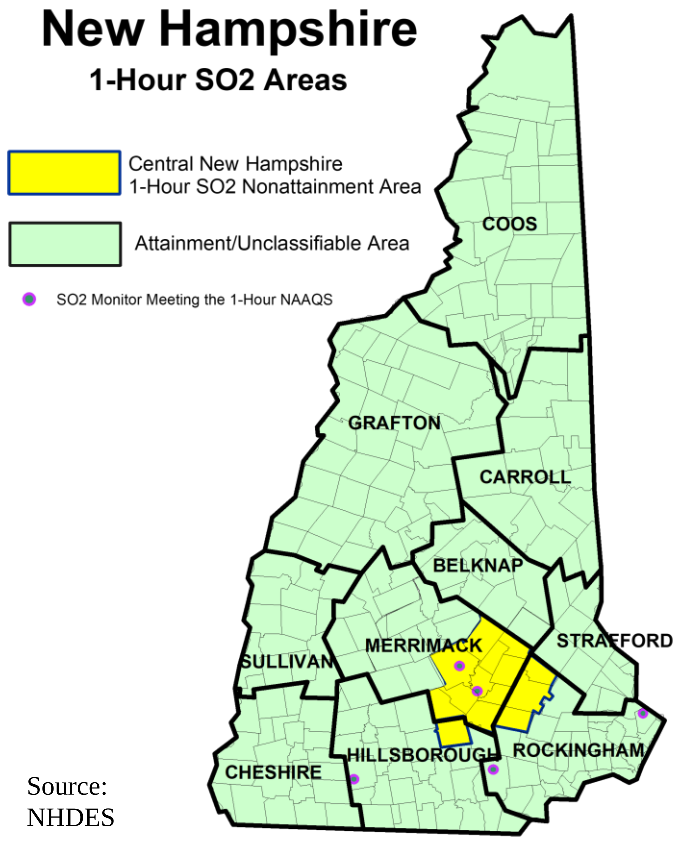
[a] In 1980, EPA designated the City of Manchester and the City of Nashua as nonattainment areas for CO (45 FR 24869 and 48 FR 29479, respectively). Following passage of the Clean Air Act Amendments of 1990, both cities were designated as "nonattainment" and "not classified" for CO (56 FR 56694), although ambient monitoring showed that air quality was meeting the NAAQS by then. In 2000, EPA re-designated Manchester and Nashua to attainment of the CO standard, effective on January 29, 2001 (65 FR 71078).
[b] New Hampshire's area designations for the 1-hour primary ozone NAAQS (now revoked) are codified at 40 CFR 81.330.
[c] New Hampshire's area designation for the 8-hour primary ozone NAAQS is codified at 69 FR 23857. Improved air quality made it possible for this area to be re-designated to attainment on December 27, 2012 (78 FR 6741).
[d] New Hampshire's SO_2 nonattainment area was established in EPA's initial round of air quality designations on July 25, 2013, for the 2010 SO_2 primary NAAQS (78 FR 47191).

Source: NHDES and EPA, 2017

As mentioned above, the only current nonattainment area in New Hampshire is for the 1-hour SO_2 NAAQS. Air quality monitoring between 2008 and 2010 identified a portion of central New Hampshire that violates the 1-hour standard of 75 parts per billion (Figure 2). This designation is likely to be revised to attainment in the next year to reflect more recent monitoring and modeling in the area, newly implemented pollution controls, and the state's 1-hour SO_2 state implementation plan.

Figure 2: SO_2 Nonattainment Area

New Hampshire's nonattainment area for the 2010 SO_2 primary NAAQS includes portions of three counties in the southern part of the state.



Source: NHDES

MONITORING AND TRENDS

Air pollution levels in the state are measured by a network of 13 air monitoring stations located throughout the state (Figure 3). These stations are strategically located to represent citizens that may be at risk for exposure to any of the six criteria air pollutants in concentrations of three-quarters of the NAAQS level or greater. As a result of emission and transport patterns, the majority of the network is located in the southern half of the state.

Figure 3: 2017 New Hampshire Air Monitoring Network

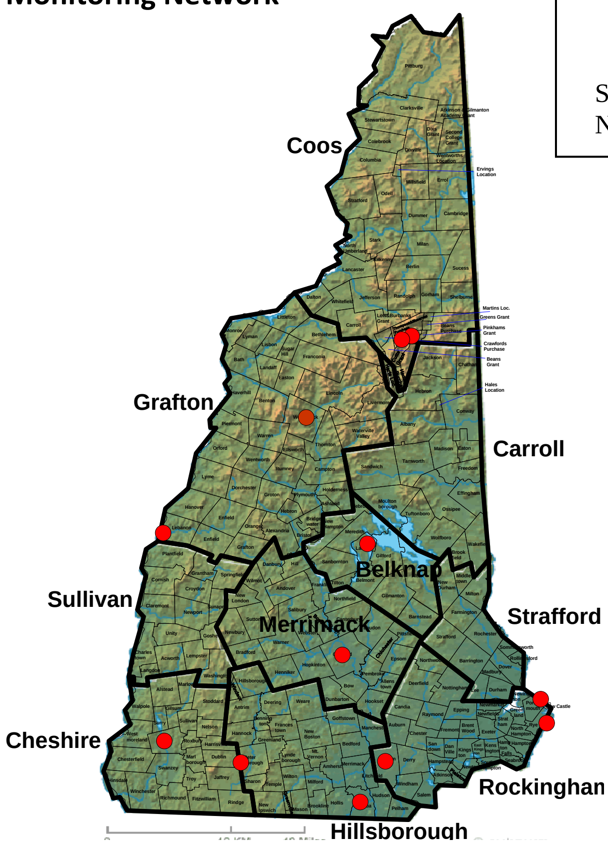
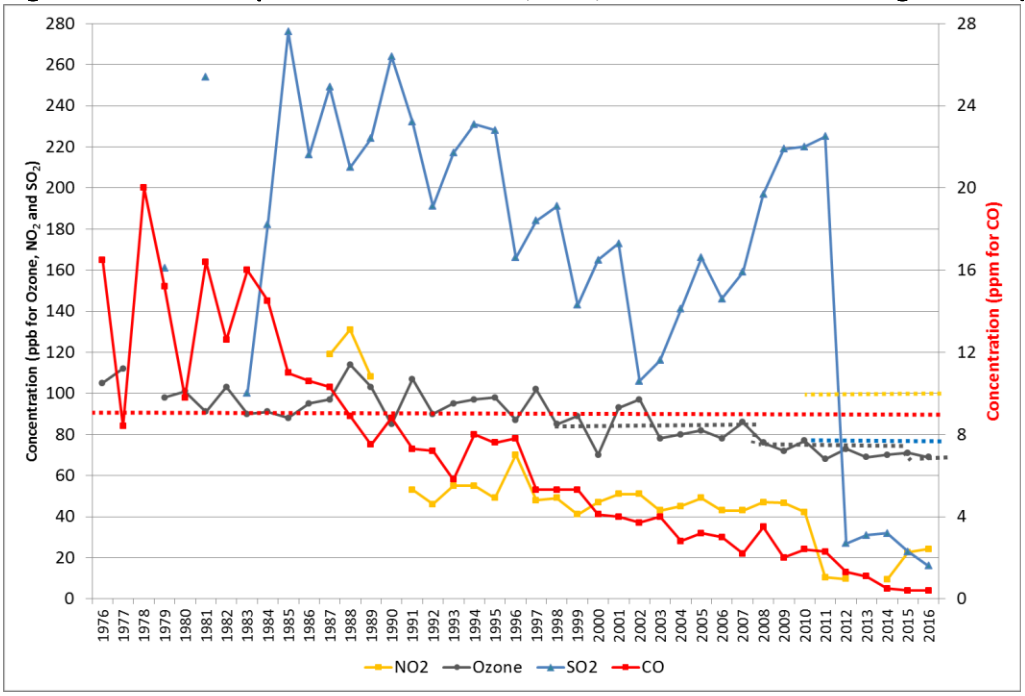


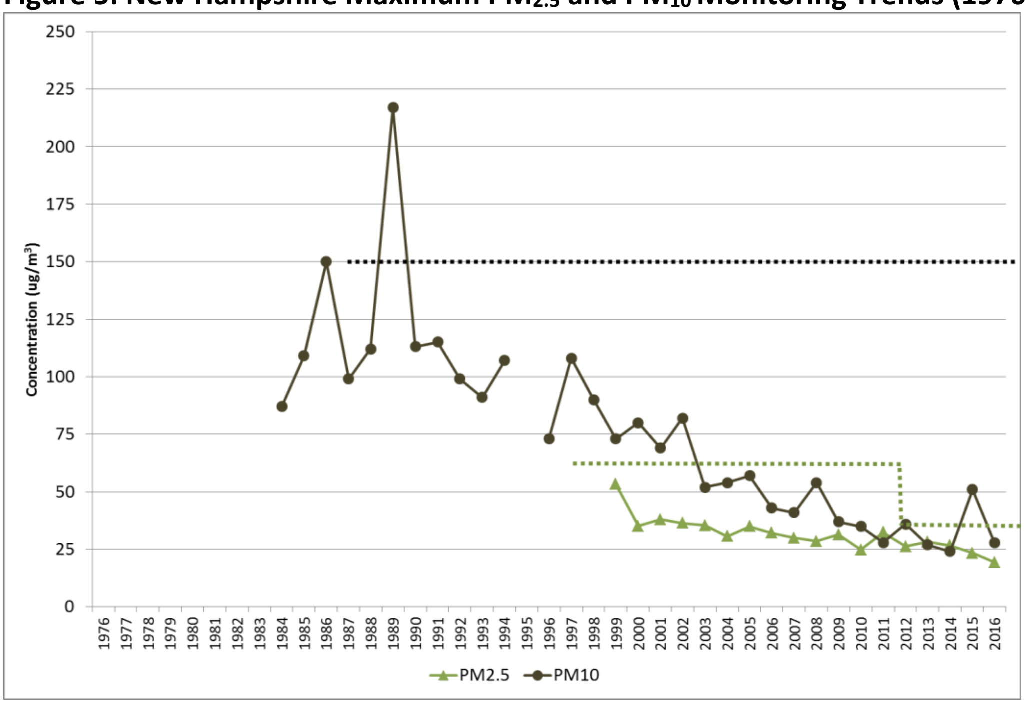
Figure 4 and 5 show concentration decreases for several of the criteria air pollutants in New Hampshire. These decreases can be directly traced to air pollution control installations, cleaner cars and fuels, and much of the regional electric generation fleet shifting from coal to natural gas. Additional benefits are expected in the next few years as an increasing number of older cars are retired in favor of new cleaner cars. Over the longer term, however, once the electric generation and motor vehicle fleets begin to stabilize, the progress trends are anticipated to begin leveling off over the next few years.

Figure 4: New Hampshire Maximum CO, NO_2, O_3 and SO_2 Monitoring Trends (1976-2016)



Notes: CO (2nd maximum 8-hour), NO_2 (98th percentile 1-hour), Ozone (4th maximum 8-hour), SO_2 (99th percentile 1-hour).Health standards are indicated by dashed lines of corresponding color.

Figure 5: New Hampshire Maximum $PM_{2.5}$ and PM_{10} Monitoring Trends (1976-2016)



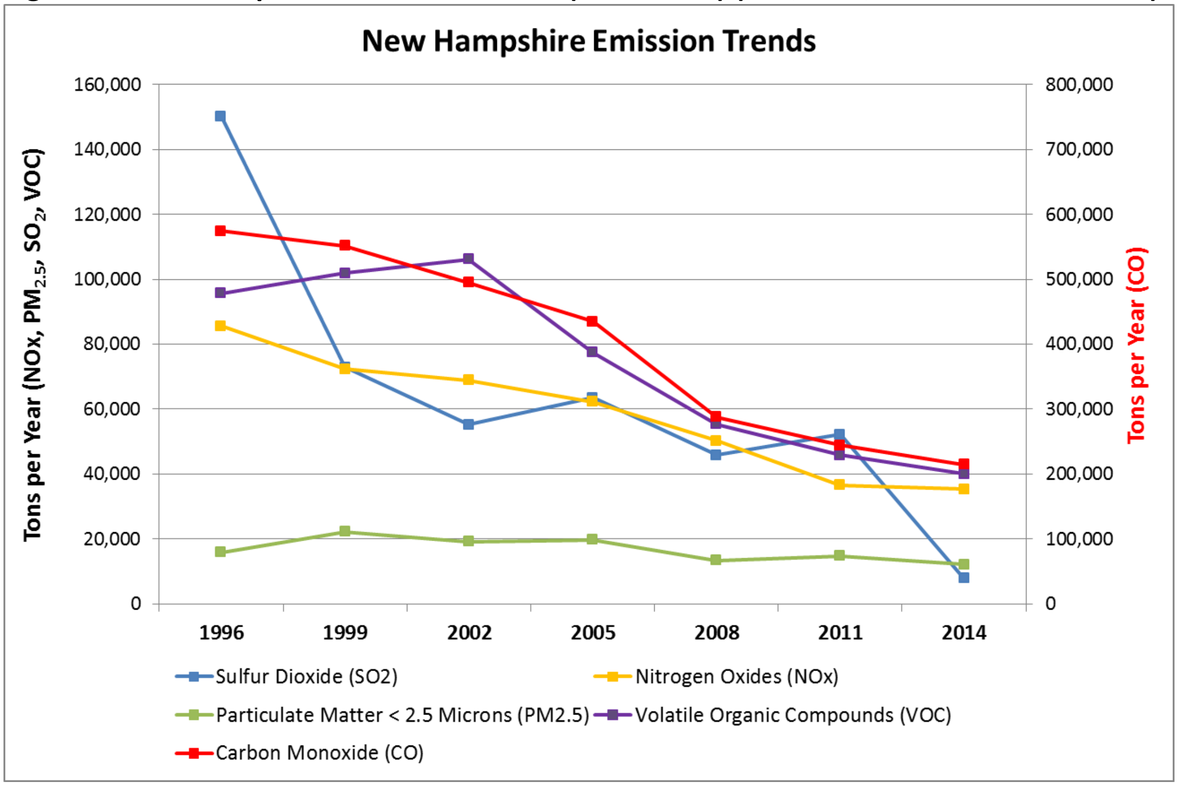
Notes: $PM_{2.5}$ (98th percentile 24-hour) and PM_{10} (maximum 24-hour). Health standards are indicated by dashed lines of corresponding color.

The Clean Air Act provisions required for nonattainment areas, such as vehicle emission inspection and maintenance programs, are not retracted when the area comes into attainment of the federal standard. To prevent emission increases that could cause a backsliding into nonattainment, they are continued in order to maintain air quality improvements.

EMISSION TRENDS

Improvements in air quality can largely be attributed to declining pollution emission trends. Figure 6 summarizes estimated total New Hampshire emissions for several pollutants.

Figure 6: New Hampshire Emission Trends (1996-2014) (SO_2, NOx, $PM_{2.5}$, VOCs, and CO)



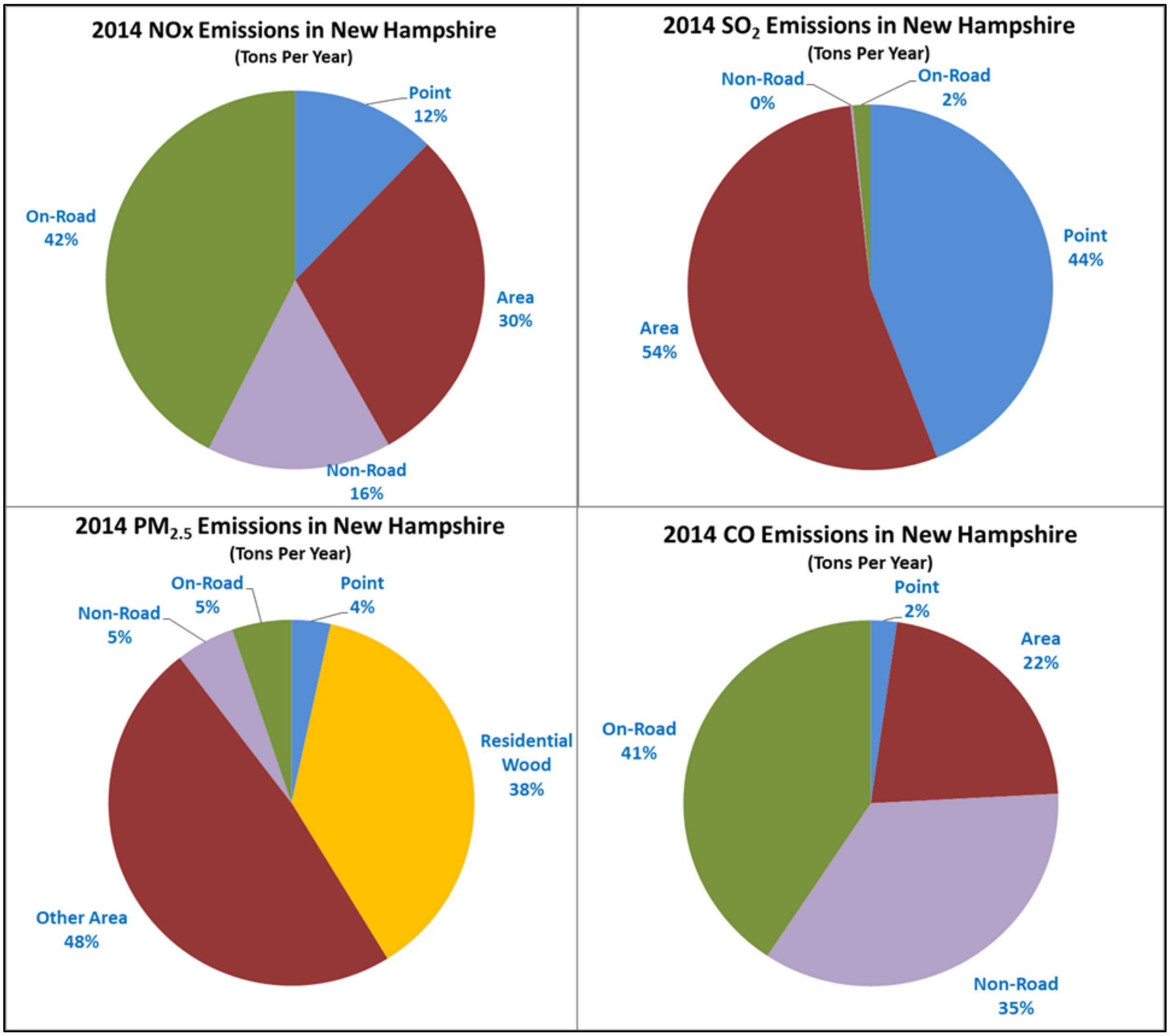
It is commonly thought that most air pollution comes from smoke stacks. Years ago, this was certainly true, however today, many of those old smoke stacks have been shut down, have been fitted with pollution controls, or burn cleaner fuels. Instead, most smog (ozone) producing emissions in New Hampshire come from mobile sources. While cars and trucks are being federally regulated to burn less fuel and emit less air pollution, their sheer numbers on the road make them a leading air pollution source category. On-Road (highway) and Non-Road (boats, aircraft, trains, construction, off-road) vehicles accounted for about 58% of the 2014 New Hampshire NOx emissions while smoke stacks (point sources) only accounted for about 12% (see Figure 7).

Smoke stacks (point) from electricity generation and other industrial facilities still account for a large portion (44%) of the State's SO_2 emissions, but SO_2 emissions are rapidly declining in the state as coal use is declining and lower sulfur fuel oils are being phased-in.

As with NOx emissions, CO emissions in New Hampshire are dominated by On-Road and Non-Road vehicles (76%) with the rest from fuel burning sources such as residential heating, industrial processes, lawn care and open burning.

About 86% of $PM_{2.5}$ emissions in New Hampshire come from the Area category which includes residential heating, open burning, cooking, construction activities, and industrial processes. For $PM_{2.5}$, Figure 7 breaks out residential wood heating from the Area emission source category to highlight its importance. This 38% of annual $PM_{2.5}$ emissions is emitted over approximately six months, meaning that during those six months residential heating is by far the dominant source of $PM_{2.5}$ in the state and the vast majority of it comes from residential wood burning.

Figure 7: New Hampshire 2014 Emissions by Sector (NOx, SO_2, $PM_{2.5}$, CO)

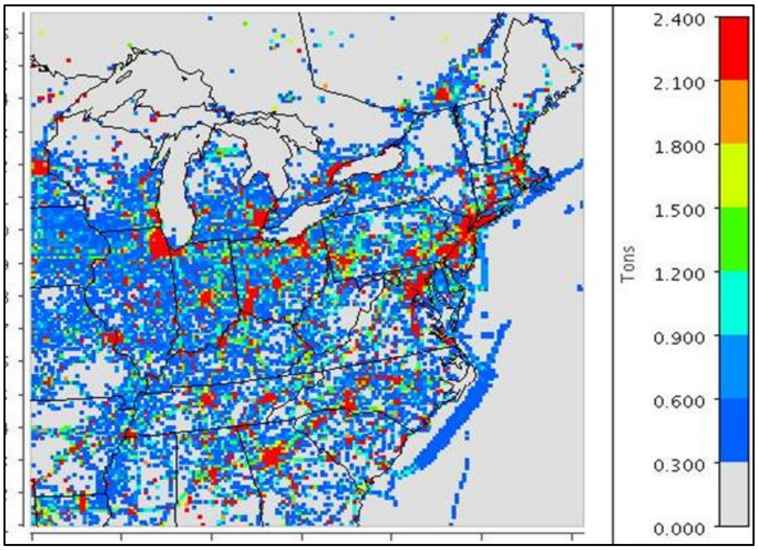


Note: Point sources are discrete emissions release points such as power plants and large industrial facilities. Area sources are emissions release points that are too widespread or numerous to be accounted for individually; one example is residential heating. On-Road sources are vehicles that operate on roadways such as cars, trucks, buses, and motorcycles. Non-Road sources are vehicles that do not typically operate on roadways such as aircraft, ships, construction vehicles, and lawn & garden equipment.

AIR POLLUTION TRANSPORT

Figure 8 demonstrates just how widespread NOx air pollution sources are in the eastern United States and Canada. This figure was generated to better understand the nature of NOx emissions needed to run a complex gridded photochemical model used for studying ozone and $PM_{2.5}$ formation and transport from one portion of the country to another. The colors represent the number of tons of NOx emitted during one day (July 22, 2011) in grid cells measuring 12 kilometers by 12 kilometers (or 7.5 by 7.5 miles).

Figure 8: NOx Emission Map – July 22, 2011



The map on the left uses a scale where warmer colors represent higher emissions than locations shown in cooler colors. Areas in grey indicate very low emissions or a lack of data for the location. In general, cities, industrial areas and major highways have the highest NOx emissions.

Source: NYSDEC, 2015

Photochemical models replicate conditions over large geographical areas, thus they are important tools for studying how air pollution emitted from one area affects other areas. These models incorporate meteorological data, atmospheric chemistry and physics, and the latest air pollution transport research.

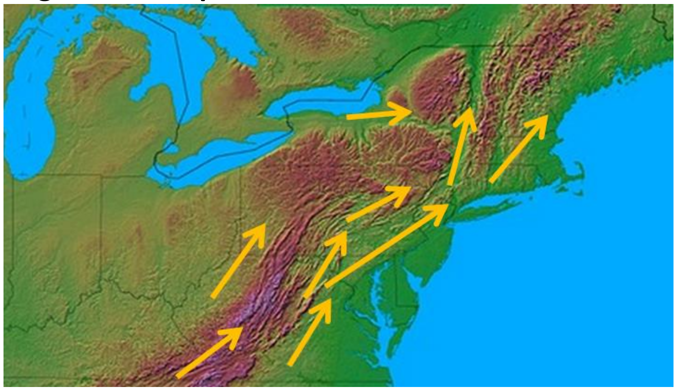
Once pollution is emitted into the air, it is blown around by the wind, dispersing it and transporting it from one location to another. Depending on environmental conditions, chemical reacts can occur to some of the air pollutants as they travel along with the winds. Three major transport pathways (patterns) and numerous sub-pathways have been discovered and tracked by researchers involved with the North American Research Strategy for Tropospheric Ozone - Northeast (NARSTO/NE) analyses. These analyses involved observations taken by aircraft, tethered balloons, and mountain-top air pollution monitors. The major pathways include:

1. Low-Level Flows (Near Surface) (Below 600 feet elevation)
2. Mid-Level (Channeled) (600 to 2,500 feet elevation)
3. High-Level (Synoptic) (2,500 to 7,000 feet elevation)

Low-Level (also called Near-Surface Flow): Most emissions are released near the ground in the lowest 600 feet of the atmosphere and move horizontally with surface-level winds (**Error! Reference source not found.**). These winds swirl around objects such as buildings and trees. There are also vertical motions to these winds that can lift ground-level pollution to higher levels and bring aloft pollution down from higher levels. In locations near large waterbodies, the low-level flow can be altered or even dominated by the maritime air sheds.

Figure 10: Near Surface Air-Sea Wind Flows – Short Range Transport

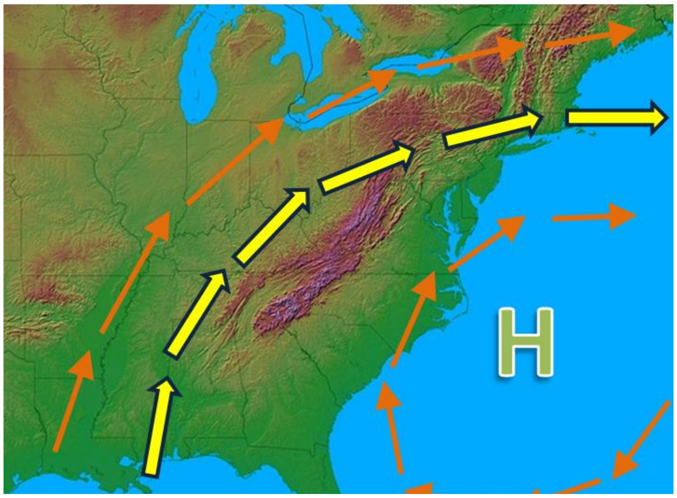
Figure 9: Channeled Air Flow in the Northeast – Regional Transport



Mid-Level (also called Channeled Flow): Mid-elevation winds (about 600 to 2,500 feet above the ground) usually follow terrain features such as mountain ridges and can move pollution fairly quickly across a region of several hundred miles (Figure 9). Power plants, which can have exhaust stacks that are hundreds of feet tall, can release pollutants directly into this layer. Because air at this altitude tends to swirl with the winds, pollution in this layer mixes up and down.

High-Level (also called Synoptic Flow): Higher-elevation winds (from around 2,500 to 7,000 feet above the ground) follow large-scale weather features such as high and low pressure systems and cold and warm fronts (Figure 11). These systems can move pollutants at speeds of up to 100 miles per hour at these higher elevations. High-level transport is largely responsible for regional, national, and global air pollution transport.

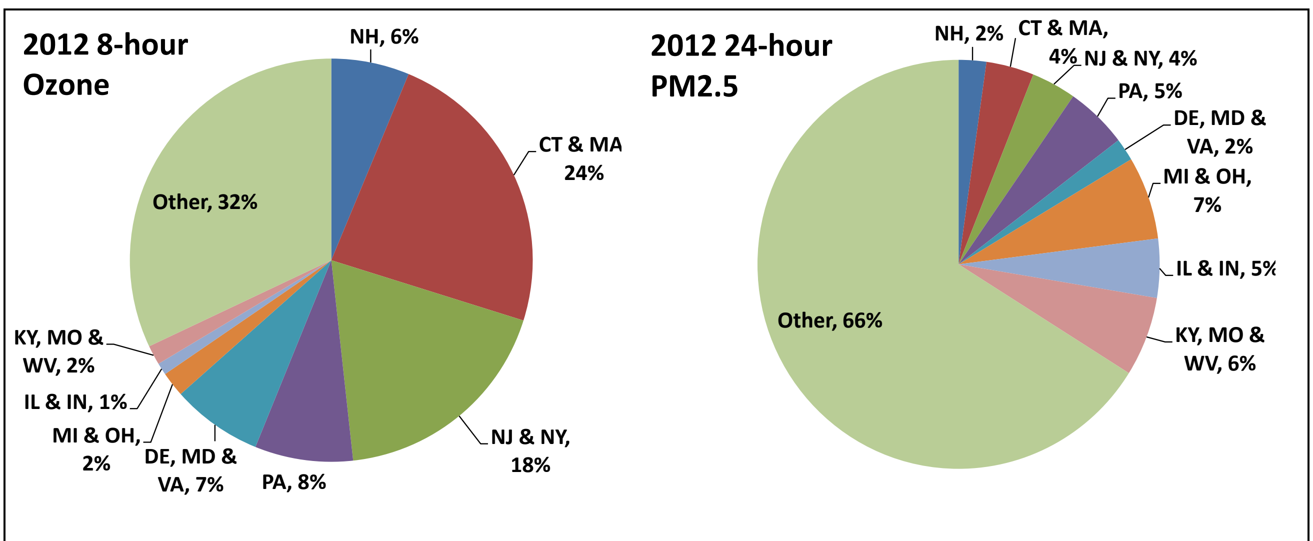
Figure 11: Synoptic Air Flow – Long-Range Transport Pattern



In order to address air pollution, it is important to understand where the pollution is coming from, which can be very challenging. Many air pollutants are localized: in other words, nearby emissions lead to locally high pollution concentrations. Carbon monoxide, lead, nitrogen dioxide, sulfur dioxide and many types of particulate matter and air toxics are considered local air pollutants. When local concentrations of one of these pollutants are high, then emissions reductions from nearby sources are usually sufficient to address the issue. However when concentrations of ozone or $PM_{2.5}$, or deposition of acid, nitrogen, or mercury are high, the cause might be local, distant, or both. Atmospheric chemistry and dispersion make it even more difficult to determine the origin of air pollution, and the longer an air pollutant stays in the air, the more chemistry and dispersion act on it. Dispersion normally lowers pollution concentration, however atmospheric chemistry can create other types of air pollution in downwind areas. Ozone and $PM_{2.5}$ are two such pollutants that can increase downwind of emission source areas.

Regional photochemical modeling analyses are designed specifically to consider ozone and $PM_{2.5}$ air pollution transport between states. One such analysis was conducted by EPA in 2009 for the Cross State Air Pollution Rule. At that time, EPA modeled interstate air pollution transport projections for the year 2012. Then in 2015, EPA updated its interstate ozone transport modeling to reflect a projected year of 2017. The findings of this EPA modeling, and other modeling analyses that have been conducted, are all fairly similar; over 90% of ozone on high ozone days in New Hampshire originates outside the state (range 91 to nearly 100%) and about 80% of $PM_{2.5}$ on most high $PM_{2.5}$ days originates outside the state (range 62 to 98%) (Figure 12). A similar range was reported for New Hampshire in the 2004 NHDES report; *Air Pollution Transport and How it Affects New Hampshire*, which used a slightly different methodology. It should be noted that there are wood smoke stagnation events that occur during colder months in some New Hampshire communities, especially Keene, that have strong local emission source causality.

Figure 12: Average Contribution of States to New Hampshire Air Quality Based on EPA CAMx Modeling (Percent -%)



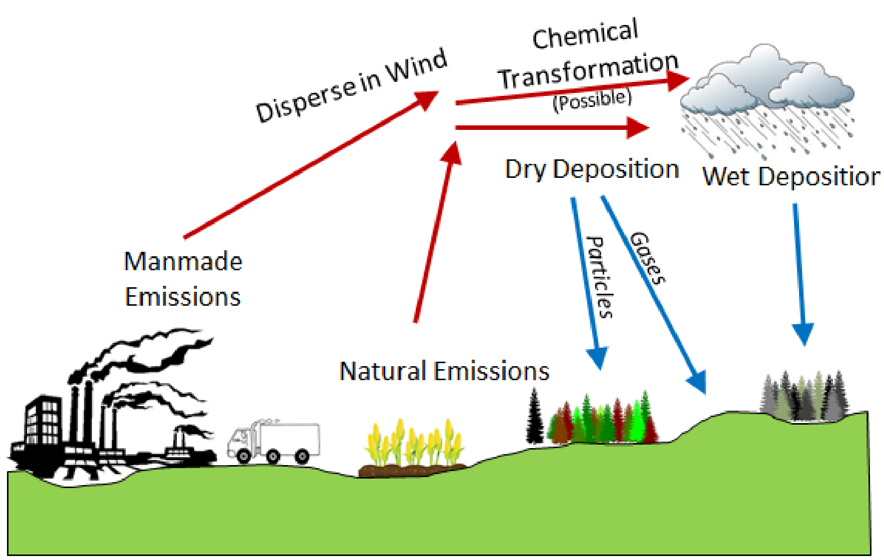
OTHER AIR POLLUTION CONCERNS

Air pollution is connected to other problems, such as acid rain (Figure 13), regional haze and climate change. Once released into the air, pollutants can undergo one or more physical processes. Usually the first of these is dispersion, where the pollution dilutes as it mixes with surrounding air. Often, air pollution becomes more dilute as it travels in the wind further and further from its release point. However, even as the pollution becomes more diluted, that does not mean that it is removed from the air or the environment. To be removed from the air, it must either deposit to the ground or chemically react into another air pollutant that cannot convert back to the original one. Some pollutants, such as volatile gases or larger particles have short airborne lifetimes before they react or fall to the ground. Other pollutants, such as freons and carbon dioxide (CO_2) can last in the air for decades. Air pollutants such as ozone, ammonium-based particles (which contribute to small particle pollution and regional haze formation) and acid rain are usually the result of chemical reactions of other air pollutants. All three have been problematic in New Hampshire for years. The longer an air pollutant stays in the air, the more widespread it can become. Residential wood smoke pollution is usually a very localized issue because of its short airborne lifetime. Ozone and small particle pollution lasts longer and can spread hundreds to thousands of miles. Freons and carbon dioxide last even longer and can be found in the atmosphere worldwide.

Deposition

Since the Acid Deposition provisions were added to the Clean Air Act in 1990, atmospheric deposition in New Hampshire is now about 10 times less acidic (one pH point higher) than it was in 1985, but more needs to be done. Figure 14 shows that precipitation measured at the NHDES offices in Concord is generally more acidic in the southern part of the state than at Hubbard Brook Experimental Forest, which is located in the northern part of the state (pH neutral is 7.0).

Figure 13: Air Pollution Fate and Transport

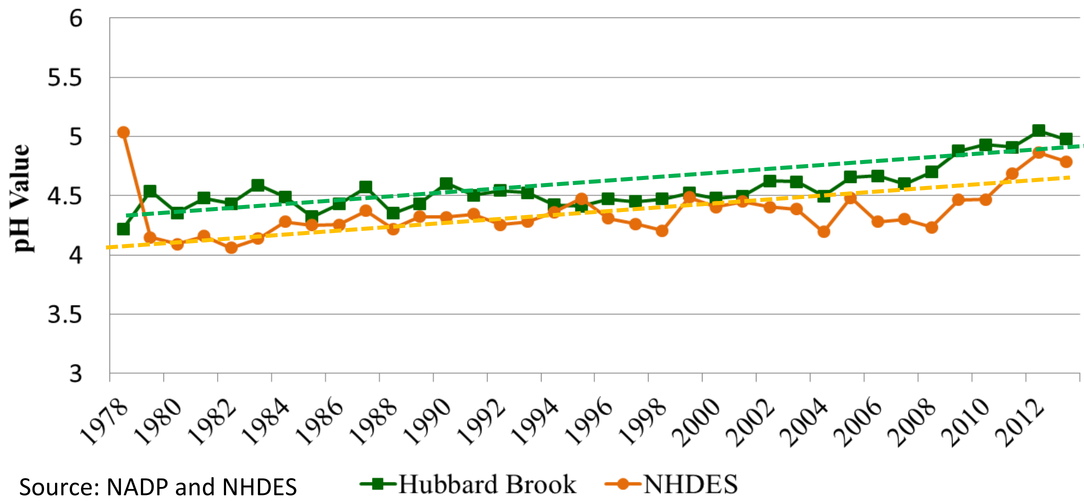


Acid rain falls in the form of nitric (HNO_3) and sulfuric (H_2SO_4) acids hundreds to thousands of miles downwind.

Source: NHDES

Recent analyses have found that air deposition of perfluorooctane sulfonate and perfluorooctanoic acid (PFOS and PFOA) compounds can be a significant source pathway to local drinking water contamination.

Figure 14: Annual Average pH Trends, 1978-2013

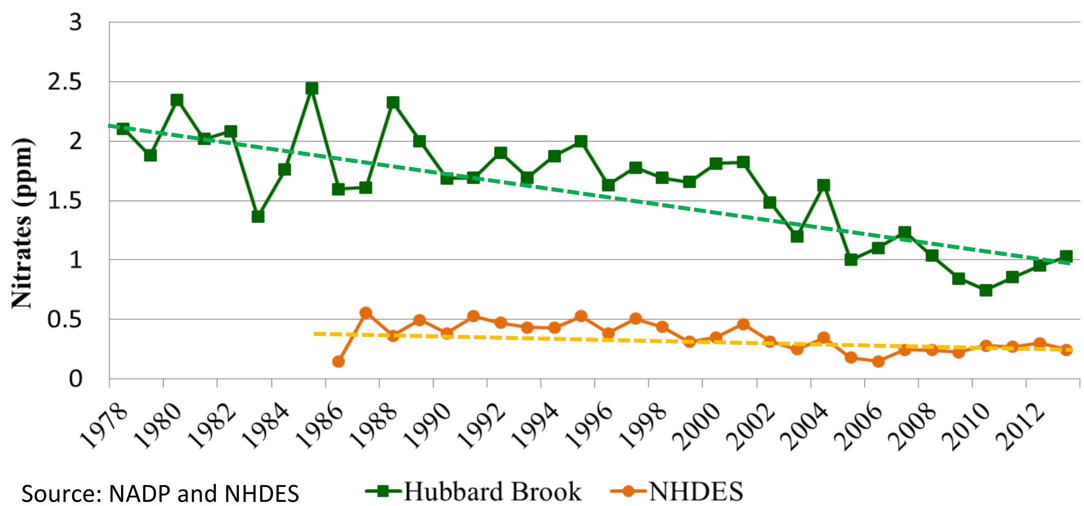


Source: NADP and NHDES

Note: Increasing pH means decreasing acidity.

Deposition of nitrogen is also decreasing in New Hampshire and is down by about 50% over the last 25 years (Figure 15). In this case, there is more nitrogen deposition measured at Hubbard Brook than in Concord, which might seem counter-intuitive when compared to acid deposition data. In this case, orographic effects of the northern mountains in New Hampshire cause extra precipitation delivering additional nitrogen.

Figure 15: Annual Average Nitrates, 1978-2012

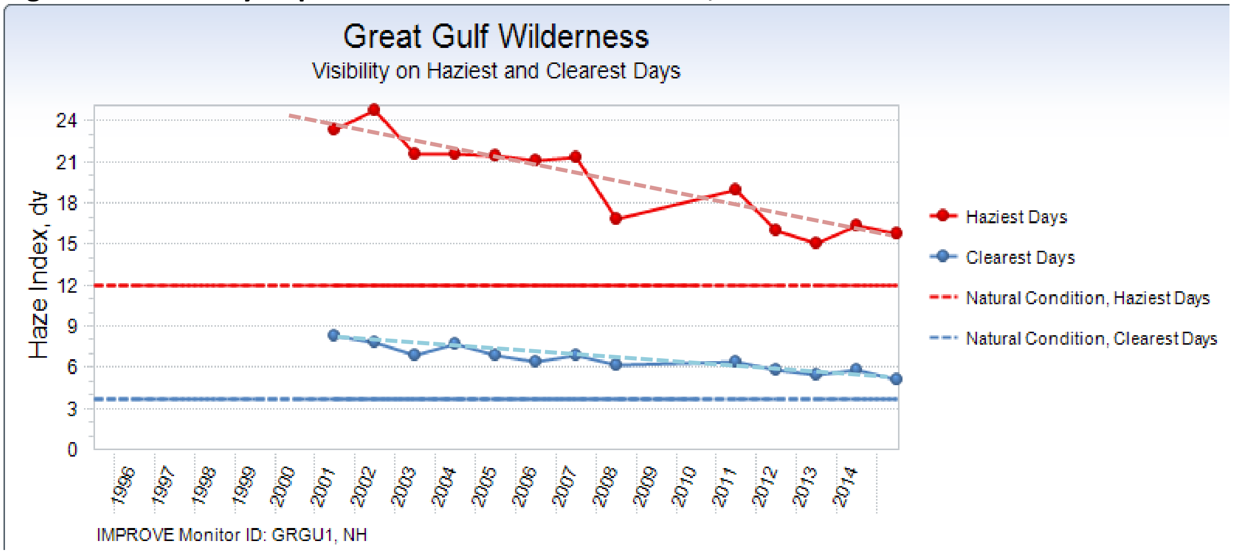


Source: NADP and NHDES

<u>*Regional Haze*</u>

The federal regional haze rule requires states to submit state implementation plans starting in 2008 and then every 10 years thereafter in order to achieve reasonable progress goals towards reaching natural visibility conditions at federally mandated Class I Areas by the year 2064. New Hampshire has two Class I Areas (Great Gulf and Presidential Range Dry Creek) located near Mt. Washington in northern New Hampshire. Monitoring in the area indicates that visibility is improving and that recent efforts to reduce air pollution levels have been working. Energy generation trends have helped the effort significantly. Lower natural gas prices and increasing use of clean, renewable energy sources have offset electricity generation from coal burning power plants. Figure 16 shows the Great Gulf Wilderness Area (near Mt. Washington) visibility improvement trend since 2001, where the lower the deciview (dv) level, the better the visibility.

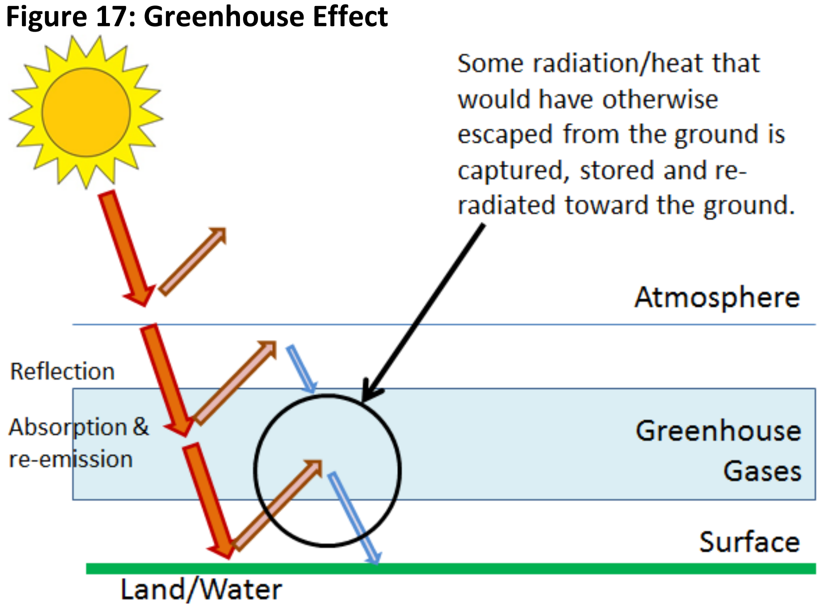
Figure 16: Visibility Improvement Trend at Great Gulf, NH



Climate Change

Other air pollutants of concern for New Hampshire include greenhouse gases. Greenhouse gases are a critical and necessary part of enabling life on Earth. Tiny percentages of the air, ranging from parts per trillion to parts per million of gases, enable the atmosphere to balance incoming and outgoing radiation from the sun. Greenhouse gases provide a blanket of sorts, trapping a portion of the heat rising from the ground before it can escape to space (Figure 17). Without it, days would be much hotter and nights much colder.

Figure 17: Greenhouse Effect



Source: NHDES

The most abundant greenhouse gas is carbon dioxide. Historical records over the past 500,000 years from ice core measurements demonstrate that concentrations of carbon dioxide varied between 180 and 300 parts per million. Since 1750, carbon dioxide levels have jumped significantly to over 400 parts per million in 2016. This increase, along with increases in other manmade greenhouse gas emissions, has made the earth's blanket to escaping heat about 30% more effective in trapping heat.

In April of 2007 (Massachusetts v. EPA, 549 U.S. 497 [2007]), the United States Supreme Court found that greenhouse gases are air pollutants covered by the Clean Air Act. The Court held that the EPA Administrator must determine whether or not emissions of greenhouse gases from new motor vehicles cause or contribute to air pollution which may reasonably be anticipated to endanger public health or welfare, or whether the science is too uncertain to make a reasoned decision. The EPA Administrator is required to follow the language of section 202(a) of the Clean Air Act. On April 17, 2009, the EPA Administrator signed a proposed "endangerment and cause or contribute" finding for greenhouse gases under Section 202(a) of the Clean Air Act. EPA reviewed, considered, and incorporated public comments prior to issuing final Findings in December 2009.

Environmental changes potentially related to climate change are being observed in New Hampshire. Some notable New Hampshire-centric observations include:

Primary Impacts

- Increases in annual & seasonal average temperature.
- Increases in the total amount and intensity of precipitation.
- Increases in extreme weather of all types.

Secondary Impacts:

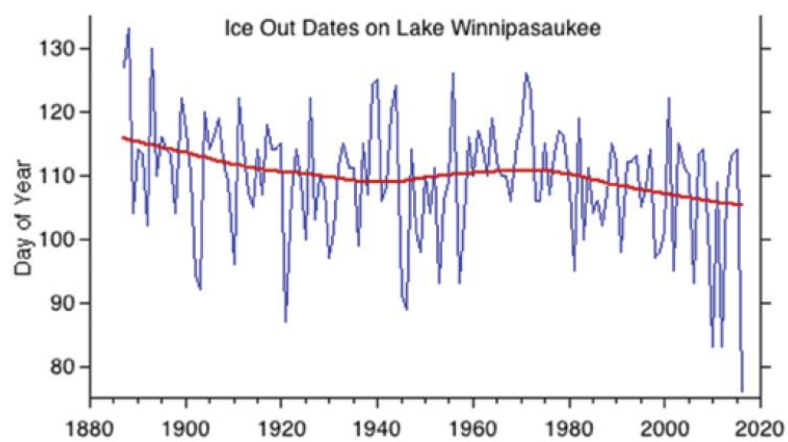
- Sea-level rise along the Seacoast.
- Later ice-in and earlier ice-out dates on New Hampshire lakes and ponds.
- Changes in garden hardiness zone maps.
- Increases in summer drought.
- Changes in maple syrup production.
- Changes in moose population.

Measurements taken by the National Weather Service in Concord, New Hampshire indicates that average temperatures have risen about 1.0°F in the 96 years since 1921. These changes didn't always appear as a steady trend. Instead, there is a lot of year to year fluctuation, but over longer durations, sustained patterns are evident. In some cases, changes appear more as surges between stable periods. During this 96-year period, the amount of cooling needed to maintain comfortable indoor summer-time temperatures increased about 25% and the amount of heating required to maintain comfortable cold weather season indoor temperatures decreased by about 2%.

Annual precipitation is also trending upward, as are the number of large precipitation events. National Weather Service data from Concord indicate that one inch (or more) precipitation events have increased in frequency from about 5.7 times per year in the early 1920s to about 8.8 per year in the mid-2010s. During the same period, three inch (or more) events have increased from about one every four years to one every three years.

These changes have resulted in slow changes to the New Hampshire way of life. For one, ice-out on Lake Winnipesaukee has been tracked in New Hampshire since the late 1800s and is considered a measure of how cold the New Hampshire winter was that year. Ice-out is called when ice in the lake has melted and cleared enough that the tour ship MS Mount Washington can make all of its ports of call on the lake. Figure 18 plots these data by year and provides a (red) best fit line to help determine if any trends exist. The blue line presents the actual ice-out data on a year-by-year basis, showing typical yearly variability, some years colder than others resulting in later ice-out dates. The long-term trend appearing is that lake ice-out dates in the 2010s are occurring 7 to 10 days sooner on average than 130 years earlier[2].

Figure 18: Ice-Out Dates on Lake Winnipesaukee, NH



Source: Climate Solutions New England

The sea level is also changing, having risen by 5.3 inches between 1926 and 2001 according to a boat launching gauge in the Portsmouth area. These gauges were never meant to measure sea level change, but they have proven to be valuable historical trending tools. A gauge located in Portland, Maine, shows a similar trend and has been in place even longer that the one in Portsmouth. The sea level rise in Portland was about 8.75 inches from 1912 to 2015.

When ambient air temperatures change, concentrations of other air pollutants change along with it. More cold weather brings more need for indoor heating. Home furnaces burn natural gas, oil, coal and wood, all of which produce their own mix of air pollutants. Normally cold weather is accompanied by winds that effectively disperse and dilute the pollutant emissions; however there are cases where calm winds and thermal inversions can trap pollution emissions.

More warm weather brings with it increased cooling needs which also increases the demand for electricity. Electric power plants that burn natural gas, oil or coal, increase their production and air pollution emissions. Heat waves lead to high electricity demand days and back-up generating units often start up and come online. Because these typically run less often than larger power plants, they often don't have the same state-of the art air pollution controls, and

[2]Hodgkins, G. A. (2010) Historical Ice-Out Dates for 29 Lakes in New England, 1807–2008. United States Geological Survey Open File Report 2010–1214. 38 p.

thus produce higher air pollution emissions. Emissions of all criteria air pollutants increase on hot days. Ozone, which is not directly emitted from sources, is created with a mixture of NOx and volatile organic compounds (VOCs) in the presence of sunlight and heat. When temperatures increase, the chemical reaction occurs faster, producing more ozone efficiently.

A changing climate due to an increased Greenhouse Effect produces not just a warmer planet (on average), but greater variability in weather patterns and extremes. Some locations on the earth have experienced more frequent and extreme heat waves than seen in past decades while other locations might be cooler than usual. Droughts and floods have been occurring at greater frequency, once again, occurring in some locations and not others. The non-uniformity of climate change is the result of a complex interaction between the Sun's energy and the oceans, land masses and frozen surfaces. Under stable conditions, this interaction leads to prevailing winds that generally blow from west to east in the northeastern United States, and ocean currents that generally flow northward along the eastern U.S. coastline. Long-term steady wind and current conditions have stabilized our climate to temperate levels with some moderate degrees of variability. However, an increased Greenhouse effect is making subtle changes to how the Earth reacts to the Sun's energy and as a result new airflow patterns are emerging. These changes have already been noted in prevailing air pollution emission and transport patterns in our region and in upwind states.

AIR POLLUTION REGULATIONS

Air pollution reduction requirements are implemented through a variety of federal and state air quality regulations and pollution control programs. As described in the following subsections and summarized in Table 4, some of these regulations and control programs are directed at **stationary sources**, including power plants and factories; others pertain to **mobile sources**, such as cars and trucks; some to **non-road sources** such as boats, trains, airplanes, and construction vehicles; and some cover **other source categories**.

These requirements have enabled New Hampshire to come into compliance with the National Ambient Air Quality Standards, and to maintain that compliance. They have also improved visibility throughout the state and reduced acid, nitrogen and mercury deposition, providing residents and visitors a cleaner and healthier environment. Once thought to be nearly impossible, having no exceedances of the health standards is closer than ever to being within reach.

Table 4: Air Pollution Requirement Quick Reference Guide

Sector	Requirement	Pollutant(s)[3]	Full Report Section
Stationary Point Smoke Stacks	1. New Source Review (NSR)		9.1.1
	a. Prevention of Significant Deterioration (PSD) Permit	Criteria	
	b. Nonattainment NSR Permit	Criteria	
(Power Plants & Industrial Sources)	c. Minor Source Permit	Criteria	
	2. Acid Rain Program	N, S	9.1.2
	3. EPA NOx Budget Trading Program	N	9.1.3
	4. Clean Air Interstate Rule (CAIR)	N, S	9.1.4
	5. Cross-State Air Pollution Rule (CSAPR)	N, S	9.1.5
	6. New Hampshire NOx Budget Program	N	9.1.6
	7. New Hampshire Clean Power Act	CO_2, M, N, S	9.1.7
	8. New Hampshire Air Toxics Control Program	T	9.1.8
	9. New Hampshire Open Market Programs	N, V	9.1.9
	10. Regulations Limiting Emissions		9.1.10
	a. New Source Performance Standards (NSPS)	Varies	
	b. Maximum Achievable Control Technology (MACT)		
	i. Mercury and Air Toxic Standards (MATS)	M, T	
	ii. Best Available Control Technology (BACT)	Criteria	
	iii. Lowest Available Emission Rate (LAER)	Criteria	
	iv. Reasonable Available Control Measures (RACM)	Criteria	
	v. Reasonably Available Control Technology (RACT)	Criteria	
	vi. BART	N, P, S	
Mobile Sources	1. Transportation Conformity	CO, N, P, V	9.2.1
	2. Diesel Emissions Reduction Act	CO, N, P	9.2.2
(On-Road Vehicles)	3. Granite State Clean Cities	F	9.2.3
	4. Enhanced Inspection and Maintenance	CO, N, V	9.2.4
	5. Emissions and Fuel Standards		9.2.5
	a. Corporate Average Fuel Economy Standards (CAFÉ)	F	
	b. Greenhouse Gas Standards	CO_2	
	c. Tier 3 Standards	N, S	
	d. Heavy Duty Vehicle Standards	N,P,S	
	6. Alternative Fuel Vehicles	Varies	9.2.6
Non-Road	1. Non-road Mobile and Portable Sources	C, N, P, T, V	9.3
Other Sources	1. General Conformity	Criteria	9.4.1
	2. OTC Model Rules	V	9.4.2
	3. Regional Haze Rule	N, P, S, V	9.4.3
	4. BART	N, P, S	9.1.10
	5. Other products may be regulated during manufacture for sales	Varies	

[3]**F**=Reduced fuel consumption **M**=mercury, **N**=NOx, **P**=PM ($PM_{2.5}$ and/or PM_{10}), **S**=SO_2,**T**=air toxics, **V**=VOC

CONCLUSION

In 2016 and 2017 New Hampshire was fortunate to enjoy a majority of good air quality days. Only six days saw some portion of the state exceed federal health standards for ozone (noting that to "exceed" the standard does not necessarily mean to "violate" the standard) and there were no instances where the other major air pollutants exceeded their respective health standards. This good news can be credited to nearly 30 years of research, regulation and air pollution control implementation in the United States. Air pollution concentrations in New Hampshire are down by 70 to over 90 percent from levels measured in the late 1970s and early 1980s.

New Hampshire air quality improvements have out-paced improvements seen in other portions of the country due to several factors:

1. New Hampshire lies in the downwind (northeastern) portion of the Ozone Transport Region (OTR), an area defined in the Clean Air Act as requiring strict air pollution regulation to lower the very high ozone levels found there. Because of this Clean Air Act classification, the OTR got a head start on reducing air pollution emissions and the OTR states learned how to effectively work together towards that goal.
2. Most states in the region are members of the Regional Greenhouse Gas Initiative (RGGI), which among other things has encouraged lower emitting electrical generation and more efficient electrical use. Both actions, when taken regionally, have benefited New Hampshire's air quality.
3. The federal acid rain program targeted emissions of large facilities in the coal burning regions of the Midwest and Northeast. Again, New Hampshire lies downwind of this region.
4. Upwind states cleaning up their own air to meet requirements benefit downwind states like New Hampshire.

Thanks to declining air pollution emissions in New Hampshire and in upwind states, New Hampshire met air pollution requirements in 2017 in all portions of the state for all six criteria pollutants. While the Central New Hampshire SO_2 nonattainment area is still in effect and an attainment plan SIP was recently submitted, the source emissions in the area have already been addressed and the region is now measuring "clean data" (air quality meeting the health standard). This area is expected to be redesignated to attainment soon.

Even though all areas of the state are currently meeting the health standards, some areas of the state still experience occasional Air Quality Action Days, or days when air quality forecasters predict that one or more air pollutants may exceed the level of the health standard. Because the federal standards consider duration of exposure to air pollution, individual days exceeding the standard do not necessarily result in violation of the standards. When Air Quality Action Days occur during spring or summer, they are usually the result of a regional air pollution event being transported into New Hampshire with the winds from upwind states. Air Quality Action Days in New Hampshire during the late fall and throughout the winter usually result from stagnation of local pollution emissions in valley communities.

Ozone and small particle air pollution in New Hampshire during 2011 was analyzed with a model that estimates health and economic impacts. Meeting federal health standards as required under the federal Clean Air Act is important for the protection of public health. It reduces physician and hospital visits, improves work and school attendance and productivity, and reduces air pollution related mortality. Ensuring current heath standards are met every day in New Hampshire is expected to provide almost $2 million in health valuation benefits beyond simply just meeting the standards (remember that compliance with a standard may still allow some days with unhealthy air pollution levels). Should the air quality in New Hampshire continue to get even cleaner, there will be additional health benefits and valuations. Modeling indicates estimated that over $3 billion in annual health impact valuations could be saved if concentrations of the two air pollutants were reduced to natural background levels throughout the state. Achieving natural background levels of air pollution may be an idealistic goal, but it is illustrative to how people continue to benefit from increasingly cleaner air down to very low air pollution concentrations.

The air quality outlook in New Hampshire over the next 10 years looks promising. We anticipate that air pollution trends will continue to improve in most cases throughout the state. Continued reductions of acid, nitrogen and mercury deposition should result in cleaner lakes and streams in the state and ultimately the removal of fish consumption advisories. Year to year weather variability, transport patterns, and the economic variability in fuel costs and consumption will likely cause some temporary increases, but long-term regulation and commitments promise continued improvement. Ultra-long-range transport from other countries along with the likelihood of increasing global temperatures presents concerns and creates uncertainty over the long-term, especially at higher elevations in the state, most indications are that New Hampshire will continue to benefit from increasingly cleaner and healthier air over the next decade.

COMMONLY USED ACRONYMS

AAL	Ambient Air Limits, a health based air limit
acf	actual cubic foot
AIM	Architectural and Industrial Maintenance
AQI	Air Quality Index
ARD	Air Resources Division
ASTM	American Society of Testing and Materials
BACT	Best Available Control Technology
BAM	Beta Attenuating Monitor
BART	Best Available Retrofit Technology
BEV	Battery Electric Vehicle
Btu	British thermal units
^{o}C	Degrees in Celsius (temperature)
CAA	Clean Air Act
CAFÉ	Corporate Average Fuel Economy
CAIR	Clean Air Interstate Rule
CAS	Chemical Abstracts Service
CASAC	Clean Air Science Advisory Committee
CCPTF	Climate Change Policy Task Force
CEMS	Continuous Emissions Monitoring System
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CH^4	Methane (a natural gas)
CNG	Compressed Natural Gas
CO	Carbon monoxide – a criteria pollutant
CO_2	Carbon Dioxide – a greenhouse gas
CPMS	Continuous Parameter Monitoring System
CSAPR	Cross State Air Pollution Rule
CTG	Control Technology Guidelines
DER	Discrete Emissions Reductions
DERA	Diesel Emissions Reduction Act
DSCFM	dry standard cubic feet per minute
EERS	Energy Efficiency Resource Standard
Env-A	New Hampshire Code of Administrative Rules - Air Resources Division
EPA	U.S. Environmental Protection Agency
ERC	Emission Reduction Credit
ETP	External temperature, temperature outside of the monitoring station
EV	Electric Vehicle
^{o}F	Degrees in Fahrenheit (temperature)
FCV or FCEV	Fuel Cell Electric Vehicle
ft	foot or feet (also f^2 – square feet, and f^3 – cubic feet)
gal	gallon
GHGs	Greenhouse Gases

GSCCC	Granite State Clean Cities Coalition
GWP	Global Warming Potential
H_2SO_4	Sulfuric Acid
H_2O	Water or water vapor
HAPS	Hazardous Air Pollutants, substances that are defined as hazardous
HCl	Hydrogen chloride
HEV	Hybrid Electric Vehicle
HFCs	Hydrofluorocarbons
Hg	Mercury
HNO_3	Nitric acid
hp	horsepower
hr	hour
^oK	Degrees in Kelvin (temperature)
LAER	Lowest Achievable Emission Rate
LLJ	Low Level Jet
LNG	Liquid Natural Gas
LPG	Liquefied Petroleum Gas
LPG	Liquid Propane Gas
m	Meter (also m^2 – square meter, and m^3 – cubic meter)
MACT	Maximum Achievable Control Technology
MATS	Mercury and Air Toxics Standards
MDE	Maryland Department of the Environment
MDN	Mercury Deposition Network
Me-Hg	Methyl mercury
MM	million
mmBTU	One million British Thermal Units – a measure of energy
MW	megawatt
NAAQS	National Ambient Air Quality Standard
NADP	National Acid Deposition Network
NASA	National Aeronautics and Space Administration
NCORE	National Core, an air monitoring network
NEG/ECP	New England Governors' and Eastern Canadian Premiers' Conference
NEPA	National Environmental Protection Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHDES	New Hampshire Department of Environmental Services
NHOST	New Hampshire OBD and Safety Testing
NOAA	National Oceanographic and Atmospheric Administration
NO_2	Nitrogen Dioxide – a criteria pollutant
N_2O	Nitrous Oxide (a greenhouse gas)
NOx	Nitrogen oxides of multiple oxidation levels – usually used as a measure of emissions
NOy	Total Reactive Nitrogen
NSPS	New Source Performance Standard
NSR	New Source Review
NYDEC	New York Department of Environmental Conservation
O_3	Ozone, a chemically reactive air pollutant – a criteria pollutant
OBD	On Board Diagnostics
OTAG	Ozone Transport Assessment Group
OTC	Ozone Transport Commission

OTR	Ozone Transport Region
OWB	Outdoor Wood Boiler – or hydronic heater
PACIS	Powdered Activated Carbon Injection System
PAMS	Photochemical Assessment Monitoring Station
Pb	Lead – a criteria pollutant
PCB	Polychlorinated Biphenyl
pDR	Personal DataRAM 1500 – portable particle monitor
PFCs	Perfluorinated chemicals
pH	A measure of acidity based on a logarithmic measure of free hydrogen atoms
PHEV	Plug-in Hybrid Electric Vehicles
PM	Particulate Matter
PM_{10}	Particulate Matter smaller than 10 microns in diameter – a criteria pollutant
$PM_{2.5}$	Particulate Matter smaller than 2.5 microns in diameter – a criteria pollutant
ppb	parts per billion, a measure of concentration (by volume for air pollutants)
ppm	parts per million, a measure of concentration (by volume for air pollutants)
ppmvd	parts per million dry volume
PSD	Prevention of Significant Deterioration
psig	pounds per square inch gauge
PSNH	Public Service of New Hampshire – An electric service provider now called Eversource
PV	Photo Voltaic
QA	Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RACM	Reasonably Available Control Measures
RACT	Reasonably Available Control Technology
REF	Renewable Energy Fund
RGGI	Regional Greenhouse Gas Initiative
RPS	Renewable Portfolio Standard
RSA	Revised Statutes Annotated
RTAP	Regulated Toxic Air Pollutant
s	second
scf	standard cubic foot
SDA	Spray Dryer Absorber
SIP	State Implementation Plan
SO_2	Sulfur Dioxide – a criteria pollutant
SOx	Sulfur oxides of multiple oxidation levels – usually used as a measure of emissions
tpy	tons per consecutive 12-month period
TSP	Total Suspended Particulate
TSU	Temporary Stationary Unit – a functional trailer for temporary air pollution monitoring
$\mu g/m^3$	Micrograms per cubic meter – a measure of concentration
USDA	United States Department of Agriculture
USG	Unhealthy for sensitive groups
UV	Ultraviolet (radiation), a type of light from the sun
VOCs	Volatile Organic Compounds