MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF AIR QUALITY

FIVE YEAR ASSESSMENT OF
MAINE'S AMBIENT AIR MONITORING NETWORK

December 1, 2015

Every five years, each state must prepare and submit to the United States Environmental Protection Agency (EPA) an assessment of its monitoring network which considers the following:

- Whether the network meets required monitoring objectives;
- Whether new sites are needed;
- Whether existing sites are no longer needed and can be terminated; and
- Whether any new technologies are appropriate for incorporation into the ambient air monitoring network.

The assessment must consider the following:

- The ability of existing and proposed sites to support air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma); and
- The effect on data users other than the agency itself for any sites that are being proposed for discontinuance.

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This following document is the current Five-Year Network Assessment for Maine. Comments were accepted until June 30, 2015. Comments could be submitted electronically or in hard copy to:

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Executive Summary

The ambient air monitoring network in the State of Maine meets required monitoring objectives as established by the EPA and the Clean Air Act. In evaluating the monitoring network, Department of Environmental Protection staff confirmed the ability of existing and proposed monitoring sites to support air quality characterization for the state and affirmed that if any sites were to be slated for discontinuance such action should have minimal or no effect on data users. The consideration criteria as specified in federal monitoring regulations are addressed in the following summary paragraphs for each monitored pollutant. More extensive discussion of Maine's monitoring network for each specified pollutant is contained in the body of this report.

Ozone Monitoring

The ozone monitoring network in Maine, which may be envisioned as having three tiers, covers the most populated regions of the State, and areas that are expected to experience the highest levels of ozone, as well as rural and sparsely populated areas. First-tier monitoring sites are strategically located throughout the southern and central coastal areas of Maine, one of the most densely populated and fastest growing regions in Maine over the last 20 years. The second tier ozone monitoring sites, located inland from the first tier and including the populous region along the downeast coastline, helps to establish and determine the attainment/nonattainment boundary and to inform forecasting efforts. The third tier ozone monitoring sites are in rural western and northern areas.

The ozone sites at Bowdoinham and Durham record very similar, possibly redundant, data. Maine plans to identify and install an ozone monitoring site closer to the Phippsburg/Georgetown area (Tier 1) and remove the Bowdoinham site (Tier 2) from service once the new Tier 1 site is established.

Maine is currently in the process of establishing a site in the Bethel area that is expected to better pick up springtime transported ozone and that site is expected to replace the North Lovell monitoring site.

No other new sites are needed, nor are other existing sites no longer needed. There are no new technologies available or appropriate for use in Maine's ozone monitoring network at this time.

Particulate Matter, Visibility/Speciation Monitoring

Particulate monitors in the state are located primarily in the most densely populated areas and in regions near sources of interest, or in regions with recorded exceedances of the standard in the distant past (the most recent exceedance occurring in 2006.) Other sites include those located to monitor for potential wintertime wood combustion impacts. Although there are no new sites needed to meet required monitoring objectives, the Maine DEP is currently in the process of establishing a continuous recording particulate monitor at a site in Carrabassett, Maine, a valley location with a significant number of nearby or impacting wood burning sources. At this time, there are no existing sites slated for closure and no new technologies appropriate for incorporation into Maine's particulate monitoring network.

The visibility/speciation monitoring network meets the monitoring requirements for all three Class I areas in and near Maine. Currently, the EPA is considering the defunding of two visibility/speciation monitoring sites, which may result in operations at these sites ceasing by January 1, 2016. Maine will explore other funding sources to keep the sites in operation.

Carbon Monoxide Monitoring

Carbon monoxide is currently monitored at three locations in Maine. Based on the historically low concentrations monitored to date, the only required CO monitors in the State are the monitor in Acadia National Park and the urban monitor in Portland to support the licensing program. The Micmac tribe operates the other site. The currently operated monitors meet monitoring requirements. At this time, there are no new sites needed, no sites deemed unnecessary, and no new technologies appropriate for incorporation into Maine's CO monitoring network.

Sulfur Dioxide Monitoring

There are currently five SO_2 monitoring sites in Maine. Of these five sites, only the NCORE site in Acadia National Park is required to meet mandated monitoring objectives for the State as established by the EPA. Two others (Gardiner and Portland) are operated to provide data in support of the licensing program. A special purpose site in Eliot is operated in conjunction with the New Hampshire Department of Environmental Services at the request of the EPA until April 2016, and the Micmac tribe operates one. At this time, there are no new sites needed, no unnecessary sites, and no new technologies appropriate for incorporation into Maine's SO_2 monitoring network.

Nitrogen Dioxide Monitoring

There are currently five sites in Maine where monitoring is conducted for nitrogen dioxide (NO_2) and reactive oxides of nitrogen (NO_y). The established monitoring sites meet the required monitoring objectives, and at this time, there are no new sites needed, no existing sites no longer needed, and no new technologies appropriate for incorporation into Maine's NO_2 monitoring network.

Lead Monitoring

Maine does not monitor for lead. National monitoring data indicates no lead (Pb) monitoring sites in Maine are necessary. EPA lead monitoring is required only at urban National Core (NCore) Multipollutant Network sites and the Acadia National Park NCore site is designated as a rural site. There is no anticipated lead monitoring requirement in Maine.

Hazardous Air Pollutants Monitoring

Maine samples year-round at many sites throughout the state for a suite of hazardous air pollutants. This ambitious program, constituting a major portion of the ambient air monitoring program, along with the other monitoring required in 40 CFR Part 58, *Ambient Air Quality Surveillance*, helps to increase our understanding of total air quality trends in the region and state. The main basis for selection of the pollutants monitored is an analysis of cancer risk factors associated with compounds listed in the recent National Air Toxics Assessment results, but monitoring is also constrained by the sampling technology available. Maine's target pollutants include some of the most prevalent combustion by-products, such as benzene, toluene, ethylbenzene, and certain xylenes, as well as ozone precursor compounds. Hazardous air pollutant monitoring provides background and baseline data for the pollutants monitored, a means to assess long-range transport from

outside Maine and, for sites located upwind of emission sources in the State, assessment of pollution loads from in-state sources.

Atmospheric Deposition Monitoring

Maine operates monitors as part of the National Atmospheric Deposition Program's National Trends Network and the Mercury Deposition Network. While these monitors are not required under 40 CFR Part 58, the monitors within Maine are part of a nationwide program of approximately 250 other identical monitors, all operating with the same quality assurance protocols, geared toward understanding and addressing the national problem of acidic and mercury contamination of managed and natural ecosystems and cultural resources.

Regulatory Background

Five-Year Monitoring Assessment

Section 58.10(d) of Title 40 of the Code of Federal Regulations (40 CFR §58.10(d)) requires each state to prepare and submit to the U.S. Environmental Protection Agency (EPA) an assessment of its ambient air monitoring network once every five years. The second of these five-year assessments is to be submitted to EPA by July 1, 2015. In the five-year assessment, the State must determine the following:

- Whether the network meets required monitoring objectives;
- Whether new sites are needed;
- Whether existing sites are no longer needed and can be terminated; and
- Whether any new technologies are appropriate for incorporation into the ambient air monitoring network.

The assessment must also consider the following:

- The ability of existing and proposed sites to support air quality characterization for areas with relatively high populations of susceptible individuals (e.g., children with asthma); and
- The effect on data users other than the agency itself for any sites that are being proposed for discontinuance.

This document serves as Maine's second Five-Year Ambient Air Monitoring Network Assessment. The conclusions of this assessment are that Maine's ambient air monitoring network meets required monitoring objectives, except as noted and explained in the specific sections of this report no new sites are needed and existing sites shall be maintained, and no new technologies are appropriate for incorporation at this time.

National Ambient Air Quality Standards (NAAQS)

The Clean Air Act (CAA) (http://epa.gov/air/caa/), last amended in 1990, and 40 CFR Part 50, *National Primary and Secondary Ambient Air Quality Standards,* require the EPA to set National Ambient Air Quality Standards (NAAQS) for pollutants considered harmful to public health and the environment (http://www.epa.gov/ttn/naaqs/). The CAA established two types of national ambient air quality standards: primary standards to protect public health, including the health of sensitive populations such as asthmatics, children, and the elderly; and secondary standards to protect public welfare, including protection against decreased visibility and against damage to animals, crops, vegetation, and buildings.

The EPA Office of Air Quality Planning and Standards (OAQPS) has set NAAQS for six principal pollutants, called "criteria" pollutants, as given in the following table. Maine Ambient Air Quality Standards are identical to the NAAQS, as enacted in 38 M.R.S.A.§584-A. Units of measure for the standards are as follows:

µg/m^3 = micrograms per cubic meter of air
mg/m^3 = milligrams per cubic meter of air
ppm = parts per million by volume
ppb = parts per billion by volume

National Ambient Air Quality Standards					
Pollutant		**Type of Standard**	**Averaging Time**	**Standard**	**Applicable Caveats**
Carbon Monoxide (CO) [76 FR 54294, Aug 31, 2011]		Primary	8-hour	9 ppm	Not to be exceeded more than once per year
			1-hour	35 ppm	
Lead (Pb) [73 FR 66964, Nov 12, 2008]		Primary and Secondary	Rolling 3-month average	0.15µg/m^3 [1]	Not to be exceeded
Nitrogen Dioxide (NO_2) [75 FR 6474, Feb 9, 2010] [61 FR 52852, Oct 8, 1996]		Primary	1-hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Primary and Secondary	Annual	53 ppb [2]	Annual Mean
Ozone [80 FR 65292, Oct 26, 2015]		Primary and Secondary	8-hour	0.070 ppm	Annual fourth-highest daily maximum 8-hr concentration, averaged over 3 years
Particulate Matter (PM) [78 FR 3086, Jan 15, 2013]	$PM_{2.5}$	Primary	Annual	12 µg/m^3	Annual mean, averaged over 3 years
		Secondary	Annual	15 µg/m^3	Annual mean, averaged over 3 years
	PM_{10}	Primary and Secondary	24-hour	35 µg/m^3	98th percentile, averaged over 3 years
		Primary and Secondary	24-hour	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2) [75 FR 35520, Jun 22, 2010]		Primary	1-hour	75 ppb [3]	99th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Secondary	3-hour	0.5 ppm	Not to be exceeded more than once per year

[1] Final rule signed October 15, 2008. The 1978 lead standard (1.5 µg/m3 as a quarterly average) remains in effect until one year after an area is designated for the 2008 standard, except that in areas designated nonattainment for the 1978, the 1978 standard remains in effect until implementation plans to attain or maintain the 2008 standard are approved.

[2] The official level of the annual NO_2 standard is 0.053 ppm, equal to 53 ppb, which is shown here for the purpose of clearer comparison to the 1-hour standard.

[3] Final rule signed June 2, 2010. The 1971 annual and 24-hour SO_2 standards were revoked in that same rulemaking. However, these standards remain in effect until one year after an area is designated for the 2010 standard, except in areas designated nonattainment for the 1971 standards, where the 1971 standards remain in effect until implementation plans to attain or maintain the 2010 standard are approved.

Maine's Monitoring Network: Background and Overview

The Maine Department of Environmental Protection (the Department or DEP), in conjunction with Maine tribes and the EPA, operates a network of air monitoring stations which measure ambient concentrations of specific pollutants for which the EPA has established National Ambient Air Quality Standards (NAAQS). Those pollutants include ozone (O_3), particulate matter smaller than 10 microns (PM_{10}), fine particulate matter smaller than 2.5 microns ($PM_{2.5}$), nitrogen dioxide (NO_2) sulfur dioxide (SO_2), carbon monoxide (CO), and lead (Pb). The criteria pollutant monitoring sites are part of the EPA's State or Local Air Monitoring Stations (SLAMS) network.

The majority of Maine's air monitoring is located in or near Maine's population centers, primarily along the coast in the south and south-central region of the State. Maine's northeast location in the continental United States and the prevailing air flow pattern make Maine particularly vulnerable to pollution generated elsewhere along the eastern U.S. seaboard, central U.S., and eastern Canada. Many pollutants, including ozone and its precursors, air toxics, heavy metals, and particulates which includes sulfates, nitrates, and organic compounds, are being transported into Maine's ambient air from upwind emissions sources. The following paragraphs describe specific public health and welfare concerns pertaining to specific monitored pollutants.

Ozone and Ozone Precursor Pollutants

Motor vehicle exhaust, industrial emissions, gasoline vapors, chemical solvents, and natural sources emit NO_x and VOC that contribute to ozone formation. Ground-level ozone has been associated with a variety of health problems including chest pain, coughing, and congestion, and the exacerbation of symptoms of bronchitis, emphysema, and asthma. Inhalation of ground-level ozone also can reduce lung function, inflame the linings of the lungs, and may permanently scar lung tissue.

Particle Pollution

Particle pollution, especially the fine particles ($PM_{2.5}$), has been linked to a variety of ailments including irritation of respiratory airways, coughing, or difficulty breathing; decreased lung function; aggravated asthma; development of chronic bronchitis; irregular heartbeat; and nonfatal heart attacks.

Fine particle pollution (sulfates, organic matter, nitrates, elemental carbon and soil dust) is the primary cause of reduced visibility (haze) in scenic areas such as national parks and wilderness areas and of regional haze (visibility degradation). Particle pollution can also stain and damage stone and other materials, including culturally important objects such as statues and monuments.

Particles can be carried over long distances by wind and then settle on ground or water. Effects of this settling include the following: increasing the acidity of lakes and streams; changing the nutrient balance in coastal waters and large river basins; depleting nutrients in soil; damaging sensitive forests and farm crops; and affecting the diversity of ecosystems.

Carbon Monoxide
Carbon monoxide (CO) is a colorless and odorless gas which is a byproduct of incomplete combustion of carbon based fuels. When inhaled, CO reacts with hemoglobin in the blood, preventing uptake and transportation of oxygen. Most health effects directly associated with CO are likely due to decreases in oxygen delivery to vital organs such as the heart and brain. People with cardiovascular disease such as angina and people with asthma, emphysema, and other lung diseases which limit efficient use of inhaled oxygen may be especially sensitive to the effects of CO inhalation.[4]

Sulfur Dioxide
Sulfur dioxide (SO_2) is a colorless, irritating gas. It is emitted mainly from stationary sources that utilize fossil fuels (coal, oil) such as power plants, ore smelters, and refineries. SO_2 is severely irritating to the eyes, mucous membranes, skin, and respiratory tract and can trigger bronchospasms, pulmonary edemas, pneumonitis, and acute airway obstruction. Inhalation at very low concentrations can aggravate chronic pulmonary diseases. Respiratory irritation from SO_2 can induce symptoms such as sneezing, sore throat, wheezing, shortness of breath, chest tightness, and a feeling of suffocation.[5]

Nitrogen Dioxide
Nitrogen dioxide (NO_2) can irritate the lungs and lower resistance to respiratory infections such as influenza. Continued or frequent exposure to higher NO_2 concentrations is associated with increased incidences of acute respiratory illness in children. NO_2 has also been identified as contributing to ozone formation and to the formation of acid rain.[6]

Lead
Once taken into the body via inhalation or ingestion, lead distributes throughout the body and accumulates in the bones. Depending on the level of exposure, lead can adversely affect the nervous system, kidney function, immune system, reproductive and developmental systems, and the cardiovascular system. Lead exposure also affects the oxygen carrying capacity of the blood. Lead effects most commonly encountered are neurological effects in children and cardiovascular effects in adults.[7]

In addition, to better understand potential public health and welfare impacts from airborne pollutants, the Department, Maine tribes, and the EPA monitor ambient levels in Maine of toxic air pollutants and of ozone precursors (substances that react in the atmosphere to form ground-level ozone), and conduct atmospheric deposition monitoring of mercury and ions contributing to acidic precipitation. Each of these is discussed in more detail in this report.

Maine Specific Health Impact Evaluations

Federal regulation 40 CFR §58.20(d) specifies that five-year assessments must include an evaluation of whether changes in the distribution of population within the State warrant

[4] http://www.capcoa.org/health-effects/#AIR_QUALITY_GUIDE_FOR_CARBON_MONOXIDE
[5] http://www.atsdr.cdc.gov/mmg/mmg.asp?id=249&tid=46
[6] World Health Organization/Europe, at http://www.euro.who.int/__data/assets/pdf_file/0017/123083/AQG2ndEd_7_1nitrogendioxide.pdf
[7] http://www3.epa.gov/airquality/lead/health.html

changes in the location of population-oriented monitoring sites. Based on U.S. census records from 2000 and 2010 and as shown in Figure 1, the populations in Cumberland and York Counties in southern Maine have realized considerable growth over the last 15 years, Aroostook County population has shown a fairly steady decline, and the populations of the rest of the counties in the State have remained relatively consistent. Overall, the State showed a 4.1% increase in population from 2000 to 2010, with a gain of over 52,000 residents. Over half of that population increase has been in Cumberland and York Counties.

Data for Maine's population age 19 and younger, and Maine's population age 65 and older, groups considered more sensitive to air pollution, shows trends different than overall population trends, as depicted in Figures 2 and 3. The State's population younger than 19 years old has decreased since 2000, a trend expected to continue at similar rates into the future. The State's population age 65 and older has been steadily increasing, and this rate of change is projected to increase as the present population ages and more retirees choose to live in Maine.

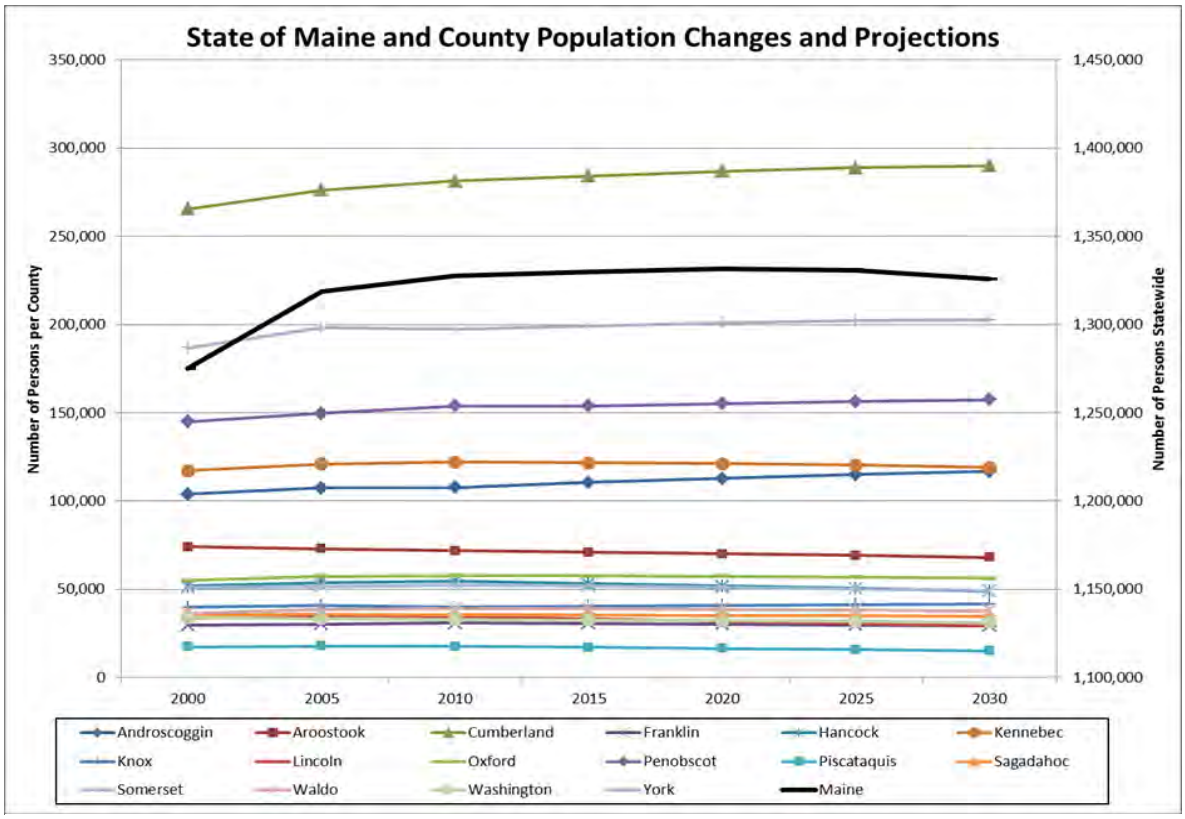

Figure 1: Maine State and County Population Changes and Projections

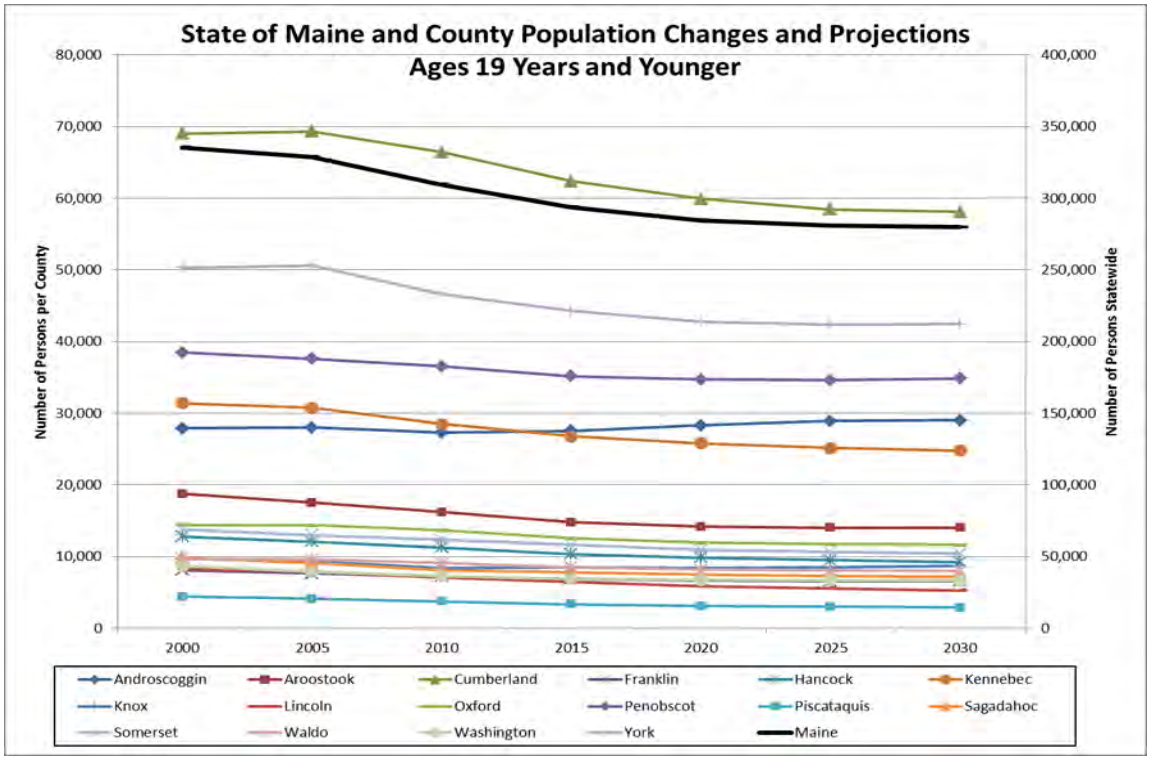

Figure 2: Maine State and County Population Changes and Projections, Ages 19 and Younger

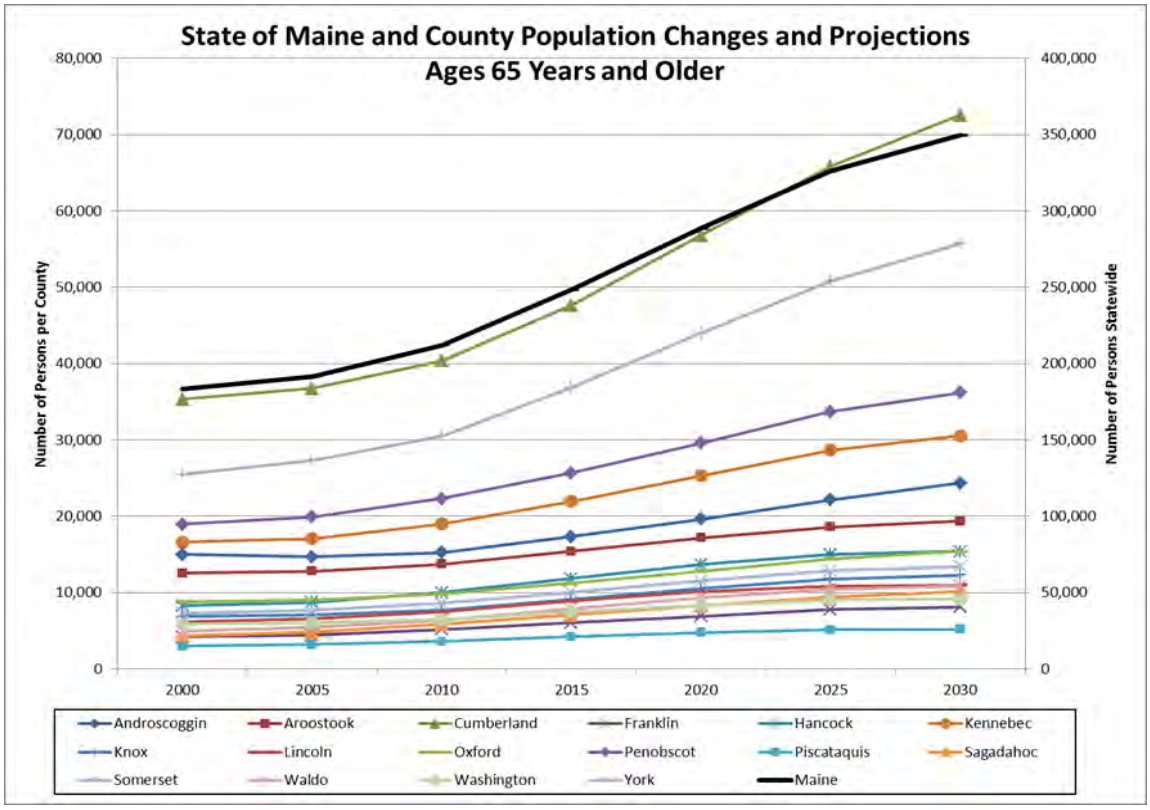

Figure 3: Maine State and County Population Changes and Projection, Ages 65 and Older

Health data was analyzed to identify areas in the State with higher concentrations of sensitive populations, recognized by higher-than-average percentages of children with asthma, incidence of heart attacks, and infants born with low birth weights. These conclusions were then used to evaluate whether or not the State's ambient air monitoring network adequately characterizes air quality in these areas.

Asthma

According to the Maine Center for Disease Control & Prevention (Maine CDC), Maine has some of the highest rates of asthma in the U.S. Data from the 2013 National Health Interview Survey shows approximately 11.9% of Maine adults with asthma, compared to 7.0% of adults in the U.S. with asthma.[8] The percentage of Maine children with asthma (8.5%) is similar to the percentage among U.S. children (8.4%).[9] Asthma-related visits to emergency departments vary throughout the State, with a high of 105.6 visits per 10,000 people in the Aroostook public health district compared to a low of 56.4 per 10,000 in the Cumberland public health district.[10]

Asthma, a chronic inflammatory disease of the airways, can be aggravated by exposures to certain substances such as microbes, allergens, airborne particle pollution, and ozone. Maintenance of the network of ozone and particulate monitors in Maine to inform accurate forecasts of air quality is important so that those with asthma can know to limit their activity during periods when high levels of ozone and/or particulates are forecast.

Heart Disease

Heart disease is the leading cause of death in the United States and second only to cancer as the leading cause of death in Maine.[11,12] According to the American Heart Association, worldwide epidemiological studies have demonstrated consistent associations between short-term elevations in PM and increases in daily cardiovascular morbidity and mortality, particularly within certain at-risk subsets of the population. Studies have also reported adverse cardiovascular outcomes in relation to long-term PM exposure, even after adjustment for a variety of individual-level risk factors such as tobacco smoking (including exposure to second hand smoke), gender, body mass index, educational attainment, occupational exposures, hypertension, and diabetes.[13] In Maine, the counties of Washington, Aroostook, Penobscot, and Piscataquis have higher rates of heart attacks than other Maine counties.[14]

Low Birth Weights

A body of evidence is emerging from several countries on the adverse consequences of ambient air pollution on fetal/birth outcomes, including pre-term birth and fetal growth

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[8] Most Recent Asthma Data. (2015, April 23). National Center for Environmental Health. http://www.cdc.gov/asthma/most_recent_data.htm.

[9] Maine Asthma Prevention and Control Program – Statewide Fact Sheet (2013). http://www.maine.gov/dhhs/mecdc/population-health/mat/information-and-publications/fact-sheets.htm

[10] Maine Asthma Prevention and Control Program – Statewide Fact Sheet (2013). http://www.maine.gov/dhhs/mecdc/population-health/mat/information-and-publications/fact-sheets.htm

[11] http://www.medicalnewstoday.com/articles/282929.php

[12] From CDC 1999-2013 data: http://www.worldlifeexpectancy.com/usa/maine-heart-disease

[13] Air Pollution and Cardiovascular Disease. (2015). AHA Scientific Statement from the American Heart Association, Inc. http://circ.ahajournals.org/content/109/21/2655.full#content-block

[14] From CDC 1999-2013 data: http://www.worldlifeexpectancy.com/usa/maine-heart-disease

restriction.[15] The percent of low birth weight rates in Maine is lower than the New England rate, and that is lower than the national average. Many other factors also influence birth weights; thus, establishing any link to air pollution in Maine may be very difficult.

The table in Figure 4 presents a collection of these at-risk population statistics, by county. Analysis of Maine's population information shows that monitors in the State's monitoring network are located appropriately, and further changes in the location of monitors are not warranted at this time.

At Risk Population Statistics by County

	Myocardial Infarction Hospitalizations (age-adjusted per 10,000) [2008]	Asthma Hospitalizations (age adjusted per 10,000) [2006-2010 combined]	Asthma Emergency Department Visits (age-adjusted rate per 10,000) [2010]	Adults with Asthma, percent [Maine data 2006-2010 combined; NE & US data 2008]	Low Birth Weight <2500 grams, percent of live births [2012]	0-19 YRS (2015 estimate)	% of County Population	65 YRS and older (2015 estimate)	% of County Population
Androscoggin	43.1	10.9	74.6	11.1	8.3	27,544	24.9	17,322	15.7
Aroostook	88.5	10.3	114.0	9.7	9.7	14,767	20.8	15,371	21.7
Cumberland	30.6	6.0	53.2	9.1	6.9	62,358	21.9	47,636	16.8
Franklin	49.8	10.6	60.3	9.0	8.2	6,883	22.6	6,015	19.7
Hancock	66.7	8.2	64.1	10.6	6.0	10,344	19.5	11,835	22.3
Kennebec	63.4	6.7	65.8	11.0	6.6	26,756	22.0	21,940	18.0
Knox	48.7	8.7	63.0	9.8	6.3	8,453	21.0	9,069	22.5
Lincoln	33.0	6.2	50.6	7.9	5.5	6,465	19.5	8,877	26.8
Oxford	38.7	8.5	69.7	10.4	6.3	12,528	21.8	11,204	19.5
Penobscot	61.7	10.7	54.9	12.9	6.9	35,179	22.9	25,634	16.7
Piscataquis	75.8	5.9	66.3	12.1	3.8	3,343	19.7	4,193	24.7
Sagadahoc	28.8	8.6	46.0	8.8	4.0	7,758	22.1	7,019	20.0
Somerset	61.8	8.0	92.9	10.5	4.8	11,602	22.5	10,025	19.4
Waldo	64.4	7.6	53.7	10.9	6.3	8,496	21.9	7,868	20.3
Washington	83.0	9.1	122.5	12.0	4.6	6,889	21.2	7,490	23.1
York	41.8	5.6	59.8	8.8	5.8	44,320	22.2	36,859	18.5
Maine	50.3	7.8	65.1	10.2	6.7	293,685	22.1	248,358	18.7
New England				9.7	7.5				
US				8.8	8.0				

Heart Attack Data: Data downloaded from the Maine Tracking Network data portal - Original source: Maine Health Data Organization (MHDO)
Asthma Data: Data dowloaded from the Maine Tracking Network data portal - Original source: Maine Health Data Organization (MHDO)
Low Birth Weight rate data: 2012; The Office of Data, Research, and Vital Statistics , Div. Public Health Systems, MECDC, Maine DHHS provided the data.
Population data provded by the Maine Office of Policy and Management, from US Census Data.
New England asthma rate from Living with Asthma in New England - Asthma Regional Council of New England, February 2010

Figure 4: Maine At-Risk Population Statistics by County

Maine's Criteria Pollutants Monitoring Network Evaluation

The following sections present the evaluation of these considerations, by pollutant:

- The current monitoring network;
- The NAAQS and a comparison of recent measurements with the NAAQS;
- Trends in pollutant levels measured;
- Whether the network meets the EPA's monitoring criteria;

[15] DQ Rich, et al, 2009, "Ambient air pollutant concentrations during pregnancy and the risk of fetal growth restriction," Journal of Epidemiology and Community Health, Vol. 63, pp. 488-496

- Whether new sites are needed;
- Whether any existing sites are no longer needed;
- Whether new monitoring technologies are available that should be adopted;
- Whether the current network adequately characterizes air quality in the State; and
- Plans for modification of the network in the future.

Ozone (O_3)

Ozone **(**O_3), a gas at ambient conditions, is considered either "good" or "bad" depending on its location in the atmosphere. "Good" ozone is found in the stratosphere approximately 10 to 30 miles above the earth's surface in a layer where the presence of ozone serves to protect the earth from the sun's harmful ultraviolet rays. Ground-level ozone has detrimental effects both on human health and on vegetation and is therefore considered "bad" ozone. Ozone is not usually emitted from sources as a pollutant directly into the air. At ground level, ozone is formed by a reaction between oxides of nitrogen (NO_x) and volatile organic compounds (VOC) in the presence of sunlight. Sunlight and hot weather facilitate ground-level ozone formation in potentially harmful concentrations; as a result, ozone is known as a summertime air pollutant.

Under the authority of the Clean Air Act, the EPA has set protective health-based standards for ozone in the ambient air to protect both public health and the public welfare (e.g., crops and vegetation). The 2008 NAAQS for ozone was the three-year average of the fourth-high maximum daily eight-hour average not to exceed 0.075 parts per million (ppm). On October 1, 2015, the EPA revised the ozone NAAQS standard to 0.070 ppm (effective December 28, 2015). Plots indicating the current and historical NAAQS status at several sites in Maine are shown in Figure 5. All monitoring sites in Maine are currently showing attainment of both the 2008 and the 2015 ozone NAAQS as has been documented and have continued to be in attainment for every three-year period starting with 2003-2005. Initial designations for the revised standard will use 2014-2016 data.

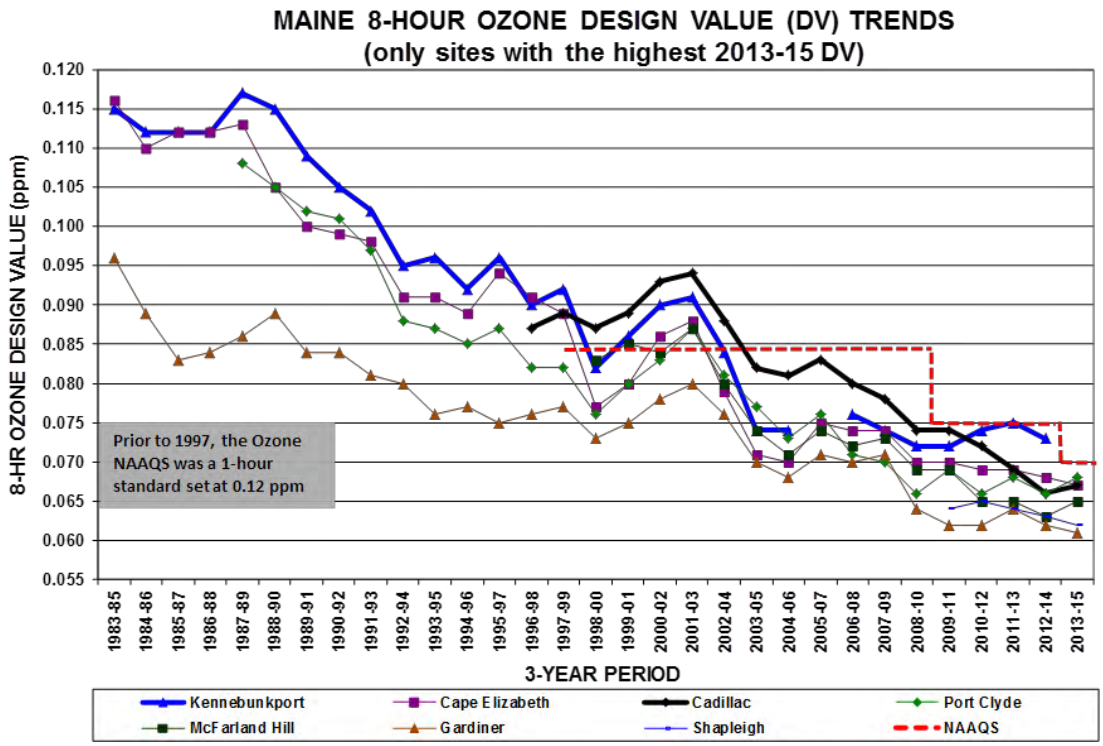


Figure 5: Maine 8-Hour Ozone Design Value Trends

Though it is more likely for urban areas to have high levels of ozone, rural areas in Maine are also subject to increased ozone levels because prevailing winds carry ozone and its precursor pollutants hundreds of miles from their original sources. Figure 6 illustrates an analysis of air masses containing high levels of ozone pollution (all monitored 2011-2013 exceedances of the 75 ppb 8-hour ozone level in Maine) which were tracked backwards based on wind direction and speed to determine where that air mass may have come from, and subsequently identify possible sources of emissions resulting in the monitored high ozone levels. The back trajectories in the figure indicate areas that most likely contributed to the monitored 2011-2013 exceedances of the 75 ppb 8-hour ozone level in Maine.

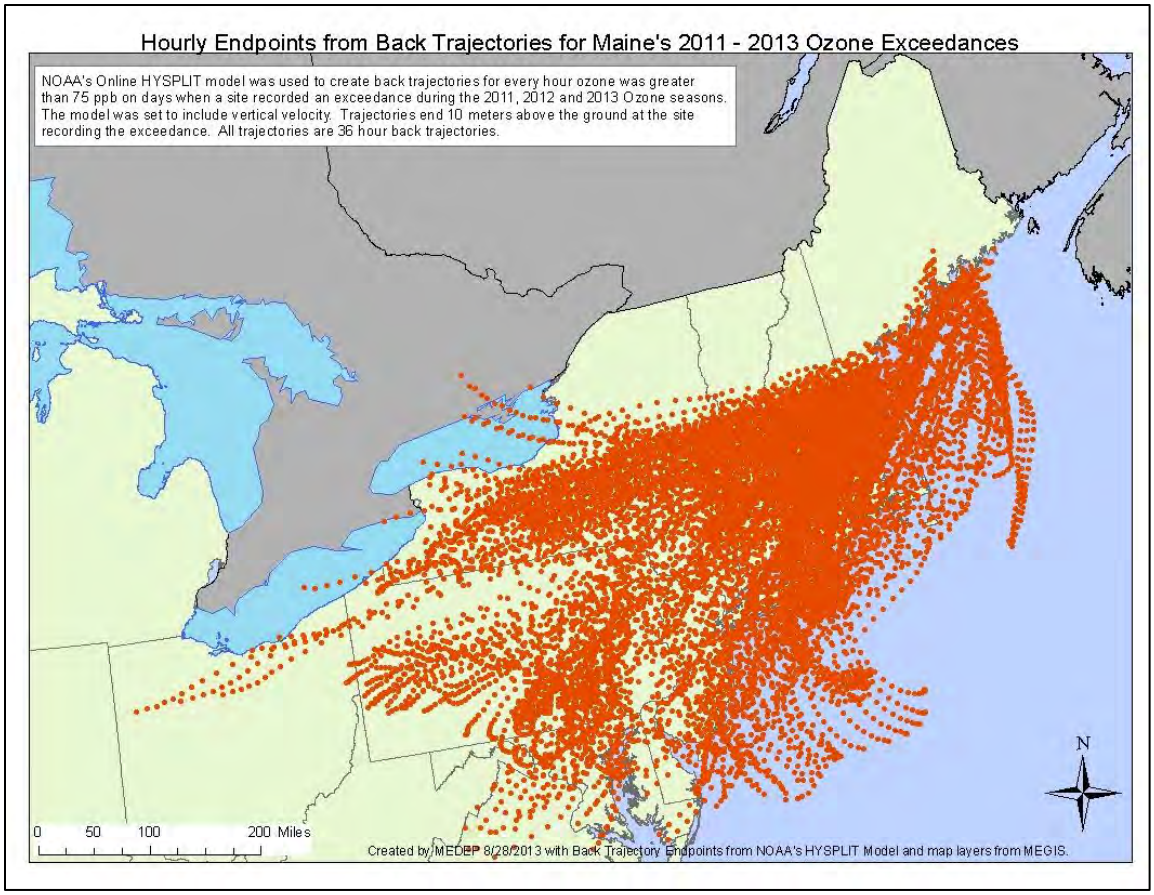
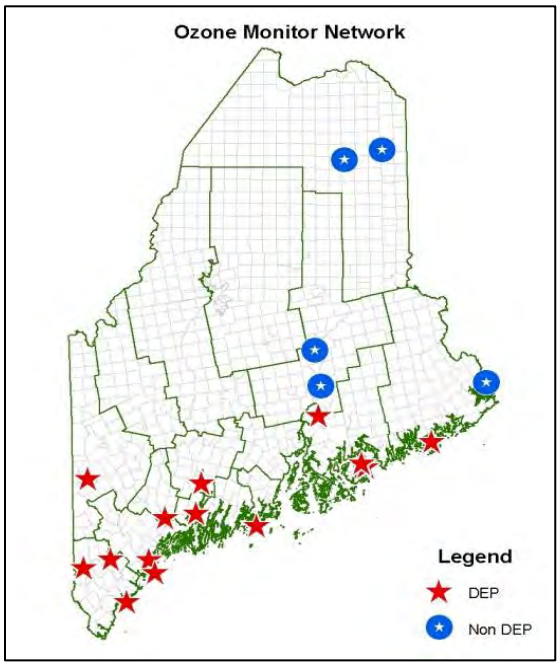


Figure 6: Hourly Endpoints from Back Trajectories for 2013 – 2014 Ozone Exceedances in Maine

Ozone Monitoring Network

Maine's program to monitor ambient levels of ozone, started in 1975, and has been expanded and modified since its initiation to most effectively identify and delineate non-attainment areas and to provide near-real-time hourly data useful for the tracking and forecasting of ozone levels throughout the State.

The Department currently operates a network of 14 sites with an additional three sites operated by Maine tribes and two sites operated by the EPA. The locations of these sites in Maine are shown in Figure 7: *Maine Ozone Monitor Network*.



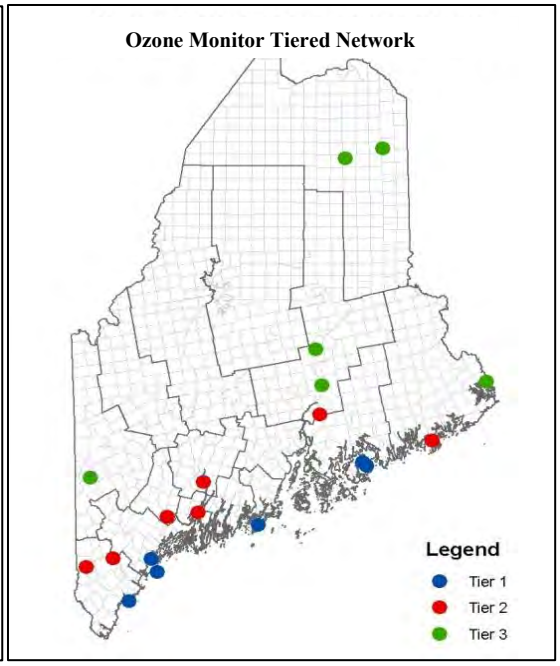


Figure 7: Maine Ozone Monitor Network

Figure 8: Ozone Monitor Tiered Network

The current Maine ozone monitoring network is essentially a three-tiered network, as depicted in Figure 8: *Ozone Monitor Tiered Network* and described in the following paragraphs. This monitoring network covers the most populated regions of the state and areas that are expected to experience the highest levels of ozone in the State. The network also covers many rural and sparsely populated areas.

The first tier is located along the southwest and mid-coastline where the highest ozone measurements in the State have historically been recorded and occasionally still occur. Monitors are located at Kennebunkport, Cape Elizabeth, Portland, Port Clyde, McFarland Hill, and the summit of Cadillac Mountain in Acadia National Park. Since a number of coastal monitoring sites in Maine are presently recording concentrations below the current standard, continued operation of those monitors is important to show continued compliance (requirement in existing maintenance plans for the 1997 ozone standard) and/or a return to non-attainment in the future. This tier contains the more populated areas in the Portland-South Portland-Biddeford Metropolitan Statistical Area (MSA) and also includes the Rockland Micropolitan Statistical Area (µSA). These monitors are strategically located throughout the southern coastal area of Maine, one of the most densely populated areas of the State and which has shown the greatest population increase over the last 20 years.

The second tier of ozone monitors is located just inland, extending from southwest and central Maine to downeast of Acadia National Park (east-northeast along the Maine coast from Acadia National Park to the Canadian border). Monitors in Tier 2 are located at Shapleigh, West Buxton, Durham, Bowdoinham, Gardiner, Holden, and Jonesport. The importance of this tier is the role it has and will continue to have in determining the attainment/nonattainment boundary and in forecasting how far inland moderate and higher air quality index (AQI) concentrations will occur. Shapleigh, Bowdoinham, and Jonesport monitors were specifically added to the Tier 2 network because of the 2008 standard. This tier also contains the most densely populated areas away from the coastline, including the

Bangor and Lewiston-Auburn MSAs, part of the Portland-South Portland-Biddeford MSA, and the Augusta-Waterville µSA.

The third tier of ozone monitors is located in the rural western and northern areas of the State. Maine currently operates a monitor at North Lovell; the EPA operates sites at Howland and Ashland; and the Micmac, Penobscot Nation, and Passamaquoddy Tribes also operate sites in this tier. Tier 3 is important for ozone mapping and forecasting purposes, especially during the spring months.

Figure 9 verifies that Tier 1 contains sites with the highest ozone levels in the State, with each site having unique statistics. Of note is how much lower the Portland monitoring site data is compared with other Tier I sites. The Portland monitor is a special purpose monitor installed for the Department of Health and Human Services, Maine Center for Disease Control and Prevention and because it does not meet NAAQS siting criteria is considered a non-regulatory monitor.

Figure 8 also verifies that Tiers 2 and 3 contain sites with lower ozone levels. The only two sites that match closely are the Bowdoinham and Durham sites, suggesting redundancy and that better use of monitoring resources might be to relocate one of these monitors. Since the Bowdoinham site was originally designed to be a replacement for the Tier 1 sites in Phippsburg and Georgetown, Maine will discontinue the Bowdoinham site after a new site is identified and installed closer to the Phippsburg/Georgetown area.

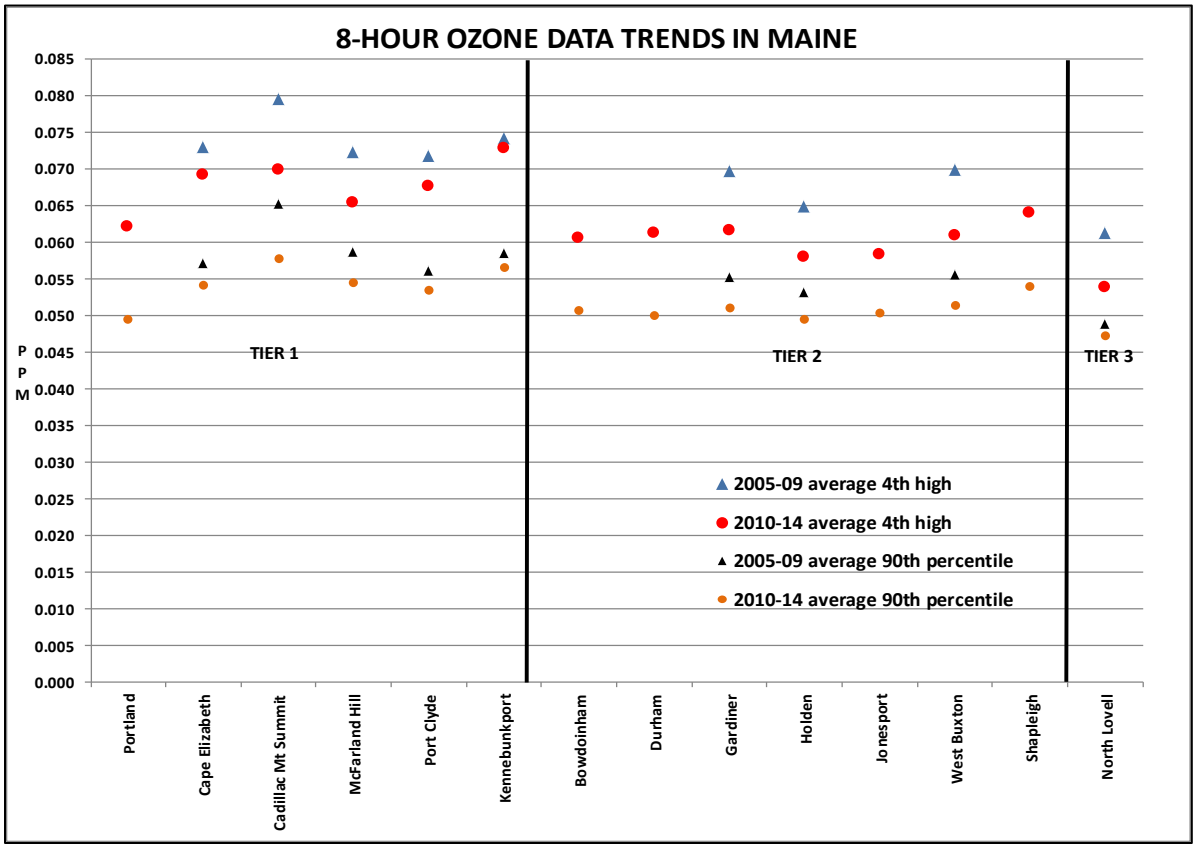


Figure 9: Maine 8-Hour Ozone Data Trends

Photochemical Assessment Monitoring Stations (PAMS) Monitoring Network

The Photochemical Assessment Monitoring Stations (PAMS) network, originally established in 1993, was designed to measure ozone precursor pollutants for Serious, Severe, or Extreme Non-attainment areas. The monitoring regulations for PAMS provide for the collection of an "enhanced" ambient air quality database which can be used to better characterize the nature and extent of ground-level ozone, aid in tracking VOC and NO_x emissions reductions, assess air quality trends, make attainment/non-attainment decisions, and evaluate photochemical grid-model performance. Maine operated two PAMS in the State, one on Cadillac Mountain and one in Cape Elizabeth, but discontinued the Cadillac Mountain site at the end of the 2014 ozone season due to lack of resources. These sites were required to operate from June to August but also usually operated for the additional months of May and September.

Both of the sites in Maine were required as a result of Serious Non-attainment areas in other states. The site in Cape Elizabeth is considered an extreme downwind site for the Greater Connecticut non-attainment area, and the Cadillac Mountain site was considered an extreme downwind site for the Boston non-attainment area that is currently attaining the 2008 ozone NAAQS. Nationally, as additional controls have been implemented and air quality has improved, many of the non-attainment areas have been reduced in size and/or severity or eliminated altogether. However, with a lowering of the standard, the status of some of these areas may change, and continued monitoring of ozone precursor pollutants remains important.

Future Ozone and PAMS Networks

Additional ozone monitoring may be justified in two areas of the State, as indicated in Figure 10, Future Ozone Network. Monitoring within the coastal area around Phippsburg had recorded some of the higher hourly concentrations in the State, but the Small Point monitor was removed after the 1999 ozone monitoring season at the request of the property owner. After that, a site was established in Reid State Park for a few years and then the monitoring was moved to a site further inland (Bowdoinham) to determine if the higher ozone concentrations were forming or being transported further inland. Relocating a site in the Phippsburg area to adequately document ozone levels in that area of the Maine coast should be a priority. The ozone network should continue to exist and be evaluated and refined as needed in the future.

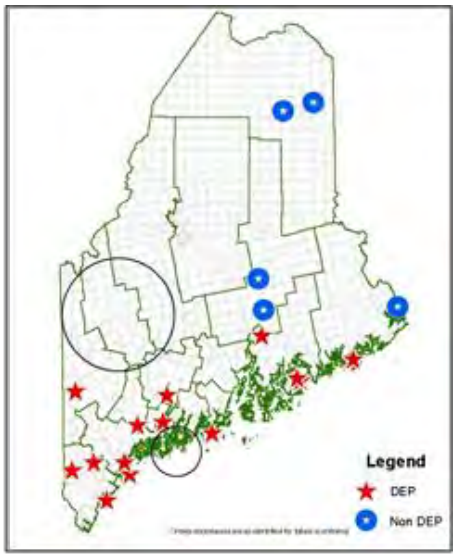


Figure 10: Future Ozone Network

There is also a need to establish a site in the mountains of western Maine. The highest background ozone concentrations during the year occur in the spring months before leaf-out. Maine has recently experienced some high spring ozone concentrations at inland sites as a result of the high background, long range transport, weather patterns and the lack of vegetation to absorb ozone. A high elevation site in the Bethel area is planned for start-up in

the springtime of 2016 and it is expected to help document transport and better forecast spring ozone events. The Bethel site will replace the North Lovell monitoring site.

National and regional discussions are currently in progress to determine the PAMS monitoring network for future, more stringent ozone standards. The current PAMS in Maine is very useful in tracking historical VOC and NO_x control programs through trends analyses and in documenting transport patterns. Future uses of the data and data analyses from this network other than trends analyses include State Implementation Plan requirements for a Section 126 of the CAA Petition, tracking implementation and effects of reformulated gasoline (RFG), Attainment Demonstration Ozone Conceptual Model, future enhanced monitoring requirements, and inputs for the Attainment Demonstration Modeling analyses. For the reasons stated above, the Cape Elizabeth PAMS should continue operation.

Particulate Matter (PM)

Particulate Matter (PM) is made up of coarse and fine particles based on size, as follows:

Name	Label	Description	Examples
--	PM_{10}	Particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (10 µm)	Smoke, soot, dust, dirt, pollen
Coarse PM	$PM_{10-2.5}$	Particles with an aerodynamic diameter less than or equal to a nominal 10 µm but greater than 2.5 µm	
Fine PM	$PM_{2.5}$	Particles with an aerodynamic diameter less than or equal to a nominal 2.5 µm	Sulfates, nitrates, heavy metals

The EPA has established primary and secondary air quality standards for $PM_{2.5}$ on an annual basis and a 24-hour basis, and for PM_{10} on a 24-hour basis, all as identified previously in this document. There is currently no NAAQS for PM Coarse.

$PM_{2.5}$ Monitoring Network

The current $PM_{2.5}$ 24-hour filter Federal Reference Method (FRM) monitors in Maine used to track compliance with $PM_{2.5}$ NAAQS are primarily located in the most densely populated and source regions. An additional $PM_{2.5}$ monitor is located in Acadia National Park at the McFarland Hill site to meet the requirements of the National Core Network (NCore), a multi-pollutant network that integrates several advanced measurement systems for particles, pollutant gases, and meteorology. Additionally, operating in the three largest cities in Maine are continuous hourly $PM_{2.5}$ Beta Attenuation Monitors (BAMs), used to help inform the public and to track compliance with NAAQS. Additional BAMs are located at sites in Maine to monitor for potential wintertime wood smoke impacts. The types of monitors and their locations are shown in Figure 11.

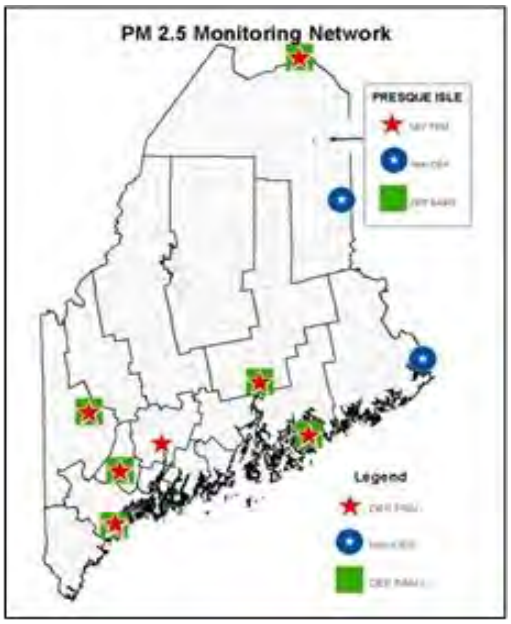


Figure 11: $PM_{2.5}$ Monitors

The State's $PM_{2.5}$ monitoring sites are listed below by monitoring strategy category:

Highest Population Areas

- Portland (FRM and BAM)
- Lewiston (FRM and BAM)
- Bangor (FRM and BAM)

Heating Season Sites of Interest

- Rumford (FRM and BAM)
- Madawaska (FRM and BAM)

NCore Site

- McFarland Hill (FRM and BAM)

Other Population Centers of Interest

- Augusta (FRM)
- Presque Isle (FRM and BAM)

In addition to depicting downward trends, Figures 12 and 13 demonstrate that all monitors are showing attainment of the 2006 24-hour $PM_{2.5}$ NAAQS and the 2012 Annual $PM_{2.5}$ NAAQS. Figure 14 shows that ambient concentrations of wintertime $PM_{2.5}$ is an important issue in Maine; thus, Maine recently installed BAMs monitors in Rumford, Madawaska, and Presque Isle. The Rumford and Madawaska sites are located in valleys where inversions occur during certain weather conditions trapping pollutants at ground level between valley walls and where wood smoke may cause higher $PM_{2.5}$ concentrations in the ambient air.

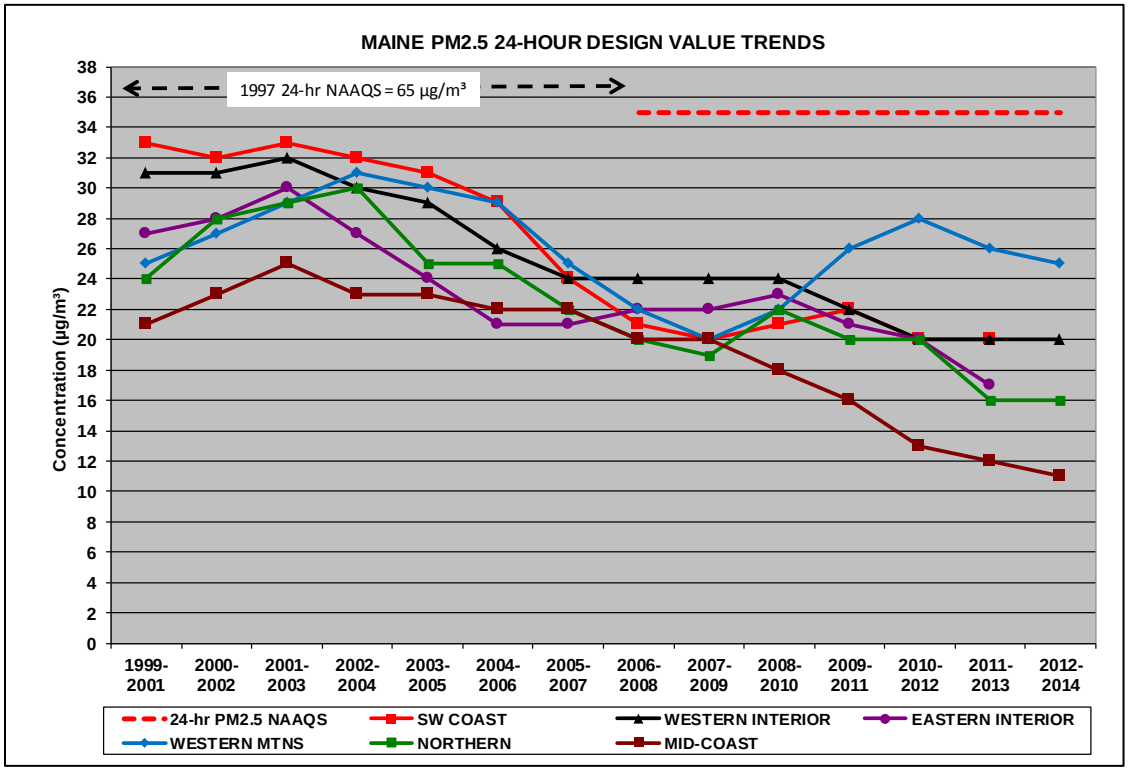


Figure 12: Maine $PM_{2.5}$ 24-Hour Design Value Trends

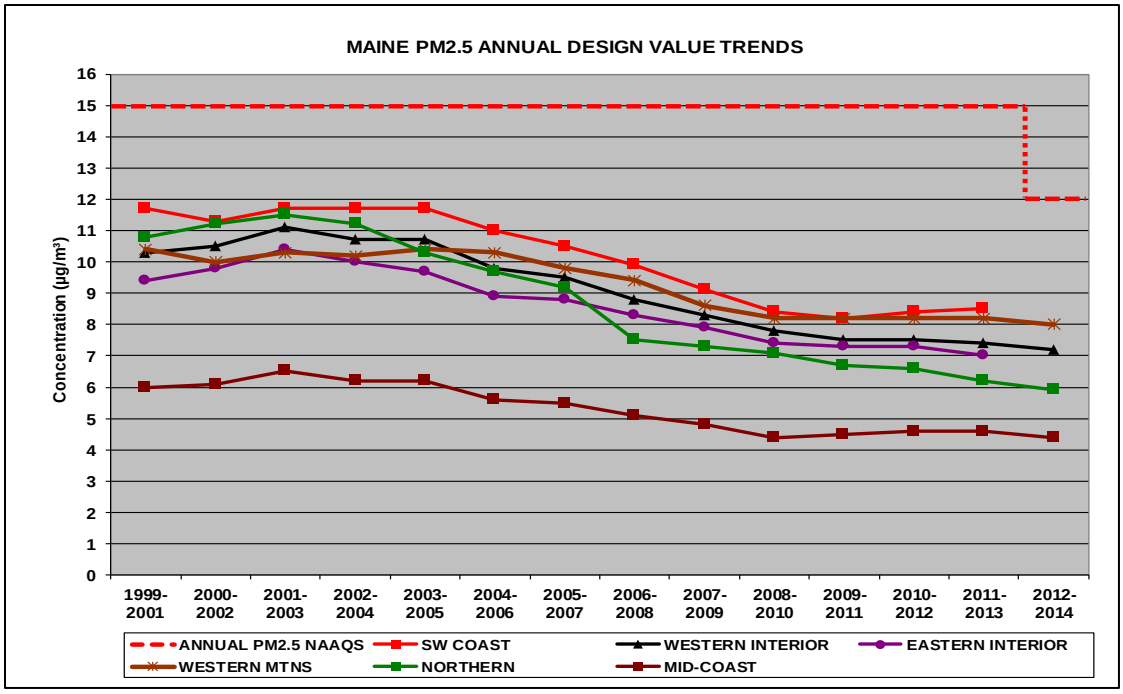


Figure 13: Maine $PM_{2.5}$ Annual Design Value Trends

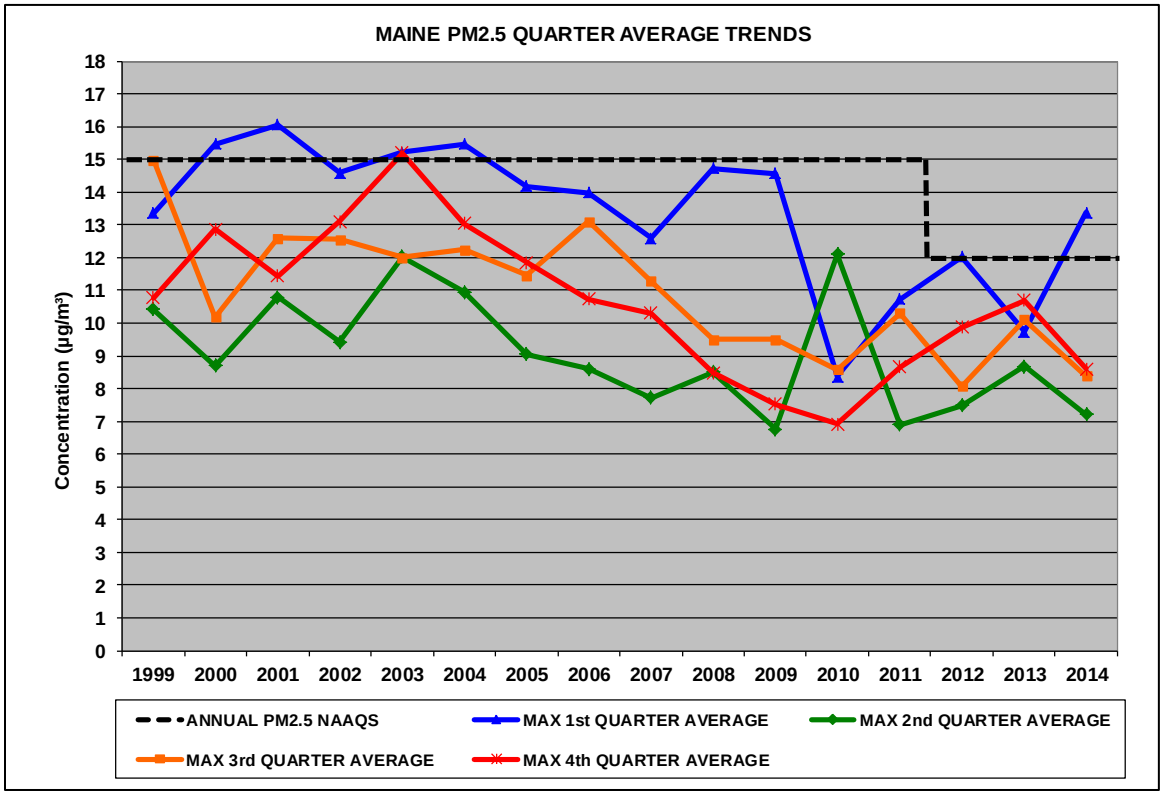


Figure 14: Maine $PM_{2.5}$ Quarter Average Trends

Future PM2.5 Monitoring Network: The only currently anticipated change in Maine's $PM_{2.5}$ monitoring network is the addition of a site to measure continuous $PM_{2.5}$ concentrations in Carrabassett, Maine, a western valley location with a number of nearby wood burning sources. Such a site will provide data to help understand and inform the forecasting of $PM_{2.5}$ levels in a complex valley area.

PM_{10} Monitoring Network

The current PM_{10} 24-hour filter and continuous PM_{10} federal reference method (FRM) and federal equivalent method (FEM) monitors in the State of Maine used to track compliance with NAAQS are located in the more populated areas, at a source of interest, and in a region that has in the distant past experienced some exceedances of the standard. The types of PM_{10} monitors and their locations are shown in Figure 15.

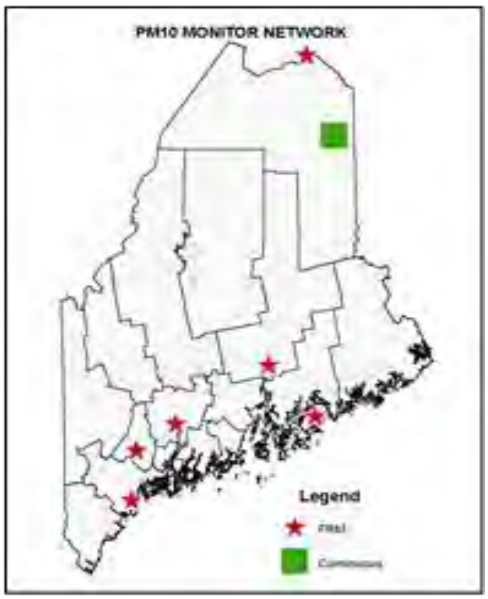


Figure 15: PM_{10} Monitors

Figure 16 shows all sites in attainment of the current PM_{10} NAAQS. The most recent exceedance of the 24-hour standard occurred in Madawaska in 2006. More frequent monitoring was initiated in Madawaska in order to document the attainment status of the area. During that period of daily sampling, there were no additional exceedances recorded.

The following is a list of Maine's PM_{10} sites in relative order of importance and identification of the measurement method at each:

Highest Population Areas

- Portland (FRM)
- Lewiston (FRM)
- Bangor (FRM)

Regions with Historical Exceedances

- Presque Isle (FRM and FEM) (maintenance plan area)
- Madawaska (FRM)

Other Population Center of Interest

- Augusta (FRM)
- Van Buren (FRM)

Source of Interest

- Bradley (FRM)

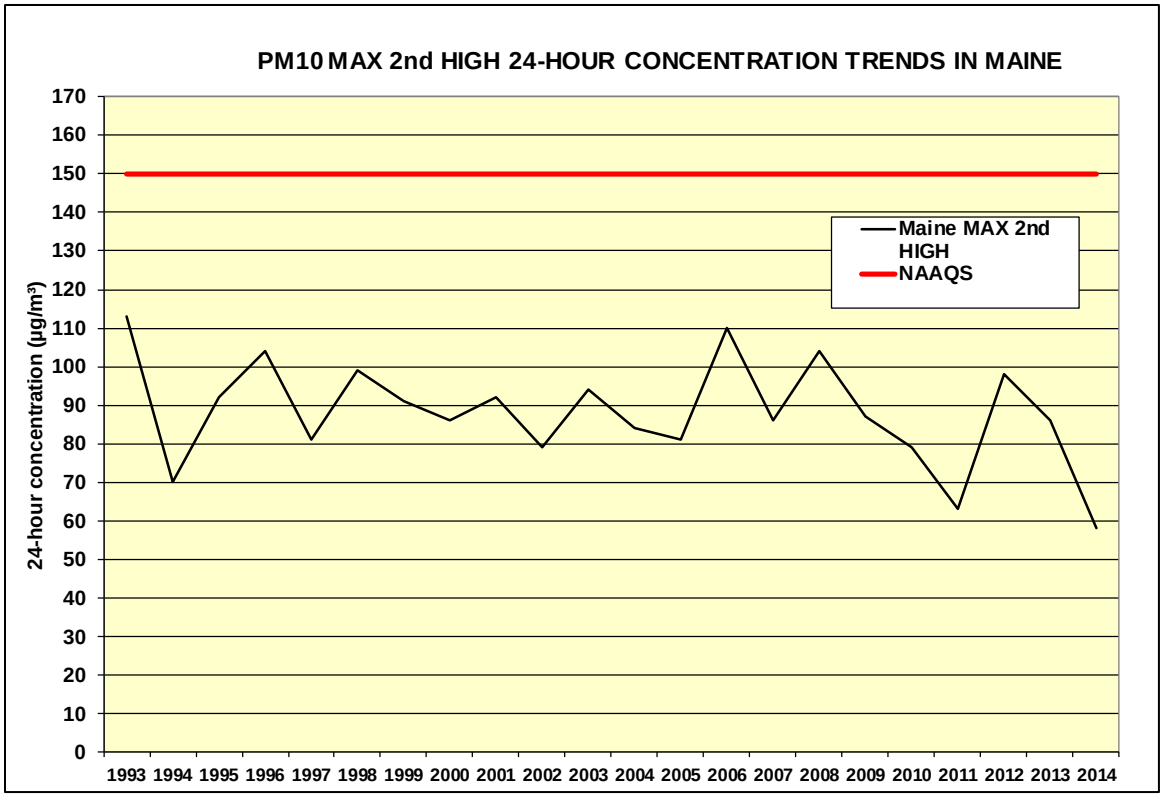


Figure 16: PM_{10} Max 2nd High 24-Hour Concentration Trends 1993- 2014

Future: The current PM_{10} network is monitoring the highest population centers and maintenance areas of the State and satisfies federal monitoring requirements.

Visibility/Speciation Monitoring Network

Maine operates a particle speciation monitoring network as part of the Interagency Monitoring of Protected Visual Environments (IMPROVE) program. Maine currently operates monitors in Bridgton and Freeport. Monitors are also operated by the National Park Service in the Acadia National Park Class I Area, by the U.S. Fish and Wildlife Service in the Moosehorn Wilderness Class I Area, and by the Penobscot and Micmac tribes. The Moosehorn Wilderness visibility/speciation monitoring provides data representative of conditions at the nearby Roosevelt-Campobello International Park (RCIP) Class I area; thus, no monitor is needed at RCIP. Figure 17 indicates the location of the IMPROVE monitors in the State.

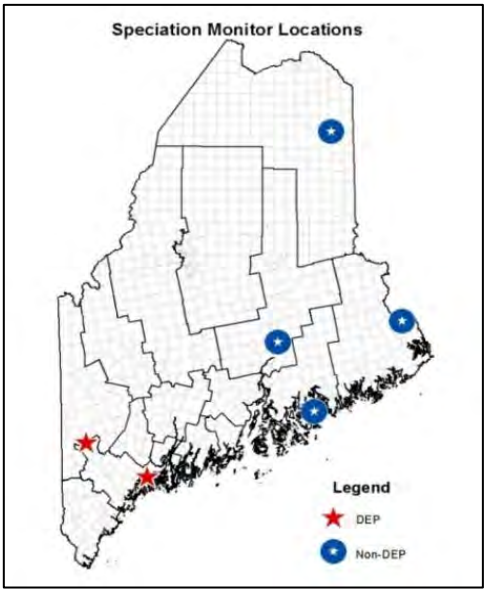


Figure 17: Speciation (IMPROVE) Monitors

Figure 18 shows how the IMPROVE data is used to track visibility using the deciview metric at the Acadia National Park site for the regional haze State Implementation Plan (SIP). Deciview is a visibility metric based on the light extinction coefficient that expresses incremental changes in perceived visibility. All other sites in Maine show similar improvements.

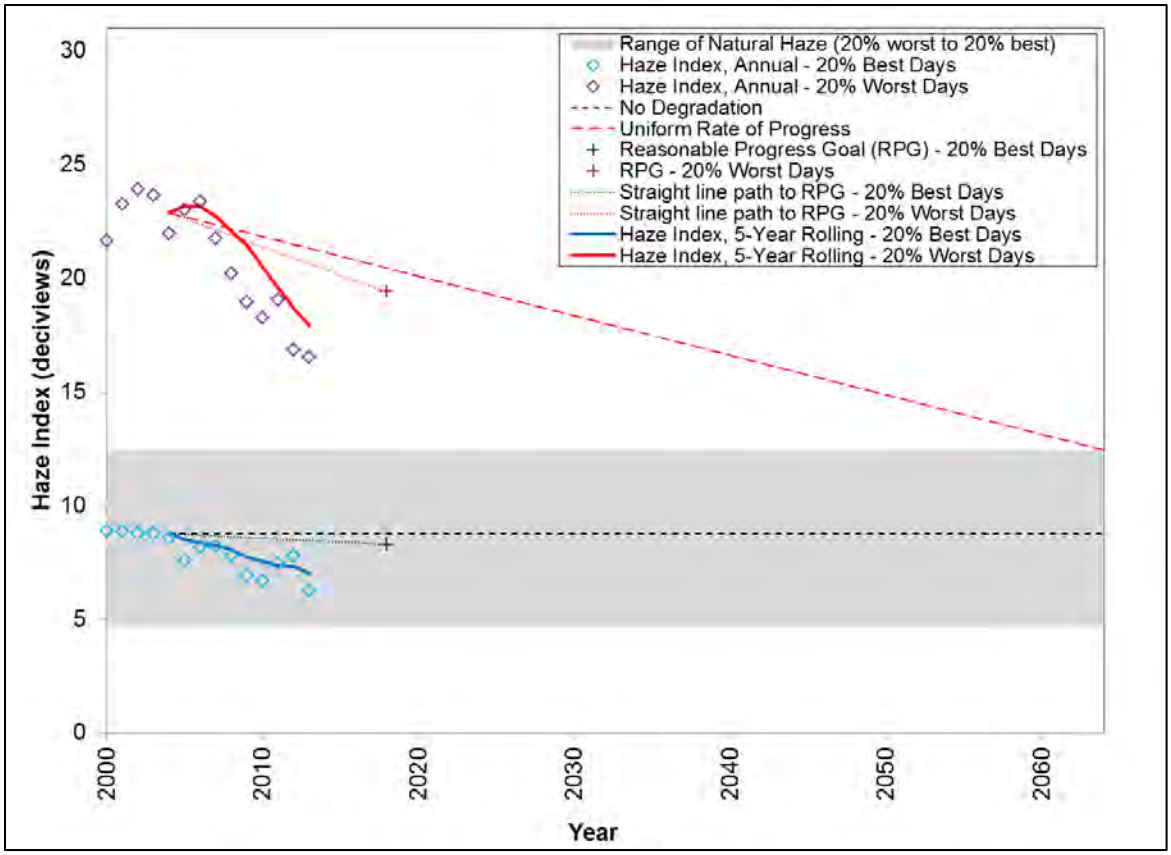


Figure 18: Acadia National Park Deciview Data

The visibility/speciation network meets monitoring requirements at all three Class I areas in and near Maine. Continued monitoring at the three Class I areas to track visibility conditions is required in the Regional Haze Rule. Such monitoring is also a commitment made in Maine's annual State Implementation Plan (SIP). The Bridgton and Freeport sites are two speciation sites as required by EPA's $PM_{2.5}$ network design criteria for Maine. Although the Bridgton and Freeport sites are in Class II areas and not in Class I areas, the Department opted to use IMPROVE Protocol samplers (required for Class I monitoring sites) at these two sites so that all PM speciation data in the State would be generated using the same equipment and collected filters would be analyzed by the same lab.

Figure 19 shows the averages of sulfate, nitrate, and organic compound measurements and the 90th percentiles since 2010 at all sites in Maine. Results clearly show that each site is measuring different local haze conditions. The Class I sites at Acadia National Park (ACAD) and Moosehorn (MOOS) measure relatively clean rural coastal conditions. The Penobscot Nation (PENO) and Freeport (CABA) sites are measuring more polluted urban conditions, while the Micmac (PRIS) and Bridgton (BRMA) sites are measuring inland rural conditions.

Future: Currently, the EPA is considering defunding the Bridgton and Freeport sites, which may result in operations ceasing by January 1, 2016. Maine has expressed to the EPA strong support and technical arguments urging the continued funding for these two sites because of the value of speciated PM data in the assessment of regional haze/visibility impairment impacts, long term trends, and emission control effectiveness. If EPA should

decide to discontinue funding of these sites, Maine will explore other funding sources to keep the sites in operation.

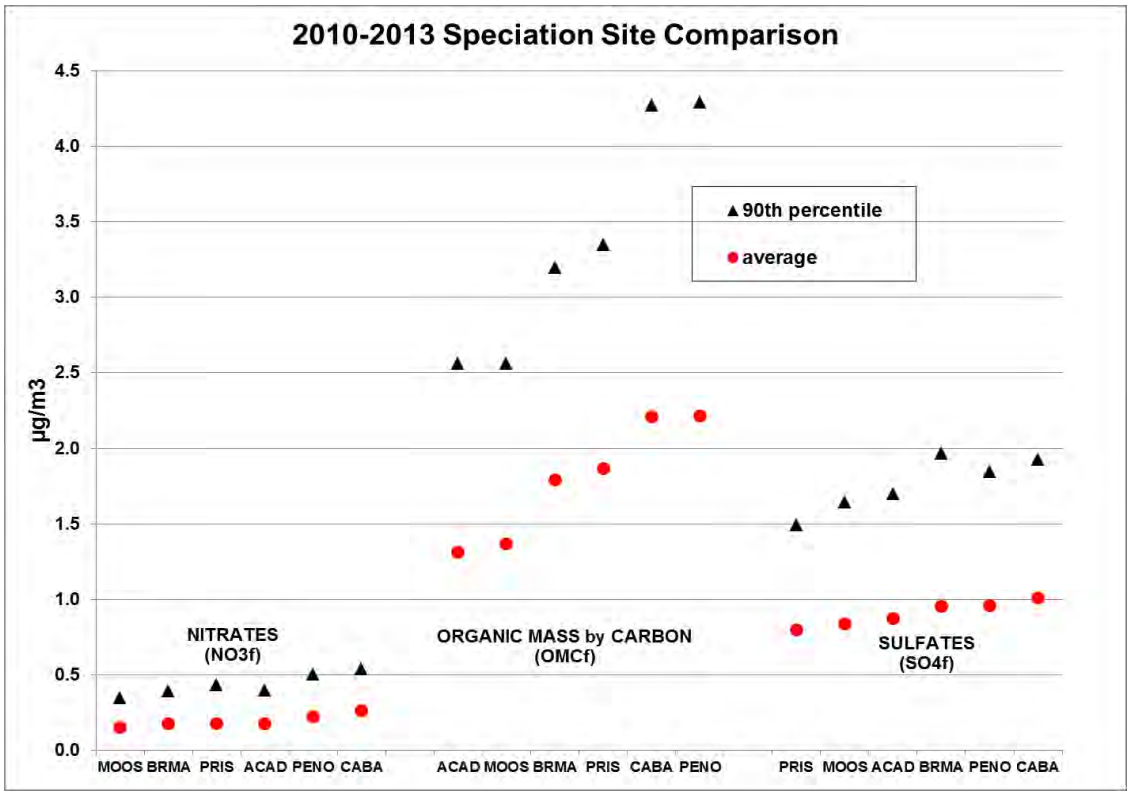


Figure 19: Speciation Site Comparisons

PM Coarse

PM Coarse is the fraction of particles from 2.5 up to 10 microns in size. There is currently no regulatory standard for this size range. EPA has proposed a standard in the past but opted to do more research rather than promulgate a standard. As of January 1, 2011, PM Coarse was required to be monitored at all NCore sites.

PM Coarse is currently monitored at two sites in Maine. PM Coarse data at the Acadia National Park NCore site is attained by the difference method: Two monitors at the site measure PM_{10} and $PM_{2.5}$, respectively, and PM Coarse is calculated by subtracting the $PM_{2.5}$ from the PM_{10}. At the Kenduskeag Pump Station in Bangor, a pair of collocated dichotomous samplers each measure $PM_{2.5}$ and PM Coarse. PM_{10} is then calculated by summing the two fractions.

The PM Coarse component of particulates could also be calculated from data collected at several other sites in the State using the difference method. The Lewiston, Augusta, Bangor, and Madawaska sites all have both PM_{10} and $PM_{2.5}$ monitors that run simultaneously.

Future: Maine plans to continue the PM Coarse monitoring at the Acadia National Park NCore site and at the Kenduskeag Pump Station in Bangor. PM coarse data may be derived from monitoring at the Lewiston, Augusta, Bangor, and Madawaska sites to be added to the Department's data collection if a standard is promulgated or there arise other reasons requiring such data collection.

Carbon Monoxide (CO)

The current NAAQS for CO, promulgated in 1971, are as follows:

- 35 ppm as a 1-hour average, not to be exceeded more than once per year (design value is the highest annual 2nd maximum 1-hour concentration); and
- 9 ppm as an 8-hour average, not to be exceeded more than once per year (design value is the highest annual 2nd maximum non-overlapping 8-hour concentration).

There is currently no secondary standard. Since the 1970s, Maine has experienced no CO non-attainment problems.

Carbon monoxide is currently monitored by the State at the Deering Oaks site in Portland (urban location) and at the NCore site in Acadia National Park (trace level monitor). The Micmac tribe also operates a CO monitor in Presque Isle. These three locations are shown in Figure 20. The maximum 1-hour concentration recorded over the last three years at the Deering Oaks site is 2.1 ppm, and the maximum 8-hour concentration recorded over that same time period is 1.8 ppm.

Future: Given these low concentrations, the only required CO monitors in the State are the trace level monitor at the NCore site in Acadia National Park and the urban monitor in Portland needed for the licensing program. Maine plans to continue this monitoring.

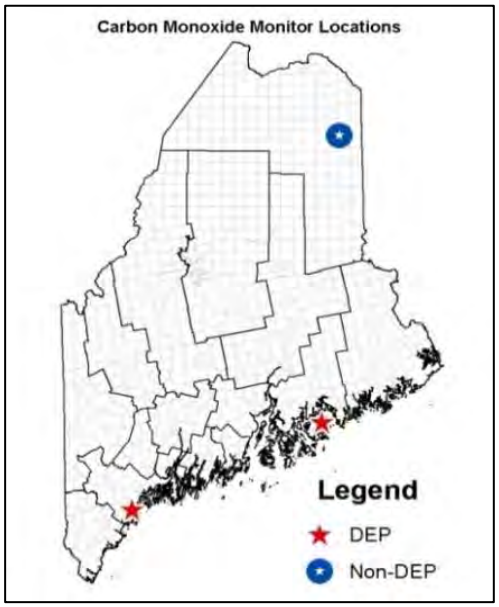


Figure 20: Carbon Monoxide Monitors

Sulfur Dioxide (SO_2)

The current NAAQS for SO_2, promulgated in 2010, is 75 ppb as a 1-hour primary standard (design value is the 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour average concentrations). The only requirement for SO_2 monitoring in Maine is the NCore site in Acadia National Park, a trace level SO_2 monitor. Other SO_2 monitors to collect urban and background/baseline data for the licensing program are located in Portland and Gardiner. In addition, a special purpose SO_2 monitor was established in Eliot, Maine in conjunction with the New Hampshire Department of Environmental Services at the request of the EPA. One year of data will be collected at the Eliot site to determine if there are impacts to the citizens of Eliot from the emissions of two coal burning power plants in New Hampshire just across the river from Eliot. The Micmac tribe also operates a SO_2 monitor at their site in Presque Isle. The locations of SO_2 monitors in Maine are indicated in Figure 21.

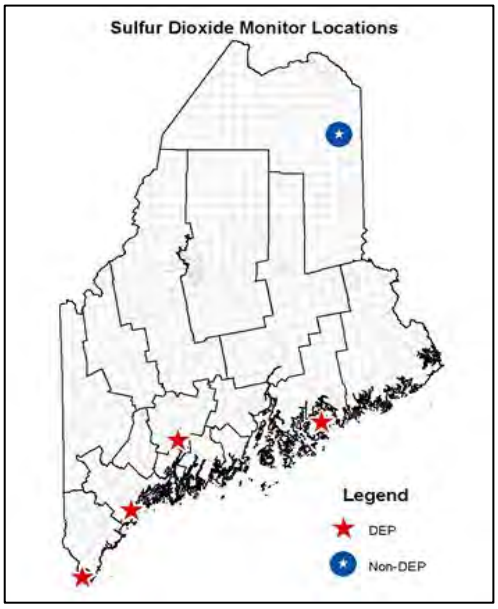


Figure 21: Sulfur Dioxide Monitors

Figure 22 depicts 99th percentile 1-hour concentration trends at all sites in Maine. The maximum 1-hour concentration recorded in Portland in the last three years is 24.8 ppb, and the 2012-14 design value is 14 ppb, which is well below the 75 ppb NAAQS.

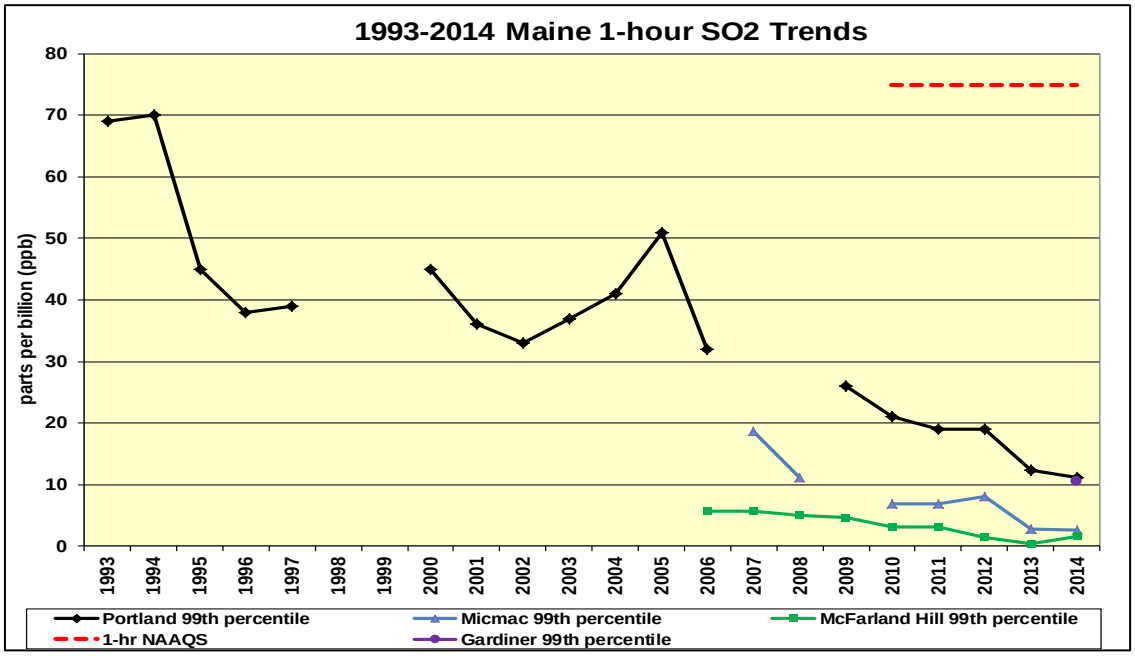


Figure 22: Maine SO_2 1 Hour Trends 1993 - 2014

Future: Maine's SO_2 monitoring network meets EPA's monitoring criteria. No new sites are needed, and there are no existing sites deemed unneeded.

Nitrogen Dioxide (NO_2)

The current NAAQS for NO_2 are as follows:

- 53 ppb, annual average standard; and
- 100 ppb as a 1-hour standard (design value is the 3-year average of the 98th percentile of the annual distribution of daily maximum 1-hour average concentrations)

The locations of monitors for nitrogen dioxide (NO_2) and reactive oxides of nitrogen (NO_y) are shown in Figure 23. NO_y is currently monitored by the State at the Deering Oaks site in Portland (urban location) and at the NCore site in Acadia National Park (trace level monitor). NO_2 is currently monitored by the State in Portland and Gardiner. The Micmac tribe also operates a NO_2 monitor in Presque Isle.

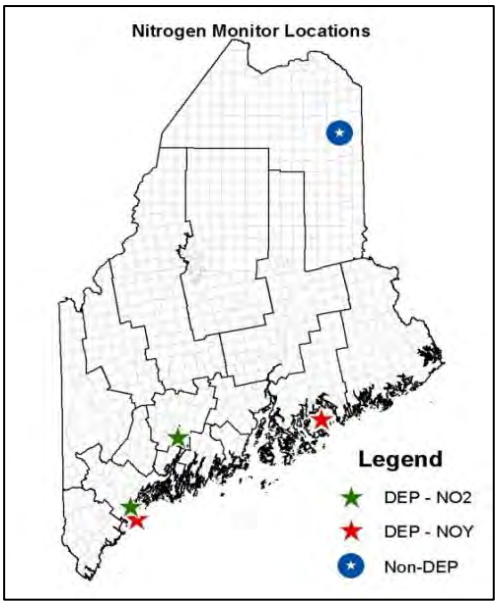


Figure 23: Nitrogen Monitors

In 2013, the EPA included provisions in the regulations for additional NO_2 monitoring in urban areas, including the addition of a monitor in any urban area with a population greater than or equal to 1 million people, such as Portland, to be in operation by January 1, 2017. Near-road sites in large metropolitan areas, with the

highest probability for high NO_2 concentrations, were required to be in operation first. However, these existing plans for additional near-road monitoring in the U.S. are being reviewed, because data from the near-road sites already in operation have not shown the expected high levels of NO_2, and there is nothing in the data to suggest that monitoring along less traveled roads such as those in Portland will show higher concentrations of NO_2.

Figure 24 depicts 1-hour concentration trends at all sites in Maine. The maximum 1-hour concentration recorded in Portland in the last three years is 76.1 ppb, and the 2012-14 Design Value is 45 ppb.

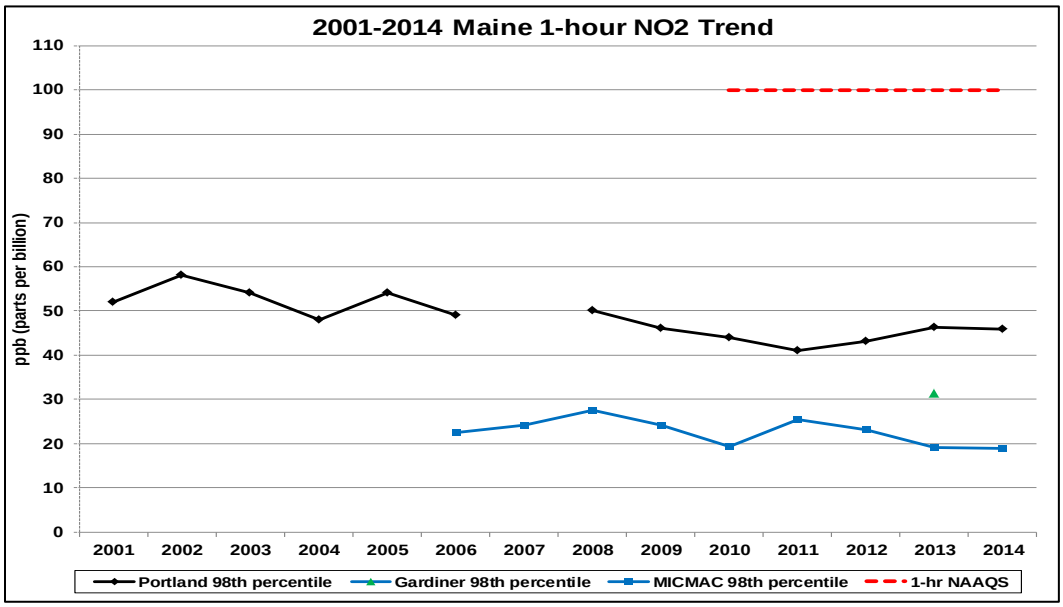


Figure 24: Maine NO_2 1-Hour Trends, 2001 - 2014

Future: The existing monitors meet EPA monitoring requirements and will provide the data necessary for urban and rural concentrations needed for the licensing program.

Lead (Pb)

National monitoring data indicates no lead monitoring sites in Maine are necessary. In 2008, EPA promulgated a new lead standard and issued minimum monitoring requirements. At that time, Maine was to be required to operate one monitor in the Portland CBSA (Core-based statistical area). So the State purchased an X-ray fluorescence (XRF) analyzer to measure lead concentrations from PM_{10} filters. The EPA lead monitoring requirement was subsequently revised to require lead monitoring at urban NCore sites only. The Bar Harbor NCore site is designated as a rural site, so there is no requirement for additional lead monitoring in Maine. The Maine DEP has analyzed, with the XRF, PM filters from Rhode Island for concentrations of lead and other metals for the past several years and is anticipating a similar arrangement with New Hampshire beginning in 2016.

Future: In the future, the Department intends to conduct XRF analysis on a random selection of Maine PM_{10} filters to determine what the State's actual background levels might be for lead and other metals. There are no projected dates for implementation of this testing and analysis program at this time.

Maine's Hazardous Air Pollutants Monitoring

Maine monitors year-round for several hazardous air pollutants (HAPs) including photochemical organics, in 12 Maine cities and towns. Although this is a major portion of Maine's ambient air monitoring program, it is not required by federal regulation 40 CFR Part 58, *Ambient Air Quality Surveillance*. Figure 25 indicates the locations and the type of monitoring done at these sites. EPA Method TO-15 is employed to sample and analyze selected compounds from the Maine Air Toxics Initiative's Air Toxics Priority List, selected based on the National Air Toxics Assessment (NATA) results. These monitors provide actual data to accurately inform estimates of toxic air pollutants, to guide the selection of specific toxic air pollutants for study and evaluation. The most current NATA data available is for the year 2005, which data was made available to the public on March 11, 2011.

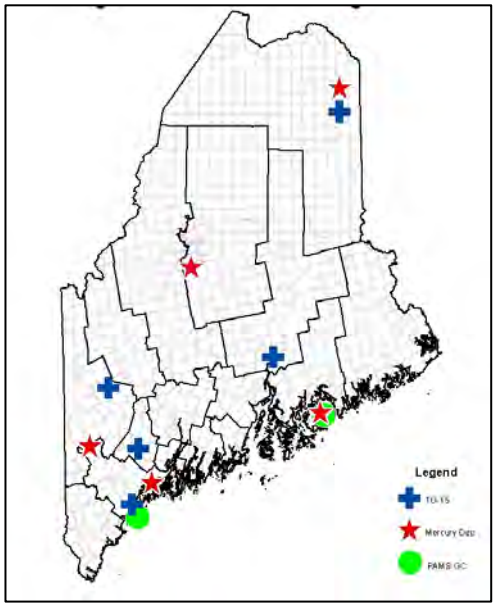


Figure 25: Hazardous Air Pollutants Monitors

The State conducts ongoing evaluation of appropriate toxic air pollutants to monitor following TO-15 National Air Toxics Trends Stations (NATTS) protocols. Maine will review the 2011 NATA data when it is released, expected later this year, to assess what this more current information reveals about changes in the occurrence and prevalence of specific toxic air pollutant compounds, their spatial distribution, and how this data compares to the ambient monitoring data collected for like compounds.

The hazardous air pollutant monitoring conducted in Maine provides background and baseline data for the pollutants monitored. Data from these sites is analyzed to determine impacts and to identify any trends in ambient air levels of these compounds, possibly identifying contributing factors to specific health problems identified in localized areas.

Maine conducted hazardous air pollutant monitoring during the ozone season at the two PAMS, in Cape Elizabeth and on Cadillac Mountain. The Cadillac Mountain PAMS was shut down at the end of the 2014 ozone season, and year-round toxic air pollutant monitoring at Cape Elizabeth began in 2014. These two sites, both up-wind of Maine emission sources, were located to assess long-range transport; thus, air pollutant measurements from both of these sites represent out-of-state pollution.

The Department measures some of the most prevalent combustion by-products – benzene, toluene, ethylbenzene, and xylenes (BTEX compounds) – at the PAMS sites and at all other hazardous air pollutants monitoring sites. PAMS measurements help the Department estimate local versus transported pollutant concentrations of the BTEX compounds at other sites. PAMS data also provides more than a decade of measurements that can be used to evaluate trends. Figures 26 and 27 indicate a significant decline in overall annual average BTEX concentrations at both sites in the late 1990s and much smaller variations in recent

years. The PAMS toxic air pollutants measurements from the two sites do not trend closely with one another, however. Year-round monitoring data is available to be examined in conjunction with PAMS data for more in-depth analyses of patterns in pollutant concentrations.

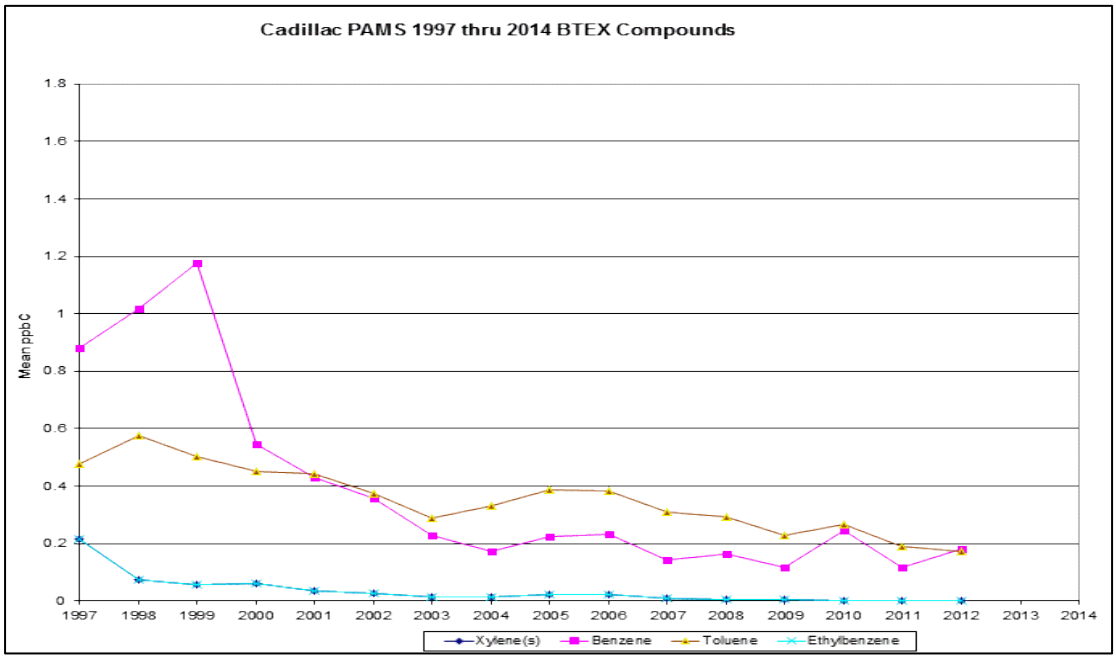


Figure 26: Cadillac Mtn. PAMS 1994 thru 2014 BTEX Compounds

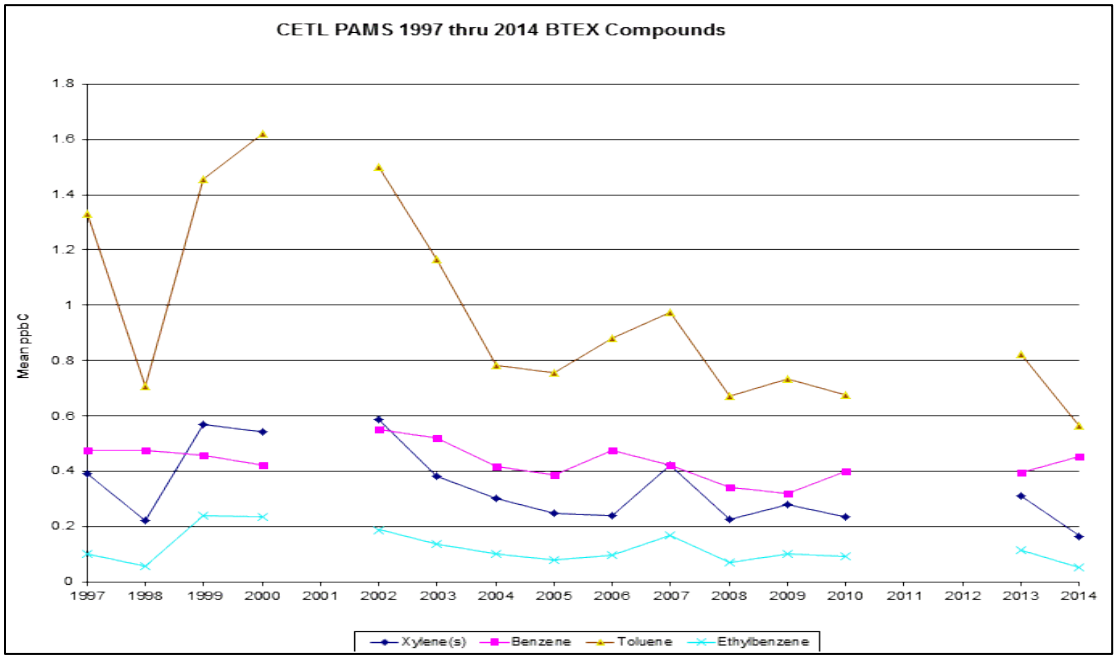


Figure 27: CETL PAMS 1994 thru 2014 BTEX Compounds

Figure 28 illustrates benzene monitoring results from five of Maine's year-round toxic air pollutant monitoring sites during the period 2010-2014. In addition to the obvious annual cycle of measured benzene concentrations higher in the colder months and lower during the warmer months, the data plots for the individual sites indicate a decline in peak levels of

benzene at the Lewiston (CKP) and Bangor (KPS) sites, but steady levels in Rumford and Presque Isle. Using the long-term data compiled from the Department's hazardous air pollutant monitoring sites, the Department can evaluate trends for any of the monitored compounds.

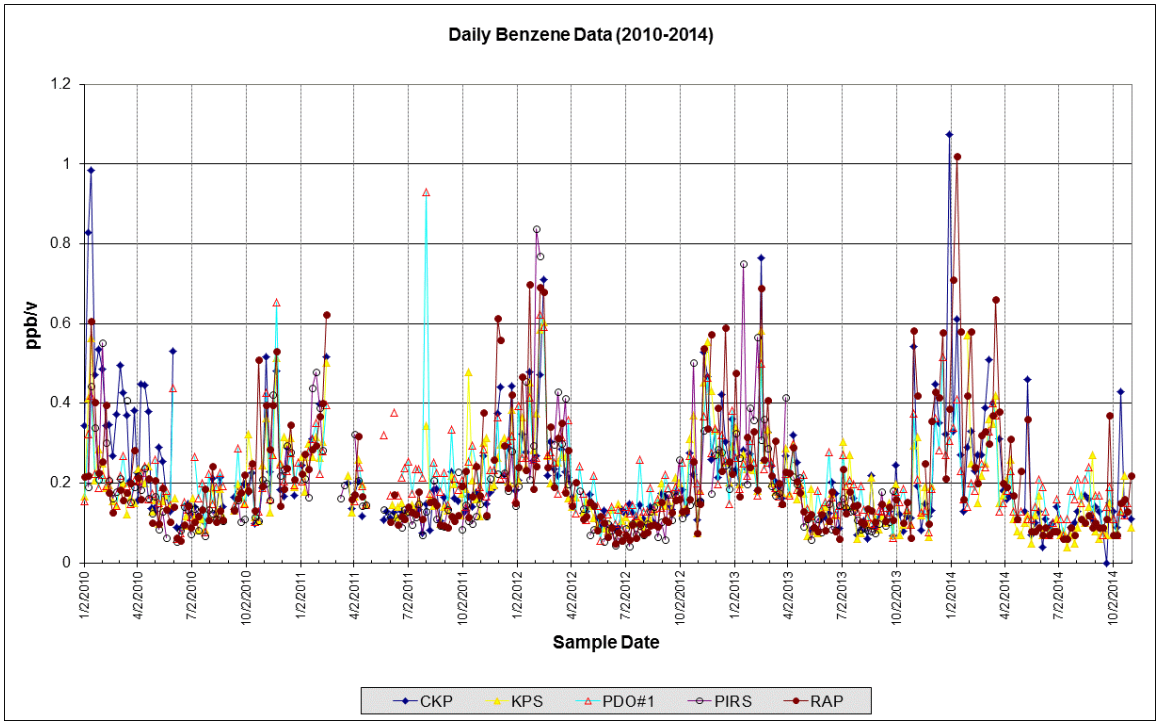


Figure 28: Daily Benzene Data (2010 – 2014)

Maine's Air Toxics Strategy includes further investigation into air quality impacts from residential wood combustion. In 2010, the Department developed and deployed a method using levoglucosan [16] as an indicator to distinguish between wood combustion PM and other PM. This provides air quality data from areas throughout the western mountains and remote areas of the State where emission estimates and inspections indicate wood combustion PM impacts may be greatest.

Maine's Atmospheric Deposition Monitoring and Relevance

The National Atmospheric Deposition Program (NADP) was organized in 1977 under the leadership of the State Agricultural Experiment Station (SAES) program to increase understanding of the causes and effects of acidic precipitation on agricultural crops, forests, rangelands, surface waters, and other natural and cultural resources. The National Trends Network (NTN), a long-term precipitation chemistry monitoring network of wet-only deposition sites, distant from point source emission influences, began operation in 1978 collecting one-week long bulk precipitation samples. Samples are analyzed by the Central Analytical Laboratory at the University of Illinois in Champaign for the parameters listed in the table below to determine amounts, temporal trends, and geographic distributions of the atmospheric deposition of acids, nutrients, and base cations by precipitation.

[16] Levoglucosan ($C_6H_{10}O_5$) is an organic compound formed from the pyrolysis of carbohydrates, such as starch and cellulose, and is often used as a chemical tracer for biomass burning in atmospheric chemistry studies, particularly with respect to airborne particulate matter.

Wet Deposition Chemistry Parameters

Calcium	Magnesium	Potassium
Sodium	Ammonium	Nitrate
Chloride	Sulfate	Bromide
Free acidity (as pH)	Specific conductance	Orthophosphate (for QA purposes)

Sites in the NTN benefit from having identical siting criteria, operating procedures, a common analytical laboratory, as well as a common quality assurance program. Presently, there are approximately 250 sites nationally in the NTN. The locations of NTN sites in Maine are identified in Figure 29. Sites within this network in Maine were established as follows:

Site Location	Year Established	Establishing Agency	Discontinued?	Notes
Greenville	1979	University of Maine		
Caribou	4/1980	National Oceanic and Atmospheric Admin. (NOAA)		
Bridgton	9/1980	Maine DEP		
Acadia National Park, Paradise Hill	11/1980	National Park Service	Yes	Relocated to McFarland Hill
McFarland Hill	11/1981	National Park Service		
Presque Isle	6/1984	NOAA	Yes	9/30/1988
Freeport	1/1998	Maine DEP		As part of the three-year Casco Bay Estuary Air Deposition Project
Gilead (White Mtn. National Forest)	9/1999	U.S. Geological Survey		
Carrabassett Valley	3/2002	Penobscot Indian Nation		
Near Scraggly Lake	6/2002	Passamaquoddy Tribe	Yes	End of 2006; replaced by Indian Township site
Indian Township	10/2013	Passamaquoddy Tribe		

In 1996, a Mercury Deposition Network (MDN) was created within NADP to provide information on the wet deposition of this pollutant to surface waters, forested watersheds, and other receptors, helping to understand the contribution of air pollution to water pollution. Samples from this network are analyzed by a central laboratory, Frontier Global Sciences in Seattle, WA, for total mercury, and may also be analyzed for methyl mercury to provide data on amounts, temporal trends, and geographic distributions of the atmospheric deposition of mercury and mercury containing compounds by precipitation. Presently, there are approximately 110 sites nationally in the MDN. Eleven upwind states have been identified as the most significant contributors to mercury deposition in Maine. The locations of MDN sites in Maine are identified in Figure 30. Monitoring sites within this network in Maine were established as follows:

Site Location	Year Established	Establishing Agency	Discontinued?	Notes
McFarland Hill in Acadia National Park, Bar Harbor	3/1996	Maine DEP and the National Park Service		
Greenville (collocated with the NTN site)	9/1996	Maine DEP		
Bridgton	6/1997	Maine DEP	Identified for discontinuance, but still operating at this time	
Freeport	1/1998	Maine DEP	Identified for discontinuance, but still operating at this time	As part of the three-year Casco Bay Estuary Air Deposition Project
Caribou	5/2007	Maine DEP		
Carrabassett Valley	2/2009	Maine DEP		Collocated with NTN site

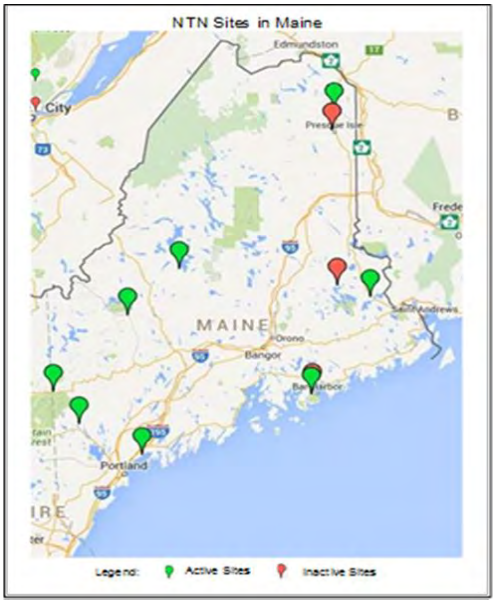


Figure 29: Maine National Trends Network (NTN)

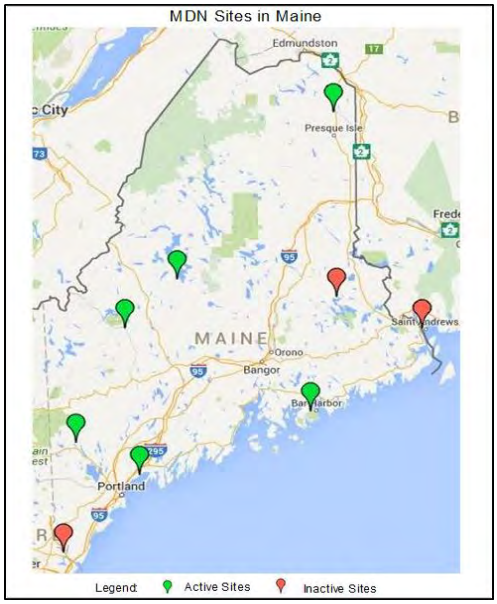


Figure 30: Maine Mercury Deposition Network (MDN)

NADP data from the collected data of NTN and MDN sites in the U.S. are used to produce national, color-shaded contour maps of both concentration and deposition amounts, shown below.

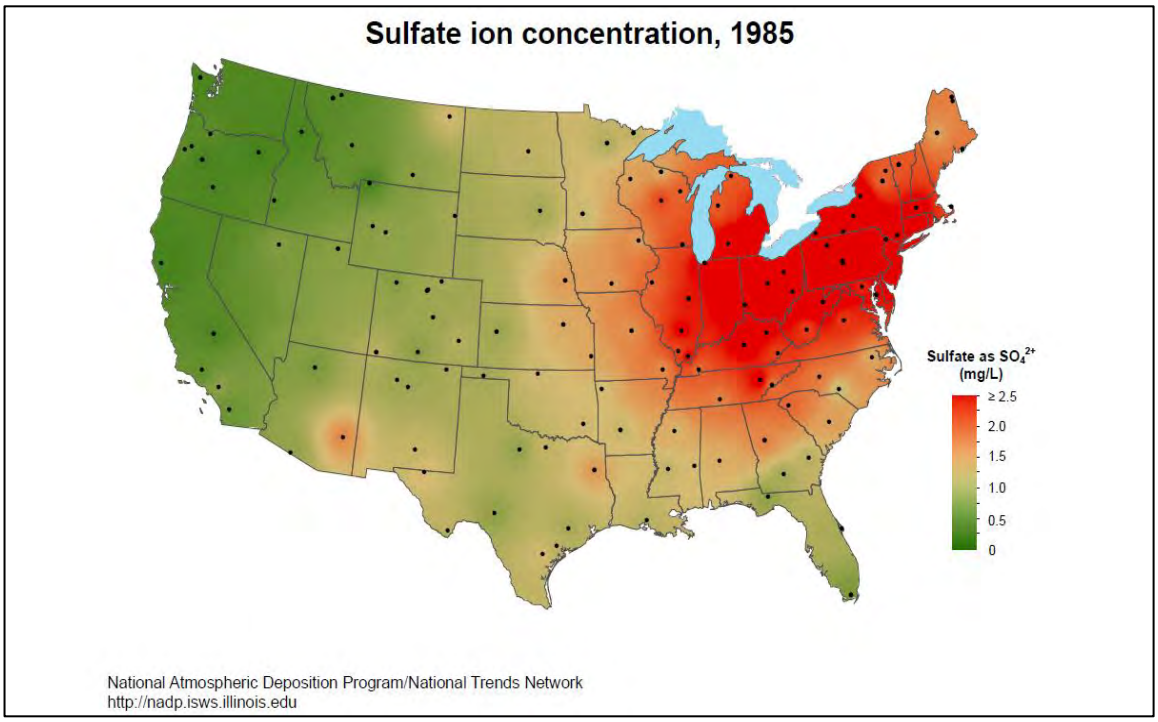


Figure 31: U.S. Annual Sulfate Ion Concentrations 1985

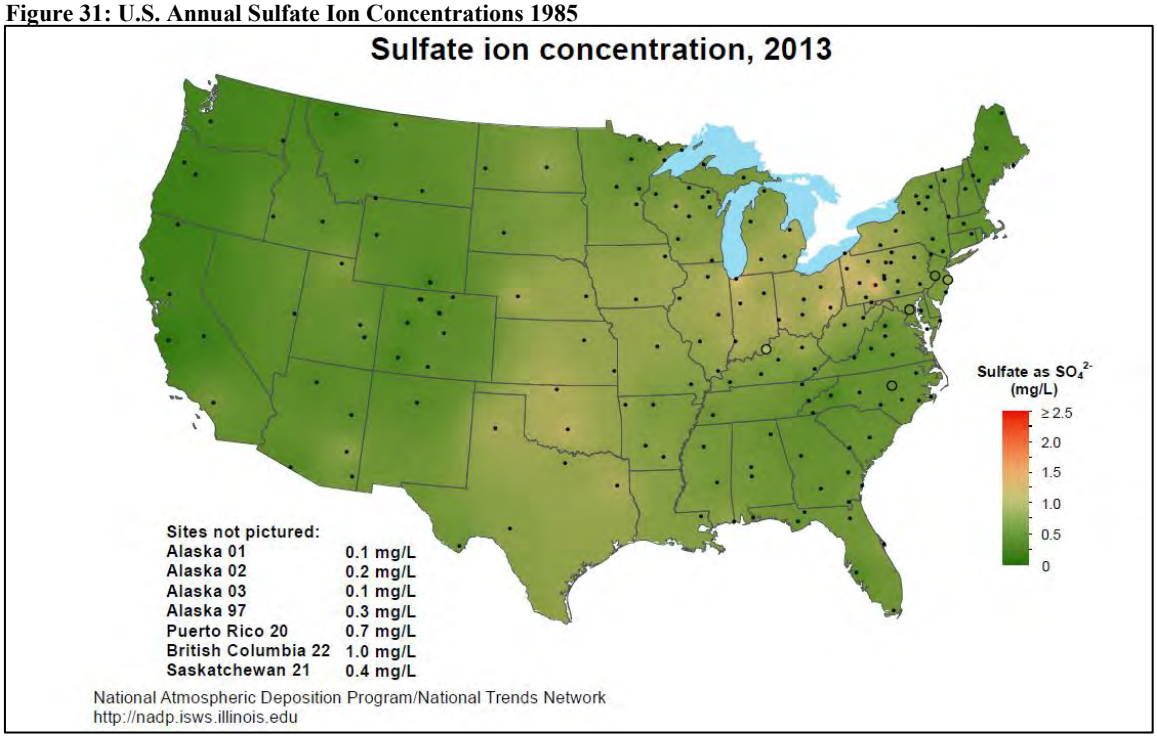


Figure 32: U.S. Annual Sulfate Ion Concentrations 2013

Comparing annual maps to one another provides the ability to look at changes over time. The comparison of Figures 31 and 32 shows a marked decrease in the concentrations of sulfate ion as measured via precipitation samples from 1985 to 2013. Figures 33 and 34

depict sulfate ion data from two of Maine's longest-term trend sites over an even longer period of time.

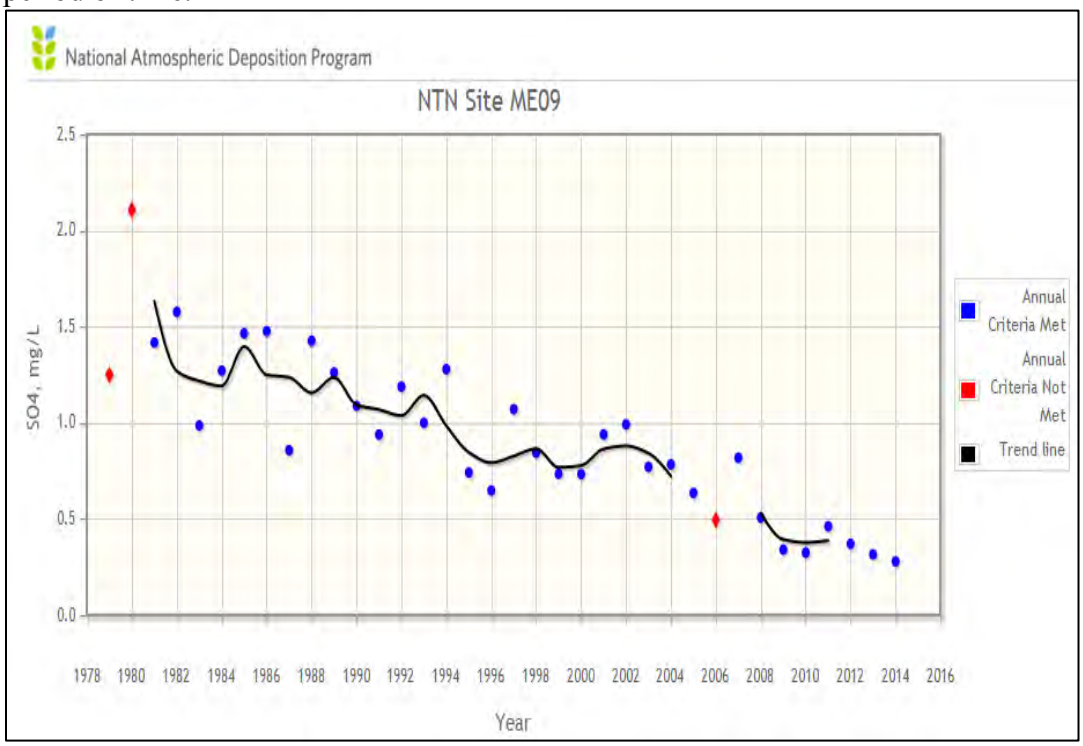


Figure 33: Annual SO_4 Concentrations ME09

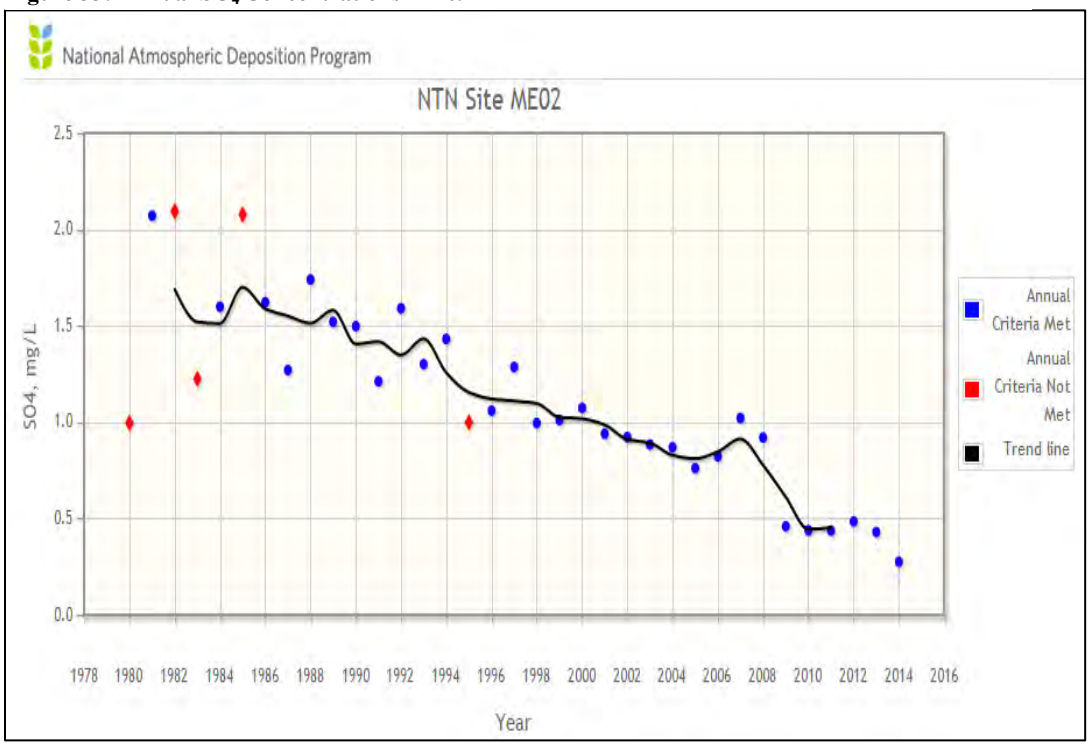


Figure 34: Annual SO_4 Concentrations ME02

The pH of precipitation samples, determined from hydrogen ion analyses, is another important ecological parameter measured by the NTN network. The annual maps shown in

Figures 35 and 36 and the trend plots shown in Figures 37 and 38 illustrate a corresponding improving trend in pH levels.

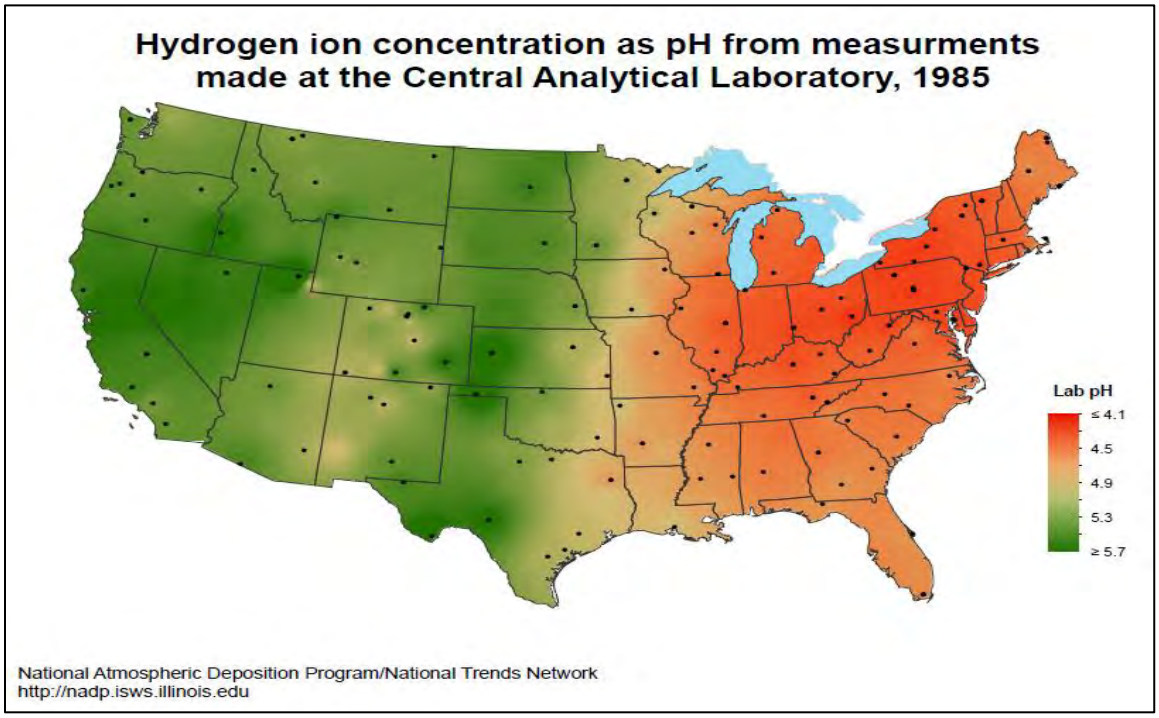


Figure 35: U.S. Annual Hydrogen Ion Concentrations, 1985

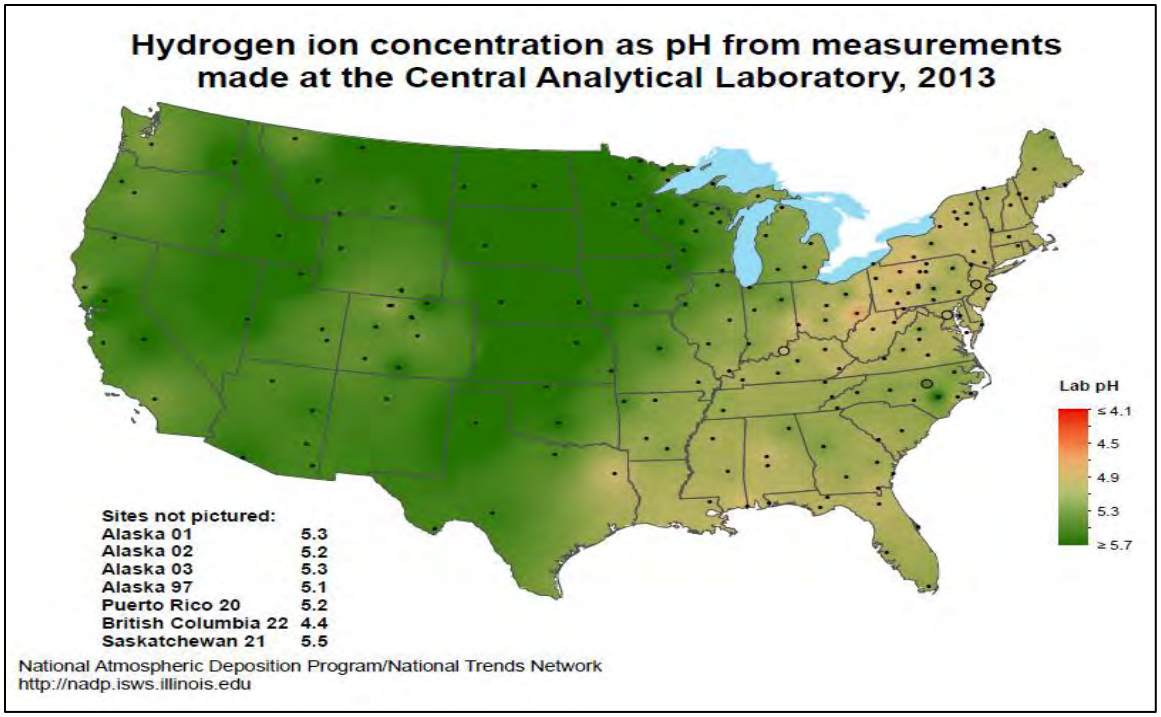


Figure 36: U.S. Annual Hydrogen Ion Concentrations, 2013

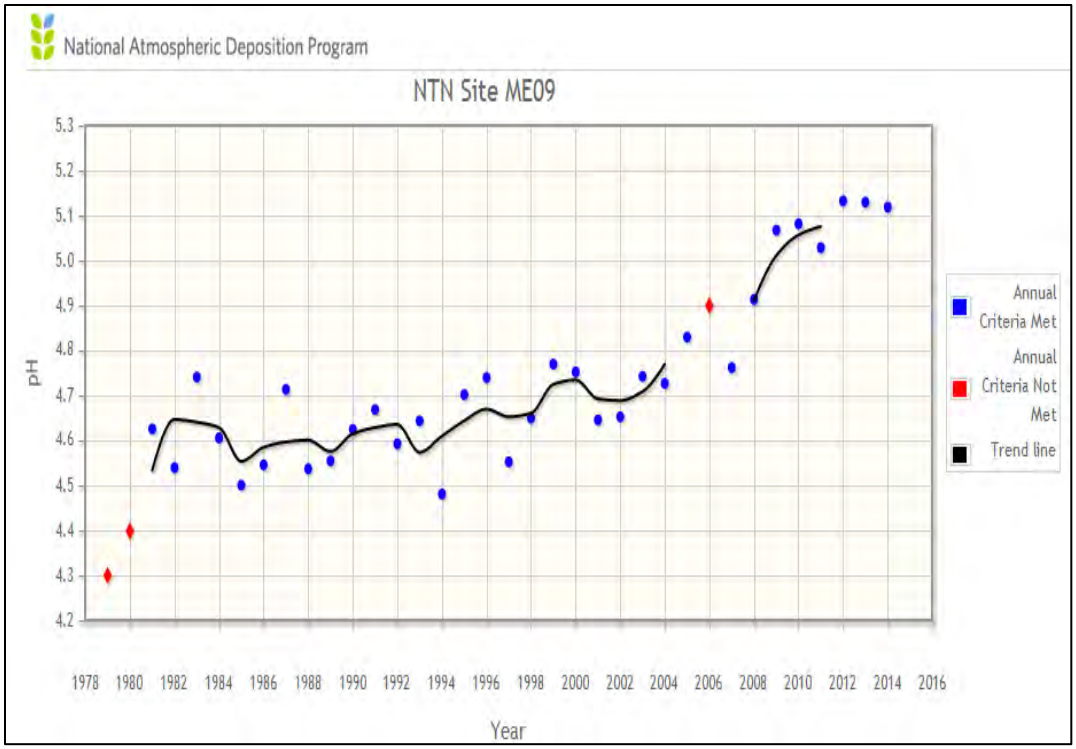


Figure 37: pH ME09 1979-2013

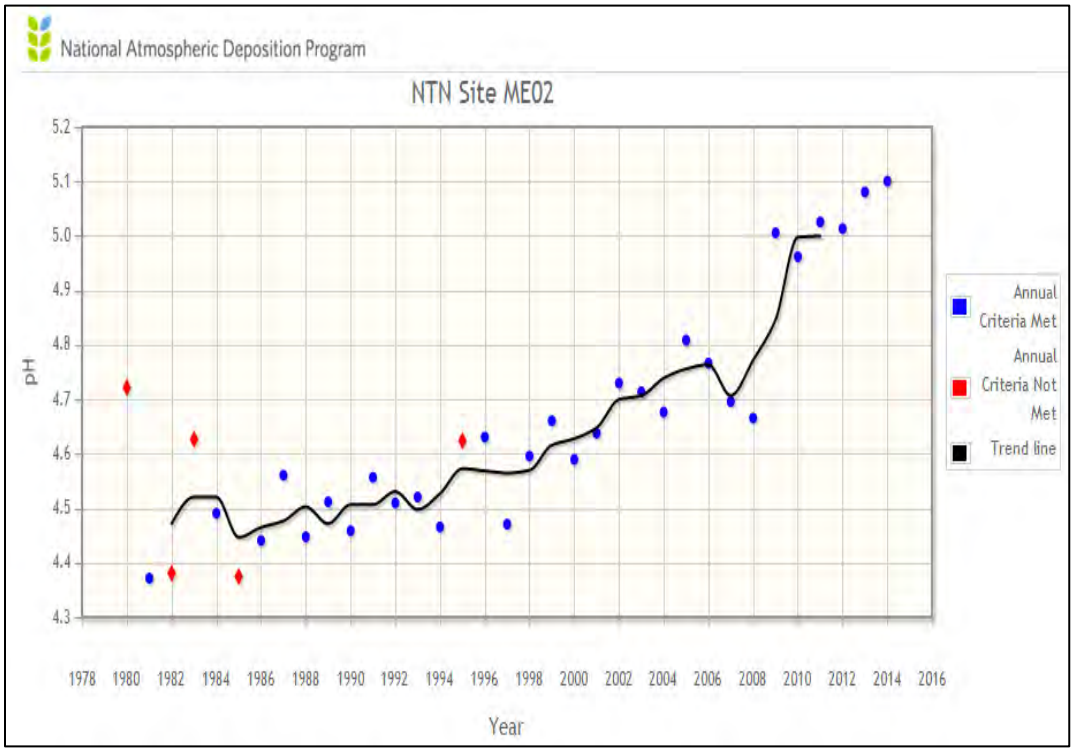
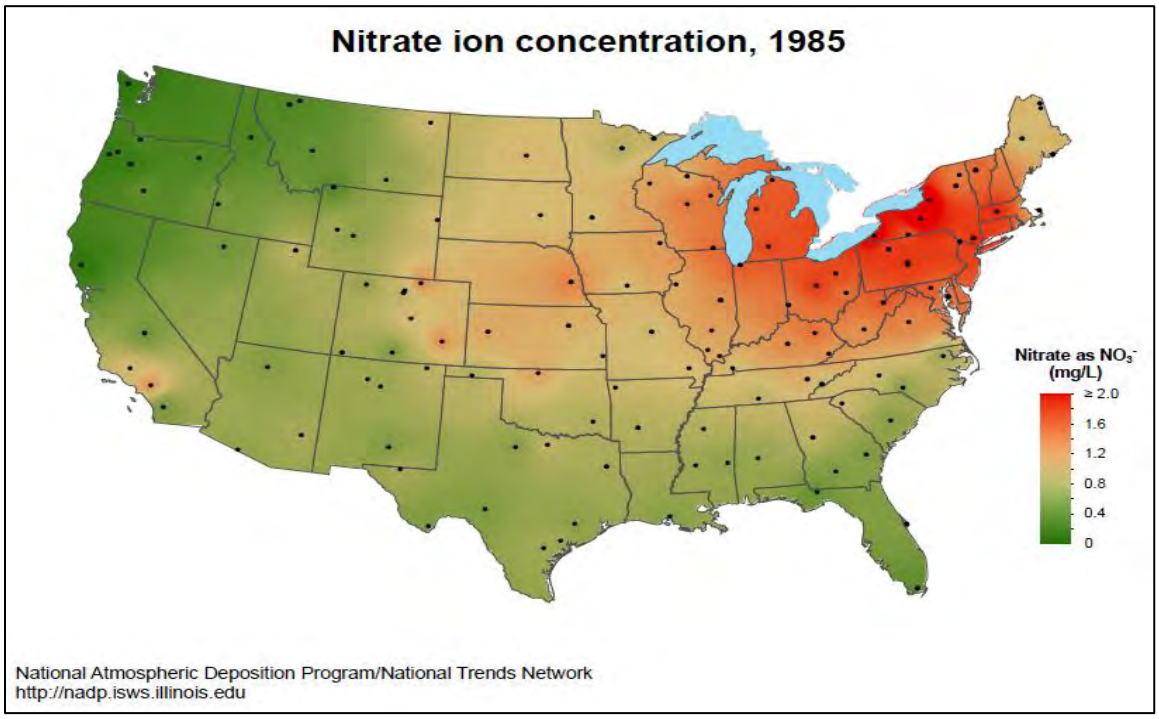


Figure 38: pH ME09 1980-2013

Nitrates also contribute to the acidity of precipitation when resulting chemical reactions create nitric acid. The nitrate ion maps, Figures 39-40, show reductions in nitrate concentrations in the eastern half of the country; however, the western half shows either no

change or some slight increases. The nitrate ion trend plots for two sites in Maine, Figures 41 and 42, also illustrate a smaller magnitude of reduction – about half of that seen for sulfate over the same period of time.



39: U.S. Nitrate Ion Concentration, 1985

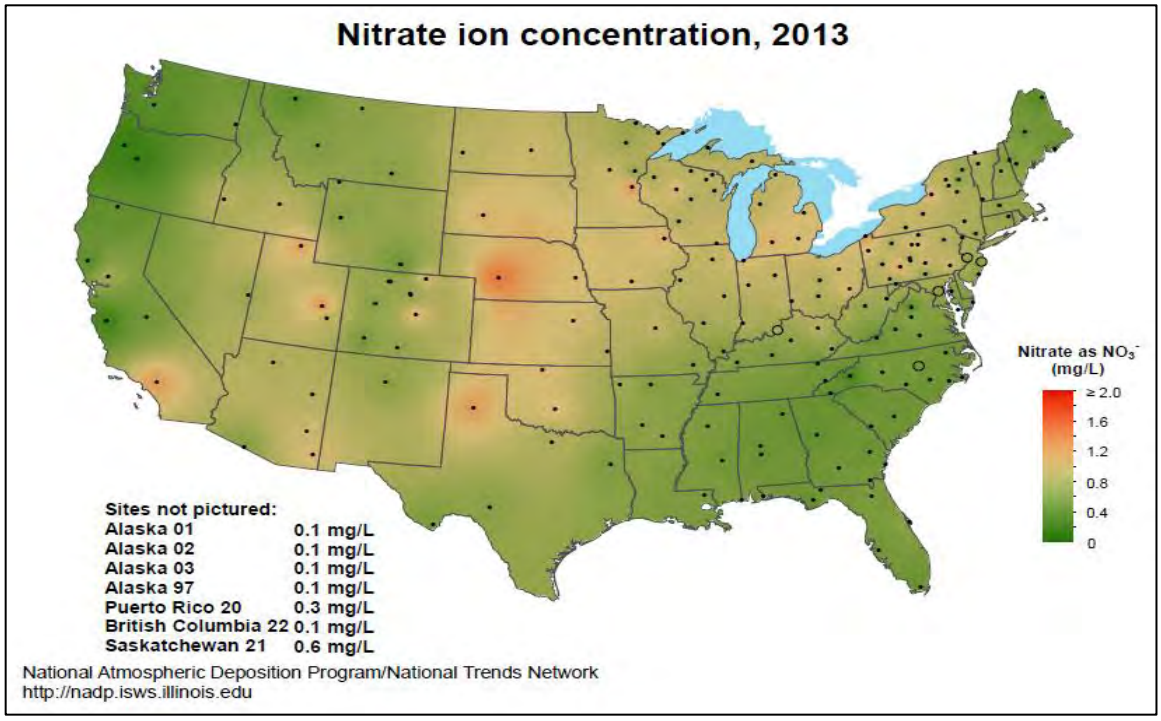


Figure 40: U.S. Nitrate Ion Concentration, 2013

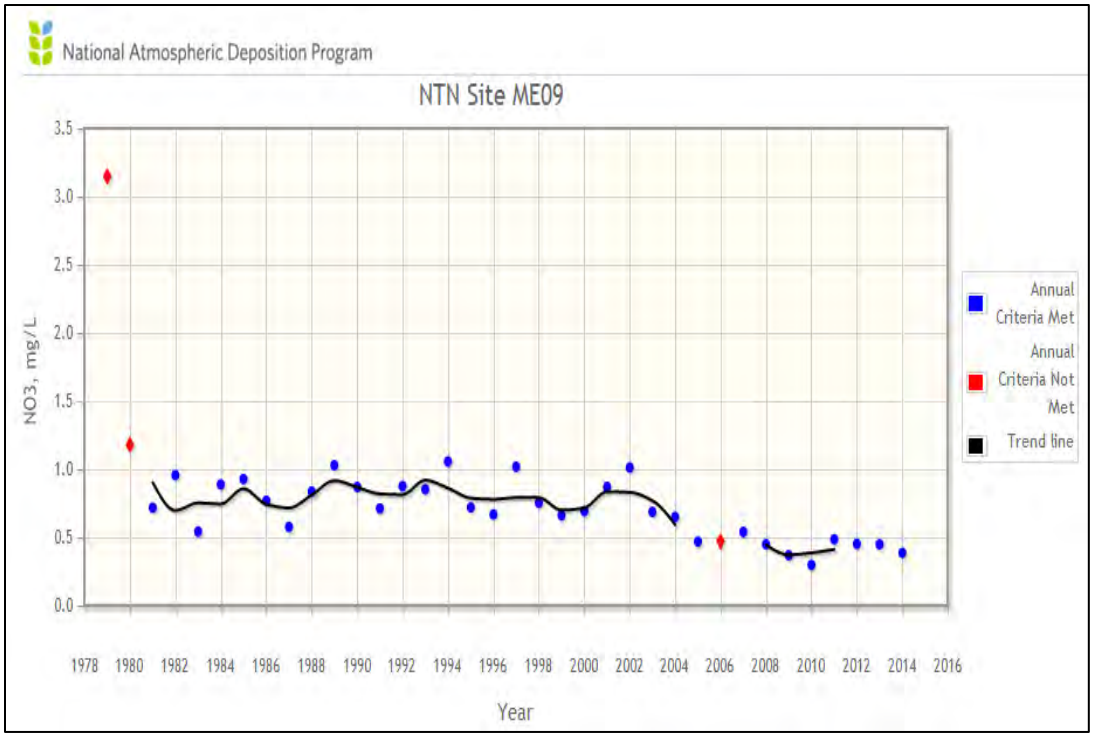


Figure 41: NO_3 ME09 1979-2013

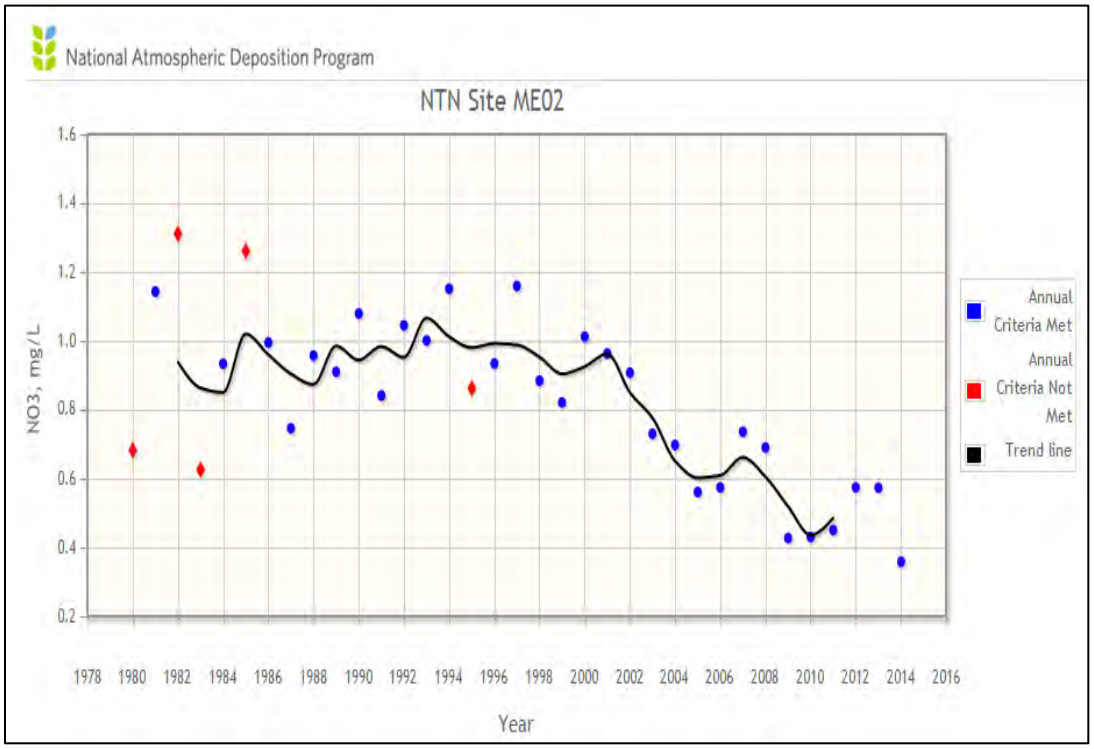


Figure 42: NO_3 ME02 1980-2013

The following Figures 43 and 44 show the annual color-shaded contour maps of the MDN sites nationally from 2003 and 2013. Trends are not as readily apparent over the 10-year time period represented by these maps. The appearance of mercury concentrations in the western half of the country between 2003 and 2013 is due in part to the increase in the

spatial density of sites in the MDN, which then provides the NADP mapping software with more data source points to use in the interpolation of concentration levels between sites, which sites and data it didn't have in 2003.

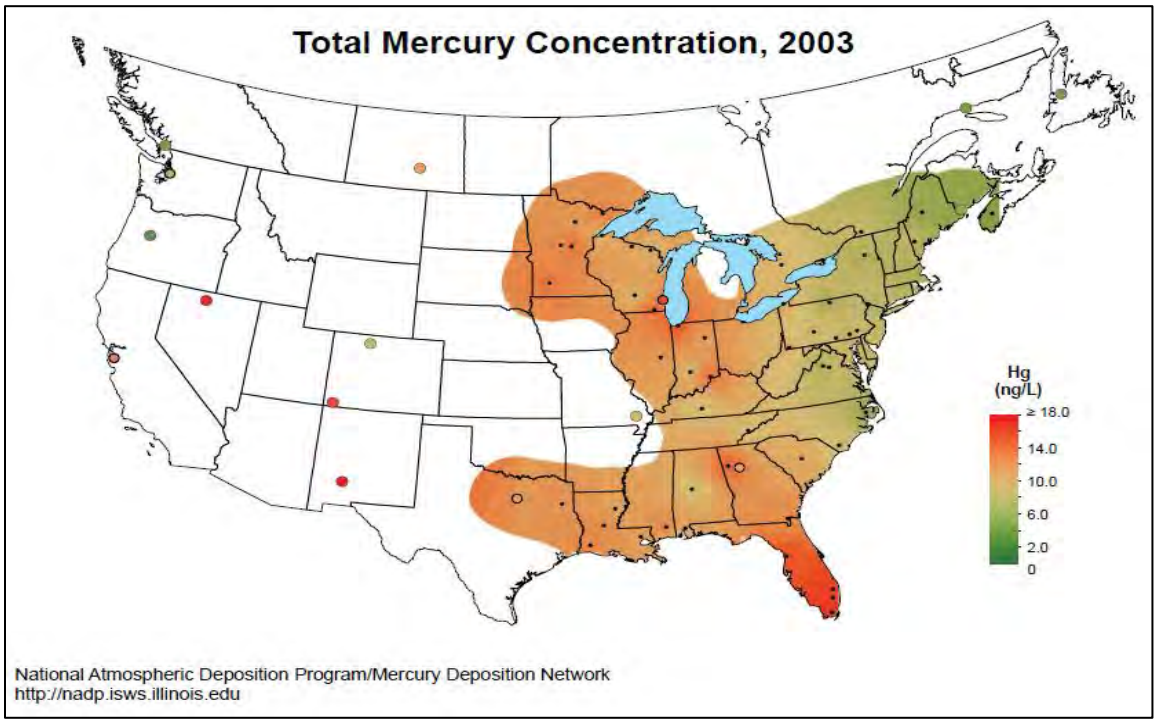


Figure 43: U.S. Total Mercury Concentration 2003

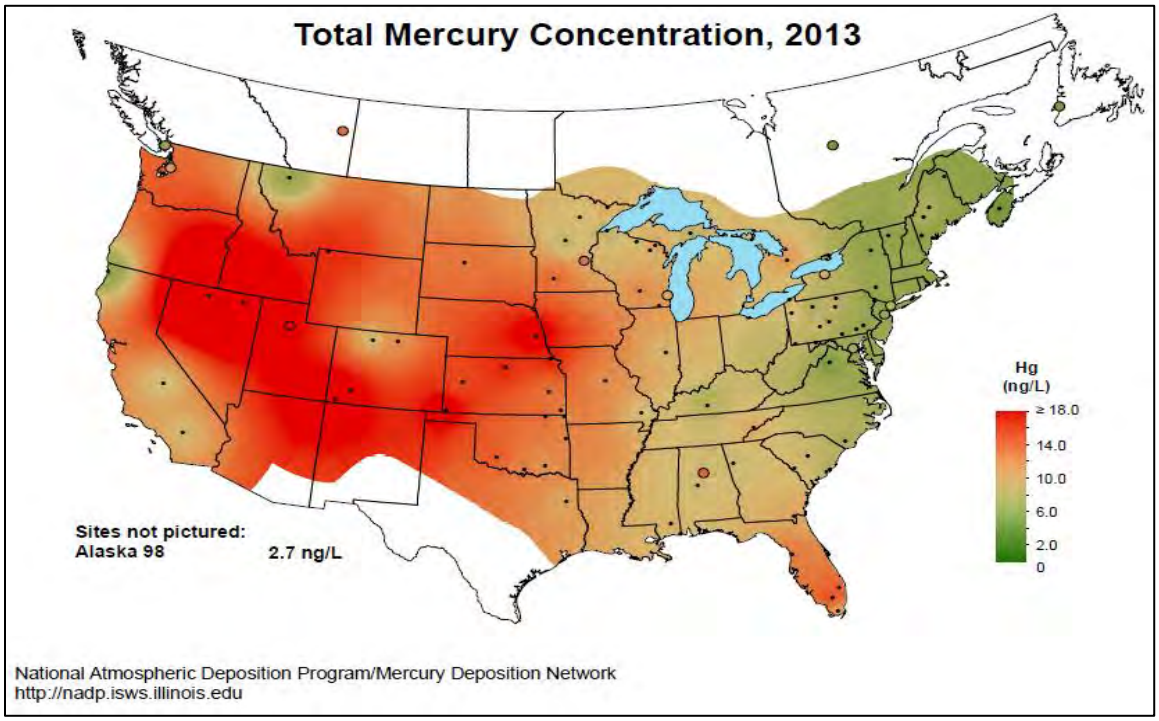


Figure 44: U.S. Total Mercury Concentration 2013

Future NTN and MDN Monitoring Plans

The State of Maine's DEP plans to continue the statewide NTN and MDN deposition monitoring networks and funding of the sites it currently sponsors. Their data are valuable not only to internal data users, policy makers, and the general public, but also to various users representing many other scientific disciplines, such as wildlife biologists, water quality specialists, epidemiologists, atmospheric chemists, government regulators, and academic researchers. In recent years, the Department has taken over both funding and operational support to some of the oldest and longest running sites in the State and the nation when the original sponsoring organizations were faced with funding cutbacks which would have meant the closing of these sites. Specifically, Maine DEP assumed responsibility for the NTN sites at Greenville (ME09) and Caribou (ME00) when the University of Maine and NOAA, respectively, had their funding cut for continued operation of these sites. The closing down of these two sites would have represented an irreversible loss in continued documentation of long term deposition trends in Maine and the country without confounding interruption in the dataset. As long as resources allow, Maine is committed to preserving the operational status of the sites in the State.

A priority effort for the agency during the past five years was collaborating with EPA Region 1 and the Passamaquoddy Tribe to re-establish the tribal NTN site (ME95), formerly located near Scraggly Lake. This was the only area of the State that did not have any wet deposition monitoring and the precipitation chemistry data it provides for this heavily forested, agricultural, and surface water based recreational area. That effort resulted in the establishment of a new site (ME94) in October 2013.

Monitoring Equipment Evaluation

The existing inventory of monitoring equipment is adequate to maintain the current network at this time. The current equipment plan calls for instrument replacement after about ten years of use. Depending on available funds and inclusive costs, the actual equipment replacement cycle for monitoring and laboratory instrumentation is usually longer, approximately 15-20 years. In recent years, Maine has purchased several new continuous particulate monitors (BAMs), replaced aging particulate filter monitors, replaced several ozone monitors and calibrators, and replaced several trace level carbon monoxide, sulfur dioxide, and nitrogen dioxide monitors.

Over the years, the Department has established special monitoring sites in Eliot, Waterville, Augusta, and Thomaston in response to monitoring requests from municipality officials with specific neighborhood health concerns, and the Department will continue to provide such support for future requests. These special monitoring sites, mostly using monitors from the Department's spare equipment inventory, are often temporary arrangements and the data representative of only very small, sub-neighborhood areas. These efforts have served to provide factual data for municipalities and industrial sources to use as a common denominator in further discussion and, in some cases, resolutions.

Quality Assurance Evaluation

EPA policy requires all projects involving the generation, acquisition, and use of environmental data to be planned and documented and to have an Agency-approved quality assurance project plan (QAPP) prior to the start of data collection. The primary purpose of the QAPP is to provide an overview of the project, describe the need for the measurements, and define quality assurance/quality control (QA/QC) activities to be applied to the project, all within a single document. The QAPP is to be detailed enough to provide a clear description of every aspect of the project and include information for every member of the project staff, including samplers, lab staff, and data reviewers. The QAPP facilitates communication among clients, data users, project staff, management, and external reviewers. Effective implementation of the QAPP assists project managers in keeping projects on schedule and within the resource budget. The EPA's QA policy is described in the Quality Manual and EPA QA/R-1, *EPA Quality System Requirements for Environmental Programs.*

Maine currently has four QAPPs in place for various air monitoring programs, for which the approval and revision status of each is identified in the table below.

QAPP	EPA Approval Date	Current Status
Particulate Matter (PM) NAAQS Pollutants	May 30, 2007	Undergoing revision to incorporate all aspects of PM_{10} monitoring using low volume manual samplers and continuous PM monitoring using TEOM samplers
Gaseous NAAQS Pollutants	June 23, 2009	Under review, additional changes expected
Photochemical Assessment Monitoring Station (PAMS)	October 28, 2005	
Air Toxic Volatile Organic Compound (VOC) Pollutants	September 28, 2004	
Trace Level Monitors, NCore Site	n/a	Effective 2016
Lead Monitoring		

Maine currently operates an extensive quality assurance program that includes auditing of all ambient monitors by staff from the Laboratory and Quality Assurance Section. To evaluate and ensure accuracy of data collected by ambient monitors, lab and QA staff conduct quarterly audits of the instruments, far exceeding minimum EPA requirements. This practice is expected to be relaxed in future revisions based on demonstrated results to date.