CANADA UNITED STATES

Air Quality Agreement
Progress Report 2012

Celebrating 20 Years

1991-2011

THE INTERNATIONAL JOINT COMMISSION REQUESTS YOUR COMMENTS ON THIS REPORT

The International Joint Commission (IJC) is interested in your views on the important work being carried out under the Air Quality Agreement. What do you think about the ongoing efforts of our two countries to address transboundary air quality; what issues do you think should have the highest priority; and what do you think about the information provided in this report?

Under the Air Quality Agreement, the IJC invites public comment and provides a synthesis of comments to the Governments of Canada and the United States (U.S.) to assist them with implementing the Agreement. The IJC invites you to send written comments on this report until September 27, 2013, at either address below:

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U.S. spelling is used throughout this report except when referring to Canadian titles.

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INTRODUCTION

The United States and Canada signed the 1991 United States–Canada Air Quality Agreement (AQA) to reduce the impact of transboundary air pollution. The Acid Rain Annex, negotiated with the original 1991 agreement, committed both the United States and Canada to reducing acid rain-causing emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_X). Since this time, there have been large reductions in SO_2 and NO_X emissions on both sides of the border with subsequent reductions in ecosystem acidification and improvements in air quality. For example, the United States has reduced total SO_2 emissions from covered sources by 67 percent in 2010 from their 1990 levels while Canada's total SO_2 emissions have decreased by 57 percent in 2010 from 1990 emission levels. The Ozone Annex, added to the Agreement in 2000, committed the countries to reducing emissions of NO_X and volatile organic compounds (VOCs), the precursors to ground level ozone, a key component of smog. Between 2000 and 2010, the United States has reduced total NO_X emissions by 42 percent in the transboundary ozone region while Canada's total NO_X emissions decreased by 40 percent in the region.

The 2012 Progress Report, prepared by the bilateral Air Quality Committee, is the eleventh biennial report completed under the 1991 United States–Canada Air Quality Agreement. The report summarizes key actions undertaken by the United States and Canada in the last two years to address transboundary air pollution within the context of the Agreement, as required under Article VIII. The report presents progress made toward meeting the commitments established in the Annexes and in implementing the Agreement.

To prepare this report, the Air Quality Committee took into consideration the public comments received through the International Joint Commission (IJC) regarding the 2010 Progress Report. A synthesis of comments can be found at the International Joint Commission (IJC) website at <www.ijc.org/php/publications/pdf/Synthesis-of-Public-Comment-2010.pdf>. The comments expressed support for the Agreement and its success in fostering cooperation on transboundary air pollution control and satisfaction with the progress made by both countries in reducing emissions of pollutants that cause acid rain and contribute to smog formation.

SECTION 1

Commitments

Acid Rain Annex

Overview

The Acid Rain Annex to the 1991 Air Quality Agreement established commitments for both countries to reduce emissions of SO_2 and NO_X, the primary precursors to acid rain. The commitments also include prevention of air quality deterioration, visibility protection, and continuous emission monitoring. Both countries have succeeded in reducing the impact of acid rain on each side of the border. Studies in each country, however, indicate that further efforts are still necessary to restore damaged ecosystems to their pre-acidified conditions.

Key Commitments and Progress: SO_2 Emission Reductions

CANADA

For more than two decades, Canada has steadily reduced SO_2 emissions, through various actions including the requirements to reduce sulfur content in fuels and the implementation of the Canada-wide Acid Rain Strategy for Post-2000. The Strategy serves as the framework for addressing the issues related to acid rain with the goal that the deposition of acidifying pollutants does not further deteriorate the environment in eastern Canada and that new acid rain problems do not occur elsewhere in Canada. In 2010, Canada's total SO_2 emissions were 1.4 million metric tons (1.5 million short tons[1]), or about 57 percent below the national cap of 3.2 million metric tons (3.5 million short tons). This also represents a 57 percent reduction from Canada's total SO_2 emissions in 1990 (see Figure 1).

The largest contribution of SO_2 emissions comes from industrial sources, which accounted for about 65 percent of national SO_2 emissions in 2010. Key sources such as the nonferrous smelting and refining industry and the upstream petroleum industry contributed 27 percent and 20 percent, respectively, to national SO_2 emissions in 2010. Electric power generation accounted for 24 percent of the national total. The majority of overall reductions in national SO_2 emission levels can be attributed to the SO_2 emission reductions undertaken by the four eastern provinces (New Brunswick, Nova Scotia, Quebec, and Ontario) targeted by the Acid Rain Strategy and recent facility closures.

While Canada has been successful in reducing emissions of acidifying pollutants, many areas across Canada have a low capacity to withstand acid deposition and continue to receive levels in excess of critical loads, most notably in eastern Canada. A critical load is the maximum amount of acidifying deposition an ecosystem can tolerate in the long term without being damaged (see the Ecological Effects chapter in Section 2 later in this report for more information).

Additional measures to reduce SO_2 and NO_X emissions from certain industrial sectors are being considered as part of the new air quality management system for Canada (see Section 3: New Actions on Acid Rain, Ozone, and Particulate Matter).

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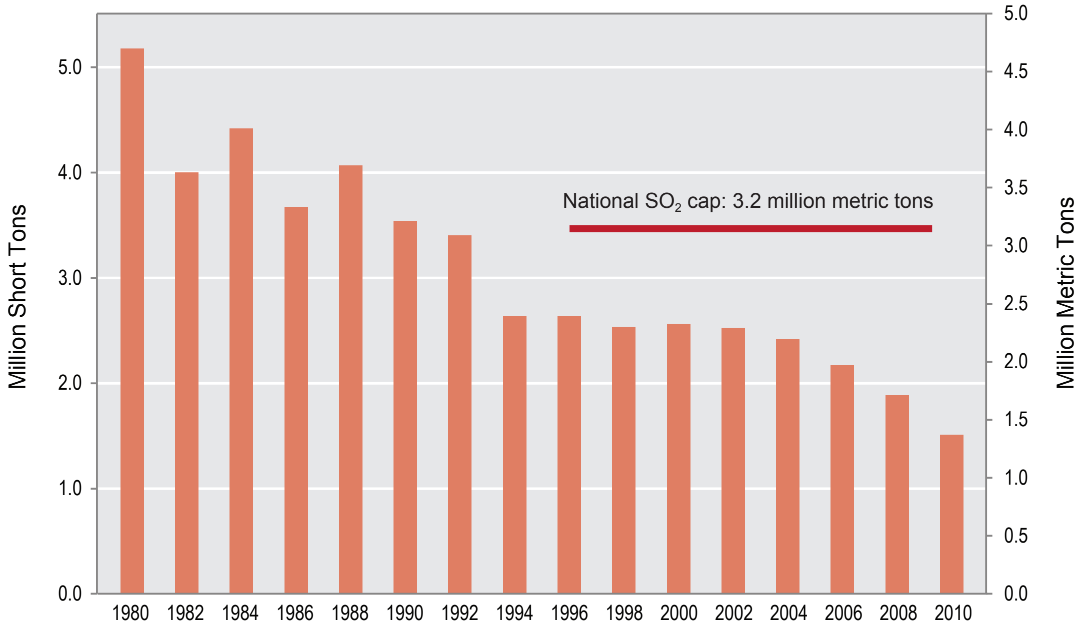
[1] One metric ton is equal to 1.1 short tons.

Figure 1. Total Canadian Emissions of SO_2, 1980–2010



Source: Environment Canada, 2012

UNITED STATES ★

The United States succeeded in meeting its commitment to reduce annual SO_2 emissions by 10 million short tons (9.1 million metric tons) from 1980 levels by 2000. Additionally, since 2007, emissions of SO_2 from the electric power sector have been below the 2010 national emission cap of 8.95 million short tons (8.1 million metric tons).

The Acid Rain Program (ARP), established under Title IV of the 1990 Clean Air Act (CAA) Amendments, requires major emission reductions of SO_2 and NO_X, the primary precursors of acid rain, from the power sector. The SO_2 program sets a permanent cap on the total amount of SO_2 that may be emitted by electric generating units (EGUs) in the contiguous United States and uses a market-based cap and trade program to achieve emission reductions. The program was phased in, with the final 2010 SO_2 cap set at 8.95 million short tons (8.1 million metric tons), a level of about one-half of the emissions from the power sector in 1980. NO_X reductions under the ARP are achieved through a program that applies to a subset of coal-fired EGUs and is closer to a traditional, rate-based regulatory system.

In 2011, the SO_2 requirements under the ARP applied to 3,640 fossil fuel-fired combustion units that served large generators greater than 25 megawatts (MW) at 1,245 facilities across the country providing electricity for sale. ARP units emitted 4.5 million short tons (4.1 million metric tons) of SO_2 in 2011, meaning that ARP sources reduced emissions by 11.2 million short tons (10.2 million metric tons, or 71 percent) from 1990 levels and 12.8 million short tons (11.6 million metric tons, or 73 percent) from 1980 levels. The vast majority of ARP SO_2 emissions result from coal-fired EGUs, although the program also applies to oil and gas units.

These reductions occurred while electricity demand (measured as heat input) remained relatively stable, indicating that the reduction in emissions was not driven by decreased electric generation. Instead, there was a drop in emission rate. A drop in emission rate represents an overall increase in the environmental efficiency of these sources as power generators install controls, run controls year round, switch to different fuels, or otherwise cut their SO_2 emissions while meeting relatively steady demand for power.

Clean Air Interstate Rule

In 2005, the U.S. promulgated the Clean Air Interstate Rule (CAIR) to address regional interstate transport of ozone and fine particle ($PM_{2.5}$) pollution. CAIR requires 24 eastern states and the District of Columbia (D.C.) to limit annual emissions of NO_X and SO_2, which contribute to the formation of $PM_{2.5}$ (particulate matter less than or equal to 2.5 microns). CAIR also requires 25 states and D.C. to limit ozone season NO_X emissions, which contribute to the formation of smog during the summer ozone season (May to September).

However, in July 2008, the U.S. Court of Appeals for the D.C. Circuit granted several petitions for review of CAIR, finding significant flaws in the rule. Subsequently, in December 2008, the court issued a ruling to keep CAIR and the CAIR Federal Implementation Plans (FIPs) — including the CAIR trading programs — in place temporarily until the U.S. Environmental Protection Agency (EPA) issued new rules to replace CAIR and the CAIR FIPs. On July 6, 2011, EPA finalized the Cross-State Air Pollution Rule (CSAPR) to replace CAIR. On December 30, 2011, the court stayed CSAPR pending judicial review and on August 21, 2012, the court issued an opinion vacating CSAPR. In its August opinion, the court also ordered EPA to continue administering CAIR.

CAIR includes three separate cap and trade programs to achieve the rule's required reductions: the CAIR NO_X ozone season trading program, the CAIR NO_X annual trading program, and the CAIR SO_2 annual trading program. The CAIR NO_X ozone season and annual programs began in 2009, while the CAIR SO_2 program began in 2010.

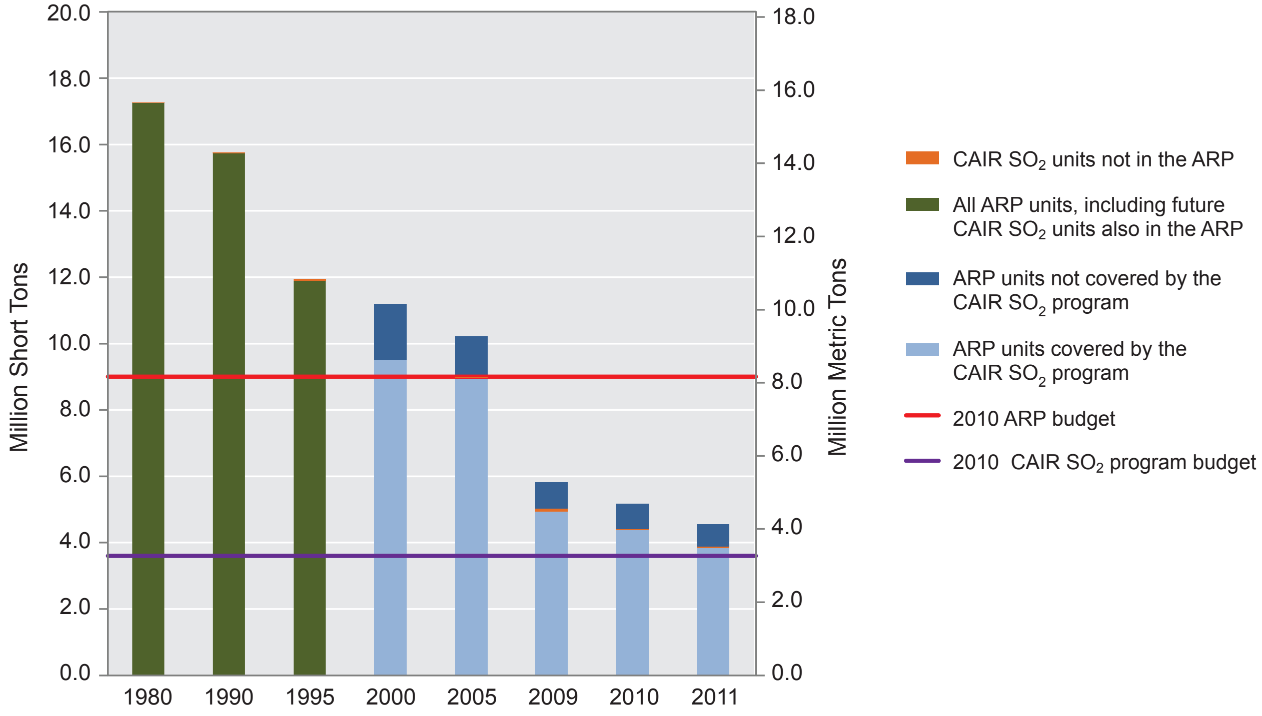
In 2011, there were 3,345 affected EGUs at 951 facilities in the CAIR SO_2 and NO_X annual programs. The CAIR programs cover a range of unit types, including units that operate year round to provide baseload power to the electric grid as well as units that provide power on peak demand days only and may not operate at all during some years. Annual SO_2 emissions from sources in the CAIR SO_2 program alone fell from 9 million short tons (8.2 million metric tons) in 2005 when CAIR was promulgated to 3.9 million short tons (3.5 million metric tons) in 2011, a 57 percent reduction. Between 2010 and 2011, SO_2 emissions fell 543,000 short tons (493,600 metric tons), or twelve percent. However, the 2011 emissions total is higher than the CAIR SO_2 program's state budget total of 3.6 million short tons (3.3 million metric tons), indicating that affected sources used banked allowances carried over from the ARP for compliance with CAIR.

U.S. EPA's Quarterly Emissions Tracking site contains the most up-to-date emission and control data for sources in the ARP and CAIR (<www.epa.gov/airmarkets/quarterlytracking.html>).

In addition to the electric power generation sector, emission reductions from other sources not affected by the ARP or CAIR, including industrial and commercial boilers and the metals and refining industries, and the use of cleaner fuels in residential and commercial burners, have contributed to an overall reduction in annual SO_2 emissions. National SO_2 emissions from all sources have fallen from nearly 26 million short tons (23.5 million metric tons) in 1980 to just under 7 million short tons (6.2 million metric tons) in 2011 (see <www.epa.gov/ttn/chief/trends>).

Figure 2 combines emission and compliance data for both the ARP and CAIR to more holistically show reductions in power sector emissions of SO_2 from these national and regional programs, as of 2011.

Figure 2. SO_2 Emissions from CAIR SO_2 Annual Program and ARP Sources, 1990–2011



Source: U.S. EPA, 2012

Key Commitments and Progress: NO_X Emission Reductions

CANADA

Canada has met its commitment to reduce NO_X emissions from power plants, major combustion sources, and metal smelting operations by 100,000 metric tons (110,000 short tons) below the forecasted level of 970,000 metric tons (1.1 million short tons). This commitment is based on a 1985 forecast of 2005 NO_X emissions. In 2010, industrial emissions of NO_X totaled 632,093 metric tons (695,302 short tons). Emissions of NO_X from all industrial sources and including emissions from electric power generation totaled 841,007 metric tons (925,108 short tons) in 2010, well below the forecasted level of 970,000 metric tons (1.1 million metric tons).

Transportation sources contribute the majority of NO_X emissions, accounting for over 55 percent of total Canadian emissions, with the remainder produced by the upstream petroleum industry (21 percent), electric power generation facilities (10 percent), and other sources (see Figure 25 on page 37). Canada continues to develop programs to further reduce NO_X emissions nationwide. Additional information on Canadian emissions can be found at: <www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=0EC58C98-1>.

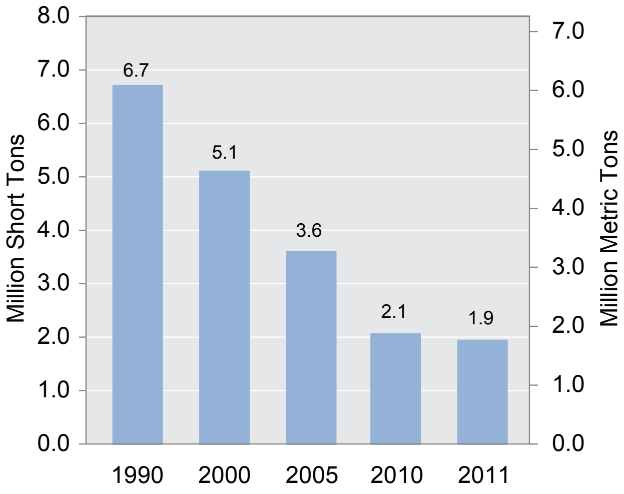
UNITED STATES ★

The United States has exceeded its goal under the Acid Rain Annex to reduce total annual NO_X emissions by 2 million short tons (1.8 million metric tons) below projected annual emission levels for 2000 without the ARP (8.1 million short tons, or 7.4 million metric tons).

Title IV of the CAA requires NO_X emission reductions from certain coal-fired EGUs. Unlike the market-based NO_X programs in CAIR, the ARP requires NO_X emission reductions for older, larger coal-fired EGUs by limiting their NO_X emission rate (expressed in lb/mmBtu). In 2011, 930 units at 375 facilities were subject to the ARP NO_X program.

Emissions of NO_X from all sources covered by the ARP (Figure 3) were 1.9 million short tons (1.7 million metric tons) in 2011. This level is over 6 million short tons (5.5 million metric tons) less than the projected NO_X level in 2000 without the ARP, and over three times the Title IV NO_X emission reduction commitment under the Acid Rain Annex.

Figure 3. U.S. Title IV Utility Unit Annual NO_X Emissions from All ARP Sources, 1990–2011



Source: U.S. EPA, 2012

While the ARP is responsible for a portion of these annual NO_X reductions, other programs—such as the CAIR NO_X ozone season and annual programs, and state NO_X emission control programs—contributed significantly to the NO_X reductions that sources achieved in 2011.

Emissions/Compliance Monitoring

CANADA

Canada has met its commitments to estimate emissions of NO_X and SO_2 from new electric utility units and existing electricity units greater than 25 MW using a method comparable in effectiveness to continuous emission monitoring systems (CEMS) and to investigate the feasibility of using CEMS by 1995. Continuous emission monitoring installation in Canada's electric utility sector has been widespread since the late 1990s. By 2011, almost all new and existing base-loaded fossil steam plants with high emission rates have been operating CEMS. Coal-fired facilities, which are the largest source of emissions from the sector, have SO_2 and NO_X CEMS installed at more than 93 percent of their total capacity. Under Canada's National Pollutant Release Inventory (NPRI) mandatory reporting program, electric power generating facilities are required to report their air pollutant emissions annually.

UNITED STATES ★

The ARP requires affected units to measure, record, and report SO_2 and carbon dioxide (CO_2) mass emissions and NO_X emission rates using CEMS or an approved alternative measurement method. The vast majority of emissions are monitored with CEMS, while the alternatives provide a cost-effective means of monitoring mass emissions for smaller and/or cleaner units. Table 1 shows the amount of SO_2 emissions monitoring using CEMS.

Table 1. Units and SO_2 Emissions Covered by Monitoring Method for the ARP, 2011

Primary Fuel	CEM or Non-CEM	Units Reporting	SO_2 Mass (short tons)	SO_2 Mass (metric tons)	Percentage of Units	Percentage of SO_2 Emissions
Coal	CEM	1,026	4,478,075	4,070,977	28.37%	99.46%
Gas	CEM	17	1,528	1,389	0.47%	0.04%
	Non-CEM	2,356	2,873	2,612	65.14%	0.06%
Oil	CEM	38	3,255	2,959	1.05%	0.07%
	Non-CEM	162	9,553	8,685	4.48%	0.21%
Other	CEM	17	7,179	6,526	0.47%	0.16%
	Non-CEM	1	1	1	0.02%	0.00%

Note: “Other” fuel units include units that in 2011 combusted primarily wood, waste, or other non-fossil fuel. The total number of units in the table excludes 23 affected units that did not operate in 2011.

Source: U.S. EPA, 2012

Affected sources are required to meet stringent quality assurance and control requirements and report hourly emission data in quarterly electronic reports to the U.S. EPA. In 2011, the average percent of monitoring data available (a measure of monitoring systems’ reliability) was 99 percent for coal-fired units. This number is based on reported monitor data availability for SO_2 monitors (98.9 percent), NO_X monitors (99.2 percent), and flow monitors (99 percent).

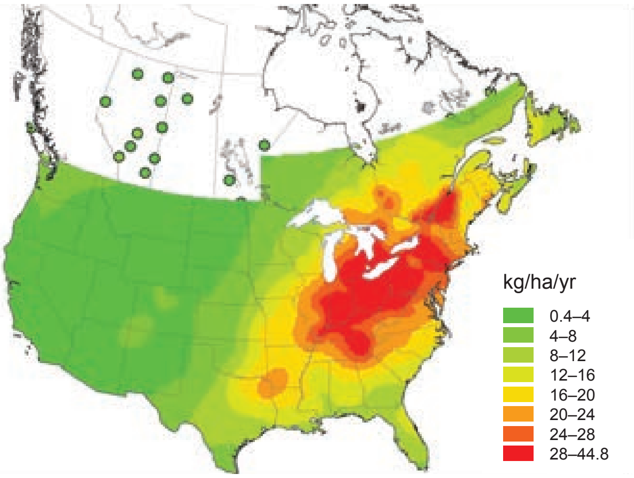
Using automated software audits, the U.S. EPA rigorously checks the completeness, quality, and integrity of monitoring data. The Agency promptly sends results from the audits to the source and requires correction of critical errors. In addition to electronic audits, the U.S. EPA conducts targeted field audits on sources that report suspect data. In 2011, source compliance with ARP emission monitoring requirements was 100 percent for the 3,640 covered units. All emission data are available to the public within two months of being reported to U.S. EPA. Data can be accessed on the Air Markets Program Data website at <www.ampd.epa.gov/ampd>.

Acid Deposition Monitoring, Modeling, Maps, and Trends

Airborne pollutants are deposited on the Earth's surface by three processes: (1) wet deposition (rain and snow), (2) dry deposition (particles and gases), and (3) deposition by cloud water and fog. Wet deposition is comparatively easy to measure using precipitation monitors, and the concentration of sulfate and nitrate in precipitation is regularly used to assess the changing atmosphere as it responds to decreasing or increasing sulfur and nitrogen emissions. In Canada, to facilitate this comparison, measurements of wet sulfate deposition are typically corrected to omit the contribution of sea salt sulfate at near-ocean sites (less than 62 miles, or 100 kilometers [km], from the coast).

Figure 4 through Figure 6 show the United States–Canada spatial patterns of wet sulfate (sea salt-corrected) deposition for 1990, 2000, and 2010 (the most recent data year). Figure 7 through Figure 9 show the patterns of wet nitrate deposition for the same three years. Deposition contours are not shown in western and northern Canada because Canadian experts judged that the locations of the contour lines were unacceptably uncertain due to the paucity of measurement sites in all of the western provinces and northern territories. To compensate for the lack of contours, wet deposition values in western Canada are shown as colored circles at the locations of the federal/provincial/territorial measurement sites.

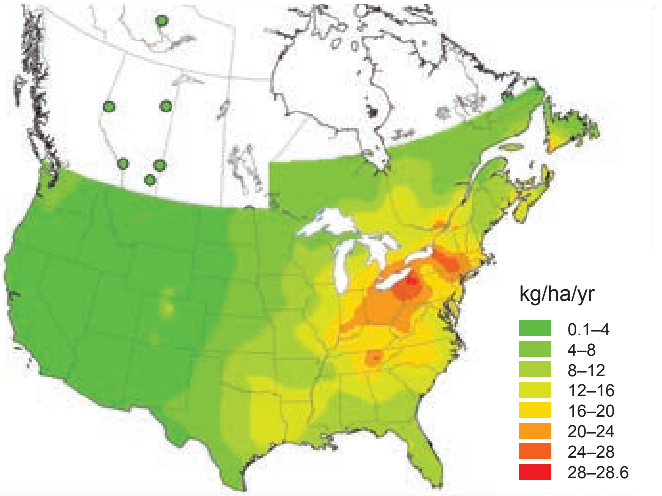
Figure 4. 1990 Annual Wet Sulfate Deposition



Source: National Atmospheric Chemistry (NAtChem) Database (<www.ec.gc.ca/natchem>) and the National Atmospheric Deposition Program (NADP) (<nadp.isws.illinois.edu>), 2010

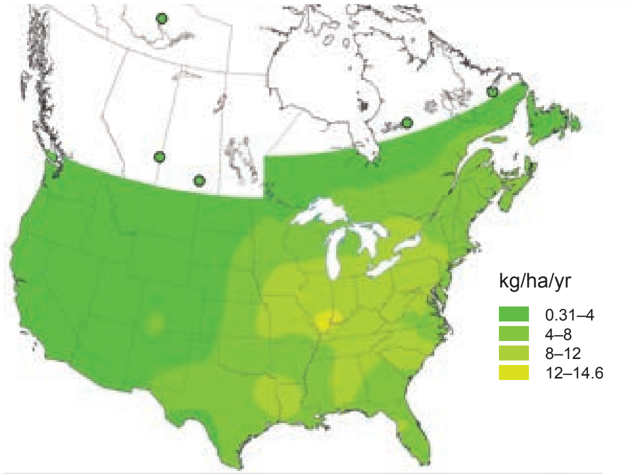
The three maps indicate that wet sulfate deposition is consistently highest in eastern North America around the lower Great Lakes, with a gradient following a southwest-to-northeast axis running from the confluence of the Mississippi and Ohio rivers through the lower Great Lakes. The patterns for 1990, 2000, and 2010 illustrate that significant reductions occurred in wet sulfate deposition in both the eastern United States and eastern Canada.

Figure 5. 2000 Annual Wet Sulfate Deposition



Source: NAtChem Database (<www.ec.gc.ca/natchem>) and the NADP (<nadp.isws.illinois.edu>), 2010

Figure 6. 2010 Annual Wet Sulfate Deposition



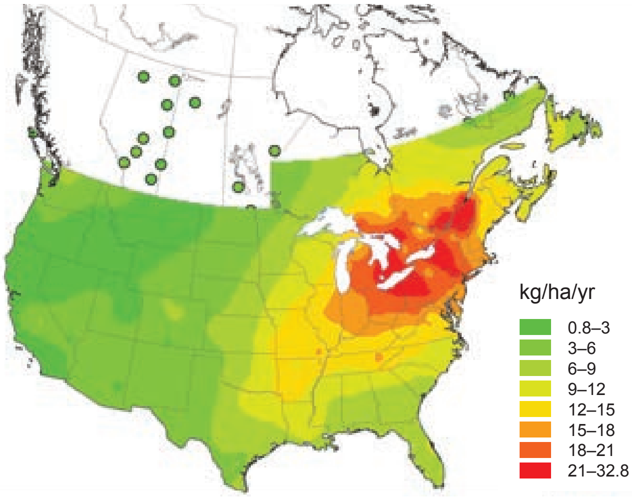
Source: NAtChem Database (<www.ec.gc.ca/natchem>) and the NADP (<nadp.isws.illinois.edu>), 2012

By 2000, the region receiving greater than 28 kilograms per hectare per year (kg/ha/yr) of wet sulfate deposition had decreased to a small area near the southern shore of Lake Erie. By 2010, all regions in eastern Canada and the eastern U.S. were receiving less than 15 kg/ha/yr of wet sulfate deposition. The wet sulfate deposition reductions are considered to be directly related to decreases in SO_2 emissions in both the United States and Canada. The emission reductions are outlined in "Key Commitments and Progress: SO_2 Emission Reductions" in Section 1 of this report.

The patterns of wet nitrate deposition (Figure 7 through Figure 9) show a similar southwest-to-northeast axis, but the area of highest nitrate deposition is north of the region with the highest sulfate deposition. Reductions in wet nitrate deposition have generally been more modest than for wet sulfate deposition, except during the period from 2000 to 2010, when large NO_X emission reductions occurred in the United States and, to a lesser degree, in Canada. As a result, by 2010, all regions were receiving less than 14 kg/ha/yr of wet nitrate deposition.

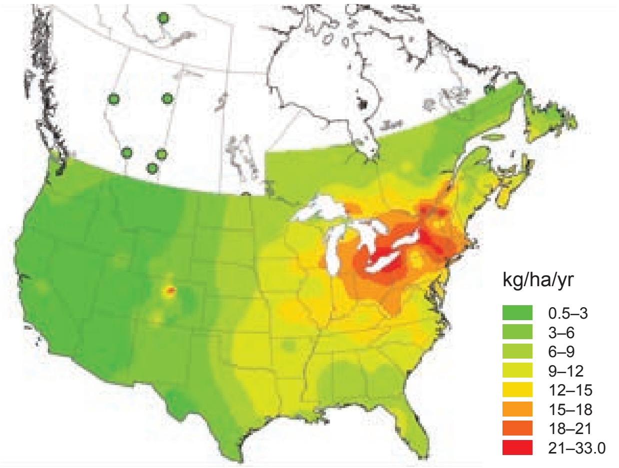
Wet deposition measurements in Canada are made by the federal Canadian Air and Precipitation Monitoring Network (CAPMoN) and networks in a number of provinces/territories, including Alberta, the Northwest Territories, Quebec, New Brunswick, and Nova Scotia. Dry deposition estimates are made at a subset of CAPMoN sites using an inferential method whereby air concentration measurements are combined with modeled dry deposition velocities. In the United States, wet deposition measurements are made by two coordinated networks: the National Atmospheric Deposition Program (NADP) / National Trends Network (NTN), which is a collaboration of federal, state, and nongovernmental organizations (<nadp.sws.uiuc.edu>), and the NADP/Atmospheric Integrated Research Monitoring Network (AIRMoN), which

Figure 7. 1990 Annual Wet Nitrate Deposition



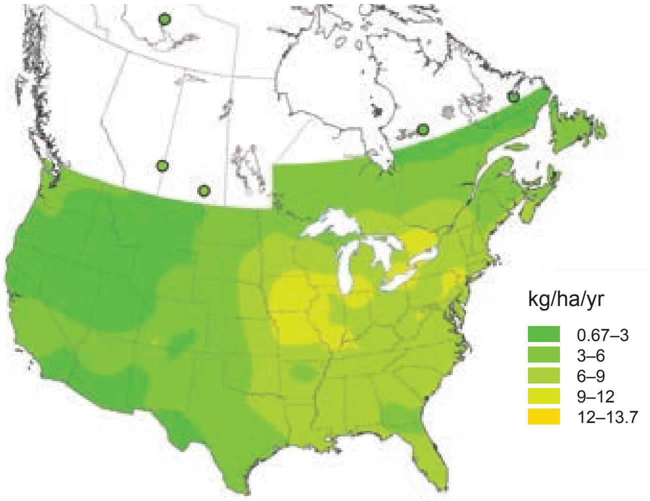
Source: NAtChem Database (<www.ec.gc.ca/natchem>) and the NADP (<nadp.isws.illinois.edu>), 2010

Figure 8. 2000 Annual Wet Nitrate Deposition



Source: NAtChem Database (<www.ec.gc.ca/natchem>) and the NADP (<nadp.isws.illinois.edu>), 2010

Figure 9. 2010 Annual Wet Nitrate Deposition



Source: NAtChem Database (<www.ec.gc.ca/natchem>) and the NADP (<nadp.isws.illinois.edu>), 2012

is a sub-network of NADP funded by the National Oceanic and Atmospheric Administration (NOAA) (<nadp.isws.illinois.edu>). Dry deposition estimates in the United States are made using the inferential technique based on modeled dry deposition velocities and ambient air concentration data collected by the Clean Air Status and Trends Network (CASTNET) (<www.epa.gov/castnet>), which is coordinated by the U.S. EPA and the National Park Service (NPS).

The measurements of wet deposition and air concentrations provided by the Canadian and U.S. networks have been shown to be reasonably comparable through collocated studies and inter-laboratory comparisons. In contrast to these measurements, the estimated dry deposition velocities from the Canadian (Big Leaf Model) and US (Multi-Layer Model) models are poorly correlated due to differences in resistance assumptions. Therefore, deposition fluxes at the collocated sites, calculated from the measured concentrations and modeled deposition velocities, are significantly different. As dry deposition is an important contributor to total deposition, ongoing efforts are in place to study the sources of these differences. At the Borden research station in Ontario, instruments were collocated for a number of years as part of a bilateral intercomparison study on modeling dry deposition. Recent studies[2] attempt to quantify the sensitivity of the CAPMoN and CASTNET dry deposition models to a variety of factors that influence dry deposition velocities, with the goal of refining model parameters for better comparability in future measurements, reconciling past measurements, and identifying further intercomparison needs. Data are available from the websites of the individual networks.

Preventing Air Quality Deterioration and Protecting Visibility

CANADA

Canada is addressing the commitment to prevent air quality deterioration and ensure visibility protection by implementing the Canadian Environmental Assessment Act, the Canadian Environmental Protection Act, 1999 (CEPA 1999), and the continuous improvement (CI) and keeping clean areas clean (KCAC) principles that are part of the Canada-wide Standards (CWS) for particulate matter (PM) and ozone.

Federal and provincial environmental assessment regulation requires that air quality be considered for all major new point sources or modifications to existing sources to ensure that Canadian objectives to protect the environment and human health are met. Mandatory provincial reporting processes require new and existing sources to file notifications, which are reviewed to determine the scale of the environmental assessment appropriate to each case. CEPA 1999 prefers to use pollution prevention in its approach to environmental protection. Implementing similar principles—pollution prevention, CI, and KCAC—is also part of the CWS.

The province of British Columbia continues to make progress towards implementing a visibility management program through the efforts of the British Columbia Visibility Coordinating Committee (BCVCC), an interagency committee consisting of representatives from different levels of government involved in air quality management in the province.

Following a 2010 workshop, the BCVCC adopted a visibility protection framework that describes the visibility management actions required to attain the BCVCC vision of “achieving clean air and pristine visibility for the health and enjoyment of present and future generations”. In 2011, Metro Vancouver adopted its new Integrated Air Quality

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[2] See for example: Schwede, D., L. Zhang, R. Vet, G. Lear, 2011. An intercomparison of the deposition models used in the CASTNET and CAPMoN networks. Atmospheric Environment, 45, 1337-1346.

and Greenhouse Gas (GHG) Management Plan, which includes the goal to “improve visual air quality”. This goal will be accomplished by reducing emissions of visibility degrading pollutants such as PM and by developing a visual air quality management program. As part of a pilot project to develop this program for the Lower Fraser Valley (LFV), the BCVCC is working in four main areas: (1) visibility science, (2) development of a visibility index, (3) development of a business case to quantify the benefits of improved visibility, and (4) communications and outreach.

Recent visibility science work includes upgrading the visibility monitoring network in the LFV, attribution of visibility impairment to emission sources, and the design of emission reduction scenarios for assessment by visibility modeling. The development of a visibility index based on human perception is nearly complete. The current index design is based on a recent perception survey carried out by the BCVCC as well as earlier survey work completed in the 1990s. Following testing, the index may be used as one of the metrics for a visibility improvement goal. The business case developed by the BCVCC outlines in dollar terms the various benefits of improving visibility in the LFV. Considerations in the business case include the health benefits of lower PM levels associated with better visibility, the results of a local study that indicated residents’ willingness to pay for better visibility and visibility impacts on tourism, the film industry, and real estate valuation. Communication and outreach efforts have resulted in the development of a visibility website for British Columbia (<www.clearairbc.ca>) as a means to promote visibility and educate the public on this issue.

In addition to the visibility protection efforts underway in British Columbia, additional activities have been undertaken in other parts of Canada as part of Environment Canada’s National Visibility Monitoring Pilot Study. In 2011, a visibility monitoring pilot site was established at Barrier Lake, Alberta, located on the eastern edge of the Rocky Mountains, close to Banff National Park. The site is operated by Environment Canada using the U.S. Interagency Monitoring of Protected Visual Environments (IMPROVE) protocol and includes both aerosol and optical measurements. This relatively pristine site provides background visibility measurements in a highly scenic part of Canada and is also well positioned to capture any transboundary impacts of air pollution on visibility. The IMPROVE protocol allows for the integration of data from this new site into the U.S. IMPROVE database and the extension of the IMPROVE visual range map into Canada for a direct transboundary comparison. An additional pilot site was established in Wolfville, Nova Scotia, in 2011. This site includes optical and camera measurements, allowing for an assessment of visibility conditions in the scenic Annapolis Valley region. Ongoing work involves the inter-comparison of IMPROVE sampler data with the CAPMoN speciation samplers at Environment Canada’s research station in Egbert, Ontario, to ensure data comparability. In 2012 and 2013, a National Air

Pollutant Surveillance (NAPS) speciation sampler will be collocated with an IMPROVE sampler at the Barrier Lake site in Alberta to assess comparability. Lastly, an updated assessment of visibility conditions across Canada using data from the NAPS speciation network is planned for 2012 and 2013.

UNITED STATES ★

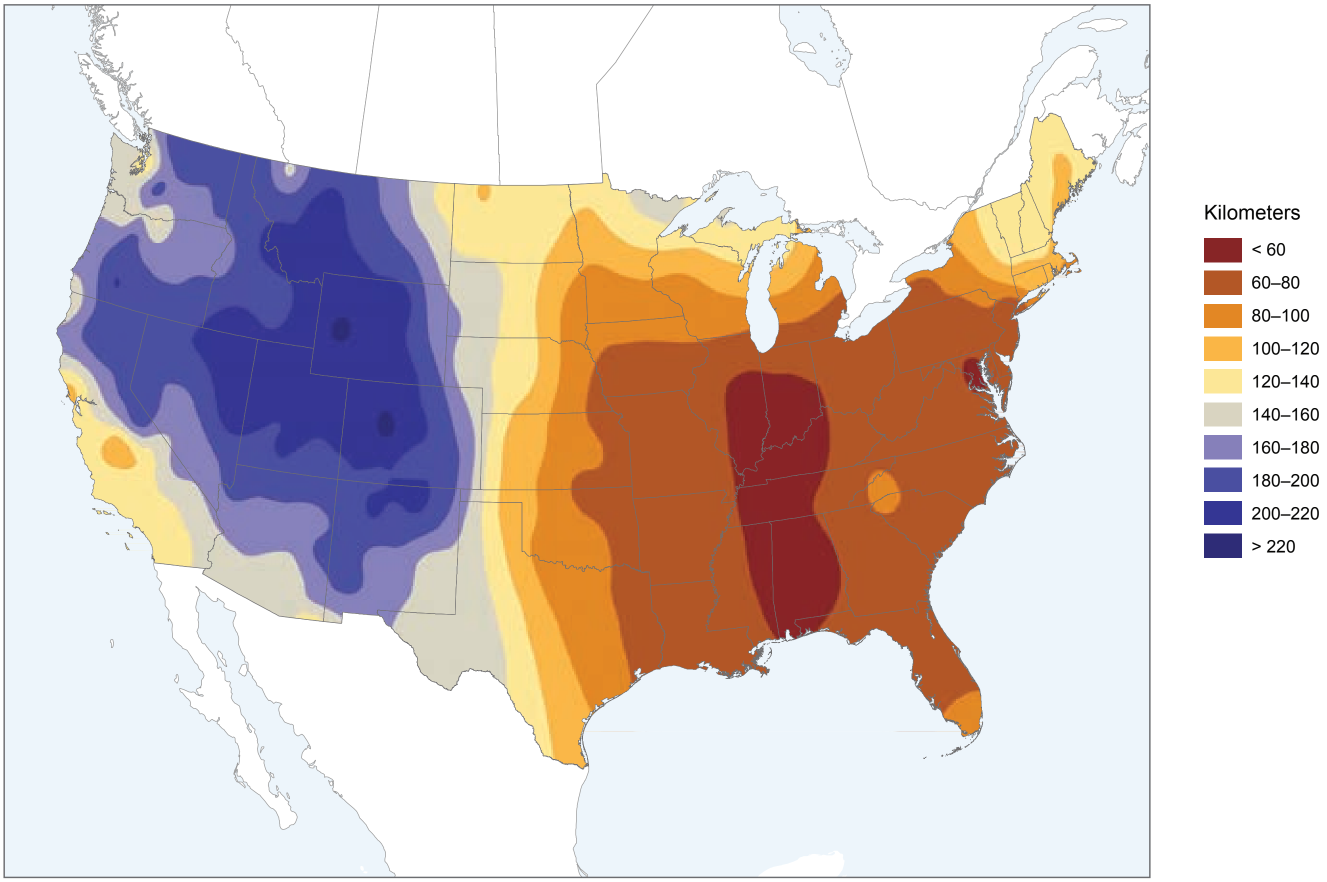
The United States has various programs to ensure that air quality is not significantly degraded by the addition of air pollutants from new or modified major sources. The CAA requires major new stationary sources of air pollution and extensive modifications to major existing stationary sources to obtain preconstruction permits. The permitting process is called New Source Review (NSR) and applies both to areas that meet the National Ambient Air Quality Standards (NAAQS) (attainment areas) and areas that exceed the NAAQS (nonattainment areas). Permits for sources in attainment areas are prevention of significant deterioration (PSD) permits, while permits for sources located in nonattainment areas are nonattainment area permits. PSD permits require air pollution controls that represent the best available control technology (BACT). BACT is an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under the CAA. BACT is determined on a case-by-case basis and considers energy, environmental, and economic impacts. Nonattainment area permits require the lowest achievable emission rate (LAER). BACT and LAER must be at least as strict as any existing New Source Performance Standards (NSPS) for sources. One important difference between NSR permits and the NSPS program is that NSR is applied on a source-specific basis, whereas the NSPS program applies to all sources nationwide. The PSD program also protects the air quality and visibility in Class I areas (i.e., national parks exceeding 6,000 acres and wilderness areas exceeding 5,000 acres). The federal land management agencies are responsible for protecting air quality-related values, such as visibility, in Class I areas by reviewing and commenting on construction permits.

The CAA established the goal of improving visibility in the nation’s 156 Class I areas and returning these areas to natural visibility conditions (visibility that existed before human-caused air pollution). The 1999 Regional Haze Rule requires that states reach that goal by 2064 and specifies the State Implementation Plan (SIP) provisions that states must develop toward that goal. In July 2005, the U.S. EPA finalized amendments to the Regional Haze Rule. These amendments require the installation of emission controls, known as best available retrofit technology (BART), on certain older, existing combustion sources within a group of 26 source categories, including certain EGUs that cause or contribute to visibility impairment in Class I areas. Many of these older sources have never been regulated, and applying BART will help improve visibility in Class I areas. The BART requirements are to be operational no later than five years after the SIP is approved. In addition to BART, the rule also requires states to assess progress toward visibility improvement that could be made by controlling other non-BART emission sources. This is referred to as “reasonable progress”. Decisions regarding potential emission controls for BART and reasonable progress are informed through an assessment of factors including cost effectiveness and the degree of visibility improvement expected.

The first planning period establishes an assessment of expected visibility conditions in 2018. The SIPs must be submitted every 10 years, and states revise their visibility goals accordingly to ensure that reasonable progress is being made to achieve natural visibility conditions by 2064. There is also a reporting check every five years, in which states report their interim progress toward reaching the goals. Additional information on the U.S. EPA’s Regional Haze Program can be found at <www.epa.gov/visibility/index.html>.

Figure 10 shows the annual average standard visual range within the United States for the period 2006 to 2010. “Standard visual range” is defined as the farthest distance a large dark object can be seen during daylight hours. This distance is calculated using fine and coarse particle data from the IMPROVE network. Increased particle pollution reduces the visual range. The visual range under naturally occurring conditions without human-caused pollution in the United States is typically 45 to 90 miles (75 to 140 km) in the east and 120 to 180 miles (200 to 300 km) in the west. Additional information on the IMPROVE program and visibility in U.S. National Parks can be found at <vista.cira.colostate.edu/improve>.

Figure 10. Annual Average Standard Visual Range in the Contiguous United States, 2006–2010



Source: U.S. NPS, 2012 (data from IMPROVE website: <vista.cira.colostate.edu/improve>)

Consultation and Notification Concerning Significant Transboundary Air Pollution

JOINT EFFORTS

The United States and Canada initiated notification procedures in 1994, to identify potential new sources and modifications to existing sources of transboundary air pollution within 100 kilometers (62 miles) of the border. Additionally, the governments can provide notifications for new or existing sources outside of the 100 km region if they believe there is potential for transboundary air pollution. Since the publication of the last Progress Report in 2010, the United States has notified Canada of three additional sources for a total of 64 U.S. notifications. Canada has notified the United States of three additional sources, for a total of 58 Canadian notifications.

Transboundary notification information is available on the government websites of each country at <www.epa.gov/ttn/gei/uscadata.html> for the United States and <www.ec.gc.ca/Air/default.asp?lang=En&n=9C1DAE11-1> for Canada.

Following guidelines approved by the Air Quality Committee in 1998 for a consultation request by a party on transboundary pollution concerns, the United States and Canada report ongoing progress on joint discussions concerning Essar Steel Algoma, Inc. (ESAI) in Sault Ste. Marie, Ontario.

Essar Steel Algoma, Inc.

The ESAI is an integrated primary steel producer located on the St. Mary's River in Sault Ste. Marie, Ontario, approximately one mile from the United States–Canada border. The United States–Canada Algoma informal consultation group was formed in 1998 to address concerns regarding local cross-border pollution. Representatives from the United States and Canada hold regular discussions to coordinate monitoring programs in the Sault Ste. Marie area and to address progress in abating potential transboundary air pollution from the ESAI facility in Ontario. Air quality monitoring on the Canadian side has been ongoing since the 1960s, and the monitoring on the U.S. side was initiated by the Inter-tribal Council of Michigan in 2001. Sampling of fine PM and toxic air contaminants continues on both sides of the border.

Canadian and U.S. representatives have continued to meet to discuss progress toward reducing emissions from ESAI and to share results of air monitoring studies. To date, the air measurements recorded at the Michigan sites do not violate U.S. ambient air quality standards, nor do they exceed air toxics levels of concern for long-term exposure. However, several pollutants, including total suspended particulates and coarse PM (i.e., PM less than or equal to 10 microns, or PM_{10}), exceed Ontario air quality criteria in the west end of Sault Ste. Marie, Ontario. The U.S. 24-hour NAAQS standard for $PM_{2.5}$ was significantly reduced in 2006, but no Michigan sites exceeded the new standard.

In 2007, the Inter-tribal Council of Michigan installed a camera, facing toward Sault Ste. Marie, Ontario, as part of the Midwest Hazecam Network (see <www.mwhazecam.net>). The Inter-tribal Council provided the Ontario Ministry of the Environment (MOE) with photographs documenting red and black particle plumes emanating from ESAI on multiple dates from 2007 to 2009. Ontario MOE staff have documented these emission events in their reporting system and contacted ESAI regarding previously unreported incidents.

ESAI completed installation of a permanent baghouse for the #7 blast furnace in February 2009. Due to the economic downturn, the #6 blast furnace is presently idle and ESAI does not have any plans to start the #6 blast furnace in the near future. When it does restart the #6 blast furnace, ESAI will have 10 months to have the permanent baghouse operating. ESAI initiated the operation of its cogeneration facility in 2009. The cogeneration facility is fully operational and produces approximately 70 MW of electricity with the potential to generate up to 120 MW if the #6 blast furnace is operating.

Also, ESAI has been ordered to conduct a modeling and monitoring study of the coke ovens, which will result in refined emission estimates for the coking operations. This study has been completed and is currently being reviewed by the company prior to release. ESAI has installed individual oven pressure controls on the #9 battery. This retrofit was the first of its kind in North America and was installed and operational on November 15, 2011. The company has commenced a second modeling and monitoring study as of May 1, 2012 to determine the effectiveness of the new controls in reducing fugitive emissions from the #9 battery. The #7 battery was retrofitted with a mechanized door and jam cleaner, which was operational on July 31, 2012. The ESAI bilateral consultation group continues to monitor and report on this facility and is in the process of analyzing air quality monitoring data collected since pollution controls were installed at the facility.

Ozone Annex

Overview

The Ozone Annex commits both the United States and Canada to address transboundary ground-level ozone by reducing emissions of NO_X and VOCs, the precursors to ground-level ozone. The commitments apply to a defined region in both countries known as the Pollutant Emission Management Area (PEMA), which includes central and southern Ontario, southern Quebec, 18 U.S. states[3] and D.C. The states and provinces within the PEMA are the areas where emission reductions are most critical for reducing transboundary ozone. The Annex was added to the AQA in 2000.

Key Commitments and Progress

CANADA

Vehicles, Engines, and Fuels

New stringent NO_X and VOC emission standards for vehicles, including cars, vans, light-duty trucks, off-road vehicles, small engines and diesel engines, as well as fuels.

Emissions from vehicles, off-road equipment, and fuels account for more than 70 percent of the NO_X emissions and more than 30 percent of the VOC emissions in the Canadian PEMA region. Consistent with its Ozone Annex obligations, Canada has implemented a series of regulations to align Canadian emission standards for vehicles and engines with corresponding standards in the United States.

The On-Road Vehicle and Engine Emission Regulations were in effect as of January 1, 2004, and introduced more stringent national emission standards, aligned with U.S. federal standards, for new 2004 and later model year light-duty vehicles and trucks, heavy-duty vehicles, and motorcycles. These regulations were amended in 2006 to introduce new requirements for 2006 and later model year on-road motorcycles. The changes ensured that Canadian emission standards for on-road motorcycles remain aligned with more stringent standards adopted by the U.S. EPA. In addition, Canada has proposed amendments to the On-Road Vehicle and Engine Emission Regulations to require on-board diagnostic (OBD) systems for on-road heavy-duty engines such as trucks and buses. The amendments were published in the *Canada Gazette*, Part I on October 29, 2011.

The Off-Road Small Spark-Ignition Engine Emission Regulations were in effect as of January 1, 2005, and established emission standards, aligned with U.S. federal standards, for 2005 and later model year engines found in lawn and garden machines, light-duty industrial machines, and light-duty logging machines.

The Off-Road Compression-Ignition Engine Emission Regulations, in effect as of January 1, 2006, have introduced emission standards aligned with U.S. federal standards (Tier 2 and 3), for new 2006 and later model year diesel engines, such as those typically found in agricultural, construction, and forestry machines. In December 2011, the Regulations Amending the Off-Road Compression-Ignition Engine Emission Regulations were published, further reducing the emission of air pollutants in Canada by establishing more stringent Canadian off-road diesel emission standards. The regulations align Canadian emission standards with the U.S. Tier 4 standards. The new standards came into force on January 16, 2012.

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[3] Connecticut, Delaware, Illinois, Indiana, Kentucky, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New York, New Jersey, Ohio, Pennsylvania, Rhode Island, Vermont, West Virginia, and Wisconsin.

The Marine Spark Ignition Engine Vessel and Off-Road Recreational Vehicle Emission Regulations have been in effect since April 5, 2011. These regulations include emission standards, aligned with U.S. federal standards, for outboard engines, personal watercraft, sterndrive and inboard engines, vessels powered by these engines, snowmobiles, off-road motorcycles, all-terrain vehicles (ATVs), and utility vehicles. Most of the standards applied beginning with the 2012 model year, while the emission standards for vessels will apply as of the 2015 model year.

Regulatory initiatives for fuels include: the Sulphur in Gasoline Regulations, which limit the level of sulfur in gasoline to 30 milligrams per kilogram (mg/kg) (equivalent to 30 parts per million [ppm]) as of 2005; and the Sulphur in Diesel Fuel Regulations, which reduce the level of sulfur in diesel fuel to 15 mg/kg (15 ppm) for on-road vehicles, as of 2006, and off-road vehicles, as of 2010. Diesel fuel for rail and small and medium-sized vessels was reduced to 500 mg/kg (500 ppm) as of 2007 and was further limited to 15 mg/kg (15 ppm) as of June 1, 2012. Since 1999, the Benzene in Gasoline Regulations have reduced benzene emissions from vehicles by limiting the benzene content in gasoline to 1.0 percent by volume.

The United States and Canada have agreed to work together under the United States–Canada Air Quality Agreement to reduce transportation emissions by:

- Harmonizing national vehicle and engine standards for emissions of smog-forming pollutants;
- Optimizing vehicle and engine emission testing activities, taking advantage of unique testing capabilities, and sharing emission test data where appropriate to facilitate regulatory administration activities in both countries; and
- Sharing information and discussing strategies and approaches on GHG emission standards for motor vehicles.

Stationary Sources of NO_X

Annual caps by 2007 of 39,000 metric tons of NO_X (as nitrogen dioxide [NO_2]) emissions from fossil fuel power plants in the PEMA in central and southern Ontario, and 5,000 metric tons of NO_X in the PEMA in southern Quebec.

In the Canadian portion of the PEMA, the largest source of NO_X emissions from industry is the fossil fuel-fired power sector. Canada has met its commitment to cap NO_X emissions from large fossil fuel-fired power plants in the Ontario and Quebec portions of the PEMA at 39 ,000 metric tons (42,900 short tons) and 5,000 metric tons (5,500 short tons), respectively, by 2007. Emissions from power plants in the Ontario portion of the PEMA were approximately 78,000 metric tons (86,000 short tons) in 1990. In 2011, NO_X emissions from Ontario fossil fuel-fired power plants are estimated to be 10,600 metric tons (11,700 short tons), or 73 percent below the 39,000 metric tons (42,900 short ton) Ozone Annex commitment. Annual NO_X emissions for 2010 from Quebec fossil fuel-fired power plants in the PEMA are estimated to be 16 metric tons (18 short tons), considerably below the cap.

Ontario's Cessation of Coal Use Regulation – Atikokan, Lambton, Nanticoke and Thunder Bay Generating Stations (O. Reg. 496/07) came into effect in August 2007 and ensures that coal is not to be used to generate electricity at Atikokan, Lambton, Nanticoke, and Thunder Bay Generating Stations after December 31, 2014. The closure of Lakeview Generating Station in April 2005 (O. Reg. 396/01) has already eliminated annual emissions of approximately 5,000 metric tons (5,500 short tons) of NO_X. To date, Ontario has shut down 11 out of the province's 19 coal units, resulting in significant emission reductions. In 2011, coal-fired electric generation reached a 49-year low in the province. Emissions of NO_X from coal plants decreased by approximately 90 percent between 2003 and 2011.

Ontario has been engaged in a number of clean energy projects to offset coal-fired electricity generation. By the end of 2011, the Ontario Power Authority executed 12,076 renewable energy contracts, totaling nearly 10,380 MW.

To ensure that the 5,000 metric ton (5,500 short ton) cap is met for the Quebec portion of the PEMA, Quebec's Clean Air Regulation, which came into effect on June 30, 2011, introduced a specific cap of 2,100 metric tons (2,310 short tons) of NO_X per year for the Sorel Tracy plant. This plant is used mainly during peak periods. After emitting 653 metric tons (718 short tons) of NO_X in 2009, it easily met the cap in 2010, with only 16 metric tons (18 short tons) of NO_X.

Proposed National Guideline on Renewable Low-Impact Electricity

Control and reduce NO_X emissions in accordance with a proposed national Guideline on Renewable Low-Impact Electricity.

A notice of a draft Guideline on Renewable Low-Impact Electricity (Green Power Guideline) was published in the *Canada Gazette*, Part I, in 2001. This guideline was developed to provide national guidance on environmentally preferable electricity products and their generation in Canada, and to establish criteria for environmental labeling of qualifying electricity products under the EcoLogo™ Program. Certification criteria derived from the draft guideline are being used to certify qualifying electricity products. Most Canadian provinces have developed their own specifications and requirements for renewable low-impact electricity. For example, New Brunswick requires their facilities to meet the certification criteria for renewable low-impact electricity, as defined by the EcoLogo™ Program. Additionally, a number of companies in many of the provinces use this certification. The EcoLogo™ certification criteria for Renewable Low-Impact Electricity are periodically reviewed and updated to promote continuous improvement in the environmental performance of this industry.

Measures to Reduce VOCs

Reduce VOC emissions by developing two regulations—one on dry cleaning and another on solvent degreasing—and using VOC emission limits for new stationary sources.

The final provision of the Tetrachloroethylene (PERC) (Use in Dry Cleaning and Reporting Requirements) Regulations came into effect in August 2005. The environmental objective of the regulations is to reduce the ambient PERC concentration in the air to below 0.3 micrograms per cubic meter ($\mu g/m^3$). The risk management goal of the regulations is to reduce PERC use in dry cleaning in Canada to less than 1,600 metric tons (1,760 short tons) per year. Environment Canada completed a use pattern study and a statistical analysis of ambient air concentrations of PERC across Canada in 2009, indicating that both the regulatory objective and goal have been achieved.

The Solvent Degreasing Regulations, which took effect in July 2003, froze the consumption of trichloroethylene (TCE) and PERC in affected cold and vapor-solvent degreasing facilities for three years (2004 to 2006) at then-current levels based on historical use. Beginning in 2007, the annual consumption levels were reduced by 65 percent for affected facilities.

Measures for NO_X and VOC Emissions to Attain the CWS for Ozone

If required to achieve the CWS for ozone in the PEMA by 2010, measures will be in place to reduce NO_X emissions by 2005 and implemented between 2005 and 2010 for key industrial sectors and measures to reduce VOC emissions from solvents, paints, and consumer products.

The CWS committed provincial jurisdictions to developing implementation plans outlining the comprehensive actions being taken within each jurisdiction to achieve the standards. As the province of Quebec is not a signatory to the CWS, it is not required to develop an implementation plan. However, the following sections describe the measures that Quebec and Ontario have put in place to reduce emissions of NO_X and VOCs.

In keeping with Ontario's commitment under the CWS, the province developed a Clean Air Action Plan that includes actions on industrial and vehicle emissions. These actions have contributed to provincial emission reductions of NO_X and VOCs by 45 percent by 2010.

Ontario's Clean Air Action Plan for reducing smog causing emissions includes the Industry Emissions—Nitrogen Oxides and Sulphur Dioxide Regulation (O. Reg. 194/05), which introduced emissions trading of NO_X and SO_2 in seven industrial sectors in 2006. Since the program's inception, NO_X and SO_2 emissions from facilities regulated under Regulation 194/05 have shown a downward trend due to a number of factors including lower economic activity and some facility improvements. More information on Ontario's Regulation 194/05 (Industry Emissions—Nitrogen Oxides and Sulphur Dioxide) can be found at <www.ene.gov.on.ca/environment/en/industry/standards/industrial_air_emissions/nitrogen_sulphur/index.htm>.

The Clean Air Action Plan also includes the province's Drive Clean program. Since 1999, Ontario has had in place a vehicle emissions inspection and maintenance program to further reduce emissions of smog precursors. From 1999 through 2010, smog-causing emissions of NO_X and hydrocarbons (VOCs) from light-duty vehicles were reduced by an estimated 335,000 metric tons (368,500 short tons).

Further details on Ontario's Clean Air Action Plan can be found at <www.ene.gov.on.ca/environment/en/resources/STD01_076142.html>.

The federal government has worked in collaboration with provinces, territories, and stakeholders and developed a new air quality management system that will further reduce ozone-causing emissions. The system includes new ambient air quality standards for ozone that are more stringent and replace the existing Canada-wide Standard, and new national emission standards for key industrial sectors. In addition, further actions to address all sources of NO_X and VOCs could be undertaken by the provinces and territories to achieve the new ambient air quality standards and improve air quality. Further details on this new system can be found in Section 3 of this report: New Actions on Acid Rain, Ozone, and PM.

VOC emissions from the manufacture and use of consumer and commercial products, such as cleaning products, personal care products, and paints, contribute significantly to the formation of smog. The federal government has therefore taken actions to reduce VOC emissions from consumer and commercial products.

Two regulations controlling VOCs in products were finalized in 2009. The Volatile Organic Compound (VOC) Concentration Limits for Automotive Refinishing Products Regulations and the Volatile Organic Compound (VOC) Concentration Limits for Architectural Coatings Regulations were finalized and published in *Canada Gazette*, Part II on July 8 and September 30, 2009, respectively. Environment Canada is currently examining other product categories to identify additional opportunities for the reduction of VOC emissions.

Actions by the Province of Quebec

Quebec has made progress in meeting its Ozone Annex commitments by way of several regulatory actions. The Clean Air Regulation, which came into effect on June 30, 2011, and replaced the Regulation Respecting the Quality of the Atmosphere, contains stricter standards aimed at reducing NO_X emissions from new and modified industrial and commercial boilers, in accordance with Canadian Council of Ministers of the Environment (CCME) guidelines. In addition, when burners on existing units must be replaced, the replacements must be low-NO_X burners.

With respect to VOC emissions, the standards in the Clean Air Regulation aim to reduce emissions from the manufacture and application of surface coatings, commercial and industrial printing, dry cleaning, above-ground storage tanks, petroleum refineries, and petrochemical plants.

Quebec's Regulation Respecting Mandatory Reporting of Certain Emissions of Contaminants into the Atmosphere, which came into force in 2007, requires Quebec enterprises to report atmospheric releases of certain contaminants. It determines the reporting thresholds, the information that these enterprises will have to provide, and the parameters applicable to the calculation of the quantities of these contaminants. The Regulation allows for improved information on emission sources of air contaminants across the province, including emissions of VOCs and NO_X. Quebec enterprises whose annual VOC emissions exceed 10 metric tons (11 short tons) and annual NO_X emissions exceed 20 metric tons (22 short tons) are required to report their emissions.

Pursuant to its Regulation Respecting Petroleum Products and Equipment, Quebec is currently applying provisions aimed at reducing gasoline volatility during the summer months in the city of Montreal and the Gatineau to Montreal section of the Windsor–Quebec City corridor. Quebec is also evaluating the possibility of introducing amendments to the above regulation to address vapor recovery initiatives, including gasoline storage, transfer depots, and service stations, regardless of whether they are new or existing facilities, in the Quebec portion of the Windsor–Quebec City corridor. The city of Montreal is currently enforcing regulatory provisions concerning gasoline vapor recovery in its territory.

Actions by the Province of Ontario

Ontario has met its commitments under the Ozone Annex to reduce emissions of NO_X and VOCs in the Ontario portion of the PEMA. Ontario has implemented the following programs, regulations, and guidelines:

- The Emissions Trading Regulation (O. Reg. 397/01), which establishes caps for NO_X and SO_2 emissions from the electricity sector.
- The Ontario Drive Clean Program (established under O. Reg. 361/98, as amended by O. Reg. 578/05), is a mandatory inspection and maintenance program designed to reduce smog-causing emissions including NO_X by requiring vehicles to undergo an emission test to identify problems and have them repaired as a condition of vehicle registration, renewal, or ownership transfer. The Vehicle Emissions Enforcement Unit (Smog Patrol) complements the Drive Clean Program by conducting roadside inspections of heavy-duty and light-duty vehicles.
- The Recovery of Gasoline Vapour in Bulk Transfers Regulation (O. Reg. 455/94), which requires gasoline facility operators to install, maintain, and operate gasoline vapor recovery systems.
- The Gasoline Volatility Regulation (O. Reg. 271/91, as amended by O. Reg. 45/97), which sets limits for gasoline vapor pressure during the summer.
- The Dry Cleaners Regulation (O. Reg. 323/94), which requires mandatory environmental training every five years for at least one full-time employee of all dry cleaning establishments in Ontario.
- Guideline A-5: New and Modified Combustions Turbines (1994), which sets limits for NO_X and SO_2 emissions from new and modified stationary combustion turbines.
- Guideline A-9: New Commercial/Industrial Boilers and Heaters (2001), which imposes a NO_X emission limit on new or modified large boilers and heaters in industrial installations.
- The Airborne Contaminant Discharge Monitoring and Reporting Regulation (O. Reg. 127/01), amended by O. Reg. 37/06 in February 2006, which harmonizes Ontario's air emission reporting system with Environment Canada's NPRI.

Beyond the Ozone Annex, Ontario is implementing the Industry Emissions—Nitrogen Oxides and Sulphur Dioxide Regulation (O. Reg. 194/05), which sets limits on emissions of NO_X and SO_2 from seven industrial sectors in Ontario.

The province also amended the Local Air Quality Regulation (O. Reg. 419/05) in 2007, 2009, and 2011 to introduce new/updated air standards and other tools to demonstrate and improve environmental performance. Since 2005, 68 new/updated air standards have been introduced, including several that address VOCs. Air standards are foundational elements of the regulation and are used to assess compliance or to trigger technology-based compliance approaches that address technological or economic challenges.

UNITED STATES ★

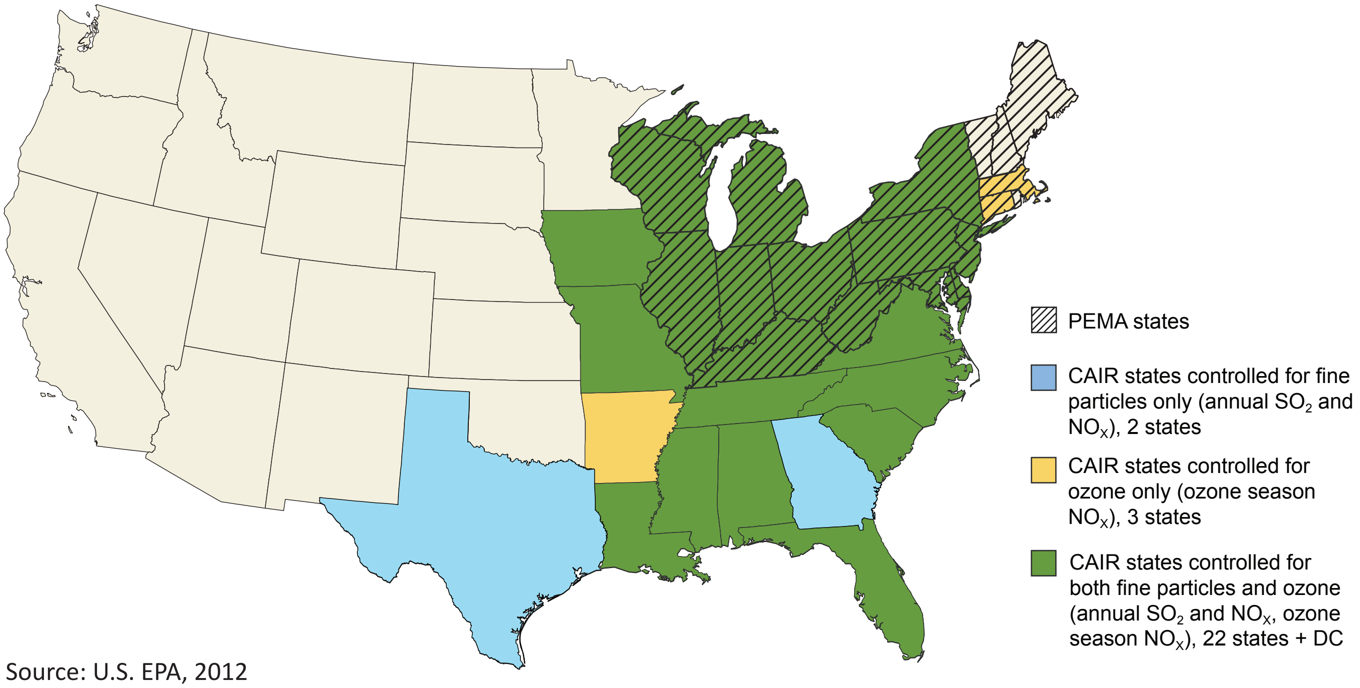
NO_X and VOC Program Updates

- **From 2003 to 2008, implementing the NO_X transport emission reduction program, known as the NO_X SIP Call, in the PEMA states that are subject to the rule.**
- **Starting in 2009, implementing the CAIR NO_X ozone season program in the PEMA states subject to the program.**
- **Implementing existing U.S. vehicle, nonroad engine, and fuel quality rules in the PEMA to achieve both VOC and NO_X reductions.**
- **Implementing existing U.S. rules in the PEMA for the control of emissions from stationary sources of hazardous air pollutants (HAPs) and of VOCs from consumer and commercial products, architectural coatings, and automobile repair coatings.**
- **Implementing 36 existing U.S. NSPS to achieve VOC and NO_X reductions from new sources.**

U.S. EPA stopped administering the NO_X Budget Trading Program (NBP) under the NO_X SIP call following the 2008 ozone season. Starting in 2009, the NO_X annual and ozone season programs under CAIR took effect. See the 2010 Canada-United States Air Quality Agreement Progress Report <www.epa.gov/airmarkets/progsregs/usca/docs/2010report.pdf> for more information on the transition from the NBP to CAIR.

Current CAIR Implementation in PEMA States

Figure 11. PEMA Region and CAIR



Source: U.S. EPA, 2012

Ozone Season Reductions

The CAIR NO_X ozone season program includes EGUs as well as, in some states, large industrial units that produce electricity or steam primarily for internal use and that have been carried over from the NBP. Examples of these units are boilers and turbines at heavy manufacturing facilities, such as paper mills, petroleum refineries, and iron and steel production facilities. These units also include steam plants at institutional settings, such as large universities or hospitals. In 2011, there were 3,307 EGUs and industrial facility units (see Table 2) at 954 facilities in the CAIR NO_X ozone season program; of these, 1,906 were covered units in the Ozone Annex PEMA.

Between 2005 and 2011, ozone season NO_X emissions from sources in the CAIR program alone have fallen 246,000 short tons (223,168 metric tons), a decrease of 30 percent. From 2010 to 2011, ozone season NO_X emissions from sources in the CAIR NO_X ozone season program decreased by 28,000 short tons (25,455 metric tons) (five percent), reversing a one-year increase in emissions from 2009 to 2010. Units in the seasonal program reduced their overall NO_X emissions from approximately 1.5 million short tons (1.4 million metric tons) in 2000 to 566,000 short tons (514,545 metric tons) in 2011 (Figure 12), nine percent below the regional emission budget of 624,698 short tons (567,907 metric tons). Despite a small increase in heat input from 2000 levels in 2011, the 65 percent improvement in NO_X rate accounted for this reduction in total summer NO_X emissions. In the PEMA states, NO_X rate decreased by 62 percent.

In addition to the CAIR NO_X ozone season program and the former NBP, prior programs such as the Ozone Transport Commission's (OTC) NO_X Budget Program and current regional and state NO_X emission control programs have also contributed significantly to the ozone season NO_X reductions achieved by sources in 2011.

Compliance: In 2011, all CAIR ozone season sources were in compliance.

Table 2. Affected Units in CAIR SO_2 and NO_X Annual and CAIR NO_X Ozone Season Programs

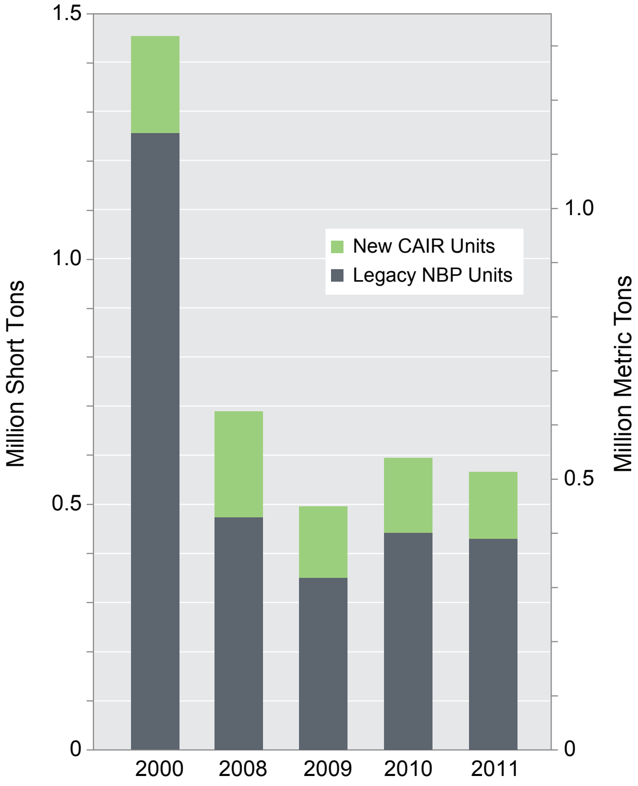
Fuel	CAIR NO_X Ozone Season Program	CAIR NO_X and SO_2 Annual Programs
Coal EGUs	845	895
Gas EGUs	1,685	1,969
Oil EGUs	543	451
Industrial Units	203	0
Unclassified EGUs	2	4
Other Fuel EGUs	29	26
Total Units	3,307	3,345

Notes:

- "Unclassified" units have not submitted a fuel type in their monitoring plan and did not report emissions.
- "Other" fuel refers to units that burn fuel such as waste, wood, petroleum coke, and tire-derived fuel

Source: U.S. EPA, 2012

Figure 12. Ozone Season Emissions from CAIR NO_X Ozone Season Sources



Source: U.S. EPA, 2012

Annual NO_X Reductions

In 2011, the third year of the CAIR NO_X annual program, NO_X emissions from all ARP and CAIR units were 1.7 million short tons (1.5 million metric tons) lower (46 percent) than in 2005 and 3.2 million short tons (2.9 million metric tons) lower (62 percent) than in 2000.

Emissions from CAIR NO_X annual program sources alone were 1.35 million short tons (1.23 million metric tons) in 2011, 146,000 short tons (132,727 metric tons) (10 percent) below the 2011 CAIR NO_X annual program's regional budget of 1.5 million short tons (1.4 million metric tons). Annual NO_X emissions were 1.3 million short tons (1.2 million metric tons) lower (49 percent) than in 2005, and 74,000 short tons (67,273 metric tons) lower (5 percent) than in 2010.

Although the ARP and CAIR NO_X programs were responsible for a large portion of these annual NO_X reductions, programs such as the NBP, the OTC NO_X Budget Program, and other regional and state NO_X emission control programs also contributed significantly to the annual NO_X reductions achieved by sources in 2011.

Compliance: In 2011, only one CAIR facility did not hold enough allowances to cover its emissions for the NO_X annual program. That facility automatically surrendered a 3-for-1 penalty deduction for a total of 9 allowances from the next year's allowance allocation under the NO_X annual program.

NSPS: All of the 36 categories of NSPS identified in the Ozone Annex for major new NO_X and VOC sources are promulgated and in effect. In addition, the U.S. EPA finalized the NSPS for Stationary Compression-Ignition Internal Combustion Engines in July 2006, which is helping these sources achieve significant reductions in NO_X and VOC emissions. Furthermore, in December 2007, the U.S. EPA finalized an additional nationally applicable emission standard—an NSPS for NO_X, carbon monoxide (CO), and VOC emissions from new stationary spark-ignited (SI) internal combustion engines (for more information on the Spark Ignited Internal Combustion Engine rule, see <www.epa.gov/ttn/atw/nsps/sinsps/sinspspg.html>).

In February 2006, the U.S. EPA promulgated the NSPS for utility and industrial boilers and combustion turbines. The updated standards for NO_X, SO_2, and direct filterable PM are based on the performance of recently constructed boilers and turbines. In February 2012, the U.S. EPA promulgated amendments to the NSPS for utility boilers to reflect improvement in the controls for NO_X, SO_2, and direct filterable PM. The U.S. EPA is also currently amending the NSPS for petroleum refineries that was promulgated in 2008 to address issues regarding flares and process heaters.

VOC Controls on Smaller Sources: In 1998, the U.S. EPA promulgated national rules for automobile repair coatings, consumer products, and architectural coatings. The compliance dates for these rules were January 1999, December 1998, and September 1999, respectively. From a 1990 baseline, the consumer products and architectural coatings rules are each estimated to achieve a 20 percent reduction in VOC emissions, and the automobile repair coatings rule is estimated to achieve a 33 percent reduction in VOC emissions. The U.S. EPA is planning to review and revise, as necessary, the automobile repair coatings, consumer products, and architectural coatings rules.

In addition, the U.S. EPA had previously scheduled for regulation 18 other categories of consumer and commercial products under section 183(e) of the CAA. To date, U.S. EPA has regulated or issued guidance on all 18 categories, including shipbuilding and repair coatings; aerospace coatings; wood furniture coatings; flexible packaging printing materials; lithographic printing materials; letterpress printing materials; industrial cleaning solvents; flatwood paneling coatings; aerosol spray paints; paper, film, and foil coatings; metal furniture coatings; large appliance coatings; portable fuel containers; miscellaneous metal products coatings; plastic parts coatings; auto and light-duty truck assembly coatings; miscellaneous industrial adhesives; and fiberglass boat manufacturing materials.

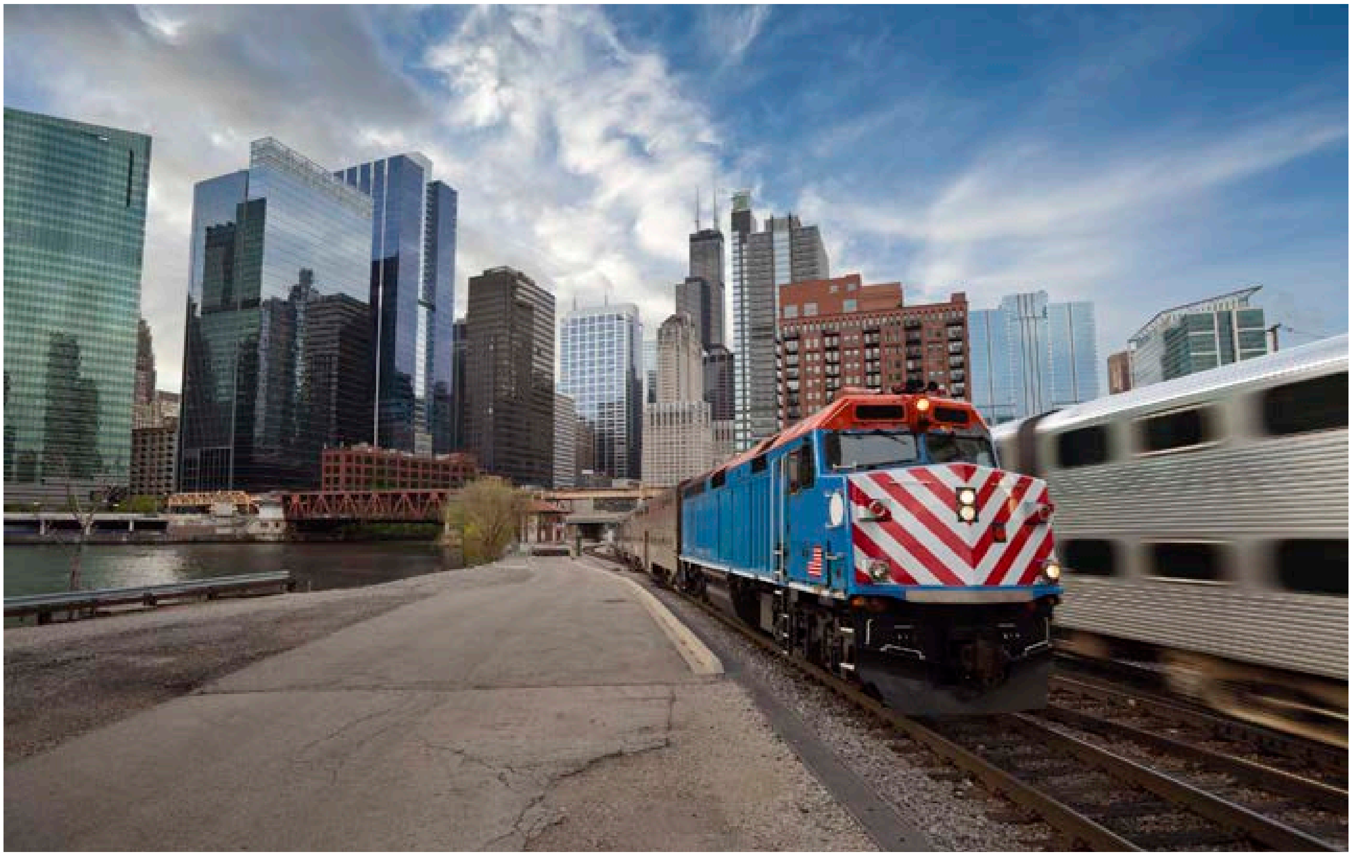
Motor Vehicle Control Program: To address motor vehicle emissions, the United States committed to implementing regulations for reformulated gasoline; reducing air toxics from fuels and vehicles; and implementing controls and prohibitions on gasoline and diesel fuel quality, emissions from motorcycles, light-duty vehicles, light-duty trucks, highway heavy-duty gasoline engines, and highway heavy-duty diesel engines.

On the fuel side, the U.S. EPA fully phased in requirements for reformulated gasoline in nonattainment areas in 1995 and implemented low-sulfur requirements for gasoline in 2005 and on-road diesel fuel in fall 2006 (30 ppm and 15 ppm sulfur levels, respectively).

The U.S. EPA implemented much tighter PM emission standards for highway heavy-duty engines in 2007 and correspondingly tighter NO_X standards in 2010. The U.S. EPA implemented Tier 2 exhaust and evaporative standards for light-duty cars and trucks from 2004 to 2009. The U.S. EPA has also implemented on-board refueling standards and on-board diagnostic systems (OBD II) requirements for these vehicles. In 2004, the U.S. EPA published new motorcycle emission standards, which took effect in 2006 and 2010.

Nonroad Engine Control Program: The U.S. EPA has applied engine standards in all five nonroad engine categories identified in the Ozone Annex: aircraft, compression-ignition engines, spark-ignition engines, locomotives, and marine engines. Nonroad diesel fuel was aligned with on-highway diesel fuel at 15 ppm sulfur in 2010. Locomotive and marine diesel fuel was aligned with on-highway and nonroad diesel fuel at 15 ppm in 2012.

The U.S. EPA began regulating nonroad SI engines in 1997 with its small SI engine rule, which applies to lawn and garden engines under 25 horsepower (hp) (19 kilowatts [kW]). Marine outboard engines and personal watercraft engines were first regulated in 1998 and 1999, respectively. Since then, the U.S. EPA has implemented tighter standards covering a wider range of SI engines. The U.S. EPA published regulations for recreational vehicles and large SI



engines in November 2002. These regulations cover snowmobiles, ATVs, off-highway motorcycles, and nonroad equipment with engines larger than 25 hp (19 kW). Phase-in of the emission reductions began with the 2004 model year, and full emission reductions will be achieved by the 2012 model year. The U.S. EPA's Phase 3 standards for small SI engines including marine inboard and sterndrive engines began phase-in in 2010.

In addition, the U.S. EPA began regulating nonroad compression-ignition engines (diesels) with the 1996 model year and has now promulgated more stringent (Tier 4) standards for nonroad compression-ignition engines. The Tier 4 standards for nonroad diesels will phase in through 2014. New locomotive and marine engine standards (for engines less than 30 liters/cylinder) were finalized in March 2008 and took effect in 2008 for remanufactured locomotive and marine engines. Stringent Tier 3 standards began in 2009 for newly manufactured engines. Even more stringent Tier 4 standards requiring catalytic aftertreatment will phase in for most newly manufactured locomotive and marine engines beginning in 2014.

Anticipated Additional Control Measures and Indicative Reductions

CANADA

National Reductions

The North American Emission Control Area (ECA), covering the waters of Canada and the United States, took effect on August 1, 2012 and subjects ships to environmental standards that will significantly reduce air pollution. As a result of the ECA standards, NO_X emissions from new ships will be reduced by 80 percent, SO_X (oxides of sulfur) by 95 percent, and PM by 85 percent, when requirements are fully implemented. In 2009, the U.S. EPA finalized these standards in their domestic regulations and in summer 2012, Transport Canada's proposed regulations were published, with final regulations to follow. Environment Canada's Regulations Amending the Sulphur in Diesel Fuel Regulations are now in force and set a 1,000 ppm sulfur standard in marine diesel fuel available for large ships, in effect on June 1, 2014. The new diesel fuel standards will allow for a supply of cleaner shipping fuel, with the ECA standard of 1,000 ppm taking effect in January 2015.

Canada initiated a national vehicle scrappage program in January 2009. The program ended in March of 2011 after retiring more than 138,000 high-polluting vehicles of model year 1995 and earlier resulting in a total reduction of 5,600 metric tons (6,160 short tons) of NO_X and VOC emissions. Canadians in every province were offered a selection of incentives as rewards for retiring their older vehicles that included $300 per vehicle, free transit passes, rebates on bicycles or replacement vehicles, and memberships in car-sharing programs, etc.

Since the federal government published the Regulatory Framework for Air Emissions in 2007, it has collaborated with the provinces, territories, and stakeholders and developed a new air quality management system. The system includes the establishment of national standards to reduce ozone precursor emissions from key industrial sectors and new ambient air quality standards for $PM_{2.5}$ and ozone. The new system is expected to reduce air pollutant emissions and improve air quality across the country, including in regions currently in attainment of the CWS for ozone and in the PEMA, as well as where ozone levels still exceed the CWS.

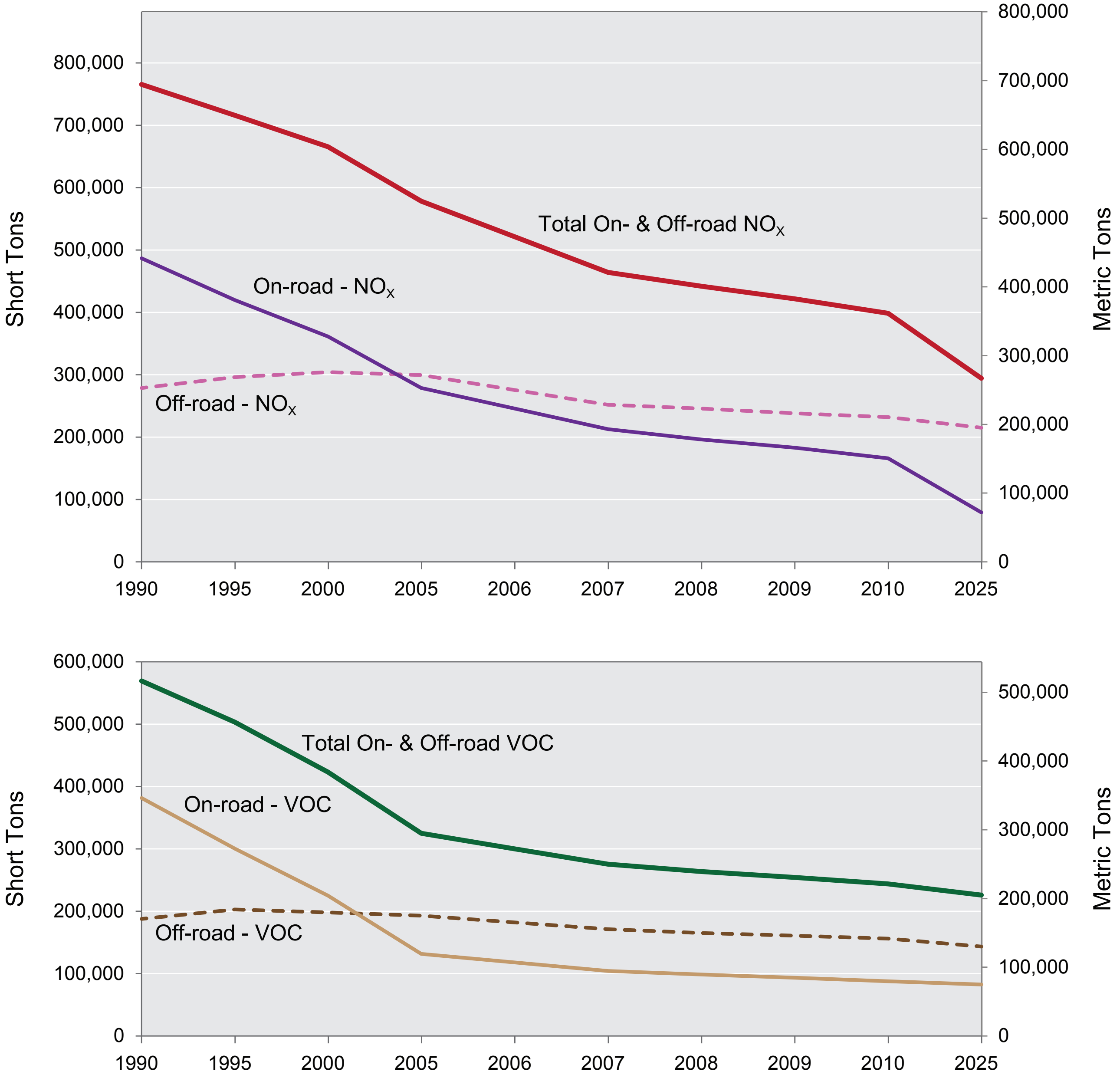
Quantitative Estimates

In the Ozone Annex, parties provided 2010 NO_X and VOC emission reduction estimates associated with applying the control measures identified under Part III of the Annex. The parties further agreed to update these reduction forecasts to demonstrate that the obligations are being implemented and to ensure that quantitative estimates reflect any emission estimation methodology improvements. The largest source of NO_X and VOC emissions in the Canadian

PEMA region is transportation. Figure 13 shows that NO_X and VOC emissions from transportation sources in the PEMA are expected to decrease by 60 percent and by nearly 62 percent, respectively, by 2025 from 1990 levels. Note that Canada will be switching to the Motor Vehicle Emission Simulator (MOVES) model in the summer of 2012, as well as incorporating new and additional spatial data to improve the transportation emission estimates.

Using national emission data, the specific NO_X and VOC emission reduction obligations in the Ozone Annex reduced annual NO_X emissions in the PEMA by 43 percent and annual VOC emissions in the

Figure 13. Canadian Transportation NO_X and VOC PEMA Emission Projections, 1990–2025

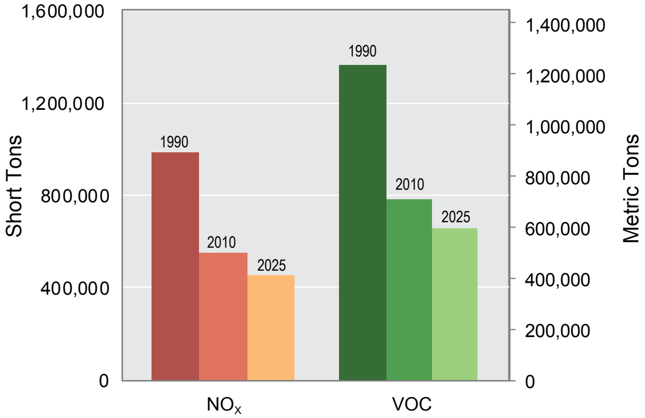


Source: Environment Canada, 2012

PEMA by 42 percent by 2010, from 1990 levels (see Figure 14). Canada has developed new emission projections for 2025 based on the 2009 emissions data that took into consideration the impact of the recent economic slowdown and the latest economic projections. Figure 14 shows Canada's projected emission reductions for 2025.

The projected emissions are based on the 2009 emission inventory and projected into the future using Environment Canada's energy, emission, and economy forecast model (E3MC). Based on the projected Canadian emissions for 2025, it is estimated that annual NO_X emissions in the PEMA will be reduced by 53 percent and annual VOC emissions in the PEMA by 52 percent by 2025, from 1990 levels.

Figure 14. Canadian NO_X and VOC PEMA Emissions and Projections



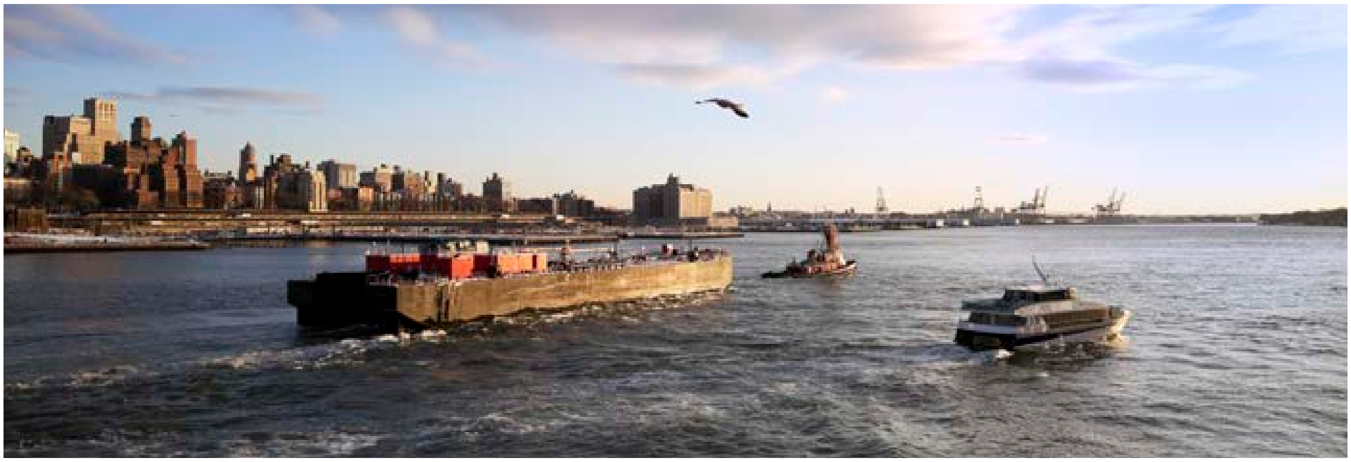
Source: Environment Canada, 2012

UNITED STATES ★

National Reductions

The U.S. EPA and the National Highway Traffic Safety Administration (NHTSA) have been working together on developing a national program of harmonized regulations to reduce GHG emissions and improve fuel economy of light-duty vehicles. The agencies issued a final rulemaking establishing standards for 2012–2016 model year vehicles on April 1, 2010. The agencies also issued a final rulemaking with standards for 2017 to 2025 model year vehicles on August 28, 2012 (both final rules can be found at <www.epa.gov/otaq/climate/regs-light-duty.htm>. The combined National Program for model years 2012–2025 passenger vehicles is projected to reduce U.S. oil consumption by more than 2 million barrels per day in 2025 and will cut 6 billion metric tons of GHGs over the lifetimes of the vehicles sold in model years 2012–2025. The U.S. EPA, with NHTSA, also finalized heavy-duty GHG standards in a 2011 joint rulemaking (found at <www.epa.gov/otaq/climate/regs-heavy-duty.htm>) that will phase in between 2014 and 2018. In addition to reducing the emissions of GHGs, the heavy-duty GHG standards will also reduce criteria pollutants, including significant reductions in NO_X and air toxics emissions.

In another action, the U.S. EPA finalized stringent new standards for ocean going vessels (engines larger than 30 liters per cylinder) in 2009. These standards, which phase in through 2016, are linked to the joint establishment of ECAs around the U.S. and Canadian coasts and internal waters such as the Great Lakes.



These standards will impose stringent NO_X standards for ships operating in the ECA and will greatly reduce PM by reducing the sulfur allowed in fuel used in the ECA. NO_X emissions are expected to be reduced by 80 percent, SO_X by 95 percent, and PM by 85 percent when the requirements are fully implemented.

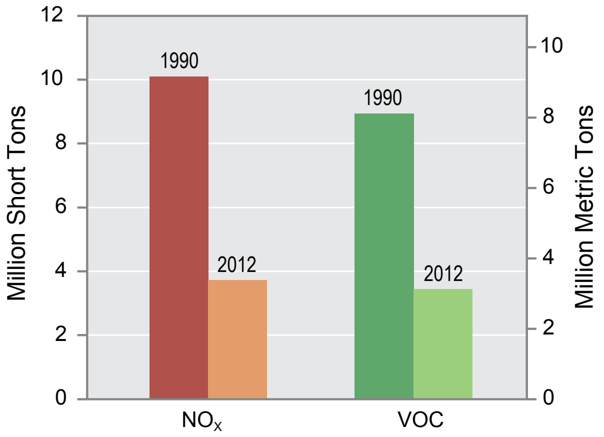
Area-Specific Reductions

The U.S. EPA is implementing NO_X and VOC control measures in specific areas, as required by applicable provisions of the CAA. The measures include NO_X and VOC reasonably available control technology, marine vessel loading, treatment storage and disposal facilities, municipal solid waste landfills, onboard refueling, residential wood combustion, vehicle inspection and maintenance, reformulated gasoline, cement kilns, internal combustion engines, large non-utility boilers and gas turbines, fossil fuel-fired utility boilers, and additional measures needed to attain the NAAQS.

Quantitative NO_X and VOC Emission Reductions

In the Ozone Annex, the United States provided NO_X and VOC emission reduction estimates associated with the application of the control strategies identified under Part III B and Part IV of the Annex. The U.S. EPA has updated the estimates using more recent national trends data available in 2012.

Figure 15. U.S. NO_X and VOC PEMA Emissions and Projections



Source: U.S. EPA, 2012

The specific emission reduction obligations (see Figure 15) are now estimated to reduce annual NO_X emissions in the PEMA by 63 percent (versus the predicted overall emission reduction rate of 43 percent) and annual VOC emissions in the PEMA by 61 percent (versus the predicted overall emission reduction rate of 36 percent) by 2012, from 1990 levels. The U.S. 2012 estimate is based on emission projections for mobile on-road and nonroad sources and holding emissions constant for other sectors from year 2008, and for the electric utilities from year 2011.

JOINT COMMITMENT

Reporting PEMA Emissions

Provide information on all anthropogenic NO_X and all anthropogenic and biogenic VOC emissions within the PEMA from a year that is not more than two years prior to the year of the biennial progress report, including:

- **Annual ozone season (May 1 to September 30) estimates for VOC and NO_X emissions by the sectors outlined in Part V, Section A, of the Ozone Annex; and**
- **NO_X and VOC five-year emission trends for the sectors listed above, as well as total emissions.**

Canada and the United States have complied with emission reporting requirements in the Ozone Annex. Canada's NPRI provides a comprehensive emissions inventory for pollutants such as NO_X, VOCs, SO_2, total PM, PM_{10}, $PM_{2.5}$, and CO that contribute to acid rain, ground-level ozone and components of smog. This comprehensive inventory is based on two components:

- Mandatory annual reporting of emissions by more than 8,700 facilities; and
- Emission estimates compiled for various sources such as motor vehicles, residential heating, forest fires, and agricultural activities.

The information reported by facilities is publicly available on the Environment Canada website at <www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=B85A1846-1>.

The compilation of the comprehensive 2010 air pollutant emission summaries were completed in early 2012, and the emission data have been included in this 2012 Progress Report. The Canadian emission summaries are available on Environment Canada's website at <www.ec.gc.ca/inrp-npri/default.asp?lang=En&n=F98AFAE7-1>.

New emission inventory modeling files for the calendar years 2009 and 2010 are now available and include updated information on the temporal and the spatial allocation of the emissions for various sources and pollutants.

In the United States, the U.S. EPA develops the National Emissions Inventory (NEI) as a comprehensive inventory covering emissions in all U.S. states for point sources, nonpoint sources, on-road mobile sources, nonroad mobile sources and natural sources at <www.epa.gov/ttnchie1/trends/>. The NEI includes both criteria pollutants and HAPs. The U.S. regulations require that states report criteria pollutant emissions from large point sources every year and for all sources once every three years. The states voluntarily submit HAP emissions. The 2008 NEI is the most recent comprehensive national compilation of emission sources collected from state, local, and tribal air agencies as well as emission information collected from the EPA emission programs including the Toxics Release Inventory (TRI) <www.epa.gov/tri/>, emission trading programs such as the ARP <www.epa.gov/airmarkt/quarterlytracking.html> and <www.epa.gov/ampd>, and data collected as part of EPA regulatory development for reducing emissions of air toxics. The next comprehensive NEI for 2011 is expected to be released in mid-2013.

Table 3 shows preliminary 2010 U.S. and Canadian emissions in the PEMA. Note that Canadian 2010 biogenic emissions are not currently available. Most of the estimated annual biogenic VOC emissions occur during the ozone season. For the U.S. 2010 emissions, 2008 year emissions are used as a surrogate for 2010 because state-level (PEMA) data is not readily available for 2010. Ozone season emissions are estimated as a five-month fraction of the annual emission category totals. Figure 16 and Figure 17 show U.S. emission trends in these areas for 1990 through 2010. The trend in the PEMA states is similar to the U.S. national trend. For NO_X, most of the emission reductions come from on-road mobile sources and electric power generation. The sharp decline in EGU NO_X after 2008 may illustrate the effect of the CAIR NO_X ozone season program starting in 2009.

Over this same period, the reductions in VOC emissions are primarily from on-road and nonroad mobile sources and solvent utilization. VOC emissions from non-industrial fuel combustion sources increased after 1998 and then returned to a downward trend by 2000, but saw a significant spike upward in 2001. This general rise in non-industrial fuel combustion VOC emissions from 2001 to 2002 is in part due to improved emission characterization methods for non-industrial fuel combustion sources (e.g., commercial and institutional sources such as office buildings, schools, and hospitals). There are also changes to VOC emissions around 2005 when compared to the 2010 Report due to a correction for VOC emission rates for residential wood combustion and a more complete exclusion of wildfire data.

Table 3. PEMA Emissions, 2010

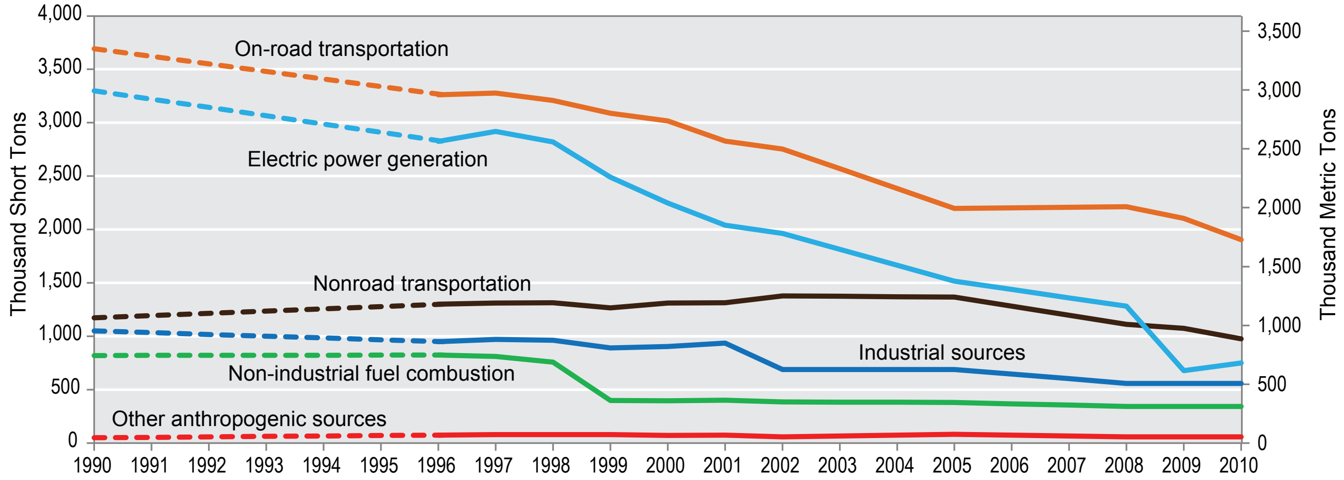
		2010 Annual				2010 Ozone Season			
		NO$_X$		VOCs		NO$_X$		VOCs	
	Emissions Category	1000 Short Tons	1000 Metric Tons	1000 Short Tons	1000 Metric Tons	1000 Short Tons	1000 Metric Tons	1000 Short Tons	1000 Metric Tons
Canadian PEMA Region: Annual and Ozone Season Emissions	Industrial Sources	74	67	83	75	32	29	44	40
	Non-industrial Fuel Combustion	47	43	100	91	24	22	32	29
	Electric Power Generation	27	25	0	0	14	13	0	0
	On-road Transportation	168	152	88	80	75	69	38	34
	Nonroad Transportation	232	211	156	142	113	102	75	68
	Solvent Utilization	0	0	261	237	0	0	112	102
	Other Anthropogenic Sources	6	5	97	88	3	3	41	38
	Forest Fires	0	0	0	0	0	0	0	0
	Biogenic Emissions	--	--	--	--	--	--	--	--
	TOTALS	**554**	**504**	**784**	**713**	**262**	**238**	**342**	**311**
	TOTALS without Forest Fires and Biogenics	**554**	**504**	**784**	**713**	**262**	**238**	**342**	**311**
U.S. PEMA States: Annual and Ozone Season Emissions	Industrial Sources	559	507	182	165	233	211	76	69
	Non-industrial Fuel Combustion	344	312	194	176	143	130	81	73
	Electric Power Generation	1,281	1,162	15	13	534	485	6	6
	On-road Transportation	2,212	2,007	977	886	923	837	407	369
	Nonroad Transportation	1,113	1,009	1,020	925	464	421	425	386
	Solvent Utilization	0	0	1,282	1,163	0	0	534	485
	Other Anthropogenic Sources	60	54	462	419	25	23	193	175
	Forest Fires	1	1	23	21				
	Biogenic Emissions	150	136	3,817	3,463				
	TOTALS	**5,720**	**5,190**	**7,971**	**7,231**	**2,322**	**2,107**	**1,723**	**1,563**
	TOTALS without Forest Fires and Biogenics	**5,569**	**5,053**	**4,131**	**3,748**	**2,322**	**2,107**	**1,723**	**1,563**

Note:

Short tons and metric tons are rounded to the nearest thousand. Totals in rows may not equal the sum of the individual columns.

Source: Environment Canada and U.S. EPA, 2012

Figure 16. U.S. NO_X Emission Trends in PEMA States, 1990–2010

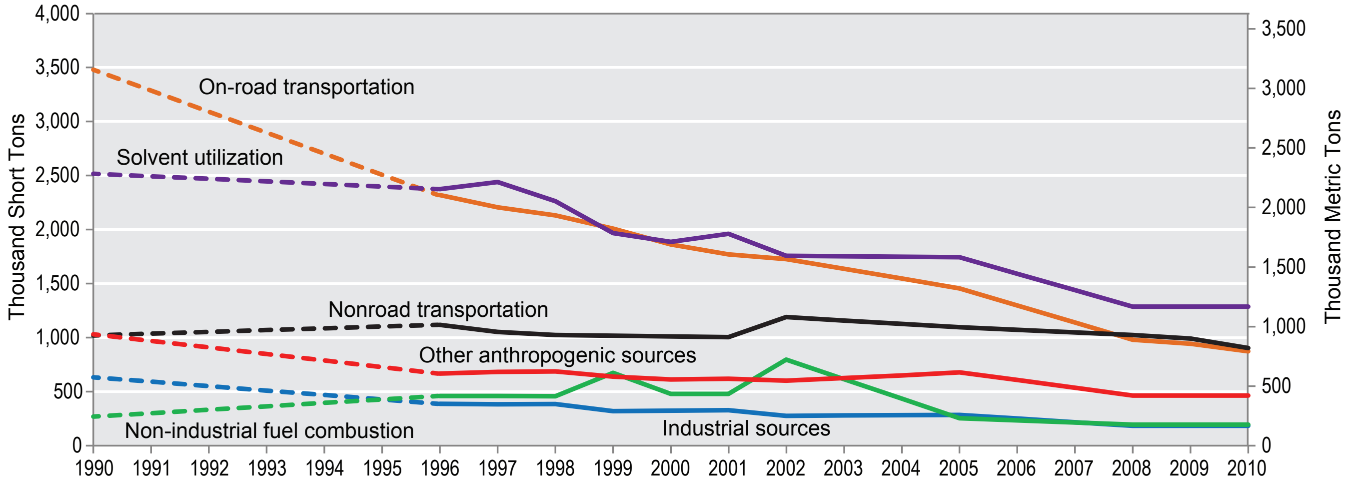


Note:

- The scales used to display U.S. and Canadian emissions in Figures 16 through 19 are significantly different.
- Dotted line indicates that data are not available.

Source: U.S. EPA, 2012

Figure 17. U.S. VOC Emission Trends in PEMA States, 1990–2010

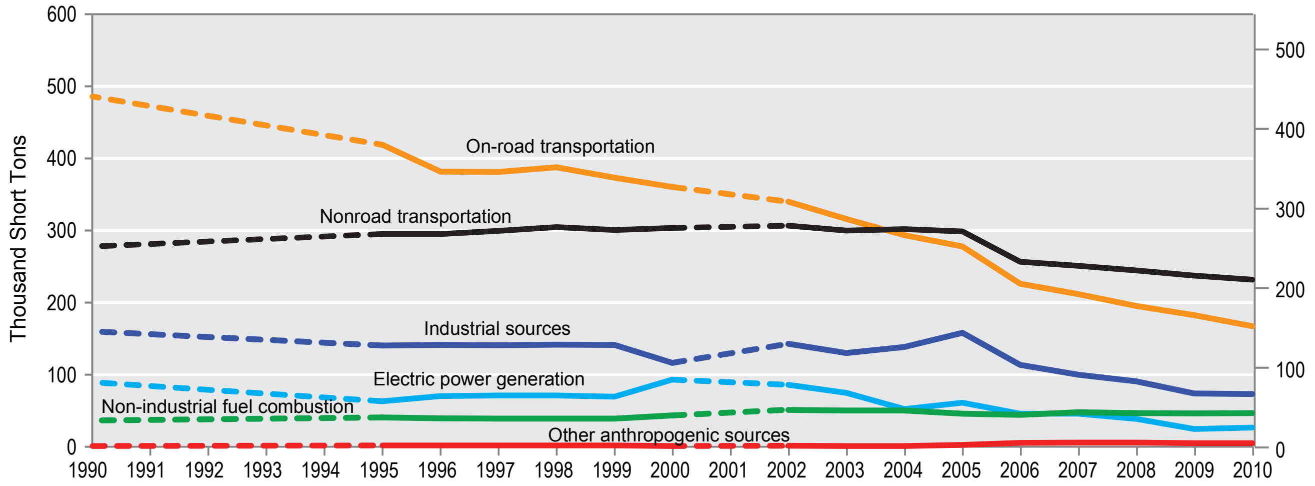


Note: Dotted line indicates that data are not available.

Source: U.S. EPA, 2012

Figure 18 and Figure 19 show Canadian NO_X and VOC PEMA emission trends for 1990 through 2010. For NO_X, most of the reductions come from on-road mobile sources and electric power generation, with increases in non-industrial fuel combustion and other anthropogenic sources. Similar reductions and increases were observed for VOC emissions. VOC emission reductions were primarily from on-road mobile sources, electric power generation, industrial sources, and solvent utilization, with a slight increase in non-industrial fuel combustion.

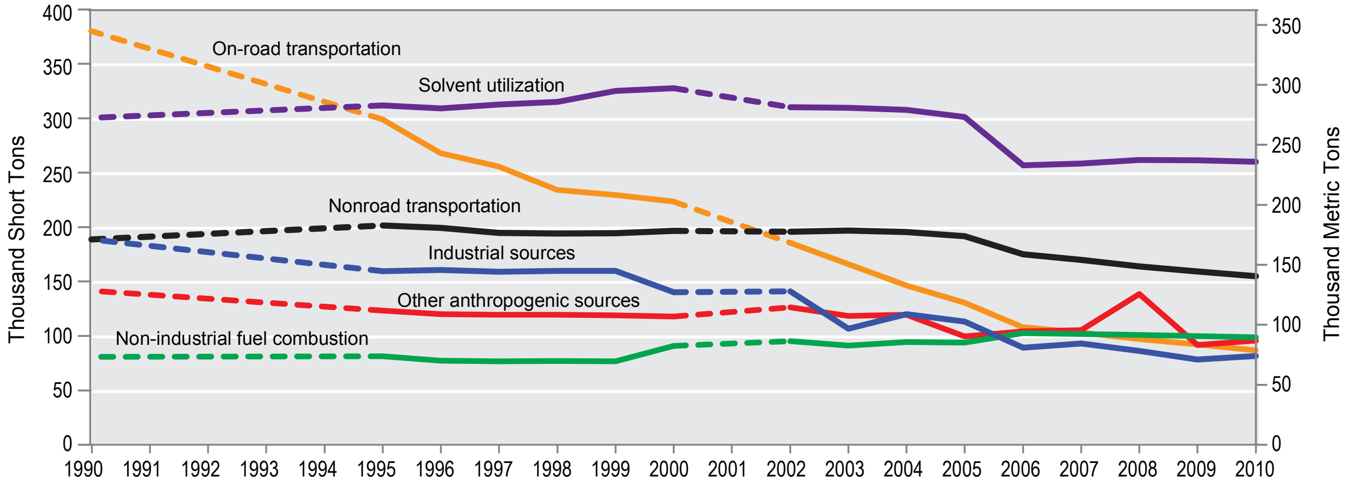
Figure 18. Canada NO_X Emission Trends in the PEMA Region, 1990–2010



Note: Dotted line indicates that data are not available.

Source: Environment Canada, 2012

Figure 19. Canada VOC Emission Trends in the PEMA Region, 1990–2010



Note: Dotted line indicates that data are not available.

Source: Environment Canada, 2012

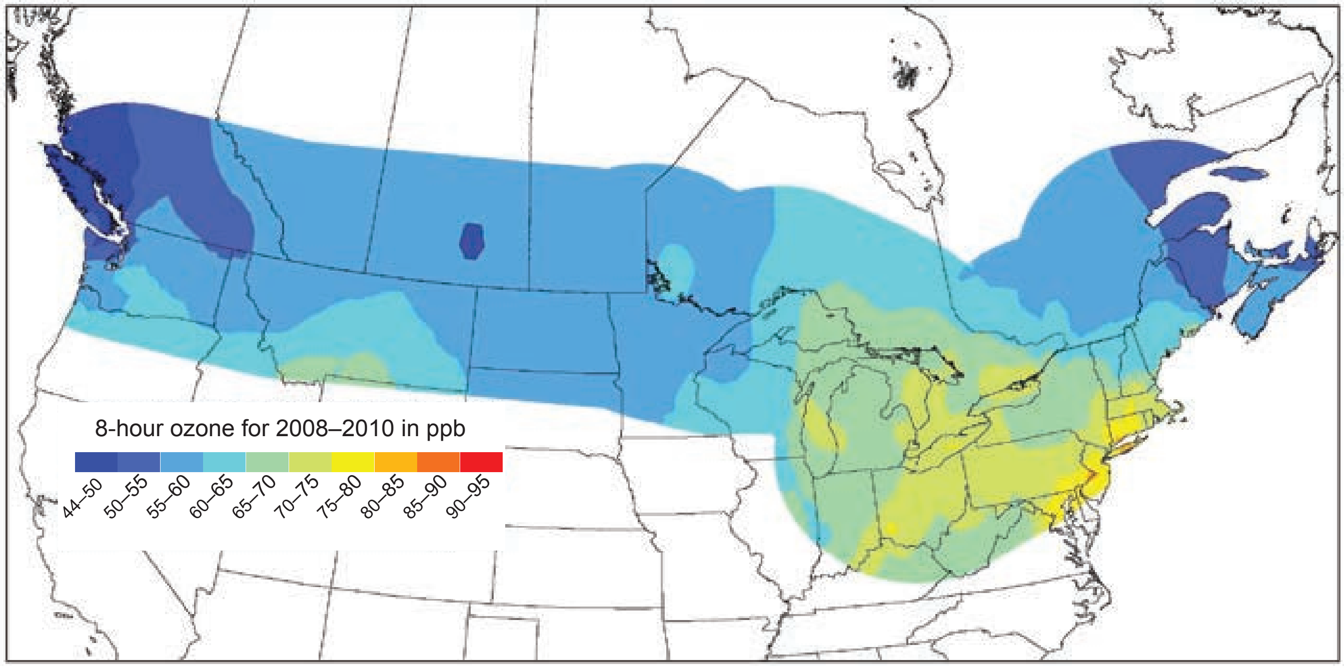
Reporting Air Quality for All Relevant Monitors within 500 km of the Border between Canada and the United States

Both the United States and Canada have extensive networks to monitor ground-level ozone and its precursors. Both governments prepare routine reports summarizing measurement levels and trends. The latest quality-assured complete data set from both countries is 2010.

Ambient Levels of Ozone in the Border Region

Figure 20 illustrates ozone conditions in the border region in the metrics of national standards. The reference period is 2008 through 2010. Only data from sites within 500 km (310 miles) of the United States–Canada border that met data completeness requirements were used to develop this map. Figure 20 shows that higher ozone levels occur in the Great Lakes and Ohio Valley regions and along the U.S. East Coast. Lowest values are generally found in

Figure 20. Ozone Concentrations along the United States–Canada Border (Three-Year Average of the Fourth-highest Daily Maximum 8-hour Average) 2008–2010



Note: Data contoured are the 2008–2010 averages of annual fourth-highest daily values, where the daily value is the highest running 8-hour average for the day. Sites used had at least 75 percent of possible daily values for the period.

Sources: Environment Canada NAPS Network Canada-wide Database, 2010 (<www.ec.gc.ca/rnspa-naps/default.asp?lang=En&n=6553D03F-1>); U.S. EPA Air Quality System (AQS) Data Mart (<www.epa.gov/airdata>).

the West and in Atlantic Canada. Levels are generally higher downwind of urban areas, as can be seen in the western portions of lower Michigan, though the full detail of urban variation is not shown. For ozone, the data completeness requirement was that a site's annual fourth-highest daily maximum 8-hour concentration, in parts per billion (ppb) by volume, be based on 75 percent or more of all possible daily values during the U.S. EPA-designated ozone monitoring seasons.

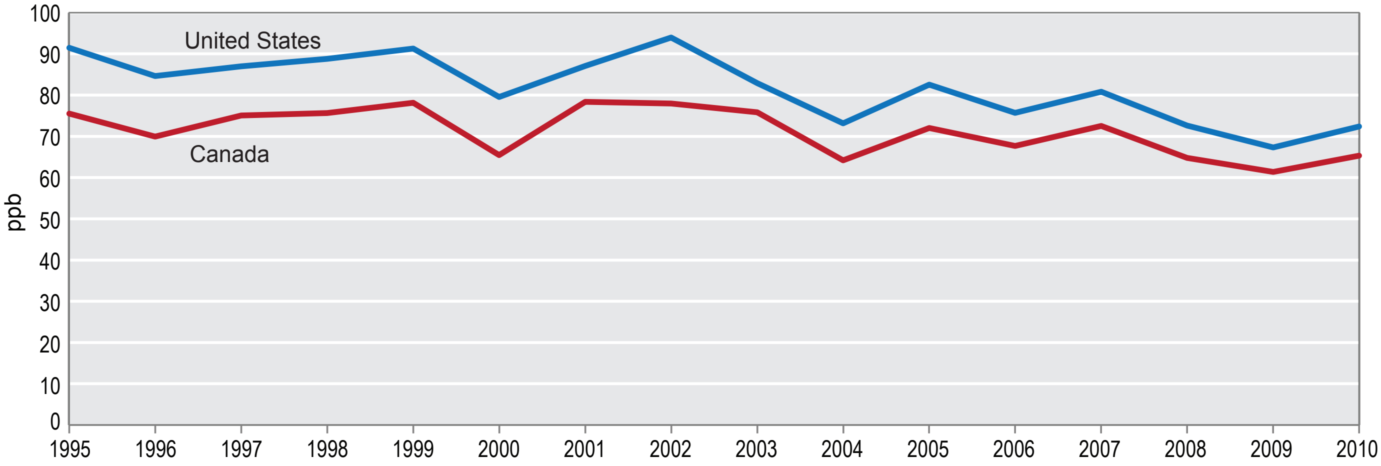
Ambient Concentrations of Ozone, NO_X, and VOCs

Annual ozone levels over the 1995 to 2010 time period are presented in Figure 21, based on information from longer-term eastern monitoring sites within 500 km (310 miles) of the United States–Canada border. Ozone levels have decreased over the period with a notable decline in ozone levels since 2002. The lower ozone levels shown for 2004 and 2009 were due, in part, to the cool, rainy summers in eastern North America. There is also a complex regional pattern in ozone level variations, which is not evident from the graph shown in Figure 21. Figure 22 and Figure 23 depict the average ozone season levels of ozone precursors NO_X and VOCs in the eastern United States and Canada. These measurements represent information from a more limited network of monitoring sites than is available for ozone. Figure 24 shows the network of monitoring sites actually used to create the trend graphs in Figure 21 through Figure 23. The data in Figure 22 and Figure 23 represent measurements for the ozone season (i.e., May through September). Although NO_X and VOC concentrations have fluctuated over recent years, because VOC concentrations are influenced by temperature, these fluctuations are most likely due to varying meteorological conditions. Overall, the data indicate a downward trend in the ambient levels of both NO_X and VOCs. The limited correspondence between composite ozone and precursor trends could reflect the regional complexity of the problem as well as network limitations. Note that the NO_X and VOC concentration trends shown in Figures 22 and 23 are based on a limited number of U.S. and Canadian monitoring sites with sufficient long-term data availability. Thus, the trends in Figures 22 and 23 may reflect slightly different values than previous versions of the Progress Report.

Recently in the United States, there has been much investigation into the relationship between NO_X emission reductions and observed concentrations of ambient ozone in the PEMA states. Generally, a strong association exists between areas with the greatest NO_X emission reductions and downwind monitoring sites measuring the greatest improvements in ozone.

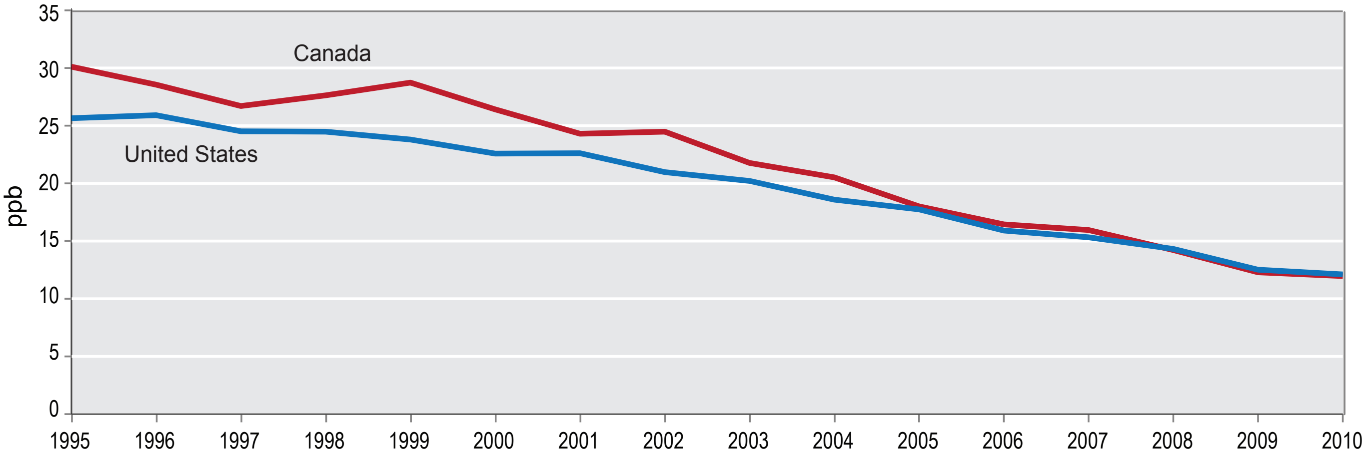
From 2008 to 2010, reductions in NO_X emissions during the ozone season from power plants under the NO_X SIP Call, ARP, and CAIR have continued to contribute to significant regional improvements in ambient total nitrate: nitrate (NO_3^-) plus nitric acid (HNO_3) concentrations. For instance, annual mean ambient total nitrate concentrations for 2008 to 2010 in the Mid-Atlantic region were 45 percent less than the annual mean concentration in 1989 to 1991. These improvements can be partly attributed to added NO_X controls installed for compliance with the NO_X SIP Call and CAIR. More information on the changes in ozone concentrations before and after implementation of the NBP and CAIR as well as a comparison of regional and geographic trends in ozone levels to changes in meteorological conditions (such as temperature) and NO_X emissions from CAIR sources is available at <www.epa.gov/airmarkets/progress/ARPCAIR10_02.html>.

Figure 21. Annual Average Fourth-Highest Daily Maximum 8-hour Ozone Concentration for Sites within 500 km of the United States–Canada Border, 1995–2010



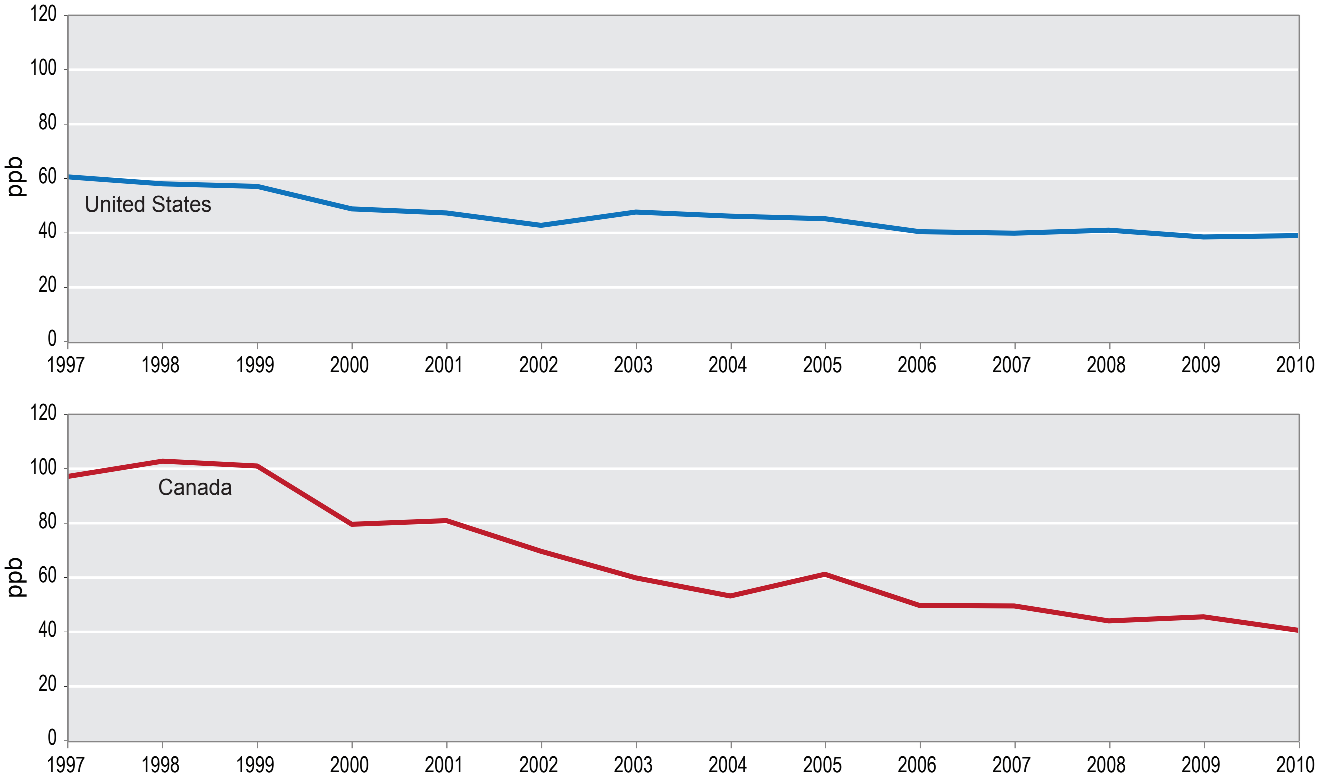
Source: U.S. EPA and Environment Canada, 2012

Figure 22. Average Ozone Season (May–September) 1-hour NO_X Concentrations for Sites within 500 km of the United States–Canada Border, 1995–2010



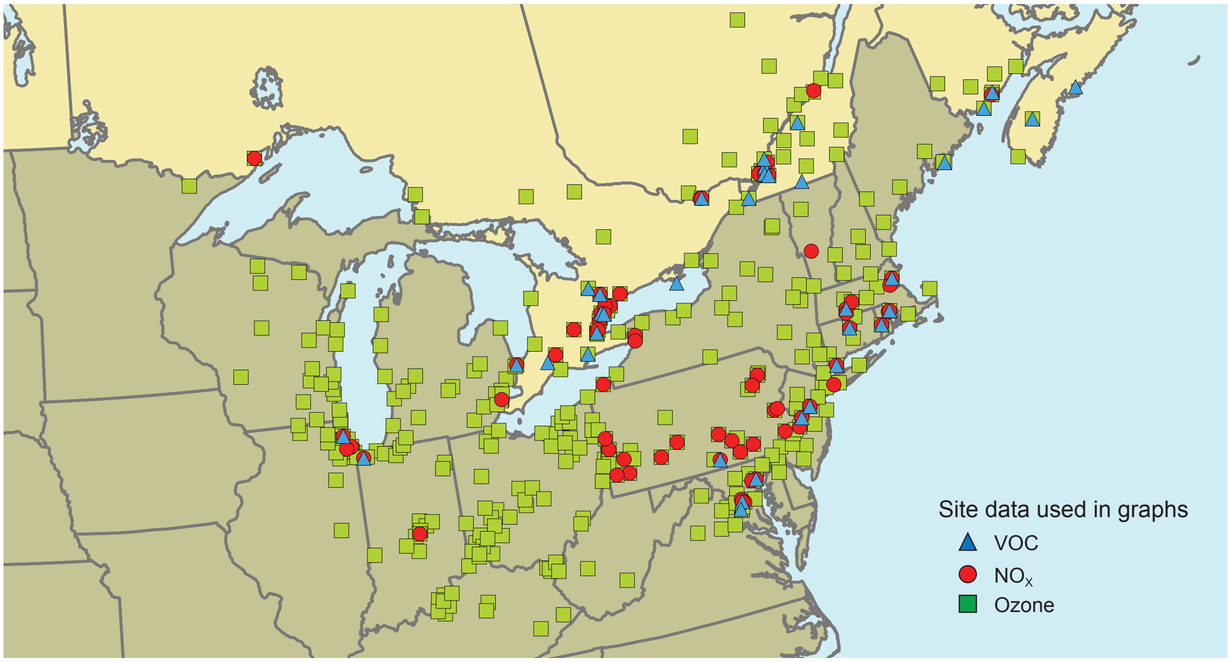
Source: U.S. EPA and Environment Canada, 2012

Figure 23. Average Ozone Season (May–September) 24-hour VOC Concentrations for Sites within 500 km of the United States–Canada Border, 1997–2010



Source: U.S. EPA and Environment Canada, 2012

Figure 24. Network of Monitoring Sites Used to Create Graphs for Ambient Ozone, NO_X, and VOC Levels



Source: U.S. EPA and Environment Canada, 2012

SECTION 2

Scientific and Technical Cooperation and Research

JOINT EFFORTS

Emission Inventories and Trends

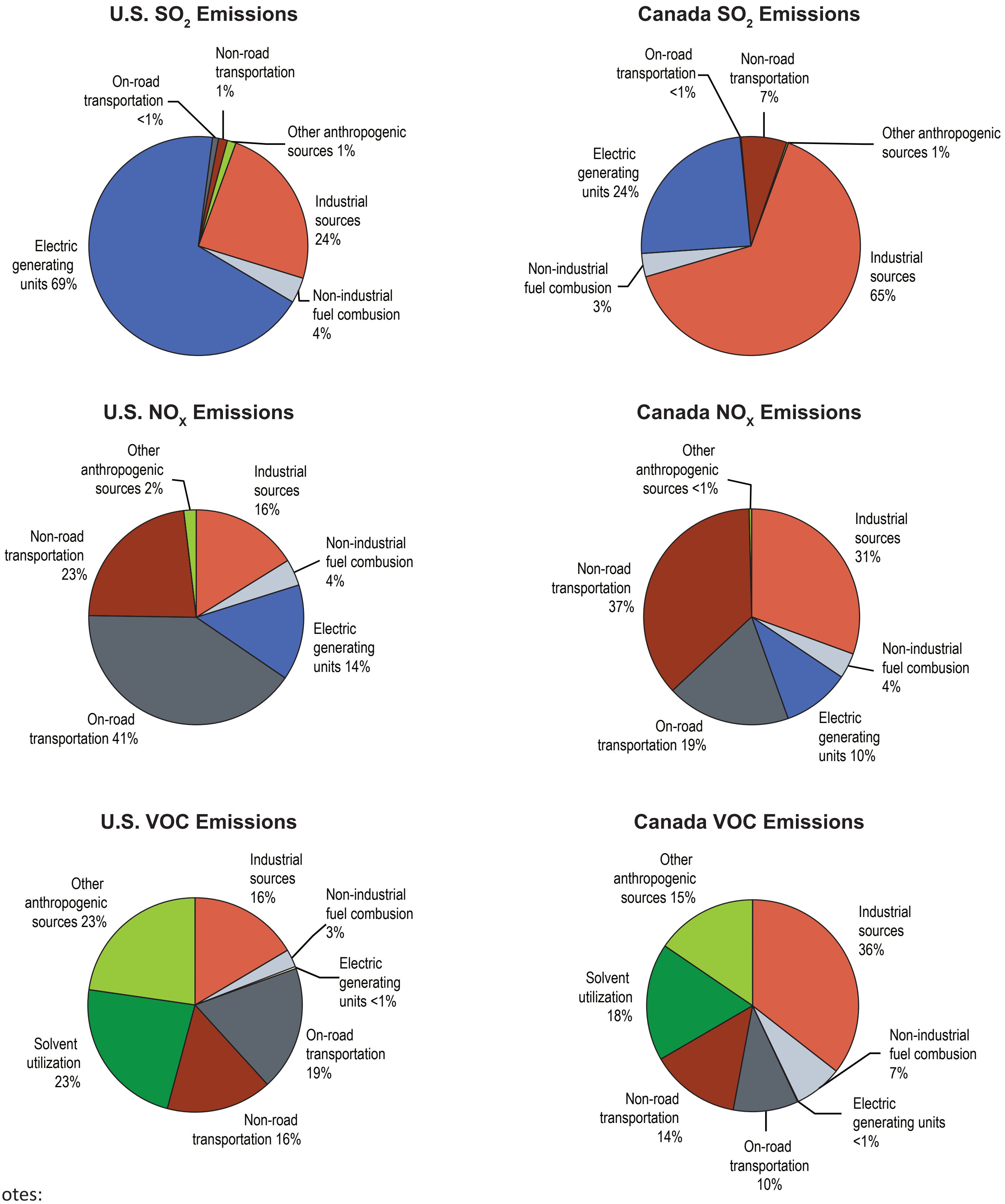
The United States and Canada have updated and improved their emission inventories and projections on PM_{10}, $PM_{2.5}$, VOCs, NO_X, and SO_2 to reflect the latest information available. These inventories are also being used in U.S. and Canadian air quality models to support the technical assessment of air quality problems and for the development of air quality management strategies. In the United States, the most recent complete emission inventory data are for the year 2008. The 2010 emission data in this section of the 2012 Progress Report are estimated based on 2008 and projected 2012 inventory data for the mobile source sectors, reported 2010 data for EGUs, and 2008 emissions held constant for other sectors. The 2008 emission inventory and 2010 emission trends data are available at <www.epa.gov/ttn/chief/eiinformation.html>. The 2012 projected inventory was used for U.S. EPA rulemaking and is a product of the 2005-based modeling platform described at <www.epa.gov/ttn/chief/emch/index.html>. For Canada, the 2010 emission inventory was developed using the latest emission estimation methods and statistics, and includes the pollutant emission information reported by more than 8,700 facilities to the NPRI for 2010. The Canadian inventories are available at <www.ec.gc.ca/inrp-npri/default.asp?lang=en&n=0EC58C98-1>.

Figure 25 shows the distribution of emissions by source category grouping for SO_2, NO_X, and VOCs. The following observations can be made from this figure:

- SO_2 emissions in the United States stem primarily from coal-fired combustion in the electric power sector and industrial boilers.
- Canadian SO_2 emissions come mostly from the nonferrous smelting and refining industry, upstream petroleum industry, and electric power generation utilities. The relative contribution from electric power generation utilities is lower in Canada due to the large hydroelectric and nuclear capacity in place, and differences in population and demand.
- The distribution of NO_X emissions in the two countries is similar, with nonroad and on-road vehicles accounting for the greatest portion of NO_X emissions.

VOC emissions are the most diverse of the emission profiles in each country. The most significant difference is that most VOCs (36 percent) in Canada come from the industrial sector. This is the result of the proportionately higher contribution of oil and gas production in Canada. In the United States, solvent utilization (23 percent) and other anthropogenic sources (23 percent)—e.g., agricultural livestock waste and field burning, prescribed burns, and petroleum storage and transport—contribute the highest percentage of VOCs.

Figure 25. U.S. and Canadian National Emissions by Sector for Selected Pollutants, 2010



Notes:

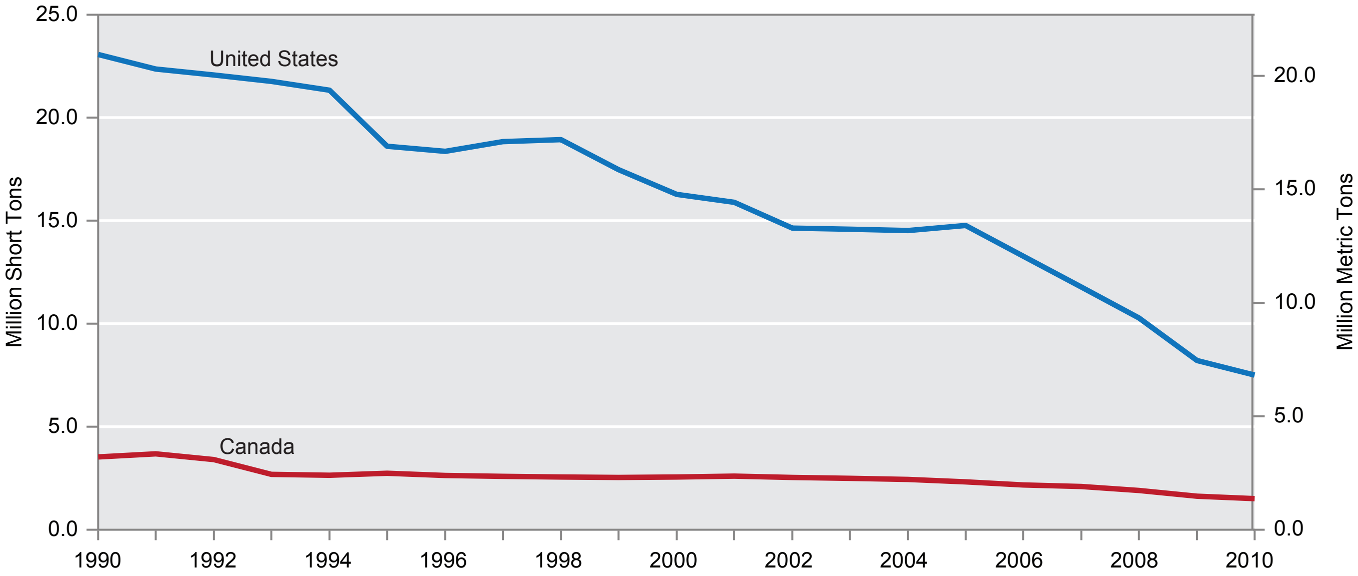
- Emissions exclude natural sources (biogenics and forest fires).
- Percentages may not add up to 100 due to rounding.

Source: U.S. EPA and Environment Canada, 2012

Figure 26, Figure 27, and Figure 28 for SO_2, NO_X, and VOCs, respectively, show emissions from 1990 through 2010. Both countries have seen major reductions in SO_2 emissions. In the United States, there is an overall trend of emission reduction for both SO_2 and NO_X. The major reductions in SO_2 emissions came from electric power generation sources as well as industrial and commercial fuel combustion sources. For NO_X, the reductions came from on-road and nonroad mobile sources, electric power generation sources, and other industrial fuel combustion sources. For VOCs, the largest reductions were mainly from on-road and nonroad mobile sources, solvent utilization, and petroleum storage and transport. As noted earlier, the increase in VOC emissions around 2002 was due to improved characterization methods for nonroad mobile sources and residential fuel combustion, as well as more complete characterization and exclusion of wildfires to account for anthropogenic sources only.

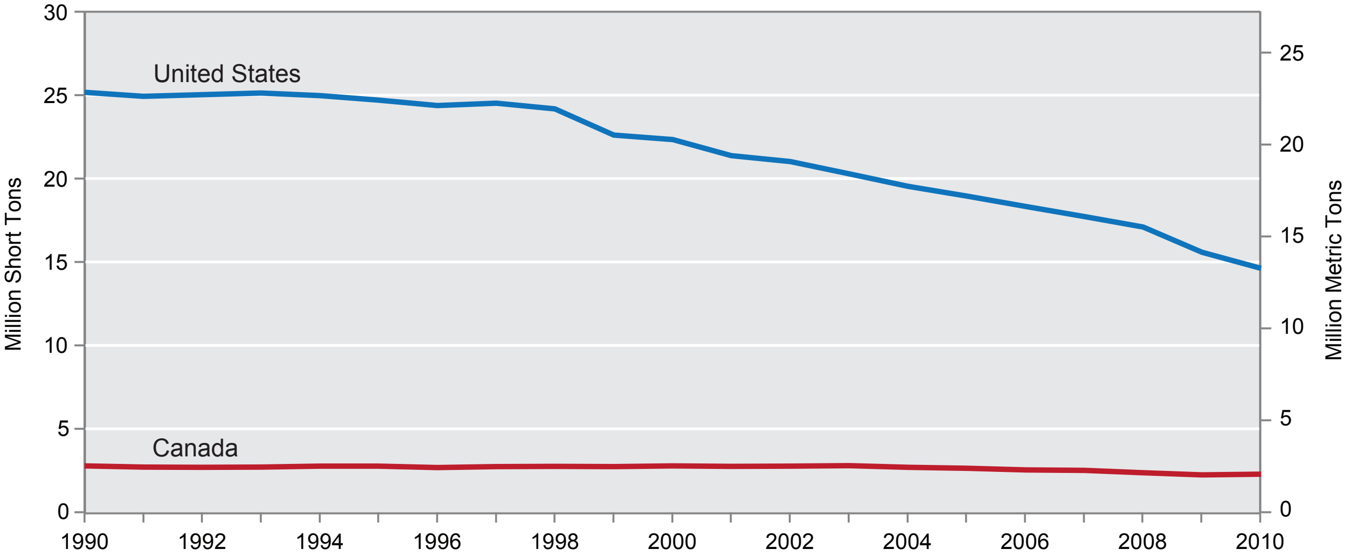
In Canada, the reductions in SO_2 emissions came from the nonferrous smelting and refining industry and the electric power generation utilities. For NO_X, the reductions were from on-road mobile sources, electric power generation utilities, and the mining and rock quarrying industry. The VOC reductions came from on-road mobile sources and the downstream petroleum industry, with additional reductions from various industrial sectors such as chemical, pulp and paper, wood products, and iron and steel industries.

Figure 26. National SO_2 Emissions in the United States and Canada from All Sources, 1990–2010



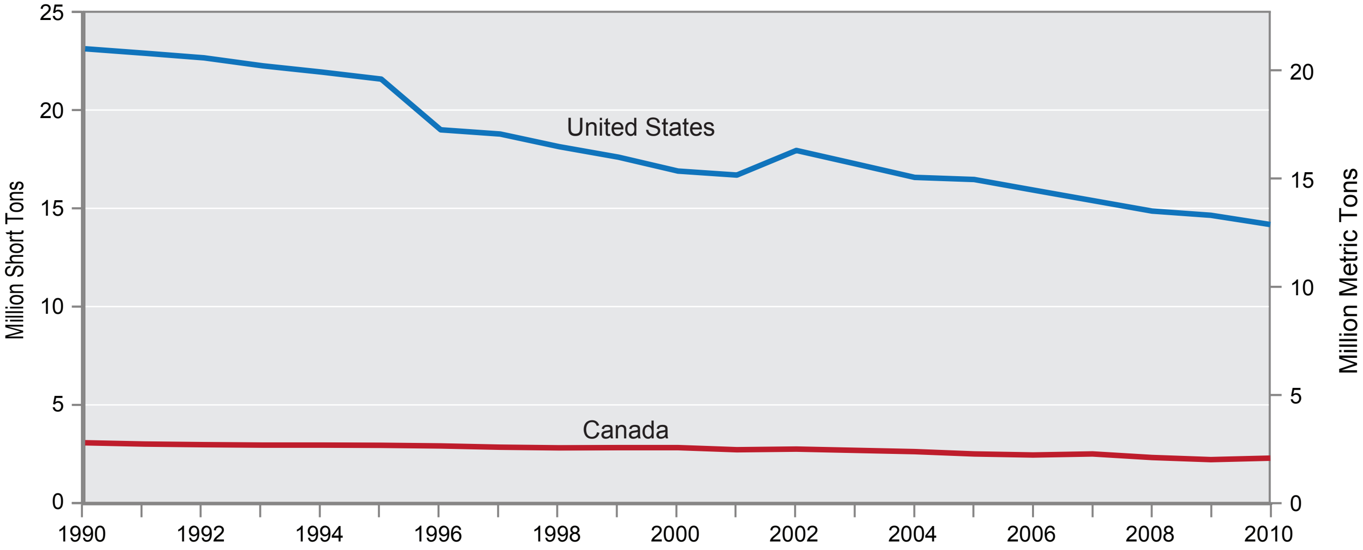
Source: U.S. EPA and Environment Canada, 2012

Figure 27. National NO_X Emissions in the United States and Canada from All Sources, 1990–2010



Source: U.S. EPA and Environment Canada, 2012

Figure 28. National VOC Emissions in the United States and Canada from All Sources, 1990–2010



Source: U.S. EPA and Environment Canada, 2012

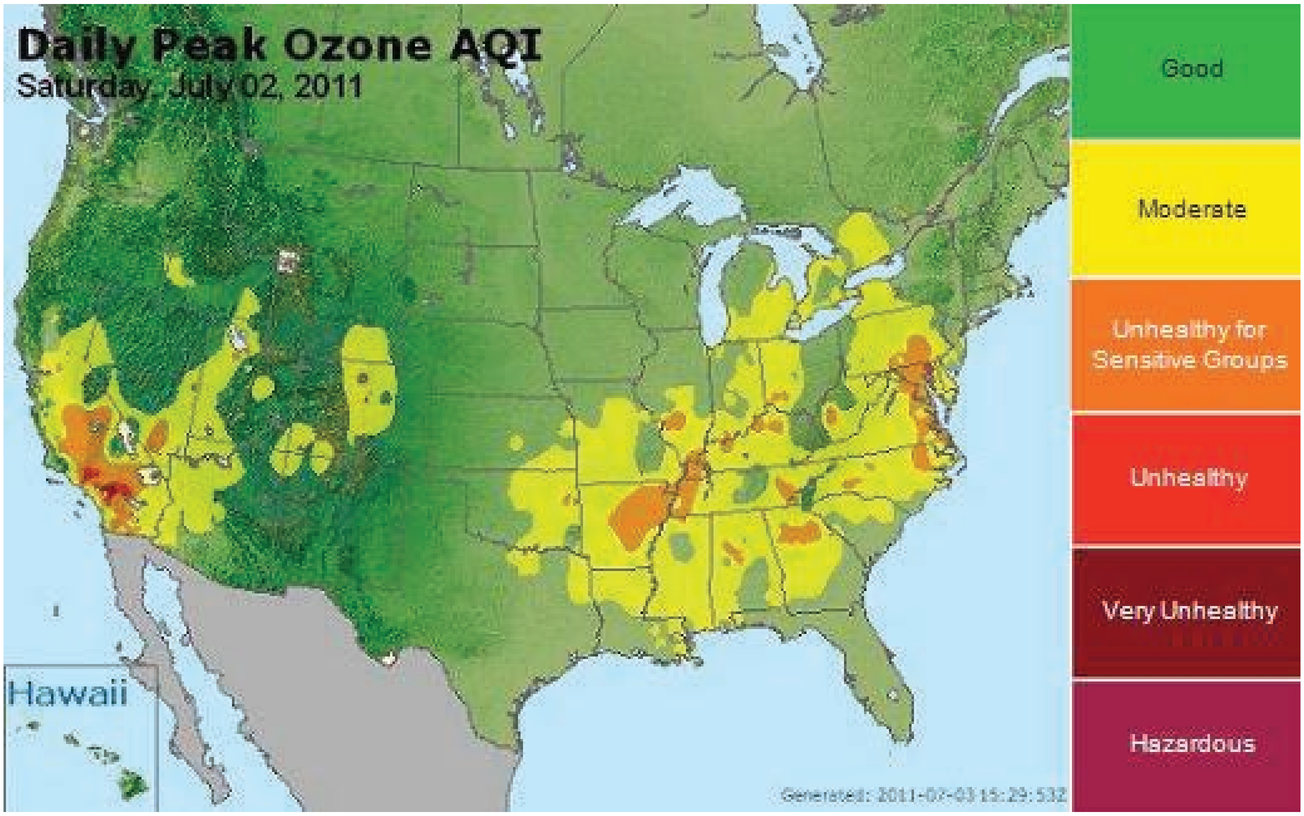
Air Quality Reporting and Mapping

Canada and the U.S. collaborate closely on real-time air quality reporting and mapping through the AIRNow program (<www.airnow.gov>), which was initiated by the U.S. EPA more than a decade ago. The AIRNow program provides current and forecasted air quality information for monitoring sites throughout the U.S. and Canada. Each country is responsible for ensuring instrument calibration and comparability of ambient measurements of ozone and $PM_{2.5}$. In 2004, the AIRNow program was expanded to provide information on $PM_{2.5}$ and ozone measurements on a continental scale year-round. Figure 29 is an example of the kind of maps available on the AIRNow website which display pollutant concentration data expressed in terms of the color-coded Air Quality Index (AQI).

AIRNow also distributes air quality data via web services and text files through AIRNow Gateway <www.airnowgateway.org>.

Note: The AQI for ozone reflects 8-hour average ozone concentrations. Areas shaded orange indicate values that are “unhealthy for sensitive groups.” More information on the AQI is available at <www.airnow.gov>.

Figure 29. AIRNow Map Illustrating the AQI for 8-hour Ozone



Note: This map is an illustration of the highest ozone concentrations reached throughout the region on a given day. It does not represent a snapshot at a particular time of the day, but is more like the daily high temperature portion of a weather forecast. The AQI shown in the legend is based on 8-hour average ozone. More information on the AQI is available at <www.airnow.gov>.

Source: U.S. EPA, 2012

CANADA

Air quality monitoring measures the level of pollutants present in the air. This information is then used for a variety of purposes, including evaluation of the effectiveness of emission reduction measures, trends, notification of smog advisories, health studies, and comparison with standards.

The National Air Pollution Surveillance (NAPS) network and the CAPMoN are the two major ambient air monitoring networks in Canada. The NAPS Program is a joint federal, provincial, and territorial government initiative. The purpose of this Program is to coordinate the collection of air quality data from existing provincial, territorial, and regional air quality monitoring networks and provide accurate and long-term air quality data of a uniform standard in a unified Canada-wide air quality database. Information about these networks can be found at <www.ec.gc.ca/rnspa-naps/Default.asp?lang=En&n=5C0D33CF-1> and <www.ec.gc.ca/rs-mn/default.asp?lang=En&n=752CE271-1>.

The associated federal and provincial/territorial/regional monitoring networks reporting data to the Canada-wide database comprise 318 air monitoring stations located in 217 communities. In total, over 800 instruments, including continuous analyzers for SO_2, CO, NO_2, ozone, and fine particulate matter are used to provide continuous air quality measurements. Toxic substances such as polycyclic aromatic hydrocarbons, dioxins and furans, and heavy metals such as arsenic, lead, and mercury are also analyzed for 24 hour events at scheduled 1 in 3 or 1 in 6 day intervals.

CAPMoN consists of 30 stations located in rural or remote areas, including one station in the United States. The objectives of CAPMoN differ from those of NAPS in that CAPMoN measurements provide data for research into: (1) regional-scale spatial and temporal variations of air pollutants and deposition, (2) long range transport of air pollutants (including transboundary transport), and (3) atmospheric processes, and chemical transport model evaluation. To meet these objectives, the CAPMoN sites are located in rural and remote areas.

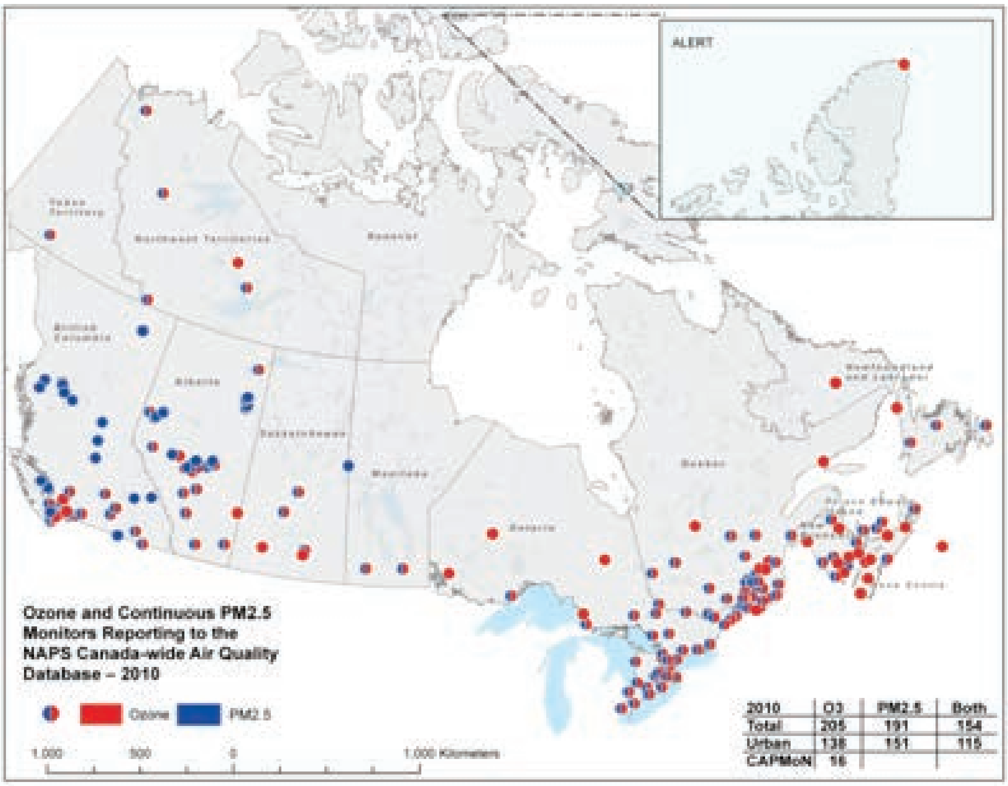
Figure 30 shows the number of $PM_{2.5}$ and ozone sites reporting to the Canada-wide air quality database in 2010. These sites are located in over 100 communities including all communities with a population greater than 100,000. In total, these communities account for about 75 percent of the Canadian population.

In addition to the continuous $PM_{2.5}$ monitors, there were 41 filter-based samplers in operation, which meet the NAPS $PM_{2.5}$ Reference Method criteria. The mass concentrations from these samplers are used for comparison with the continuous $PM_{2.5}$ instruments and the filter media also undergo chemical analysis. A subset of these sites (13) make up the $PM_{2.5}$ speciation network which measure major ions, organic and elemental carbon, metals and gas phase species including ammonia (NH_3) and nitric acid. The principle gaseous precursors to secondary $PM_{2.5}$ and ozone formation, SO_2, NO_X, and VOC are monitored at 152, 176, and 53 sites, respectively, reporting to the unified database. Measurements from these instruments are used to analyze source attribution and for the development of effective management strategies.

Recent investments to the air monitoring networks include:

- A multi-million dollar investment to ensure that monitoring instruments are properly maintained and replaced when an instrument has reached its end of life. This has reduced the average age of NAPS instruments from over 15 years to 5 years over the past decade.
- Conversion of the existing continuous $PM_{2.5}$ instruments to U.S. Class III Federal Equivalent Method (FEM) instruments.
- Modernization of federal, provincial, and regional data logging and data reporting systems to allow more timely reporting of data and improve quality of real time data, used to report air quality indices (e.g., the Canadian Air Quality Health Index [AQHI]) and for real-time mapping websites (e.g., AIRNOW).
- Purchase of new samplers to update the existing $PM_{2.5}$ chemical speciation network and existing measurement programs for VOCs have also been enhanced.
- Expansion of the laboratories and analytical equipment used to carry out detailed chemical analysis such as VOC and $PM_{2.5}$ speciation.

Figure 30. Ozone and Continuous $PM_{2.5}$ Monitors Reporting to the NAPS Canada-wide Air Quality Database, 2010



Source: Environment Canada, 2010

UNITED STATES ★

The majority of air quality monitoring performed in the United States is carried out by state, local, and tribal agencies in four major networks of monitoring stations: State and Local Air Monitoring Stations (SLAMS), Photochemical Assessment Monitoring Stations (PAMS), $PM_{2.5}$ Chemical Speciation Network (CSN), and air toxics monitoring stations. In addition, ambient air monitoring is performed by the federal government (U.S. EPA, NPS, NOAA, the U.S. Geological Survey, and the U. S. Department of Agriculture), tribes, and industry. Air quality monitoring in the United States supports several air quality management objectives:

- NAAQS attainment/nonattainment determination
- Human exposure assessment for health research studies
- Public air quality reporting and forecasting (AQI/AIRNow)
- Accountability of control programs (ARP, NO_X SIP Call, NBP, and CAIR)
- Model evaluation
- Determination of source-receptor relationships
- Characterization of regional air masses and transport
- Ecological exposure assessments (acidity; nutrients; ozone; mercury and other persistent, bioaccumulative, and toxic chemicals)
- Assessments for toxic air pollutants, trends, hotspots, human health exposure, and research

A summary of monitoring networks is provided in Table 4.

Table 4. U.S. Air Quality Monitoring Networks

MAJOR ROUTINE OPERATING AIR MONITORING NETWORKS:
State / Local / Tribal / Federal Networks

	Network*	Sites	Initiated	Measurement Parameters	Source of Information and/or Data
Urban/Human-Health Monitoring	National Core Monitoring Network (NCore)	~80	2011	Ground level ozone (O_3), reactive oxidized nitrogen, (NO)/NO_Y, SO_2, CO, $PM_{2.5}$/$PM_{10-2.5}$, $PM_{2.5}$ speciation, Surface Meteorology	<www.epa.gov/ttn/amtic/ncore/index.html>
	SLAMS	~3000	1978	O_3, NO_X/NO_2, SO_2, $PM_{2.5}$/PM_{10}, CO, lead (Pb)	<www.epa.gov/airdata>
	CSN	~200 currently active	1999	$PM_{2.5}$ mass, $PM_{2.5}$ speciation, major ions, metals	<www.epa.gov/airdata>
	PAMS	75	1994	O_3, NO_X/NO_Y, CO, speciated VOCs, carbonyls, surface meteorology, upper air	<www.epa.gov/ttn/amtic/pamsmain.html>
Rural/Regional Monitoring	IMPROVE	110 plus 67 protocol sites	1988	$PM_{2.5}$/PM_{10}, major ions, metals, light extinction, scattering coefficient	<vista.cira.colostate.edu/IMPROVE>
	CASTNET	80+	1987	O_3, weekly concentrations of SO_2, nitric acid (HNO_3), sulfate (SO_4^{2-}), NO_3^-, chlorine (Cl^-), ammonium (NH_4^+), calcium ions (Ca^{2+}), magnesium ion (Mg^{2+}), sodium ion (Na^+), potassium ion (K^+) for dry and total deposition, surface meteorology	<www.epa.gov/castnet>
	Gaseous Pollutant Monitoring Program (GPMP)	33	1987	O_3, NO_X/NO/NO_2, SO_2, CO, surface meteorology, enhanced monitoring of CO, NO, NO_X, NO_Y and SO_2, canister samples for VOC at three sites	<www.nature.nps.gov/air/Monitoring/network.cfm>
	NADP/NTN	250+	1978	Precipitation chemistry and wet deposition for major ions (SO_4^{2-},NO_3^-, NH_4^-, Ca^{2+}, 3 Mg^{2+}, Na^+, K^+, hydrogen ion [H^+] as the measure of the activity of the solvated hydrogen ion [pH])	<nadp.isws.illinois.edu>
	NADP/Ammonia Monitoring Network (AMoN)	57	2010	Bi-weekly NH_3 concentrations	<nadp.isws.illinois.edu>
Air Toxics Monitoring	National Air Toxics Trends Stations (NATTS)	27	2005	VOCs, carbonyls, PM_{10} metals**, mercury (Hg)	<www.epa.gov/ttn/amtic/natts.html>
	State/Local Air Toxics Monitoring	250+	1987	VOCs, carbonyls, PM_{10} metals**, Hg	<www.epa.gov/ttnamti1/local.html>
	National Dioxin Air Monitoring Network	34	1998–2005	Chlorinated dibenzo-p-dioxins (CDDs), furans (CDFs), dioxin-like polychlorinated biphenyls (PCBs)	<cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=54936>
	NADP/Mercury Deposition Network	100+	1996	Mercury measured in precipitation and wet deposition	<nadp.isws.illinois.edu/mdn>
	NADP/AMNet	21	2009	Speciated ambient mercury concentrations, gaseous oxidized mercury (GOM), particulate bound mercury (PBM), gaseous elemental mercury (GEM)	<nadp.isws.illinois.edu/amn>
	Integrated Atmospheric Deposition Network (IADN)	20	1990	Polycyclic aromatic hydrocarbons (PAHs), PCBs, and organochlorine compounds are measured in air and precipitation	<www.epa.gov/greatlakes/monitoring/air2/iadn/resources.html>

Notes:

* Some networks listed separately may also serve as subcomponents of other larger listed networks; as a result, some double counting of the number of individual monitors is likely. This list of networks is not meant to be totally inclusive of all routine monitoring in the United States.

** PM_{10} metals may include arsenic, beryllium, cadmium, chromium, lead, manganese, nickel, and others.

Source: U.S. EPA, 2012

The U.S. EPA introduced a new multi-pollutant monitoring network referred to as NCore that became operational in 2011. Monitors at NCore sites measure particles (e.g., $PM_{2.5}$, speciated $PM_{2.5}$, $PM_{10-2.5}$), ozone, SO_2, CO, NO, NO_Y, Pb, and basic meteorological parameters. Sites are broadly representative of urban (about 60 sites) and rural (about 20 sites) locations across the U.S. Where possible, states locate urban NCore sites next to existing monitoring operations to leverage existing resources. The objective of the NCore network is to gather additional information needed to support emissions and air quality model development, air quality program accountability, and future health studies. General information on the NCore network is available at <www.epa.gov/ttn/amtic/ncore/index.html>. More specific information on each NCore site can be viewed or downloaded from <ncore.sonomatechdata.com>.

The U.S. EPA has completed transitioning of the carbon measurement at CSN-speciated $PM_{2.5}$ stations to the IMPROVE protocol to support better comparability between CSN and IMPROVE networks. This effort was initiated in 2007.

The U.S. EPA finalized revisions to monitoring requirements for lead in 2008 to support the tightening of the lead NAAQS from 1.5 µg/m^3 (quarterly average) to 0.15 µg/m^3 (rolling three-month average). New monitoring requirements included the establishment of source-oriented lead monitoring sites around lead sources emitting 1.0 or greater short tons (0.9 metric tons) of lead per year by January 1, 2010. Additional lead monitoring requirements were finalized at the end of 2010 including the addition of lead trends monitoring at urban NCore sites, and the establishment of a short-term monitoring study at 15 general aviation airports across the U.S. Information on changes to the lead NAAQS and associated monitoring requirements is available at: <www.epa.gov/air/lead/actions.html>.

New ambient monitoring requirements have been established for the recently revised NO_2 and SO_2, and CO NAAQS, including a near-roadway requirement for NO_2 and CO monitoring. All new NO_2 and SO_2 monitors must begin operating no later than January 1, 2013, while new CO near-road monitors will be phased in to the NO_2 near-road sites between January 1, 2015 and January 1, 2017. Information on the near-roadway effort is available at: <www.epa.gov/ttnamti1/nearroad.html>. Additional details on the NO_2, SO_2, and CO monitoring requirements and the proposed changes to ozone monitoring requirements are available at <www.epa.gov/air/airpollutants.html>.

The NADP is operating the Ambient Mercury Network (AMNet), which measures ambient concentrations of speciated mercury at 21 sites throughout the U.S. and Canada. The data from this network will provide status and trends of ambient mercury concentrations, as well as information for model development including validation and source apportionment.

EPA collaborated with NADP to establish the AMoN as a NADP sub-network in 2010. The NADP operates AMoN, which uses passive devices to measure gaseous NH_3 concentrations. Currently there are 57 sites collecting two-week samples of ambient NH_3 concentrations. These measurements are needed to enhance atmospheric and deposition models, validate emission inventories, and understand the chemistry driving $PM_{2.5}$ formation. Both efforts aim to utilize the NADP committee structure as a platform for initiation and continued growth. The NADP website contains data, maps, and other program information (<nadp.isws.illinois.edu>). In the past two years, EPA has collocated AMoN with more than twenty-five CASTNET sites, and the NPS has collocated AMoN with nine CASTNET sites. Other recent activities related to CASTNET include transitioning its ozone monitoring operations to fully meet the regulatory quality requirements applicable to SLAMS air monitoring data and real-time reporting of hourly ozone and meteorological data to the AIRNow system for use in forecasting and mapping current air quality conditions. In addition, CASTNET is evaluating monitoring methods that provide highly time-resolved (i.e., hourly) measurements of both gaseous (SO_2, HNO_3, NH_3) and aerosol (sulfate, ammonium, nitrate, chloride and other base cations) components. The website for CASTNET includes program information, data and maps, annual network reports, and quality assurance information (<www.epa.gov/castnet>).

Health Effects

CANADA

Health Canada assessments and research provide health-based guidance for regulatory and non-regulatory actions to improve air quality and human health, including the new national framework for managing air quality called the Air Quality Management System (AQMS), which was developed in collaboration with Environment Canada, the provinces, territories and stakeholders.

Current priorities for addressing ambient air quality include:

- Implementing the new Canadian Ambient Air Quality Standards
- Assessing the contribution of different industrial sectors to air pollution and the resulting health risks
- Improving understanding of the transportation sector's contribution to air pollution
- Improving and updating the Air Quality Benefits Assessment Tool (AQBAT) used in the cost-benefit analysis of policies to reduce air pollution
- Advancing the AQHI as an information tool for the general public and vulnerable populations

Some recent highlights of Health Canada's air quality and health research include:

Canadian Smog Science Assessment

Health Canada and Environment Canada have finalized a comprehensive Canadian Smog Science Assessment covering 2002–2006, to provide credible and relevant scientific information to support actions to improve air quality in Canada. The Highlights and Key Messages were published in April 2012 (see <www.ec.gc.ca/Publications/default.asp?lang=En&xml=AD024B6B-A18B-408D-ACA2-59B1B4E04863>).

Canadian Health and Exposure Research

Canadian Census Cohort – Mortality and Air Pollution Study

The study was initiated in 2009, in collaboration with Statistics Canada, to examine the mortality risk of long-term exposure to air pollution in the Canadian population using long-form census data (1991) on 2.7 million Canadians linked to vital status information up to 2007. Exposure to $PM_{2.5}$ was estimated from ground-based observations and satellite data. The results showed a statistically significant positive association between long-term exposure to $PM_{2.5}$ and mortality. This association was observed at $PM_{2.5}$ concentrations that were lower than have been previously reported (mean = 8.7 µg/m^3, inter-quartile range = 6.2 µg/m^3).

Some results from this large cohort study have been published in a 2012 article by Crouse et al. entitled "Risk of Mortality Associated with Long-term Exposure to Low Concentrations of Fine Particulate Matter: A Canadian National-level Population-based Cohort Study" (Environmental Health Perspectives 120: 708-71). Additional analyses of the cohort will focus on specific causes of death and will investigate individual communities.

Multi-pollutant Modeling and Monitoring

The management of industrial emissions of air pollutants is an important element of the proposed AQMS. To support this initiative, multi-pollutant modeling and monitoring of emissions from specific industrial sectors are being conducted. These studies will characterize Canadians' exposure to the range of pollutants emitted from major industrial sources and assess the associated hazards. A major focus is the chemical characterization of PM coming from the different sources. Studies of pulp and paper, aluminum, cement, base-metal smelting, iron and steel, and coal-fired electricity sectors are currently in progress. It is expected that up to 14 major industrial sectors will be addressed in this manner. This information will be used to guide the development of cost-effective actions to reduce industrial emissions.

Industrial Emissions and the Exacerbation of Adverse Health Effects in Asthmatic Children

In 2009, Health Canada initiated a study to examine the impact of industrial emissions on respiratory and cardiovascular health in asthmatic children. A panel of 72 asthmatic children underwent daily tests of pulmonary function, lung inflammation, blood pressure, and heart rate. Preliminary results showed an association between personal exposures to $PM_{2.5}$ and increased airway inflammation in children with asthma. Data analysis comparing refinery emissions and health measures continues.

In Vitro and In Vivo Toxicity Models for Characterization of the Relative Potency of PM

A cytotoxicity assay platform has been developed that reduces the particle mass required for in vitro toxicity bioassays and targeted gene expression analyses. This platform facilitates the assessment of the toxicity of PM samples and supports interpretation of the data in the context of human health risk. This method has been used, for example, to assess the impact of particle composition, size, and aging on particle potency and to assess variability of potency among seasons.

Regression of potency data against elemental composition identified several metals as drivers of toxicity, including zinc, which has been previously implicated in certain adverse health outcomes in toxicological and epidemiological literature. Importantly, the data show that particle potency rankings generated using individual cell lines or assays may differ from one another, indicating that a number of assays and cell lines should be used to assess the cytotoxic potency of particles in an integrated fashion. Regressing in vivo data against in vitro assays showed that subsets of in vitro assays can be predictive of effects observed in vivo.

Canadian Health and Exposure Tools to Support Risk Management

Air Quality Benefits Assessment Tool

The AQBAT is a computer simulation program similar to the Environmental Benefits Mapping and Analysis Program developed by Health Canada to estimate the human health costs and/or benefits associated with changes in ambient air quality. AQBAT was made publicly available in 2006 and has been applied to federal government policy proposals on air quality as well as by a number of municipal governments and consultants in specific policy contexts. An updated version (AQBAT 2.0) was released in April 2012. The revised version includes a number of improvements, including updated population, air pollution, baseline incidence data of hospital admissions and mortality, and revised concentration-response functions and valuation parameters for selected outcomes. Life expectancy changes associated with changes in air pollution can also be estimated in AQBAT 2.0.

Canadian Air Quality Health Index

The AQHI is a public information tool, developed jointly by Environment Canada and Health Canada, which helps Canadians protect their health on a daily basis from the negative effects of air pollution. The AQHI is based on epidemiological data that relates air pollution exposures to acute health outcomes. This index employs a linear, non-threshold concentration-response relationship of short-term health risks of the smog mixture using three pollutants (NO_2, ground-level ozone, and $PM_{2.5}$) as a surrogate measure of the more complex mixture in the urban atmosphere. The index is expressed on a 1 to 10+ scale, where higher values represent a greater health risk.

In addition to the scale, corresponding health messages have been developed for general and "at-risk" populations. The current (hourly) and forecasted (today and tomorrow) AQHI values and their associated health messages are publicly available at <www.airhealth.ca> and on the Weather Office website and on media broadcasts in locations where the AQHI is available. This information will allow Canadians to make informed choices to protect themselves and those in their care from the short-term health impacts of exposure to air pollution.

The AQHI is now available in 74 communities, representing more than 60 percent of the Canadian population, with additional communities to be added as the AQHI is implemented across the country.

In January 2012, a workshop was held to give stakeholders and scientists an opportunity to discuss the index together. It was agreed that the timing was appropriate for a review of the index. The review has begun with an update of the air pollution and mortality data analysis, particularly for the coefficients of the three current AQHI pollutants, as well as CO and SO_2. It will also consider health endpoints other than mortality and other adjustments that may be made in terms of spatial scales, pollutants, instrumentation, and presentation of the index.

UNITED STATES ★

Review of U.S. Ozone, PM, NO_2, and SO_2 Air Quality Standards

Under the Clean Air Act (CAA), the EPA is required to set NAAQS for widespread pollutants from numerous and diverse sources considered harmful to public health and the environment. The CAA established two types of NAAQS.

- Primary standards set limits with an adequate margin of safety to protect public health, including the health of at-risk populations, such as children, older adults, and persons with pre-existing cardiovascular and respiratory disease such as asthma.
- Secondary standards set limits to protect public welfare from any known or anticipated adverse effects, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.

The U.S. EPA has set NAAQS for six common pollutants, which are often referred to as "criteria" pollutants. These pollutants are: PM, ozone, SO_2, NO_2, carbon monoxide, and lead.

The CAA requires U.S. EPA to periodically review (every 5 years) the science upon which the NAAQS are based and the standards themselves. Reviewing the NAAQS is a lengthy undertaking that follows a well-established process.[4] Each review involves a comprehensive review, synthesis, and evaluation of the scientific information (Integrated Science Assessment [ISA]), the design and conduct of complex air quality and risk and exposure analyses (Risk and Exposure Assessment [REA]), the development of a comprehensive policy assessment providing a transparent staff analysis of the scientific basis for the broadest range of alternative policy options supported by the scientific and technical information (Policy Assessment), and the development of proposed and final rules. The assessments providing the foundation for the Agency's decisions undergo extensive internal and external scientific peer-review.

Ozone NAAQS review

Exposure to ozone is associated with a wide variety of adverse health effects that range from decreased lung function and increased respiratory symptoms to serious indicators of respiratory morbidity including emergency department visits and hospital admissions for respiratory causes, and new onset asthma as well as premature mortality. Children and individuals with lung disease are considered at-risk populations. In addition, repeated exposure to ozone during the growing season damages sensitive vegetation. Cumulative ozone exposure can lead to reduced tree growth, visibly injured leaves, and increased susceptibility to disease, damage from insects, and harsh weather.

On March 12, 2008, the U.S. EPA strengthened the primary and secondary 8-hour standards for ozone by lowering the levels of the standards from 0.08 to 0.075 ppm to improve both public health protection and the protection of sensitive trees and plants. Final designations for these standards were completed in May 2012 with 46 areas being designated as nonattainment.

The U.S. EPA is in the midst of its next statutorily-mandated review of the ozone standards to ensure that the NAAQS provide appropriate public health and environmental protection. As part of this review, EPA has issued a number of draft documents for external scientific and public review. Additional information on the current and previous ozone NAAQS reviews can be found at <www.epa.gov/ttn/naaqs/standards/ozone/s_o3_index.html>.

Particulate Matter NAAQS

An extensive body of scientific evidence shows that exposure to PM causes premature death and is linked to a variety of significant health problems, such as increased hospital admissions and emergency department visits for cardiovascular and respiratory effects, including non-fatal heart attacks. Exposure to PM is also linked to the development of chronic respiratory disease. There are several groups within the general population at greater risk for experiencing PM-related effects. These at-risk populations include individuals with preexisting heart and lung disease, older adults, children, and those who live in poverty.

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[4] Information on the NAAQS review process is available at <www.epa.gov/ttn/naaqs/review.html>.

In addition, the contribution of particles, especially fine particles, to visibility impairment has been recognized for a long time. Visibility is affected by particles that scatter and absorb light. Particle composition and size as well as relative humidity are important factors for understanding the impacts of particle pollution on visibility impairment. Particles are also associated with a wide range of non-visibility welfare effects including: ecological effects, effects on materials, and climate impacts.

In 2007, the U.S. EPA initiated the current review of the PM NAAQS and on June 14, 2012, the U.S. EPA proposed revisions to the NAAQS which would strengthen the primary and secondary $PM_{2.5}$ standards to provide requisite protection for public health and welfare. Specifically, the U.S. EPA proposed to lower the level of the primary annual $PM_{2.5}$ standard to provide increased protection against health effects associated with long- and short-term $PM_{2.5}$ exposures and to retain the primary 24-hour $PM_{2.5}$ standard. The Agency proposed to add a distinct secondary standard for $PM_{2.5}$ to address PM-related visibility impairment and to retain the current secondary $PM_{2.5}$ and PM_{10} standards to address non-visibility welfare effects. Also, the U.S. EPA proposed to retain the primary 24-hour standard to continue to provide protection against effects associated with short-term exposure to thoracic coarse particles (i.e., $PM_{10-2.5}$). Additional information on the proposed rule, including supporting documents, can be found at <www.epa.gov/ttn/naaqs/standards/pm/s_pm_index.html>. The U.S. EPA plans to issue a final rule in December 2012.

NO_2 NAAQS (Primary Standard)

Exposure to NO_2 has been associated with a variety of health effects, including respiratory symptoms, especially among asthmatic children, and respiratory-related emergency department visits and hospital admissions, particularly for children and older adults. On January 22, 2010, based on the results of NO_2 health effects evidence as assessed in the ISA and estimates of NO_2-associated exposures and health risks presented in the REA, the U.S. EPA revised the primary NO_2 NAAQS, and established new requirements for the NO_2 monitoring network. Specifically, the U.S. EPA promulgated a new 1-hour primary NO_2 standard with a level of 100 ppb, retained the existing annual standard with a level of 53 ppb, and established a requirement for more than 50 NO_2 monitors be sited within 50 meters of major roads and in other locations where maximum NO_2 concentrations are expected to occur. Additional information on the final rule, including supporting documents, can be found at <www.epa.gov/air/nitrogenoxides>. The U.S. EPA has recently started its next periodic review of the primary NO_2 standards; additional information can be found at <www.epa.gov/ttn/naaqs/standards/nox/s_nox_index.html>.

SO_2 NAAQS (Primary Standard)

Asthmatics are especially susceptible to the effects of SO_2. Short-term exposure of asthmatic individuals to elevated levels of SO_2 while exercising at a moderate level may result in breathing difficulties, accompanied by symptoms such as wheezing, chest tightness, or shortness of breath. Studies also provide consistent evidence of an association between short-term SO_2 exposure and increased respiratory symptoms in children, especially those with asthma or chronic respiratory symptoms. Short-term exposure to SO_2 have also been associated with respiratory-related emergency department visits and hospital admissions, particularly for children and older adults.

On June 2, 2010, based on the results of SO_2 health effects evidence assessed in the ISA, and on estimates of SO_2-associated exposure and health risks presented in the REA, the U.S. EPA strengthened the primary NAAQS for SO_2. The U.S. EPA revised the primary SO_2 standard by establishing a new 1-hour standard at a level of 75 ppb. The revised standard will improve public health protection, especially for children, older adults, and people with asthma. The U.S. EPA's evaluation of the scientific information and the risks posed by breathing SO_2 indicate that this new 1-hour standard will protect public health by reducing people's exposure to high short-term (5 minutes to 24 hours) concentrations of SO_2. The U.S. EPA revoked the two existing primary standards of 140 ppb evaluated over 24 hours, and 30 ppb evaluated over an entire year because they will not add additional public health protection given a 1-hour standard at 75 ppb. Also, there is little health evidence to suggest an association between long-term exposure to SO_2 and health effects. Additional information on the final rule, including supporting documents, can be found at <www.epa.gov/air/sulfurdioxide>.

Oxides of Sulfur and Nitrogen NAAQS (Secondary Standards)

NO_X and SO_X in the air can damage the leaves of plants, decrease their ability to produce food – photosynthesis – and decrease their growth. In addition to directly affecting plants, NO_X and SO_X when deposited on land and in estuaries, lakes and streams, can acidify and over-fertilize sensitive ecosystems resulting in a range of harmful deposition-related effects on plants, soils, water quality, and fish and wildlife (e.g., changes in biodiversity and loss of habitat, reduced tree growth, loss of fish species, and harmful algal blooms). On March 20, 2012, the U.S. EPA completed its review of the secondary NO_X and SO_X standards. This was the first time that the U.S. EPA reviewed the environmental impacts separately from the health impacts of these pollutants. It is also the first time the Agency examined the effects of multiple pollutants in one NAAQS review.

Based on its review of the currently available scientific information, the U.S. EPA retained the current annual NO_2 standard set at a level of 0.53 ppm and 2-hour SO_2 standard set at a level of 0.5 ppm to address the direct effects on vegetation (e.g., decreased growth and foliar injury). With regard to the deposition-related effects, the final rule recognized that the existing secondary standards do not provide adequate public welfare protection. While there is strong scientific support for developing a multi-pollutant standard to address these deposition-related effects, the U.S. EPA concluded it does not yet have enough information to set such a standard that would adequately protect the diverse ecosystems across the country. Additional information on the final rule, and supporting documentation, can be found at <www.epa.gov/airquality/sulfurdioxide/actions.html>.

U.S. Exposure and Health Research

Clean Air Research Centers

In March of 2011, the U.S. EPA announced the awarding of $32 million to fund four new Clean Air Research Centers at universities conducting cutting-edge air pollution research. The funds will support investigations that focus on the impacts of air pollution mixtures on people's health, moving the science beyond past studies that concentrated on single pollutants. The work will advance the understanding of the health risks associated with exposure to multiple air pollutants, providing critical insights into real world exposure scenarios.

The research centers will investigate a myriad of health effects, ranging from cardiovascular and pulmonary problems to neurological and inflammation outcomes. The research centers will also study those most susceptible to air pollution, including children, the elderly, people with pre-existing conditions, and people living in communities that present greater health risks associated with air pollution. Each center will receive approximately $8 million over five years. The Clean Air Research Centers are located at:

- Emory University and Georgia Institute of Technology, Atlanta, Georgia
- Harvard University, Boston, Massachusetts
- Michigan State University, East Lansing, Michigan
- University of Washington, Seattle, Washington

New Insights into Air Pollution and Cardiovascular Health

Recent research results in the U.S. have provided new insights into the association of air pollution and cardiovascular health. A U.S. EPA study of potential health impacts from exposure to emissions from a wildfire in North Carolina used satellite imagery and emergency room (ER) records from the affected and surrounding area to demonstrate, for the first time, an association between smoke from peat fires and an increased number of ER visits for symptoms of heart failure.[5] The study also showed a significant increase in respiratory effects (asthma, pneumonia, and acute chronic bronchitis) in the high-smoke areas and discovered that certain groups of people—older adults and those with pre-existing lung and heart problems, for example—were more susceptible to the adverse effects of wildfire smoke. Another U.S. EPA funded study, the Multi-Ethnic Study of Atherosclerosis and Air Pollution (MESA Air), is designed to examine the relationship between air pollution exposures and the progression of cardiovascular disease over longer time periods. This ten-year study, which is led by the University of Washington, involves thousands of participants, representing diverse areas of the United States. An early finding from the MESA Air study showed that exposures to fine particles is associated with narrower arteriolar diameter in the retina of middle-aged and older adults.[6] While the clinical significance of the change is yet to be determined, these results demonstrate that exposure to PM may result in measurable cardiovascular effects, which may help explain the development and exacerbation of cardiovascular disease. In addition, a study conducted at Harvard and Brown University found associations between air pollution and an increased risk of ischemic strokes.[7] The study, which was supported by the National Institute of Environmental Health Science and the U.S. EPA, used hourly measurements of fine particles and detailed information from medical records about the timing of initial stroke symptoms, involving more than 1,700 stroke patients in the Boston area over a 10-year period. Finally, in addition to the studies above which focused primarily on particle pollution, a U.S. EPA study has also provided new evidence of associations between ozone and cardiovascular

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[5] Rappold AG, Stone SL, Cascio WE, Neas LM, Kilaru VJ, et al. 2011 Peat Bog Wildfire Smoke Exposure in Rural North Carolina Is Associated with Cardiopulmonary Emergency Department Visits Assessed through Syndromic Surveillance. Environ Health Perspect 119(10): doi:10.1289/ehp.1003206.

[6] Adar SD, Klein R, Klein BEK, Szpiro AA, Cotch MF, et al. (2010) Air Pollution and the Microvasculature: A Cross-Sectional Assessment of In Vivo Retinal Images in the Population-Based Multi-Ethnic Study of Atherosclerosis (MESA). PLoS Med 7(11): e1000372. doi:10.1371/journal.pmed.1000372.

[7] Wellenius GA, Burger MR, Coull BA, et al. Ambient Air Pollution and the Risk of Acute Ischemic Stroke. Arch Intern Med. 2012;172(3):229-234. doi:10.1001/archinternmed.2011.732.

symptoms.[8]

Ecological Effects

Research and Monitoring of Aquatic Acid Deposition Effects

Precipitation Chemistry

Analyses of trends in North American precipitation and surface water chemistry for the period 1990 to 2008 were recently released as part of a report of the International Cooperative Programme (ICP) Waters program under the United Nations Economic Commission for Europe (UNECE). Canada and the United States contribute to the ICP Waters program as a party to the Convention on Long-range Transboundary Air Pollution.

Levels of sulfate in precipitation presented a decreasing trend at 97 percent of the sites in northeastern North America over the period 1990 to 2008. The decrease was 37 percent on average and was more pronounced during the first decade. The trend can be traced back to the decrease in North American sulfur emissions from coal-fired power plants and the resulting substantial decrease in atmospheric deposition of sulfate. Similarly, significant reductions in NO_X emissions in North America led to a 30 percent reduction in average nitrate levels in precipitation. The precipitation data reflected the fact that the NO_X emission reductions were not as large as for SO_2 and they predominantly occurred during the 1999 to 2008 period.

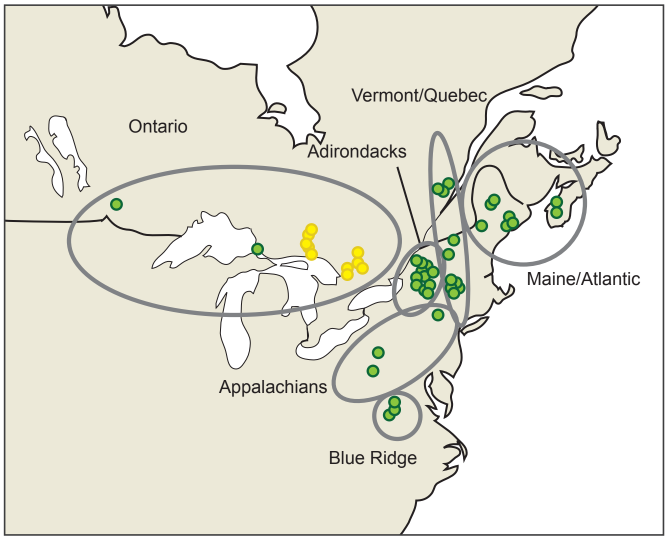
Of the other parameters that are important in assessing critical loads and exceedances (see page 56 for further discussion), the concentrations of ammonium and base cations (sum of calcium, magnesium, potassium, and sodium ions) did not exhibit a clear trend in North America, while hydrogen ions decreased by 55 percent. Similar to nitrates, the decrease in hydrogen ions, or evolution towards less acidic pH levels, occurred largely in the latter part of the period.

Surface Water Chemistry

Analysis of trends in surface water chemistry for the period 1999 to 2008 provided information on the geographic extent of acidification and recovery of lakes and streams in eastern North America. Figure 31 shows the 96 North American ICP sites that were grouped into six regions (Maine and Atlantic Canada, Vermont and Quebec, Adirondacks, Appalachian Plateau, Virginia Blue Ridge, and Ontario) and analyzed for acidification and or recovery trends. Data from 13 sites in Ontario were added to those covered by the ICP Waters program to improve the data representativeness for that region. The trends observed for 1999 to 2008 were compared to those from 1990 to 1999 to determine if the rate of recovery was changing.

Overall, water chemistry trends at the North American monitoring sites generally showed chemical recovery between 1990 and 2008 corresponding to the observed reductions in acidic deposition. The decreasing trend in sulfate

Figure 31. Eastern North American Sites Reporting Data to the ICP Waters Database (in green) and the 13 Additional Stations in Ontario (in yellow)



Source: Skjelkvåle, B.L. and de Wit, H.A. 2011. ICP Waters Report 106/2011: Trends in precipitation chemistry, surface water chemistry and aquatic biota in acidified areas in Europe and North America from 1990 to 2008. Norwegian Institute for Water Research, Report SNO 6218-2011, p. 128

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[8] Devlin et al. 2012. Controlled Exposure of Healthy Young Volunteers to Ozone Causes Cardiovascular Effects. Circulation. Published online June 25, 2012.

and increasing trends in pH and acid neutralizing capacity showed consistent chemical recovery from acidification across a large number of sites. Some exceptions occurred at a number of sites in Atlantic Canada. The concentration of base cations that is important for aquatic biota and chemical recovery had been decreasing as a result of the decline in sulfate. However, the rate of base cation decrease compared to that of sulfate slowed down after 2000, which also indicates recovery.

Compounding the recovery, levels of dissolved organic carbon (DOC) were shown to be increasing in many of the monitoring sites in North America. DOC affects (among other things) light penetration, primary production, and dissolved oxygen concentrations, and is an indicator of natural organic acidity which may impede increases in pH and alkalinity. DOC levels have been rising in many regions around the world and are believed to be influenced by the combination of decreasing sulfur deposition and climatic factors.

Recovery of Acidified Lakes and Streams in the U.S.

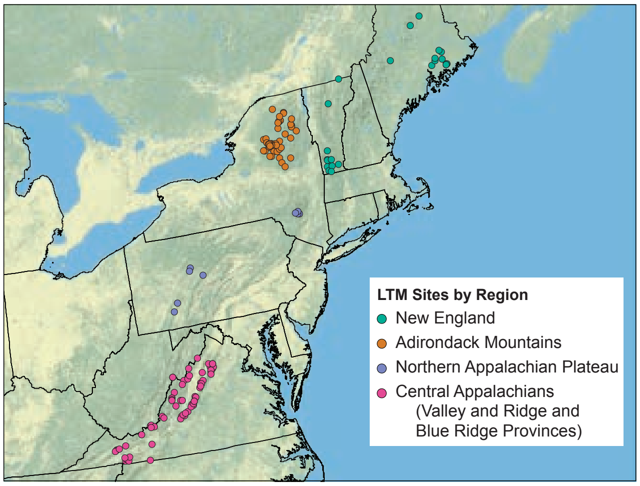
Acid rain, resulting from SO_2 and NO_X emissions, is one of many large-scale anthropogenic effects that negatively affect the health of water bodies (lakes and streams) in the United States and Canada. Surface water chemistry provides direct indicators of the potential effects of acidic deposition on the overall health of aquatic ecosystems.

Two U.S. EPA-administered monitoring programs provide information on the impacts of acidic deposition on otherwise protected aquatic systems: Temporally Integrated Monitoring of Ecosystems (TIME) and Long-term Monitoring (LTM) programs. These programs are designed to track changes in surface water chemistry in the four acid sensitive regions shown in Figure 32: New England, the Adirondack Mountains, the Northern Appalachian Plateau, and the central Appalachians (the Valley and Ridge and Blue Ridge Provinces).

Five indicators of aquatic ecosystem response to emission changes are presented: measured ions of sulfate and nitrate, base cations, ANC, and DOC. These indicators provide information regarding

- Sulfate ion concentrations in surface waters provide important information on the extent of base cation (i.e., calcium, magnesium, potassium, and sodium) leaching in soils and offer insight on how sulfate concentrations relate to the levels of ambient atmospheric sulfur and atmospheric deposition.
- Nitrogen is an important nutrient for plant growth and, therefore, most nitrogen inputs by deposition are quickly incorporated into biomass during the growing season as organic nitrogen, with little leaching of nitrate into surface waters during the growing season. As atmospheric nitrogen deposition increases, there is greater potential for increased leaching of nitrate into surface waters.
- Acid neutralizing capacity (ANC) is a measure of the acid-buffering capacity of water and an important indicator of the sensitivity and the degree of surface water acidification or recovery that occurs over time. Acidification results in a diminishing ability of water in the lake or stream to neutralize strong acids that enter aquatic ecosystems.

Figure 32. Long-Term Monitoring Program Sites



Source: U.S. EPA, 2012

the surface water sensitivity to acidification. Trends in these measured chemical receptors allow for the determination of whether the conditions of the water bodies are improving and heading towards recovery or if the conditions are still acidifying.

As seen in Table 5, significant improving (decreasing) trends in sulfate concentrations from 1990 to 2009 are found at nearly all monitoring sites in New England, the Adirondacks, and the Catskill Mountains/Northern Appalachian Plateau. However, in the Central Appalachians only 12 percent of monitored streams showed a decreasing sulfate trend, while 14 percent of monitored streams actually increased, despite decreasing sulfate deposition. The highly weathered soils of the Central Appalachians are able to store large amounts of deposited sulfate, but as long-term sulfate deposition exhausts the soil's ability to store more sulfate, a decreasing proportion of the deposited sulfate is retained in the soil and an increasing proportion is exported to surface waters.

Surface nitrate concentration trends are decreasing at some of the sites in all four regions, but some sites also indicate flat or slightly increasing nitrate trends. Improving (decreasing) trends for nitrate concentration were noted at 37 percent of all monitored sites, but this improvement may only be partially explained by decreasing deposition. Ecosystem factors, such as vegetation disturbances and soil retention of the deposited nitrogen, are also known to contribute to declining surface water nitrate concentrations.

Reductions in sulfate deposition levels likely result in many of the improving (increasing) ANC trends. From 1990 to 2009, monitoring sites in the Adirondacks (60 percent), and the Catskills/Northern Appalachian Plateau (55 percent) showed the strongest improvement in ANC trends. However, sites in New England (20 percent) and the Central Appalachians (17 percent) had few sites with improving ANC trends. The relatively flat trends in sulfate in the Central Appalachians likely account for why so few sites have improving ANC. In New England, hydrology and declining trends of base cation concentration may delay the onset of recovery. Decreasing base cation levels

Table 5. Regional Trends in Sulfate, Nitrate, ANC, and DOC at LTM Sites, 1990–2009

Region	Water Bodies Covered	Percentage of Sites with Improving Sulfate Trend	Percentage of Sites with Improving Nitrate Trend	Percentage of Sites with Improving ANC Trend	Percentage of Sites with Improving Base Cations Trend	Percentage of Sites with Improving DOC Trend
Adirondack Mountains	50 lakes in New York	94%	48%	60%	74%	48% (29 sites)
Catskills/N. Appalachian Plateau*	9 streams in New York and Pennsylvania	80%	30%	55%	80%	25% (9 sites)
New England	26 lakes in Maine and Vermont	96%	33%	20%	57%	26% (15 sites)
Central Appalachians	66 streams in Virginia	12%	50%	17%	12%	NA

Notes:

- Trends are determined by multivariate Mann-Kendall tests
- Trends are significant at the 95 percent confidence interval ($p < 0.05$)
- DOC was only examined in low-ANC water bodies (ANC less than 25 microequivalents per liter [µeq/L])
- DOC is not currently measured in Central Appalachian streams

* Data for streams in N. Appalachian Plateau are only through 2008

Source: U.S. EPA, 2011

can balance out reductions of sulfate and nitrate, thereby preventing ANC from increasing. DOC is increasing at only 30 percent of all monitored water bodies. This is likely linked to declines in sulfate concentrations as well as warmer seasonal and annual temperatures.

Critical Loads and Exceedances

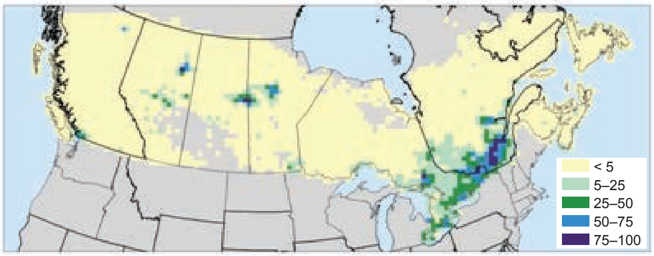
Improving the Uncertainty Estimate in Critical Loads for Canadian Forest Ecosystems

Critical loads of acidity (sulfur and nitrogen) form the basis of emission reduction policies in Canada. A critical load is developed to protect a specific biological indicator, and is defined as a quantitative estimate of an exposure to one or more pollutants below which the long-term unacceptable effects on specified elements will not occur according to present knowledge and policy.[9] A study was commissioned by the CCME to assess the impact of uncertainties in regional data sets on the probability of exceeding Canadian forest ecosystem critical loads.[10] Uncertainty increases as data are applied on national or continental scales.

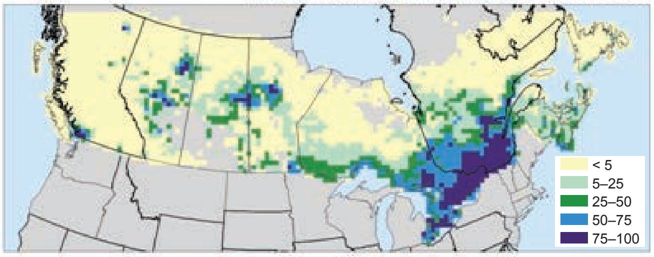
In this analysis, the probability of exceeding a critical load was evaluated for the 2002 and 2006 total S+N (sulfur + nitrogen) deposition modeled by A Unified Regional Air quality Modelling System (AURAMS), for two chemical criterion: base cation to aluminum ratios (Bc:Al) of 1 and 10. These two ratios were selected to protect tree roots and soil nutrient pools, respectively. The Bc:Al = 1 ratio is the most commonly used protection limit in Europe and elsewhere, while a Bc:Al = 10 ratio was previously used in Canada for mineral forest soil. The critical loads of acidity were estimated using the Steady-State Mass Balance model.

Figure 33. Critical Load Exceedance Probability, 2002 and 2006

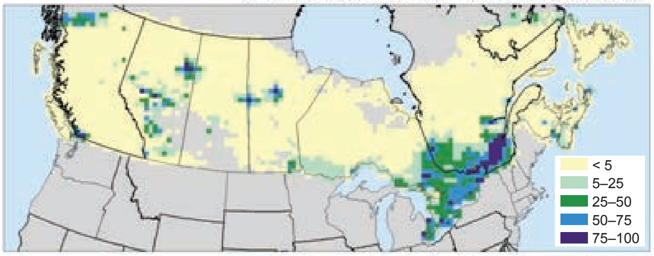
critical chemical criterion: Bc:Al = 1 | deposition: AURAMS 2006



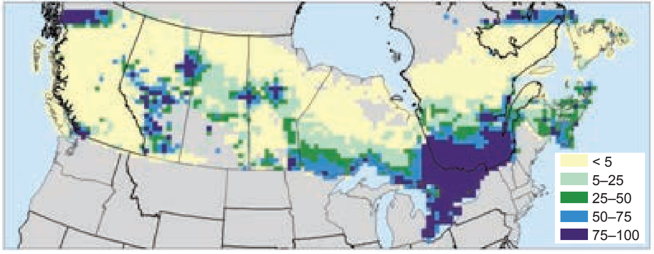
critical chemical criterion: Bc:Al = 10 | deposition: AURAMS 2006



critical chemical criterion: Bc:Al = 1 | deposition: AURAMS 2002



critical chemical criterion: Bc:Al = 10 | deposition: AURAMS 2002



Note: Under AURAMS 2002 deposition, the high exceedance probability in the northeast and northwest is an artifact caused by model domain boundary parameters.

Source: Environment Canada, 2012

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[9] Barkman, A., 1997. Applying the critical loads concept: Constraints induced by data uncertainty. Technical Report. Department of Chemical Engineering II, Lund University, Sweden.

[10] Aherne, J. and Wolniewicz, M.B. 2011. Critical loads uncertainty and risk analysis for Canadian forest ecosystems. Final Report, CCME, 19 pp.

The analysis showed a significant reduction in 2006 in the area with a high probability of exceedance compared to 2002 (Figure 33). The uncertainty in critical loads averaged 27 to 28 percent under both chemical scenarios across Canada, with greater uncertainty occuring in northern Ontario, central Manitoba and Saskatchewan, and northern British Columbia. Despite uncertainties in regional data sets, the high probabilities of critical loads exceedance in many parts of the country even in the later year of study (2006) support the need for further emission reductions.

Use of Critical Loads in the U.S.

In the United States, the critical loads approach is not an officially accepted approach to ecosystem protection. Language specifically requiring a critical loads approach does not exist in the CAA. Nevertheless, the critical loads approach is a useful ecosystem assessment tool for communicating complex scientific information. Interest in the use of critical loads in the United States has increased in recent years with the advent of the Critical Loads of Atmospheric Deposition Science Committee within NADP in 2010, several recent workshops and meetings on this topic, and several publications exploring greater use of critical loads as a policy-relevant environmental assessment tool.

Drawing on the methods from the peer-reviewed scientific literature, critical loads were calculated for over 2,300 lakes and streams using the Steady-State Water Chemistry model. These critical

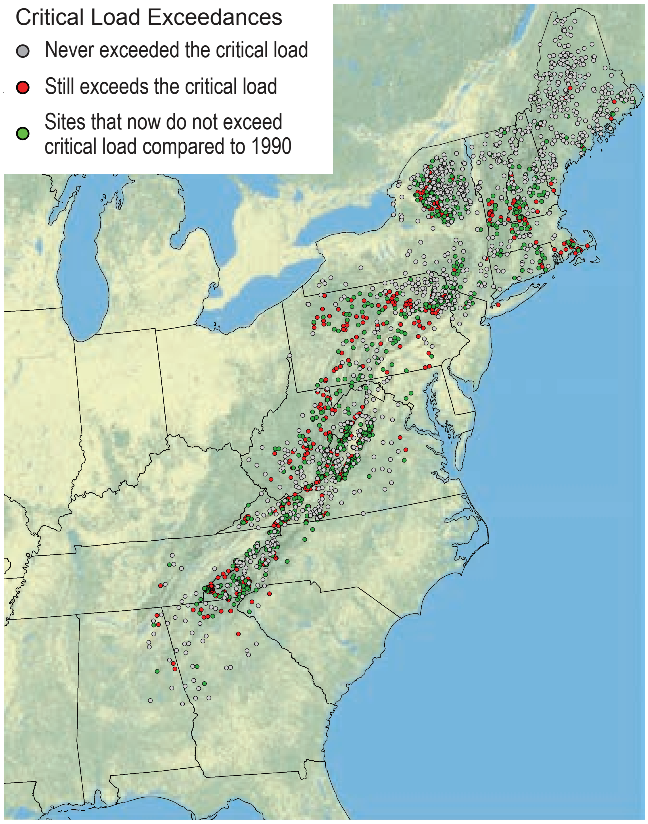
load estimates represent only lakes and streams where surface water samples have been collected through programs such as National Surface Water Survey, Environmental Monitoring and Assessment Program (EMAP), the TIME program, and the LTM program. The lakes and streams associated with these programs consist of a subset of lakes and streams that are located in areas most affected by acid deposition, but are not intended to represent all lakes in the eastern U.S.

For this particular analysis, the critical load represents the combined deposition loads of sulfur and nitrogen to which a lake or stream could be subjected and still have a calculated ANC of 50 µeq/L or higher. While a critical load can be calculated for any ANC level, this level was chosen because it tends to support healthy aquatic ecosystems and protect most fish and other aquatic organisms, although systems can become episodically acidic and some sensitive species still may be lost. Critical loads of combined total sulfur and nitrogen deposition are expressed in terms of ionic charge balance as milliequivalents per square meter per year.

If pollutant exposure is less than the critical load, adverse ecological effects (e.g., reduced reproductive success, stunted growth, loss of biological diversity) are not anticipated, and recovery is expected over time if an ecosystem has been damaged by past exposure. A critical load exceedance is the measure of pollutant exposure above the critical load. This means pollutant exposure is higher than, or exceeds, the critical load and the ecosystem continues to be exposed to damaging levels of pollutants. In order to assess the extent to which regional lake and stream ecosystems are protected by the emission reductions achieved by the Clean Air Act Amendments (CAAA) so far, this case study compares the amount of deposition systems can receive—the critical load—to measured deposition for the period before implementation of the CAAA (1989 to 1991) and for a period representing the most recent data (2008 to 2010).

Overall, this critical load analysis shows that emission reductions achieved so far have resulted in improved environmental conditions and increased ecosystem protection in the eastern United States. For the period from 2008 to 2010, 30 percent of the lakes and streams examined received levels of combined sulfur and nitrogen deposition that exceeded the critical load (Figure 34). This is an improvement when compared to the 1989 to 1991 period, during which 55 percent of lakes and streams exceeded the critical load. Areas with the largest concentration of lakes where acid deposition currently is greater than—or exceeds—estimated critical loads include the southern Adirondack mountain region in New York, southern New Hampshire and Vermont, Cape Cod (Massachusetts), and along the Appalachian Mountain spine from Pennsylvania to North Carolina.

Figure 34. Lake and Stream Exceedances of Estimated Critical Loads for Total Nitrogen and Sulfur Deposition, 1989–1991 vs. 2008–2010



Source: U.S. EPA, 2011

U.S. Atmospheric Science Research

DISCOVER-AQ

Scientists from the National Aeronautics and Space Administration (NASA) and the U.S. EPA are participating in a five-year collaborative project known as "DISCOVER-AQ"—for Deriving Information on Surface Conditions from COlumn and VERTically Resolved Observations Relevant to Air Quality (<discover-aq.larc.nasa.gov>). The overall goal of the project is to improve the use of satellites to monitor air quality for public health and environmental benefit. The project includes targeted airborne and ground-based observations, which will enable more effective use of current and future satellites to diagnose ground level conditions influencing air quality.

New Version of the Community Multiscale Air Quality Model

In 2011, U.S. EPA released a new version of the Community Multiscale Air Quality Model (CMAQ) modeling system. The release of CMAQ version 5.0 introduced additional tools for studying air quality and its impacts on climate change. Taking advantage of improved computing power and recent developments in air chemistry and atmospheric science, CMAQ 5.0 combines three individual modules—meteorology, emissions, and chemical transport. Instead of running the models in sequence, as in previous versions, the meteorology and air chemistry-transport models in CMAQ 5.0 now operate together and interact in feedback loops on the fly, providing more accurate forecasts that reflect interactions between pollution and weather. With CMAQ 5.0, scientists can model air quality at the level of individual towns and cities throughout the entire northern hemisphere. The framework combines advances in physical, chemical, mathematical, and computational sciences. On a hemispheric scale, scientists apply CMAQ 5.0 to account more accurately for "background pollution" originating from distant locations. This upgrade allows policymakers to understand and use the data to balance local and national air policy standards, and integrate them with international solutions.

United States–Canada Scientific Cooperation

Air Quality Model Evaluation International Initiative

Scientists in Canada and the U.S. have been participating in an international activity called the Air Quality Model Evaluation International Initiative (AQMEII). This initiative is supported in part by Environment Canada and U.S. EPA with participation from the North American and European modeling communities. The goal of the initiative is to advance regional air quality modeling science through the development of a common model evaluation framework and joint evaluation and analysis of European (EU) and North American (NA) regional air quality models. Phase 1 of AQMEII, which ended in 2011, included annual regional air quality simulations over NA and EU for 2006 that allowed regional AQ models from NA and EU to be compared for common long-term case studies on both continents and promoted the use of different types of model evaluation, including operational, diagnostic, dynamic, and probabilistic. The key findings from AQMEII Phase 1 are summarized in a series of manuscripts that were published in a special issue of the Air and Waste Management Association's Environmental Manager (EM) magazine in July 2012. Some of the key findings from AQMEII Phase 1 included:

- Lateral boundary conditions exert a large influence on the predictions of limited area models;
- Surface wind speeds tend to be underestimated over both continents, especially during nighttime and winter and more so over EU than NA;
- For ozone, mean summertime ozone tends to be overestimated by most models over NA and underestimated by most models over EU; and
- For PM, annual average PM_{10} and $PM_{2.5}$ tend to be underestimated over both continents.

Phase 2 of AQMEII began in 2012 with the overall objective of applying and evaluating coupled meteorology-atmospheric chemistry models over EU and NA, focusing on the evaluation of regional-scale coupled models' capability to simulate interactions of air quality and climate change.

Ammonia Workshop

Ammonia science is of interest to policy-makers in both Canada and the U.S. as ammonium sulfate and ammonium nitrate are some of the major constituents of the total mass of fine PM, which has impacts on both human and environmental health. Important policy issues relating to NH_3 include the development and implementation of national primary standards for fine particles in the U.S. as well as the secondary standards for NO_X and SO_X and potential for continued PM Annex negotiations between the two countries. As ambient air quality standards become increasingly stringent and precursor emissions of gaseous precursors continue to decrease, the issue of how much impact NH_3 emission reductions will have on ambient $PM_{2.5}$ levels and attainment of ambient standards is more and more of interest.

A joint United States–Canada workshop on NH_3 science was held in October 2010 as a follow-up to a 2006 workshop. The purpose of the 2010 workshop was to review the state of NH_3 science and to discuss joint collaboration that has occurred since the previous workshop. A further objective of the workshop was to assess whether the state of knowledge was sufficient to make concrete recommendations on NH_3 emission actions and in what context; but if not, what gaps still need to be addressed. The workshop was organized around the following topics: monitoring, processes and surface exchange, emissions, and modeling. A summary of ongoing Canadian and U.S. activities relating to each of these topics was presented at the workshop, followed by discussions that led to the identification of science gaps and potential areas of collaboration. In addition, discussions during the workshop led to the following overall key conclusions:

- There is a growing body of evidence showing that NH_3 emissions are influencing PM formation and their long-range transport.
- The amount of information on what the effect of reducing NH_3 emissions would have on ambient PM is also growing.

Black Carbon Meetings

Black carbon (BC), which is a component of PM as well as a short-lived climate forcing pollutant, was endorsed by the co-chairs of the United States–Canada Air Quality Committee as an area of discussion and exploration under the purview of the Sub-Committee on Scientific and Technical Cooperation. In response, a series of conference calls was organized between decision-makers and scientists in the two countries. The first conference call was held in August 2010, focusing on the policy issues, such as the upcoming U.S. Report to Congress, as well as the work being done on BC under the United Nations Environment Programme (UNEP), the UNECE, and the Arctic Council. The U.S. Black Carbon Report to Congress was completed in March, 2012. Additional information, including the Report, can be found at <www.epa.gov/blackcarbon>. The second conference call, which was held in March 2011, was designed to facilitate the exchange of BC-related technical information, particularly in light of the growing international focus on BC.

During the second conference call in March 2011, the U.S. and Canada shared information on the development of the BC emission inventory and additional research work to refine and improve the inventories. Areas that require particular attention and where additional opportunities for collaboration may exist are in improving speciation uncertainty and comparing forest fire emissions. Forest fires are a major source of BC emissions, and these vary from year to year. There are opportunities to further exchange information on how forest fire BC emissions are estimated, how these compare to global estimates, and whether there is a significant temporal trend. The monitoring portion of the second conference call focused on the different networks in the two countries making BC measurements and the methods being used in these networks. The U.S. and Canada have been working together to resolve differences in measurements through the collocation of measurement systems at the CAPMoN site in Egbert, Ontario. However, more opportunities exist for comparing monitoring data within each country from the different networks and methods and also between the two countries. Finally, the modeling discussion during the second conference call included an overview of work in the U.S. that is focused on understanding the integrated impacts of reducing BC emissions on air quality and climate change. A point that was emphasized, particularly for decision-makers, was that some strategies to reduce emissions of BC would also reduce emissions of sulfate, which cool the atmosphere, with the overall impact of warming of the atmosphere. However, there is a lot of uncertainty in model results, particularly in how organic carbon is treated. In Canada, the primary scientific needs driving the modeling research are to better understand the role of aerosols and particles in air pollution effects and climate change. Potential areas of collaboration and further information exchange include understanding the role of particle aging and mixing on its radiative effects.

SECTION 3

New Actions on Acid Rain, Ozone, and PM

CANADA

Over the past several years the federal government has worked with provinces, territories, and other stakeholders and developed a new AQMS to further protect the environment and the health of Canadians. The new system is expected to reduce the emissions from all sources of air pollution in order to improve air quality. The federal Minister of the Environment and his provincial and territorial counterparts (with the exception of Quebec) agreed to implement the AQMS beginning in 2013. The province of Quebec supports the general objectives of the system and will collaborate with all jurisdictions to implement some of the key elements of the system. The key elements of the AQMS include:

Canadian Ambient Air Quality Standards

New ambient air quality standards for $PM_{2.5}$ and ground-level ozone will be implemented under CEPA 1999, as approved by Ministers of the Environment. The new standards are more stringent and replace the existing CWS for these two pollutants. The federal, provincial, and territorial governments have also initiated the development of the Canadian Ambient Air Quality Standards (CAAQS) for other air pollutants of concern such as sulfur dioxide and nitrogen dioxide.

Air Zone Management/ Regional Airsheds

The system includes a framework for managing air quality through local air zones which are geographic areas within each province or territory, with similar air quality issues and challenges. The framework outlines four air quality management levels with threshold values based on CAAQS that encourage progressively more rigorous actions by jurisdictions as air quality approaches or exceeds the CAAQS. Provinces or territories will lead air quality management guided by this framework and select air quality management actions tailored to each air zone. The AQMS also promotes proactive measures to protect air quality by ensuring the CAAQS are not exceeded and do not become “pollute up to” levels.

In addition to the air zones, six regional airsheds have been established to coordinate air quality management actions across the country and to better understand the transboundary flow of pollutants. The airsheds are larger areas, cutting across jurisdictional boundaries where air quality characteristics and air movement patterns are similar. They provide a framework for interjurisdictional collaboration and coordination of overall system reporting.

Base-Level Industrial Emissions Requirements

Base-Level Industrial Emissions Requirements (BLIERs) are emissions requirements established at a national level for new and existing facilities in major industrial sectors and for some cross-sectoral equipment types. These requirements are based on what leading jurisdictions inside or outside of Canada are requiring of industry in “attainment areas,” adjusted for Canadian circumstances. The AQMS also provides a venue for information sharing and collaboration among federal, provincial and territorial governments, and facilitates the coordination of efforts to reduce emissions from mobile sources across Canada.

Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity Regulations

In September 2012, Environment Canada published final regulations on the Reduction of Carbon Dioxide Emissions from Coal-Fired Generation of Electricity in the *Canada Gazette*, Part II. The regulations apply a stringent performance standard to new coal-fired electricity generation units and to coal-fired units that have reached the end of their economic life. This fosters a transition towards lower- or non-emitting types of generation such as high-efficiency natural gas, renewable energy, or fossil fuel-fired power with carbon capture and storage.

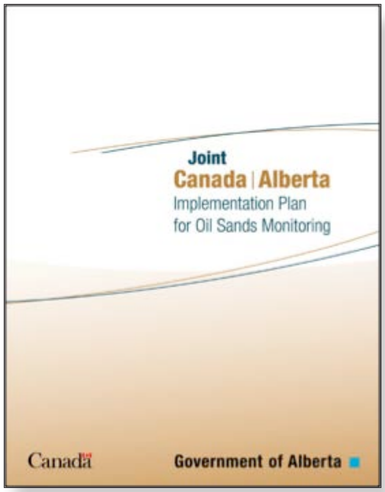
These regulations are expected to have important co benefits in reducing SO_2, NO_X, and other air pollutant emissions and improving local air quality. In 2010, coal-fired electricity generation was a significant contributor of total PM (80 percent of electric utility emissions), SO_2 (95 percent of electric utility emissions), NO_X (72 percent of electricity emissions), and Hg (95 percent of electric utility emissions).

Monitoring Downwind of Canada's Oil Sands

The oil sands deposits in western Canada are a major natural resource whose development necessitates a more comprehensive understanding of their potential cumulative environmental impact. In response to concerns on the impacts of oil sands activities and to ensure the resource is being developed in an environmentally-responsible manner, the Governments of Canada and Alberta developed a joint plan to implement a world-class monitoring program in the oil sands region.

The Joint Implementation Plan focuses on the four main component areas: air, water quantity and quality, wildlife biodiversity, and wildlife toxicology. Figure 35 shows the existing monitoring in 2011 and the monitoring proposed by year 2015.

The oil sands monitoring program will be integrated across all components and data collected from the program will add to Canada's contribution in fulfillment of its monitoring commitments under the Air Quality Agreement. The program will expand the existing monitoring networks, including better monitoring and reporting of the acid rain-causing compounds SO_2 and NO_X. It will also be able to provide additional information on deposition of acid-causing compounds in western Canada and contribute to the refining of aquatic and terrestrial critical loads downwind of the major oil sands activities. Modeling under the plan will document instances of transboundary transport of smog, including any long-range transport to the U.S.

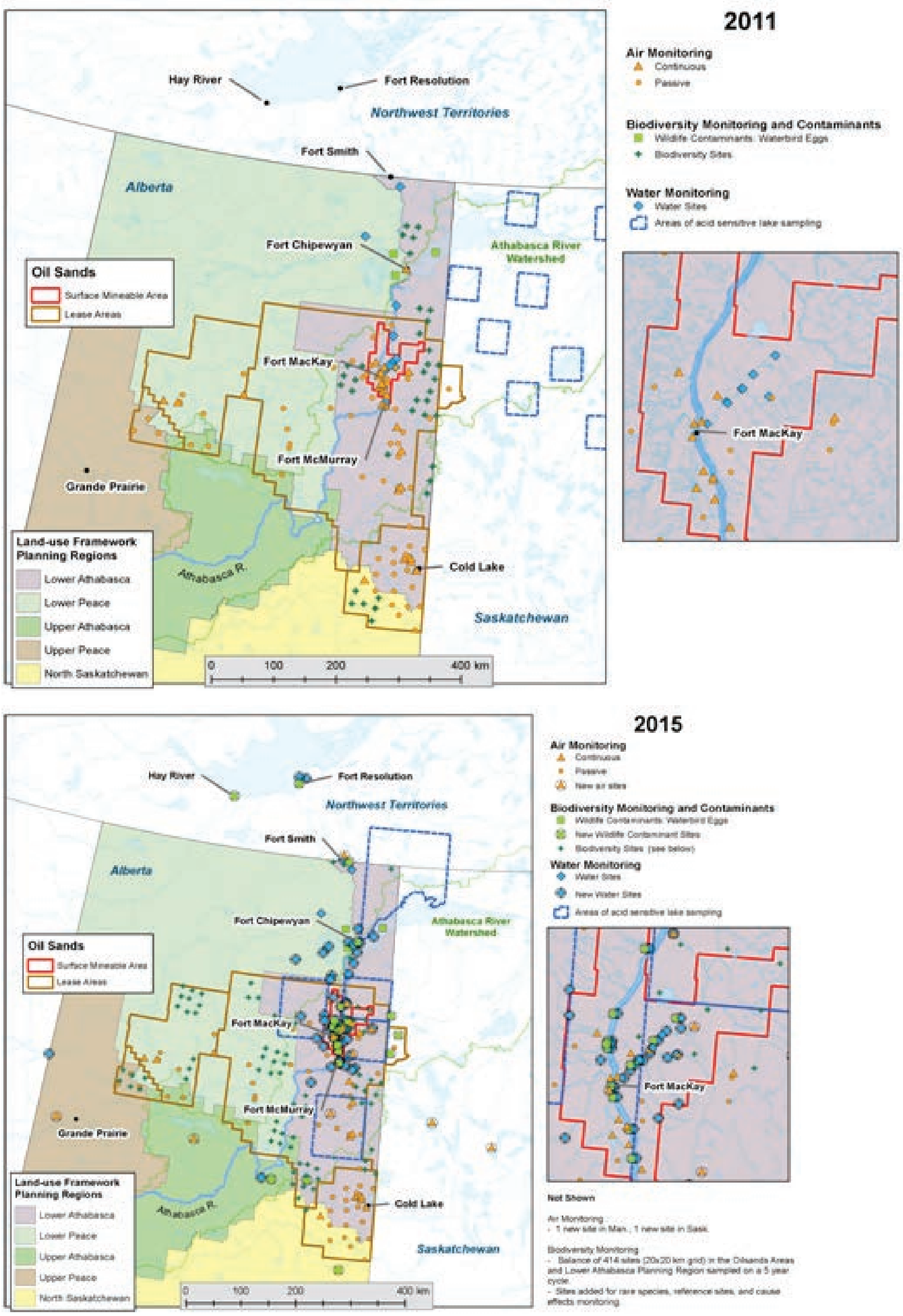


Joint
Canada | Alberta
Implementation Plan
for Oil Sands Monitoring

Canada

Government of Alberta

Figure 35. Existing Monitoring During the 2010-11 Baseline Year and Proposed Monitoring by 2015



Source: Government of Canada and Government of Alberta, 2012. Joint Canada-Alberta Implementation Plan for Oil Sands Monitoring.

UNITED STATES ★

Ozone Standards and Implementation

In March 2008, the U.S. EPA revised the NAAQS for ground-level ozone, setting them at a level of 0.075 ppm (based on the annual fourth-highest daily maximum 8-hour concentration, averaged over 3 years). Both the primary standard for the protection of health and the secondary standard for the protection of sensitive vegetation and ecosystems were set at this level. This action strengthened the standards from the previous level of 0.08 ppm (effectively 0.084 ppm) for the 1997 ozone standards. In April 2012, U.S. EPA designated 46 areas as "nonattainment" for the 2008 ozone standards. Only 3 of these areas were designated as nonattainment for the first time. States with nonattainment areas are now obligated to develop plans in 2014 to 2015 to reduce emissions as necessary to attain the standards, taking into account federal and state programs already in place that will reduce NO_X and VOC emissions across the country. Each area will have between 3 and 20 years to attain, depending on the degree to which the air quality for the area exceeds the standard. Additional information on the proposed ozone standards and other implementation issues can be found at: <www.epa.gov/air/ozonepollution/actions.html>.

Regarding ongoing implementation of the 0.08 ppm 1997 ozone standards, more than 85 percent of the 126 areas designated as nonattainment in 2005 now are attaining the standards based on 2008 to 2010 air quality. A number of national and regional measures—such as the NO_X SIP Call and CAIR for electric utilities and other large sources, more stringent requirements for car and truck engines and fuels, and issuance of new standards to reduce emissions from a wide range of sources of toxic air pollutants (and VOCs)—have helped these areas attain the standards. The U.S. EPA continues to work with the remaining areas to further reduce emissions and reach attainment.

U.S. EPA works with state, local, and Tribal governments on implementing the 1997 and 2008 ozone standards, and continues the ongoing five-year review of the updated science that supports the standards. This review is scheduled to be completed in 2014. More information on the ozone NAAQS review can be found at: <www.epa.gov/ttn/naaqs/standards/ozone/s_o3_index.html>.

PM Standards and Implementation

The U.S. EPA established the original NAAQS for $PM_{2.5}$ in 1997 to provide protection from the adverse health effects of fine particles. The primary annual $PM_{2.5}$ standard was set at a level of 15 $\mu g/m^3$ averaged over three years, and the 24-hour standard was set at a level of 65 $\mu g/m^3$ (average of the 98th percentile value for three consecutive years). The secondary standards for $PM_{2.5}$, for protection against visibility impairment, materials damage, and other environmental effects, were set at levels identical to those for the primary standards.

In April 2005, the U.S. EPA designated 39 nonattainment areas for the 1997 $PM_{2.5}$ standards. Thirty-six of these areas are in the eastern United States (including Chicago, Detroit, and Cleveland, located on the Great Lakes); two are located in California; and one area is located in northern Montana. States were required to submit SIPs to the U.S. EPA in 2008. Each plan is to include strategies and regulations for reducing emissions of $PM_{2.5}$ and its precursors, and demonstrate how the area would attain the standards "as expeditiously as practicable," presumptively within five years of designation. The U.S. EPA granted extended attainment dates up to ten years for a few areas with more severe air quality situations. The 2007 Clean Air Fine Particle Implementation Rule provided guidance to the states in developing their plans and can be found at: <www.epa.gov/pm/actions.html>.

A number of federal and regional programs have been established to reduce emissions of fine particles and important precursor pollutants from key sources such as on-road and nonroad vehicle engines and power plants. Examples include the 2000 Heavy Duty Highway Diesel Engine Rule, the 2004 Clean Air Nonroad Diesel Rule, the 2008 Locomotive and Marine Diesel Engine Rule, and voluntary diesel retrofit programs in many states. Despite legal challenges to CAIR, by 2009 U.S. power plants reduced SO_2 emissions by 4.5 million short tons (4.1 million metric tons) since 2005. Voluntary programs to change out residential wood stoves and reduce wood smoke emissions have also been successful in a number of communities. Together, these programs have led to important reductions in particle pollution in the United States. Based on 2009 to 2011 air quality data, 36 of the 39 designated nonattainment areas have air quality concentrations attaining the 1997 $PM_{2.5}$ standards.

In October 2006, the U.S. EPA completed the next review of the PM standards, reflecting findings from scientific studies published since the last review. The level of the annual $PM_{2.5}$ standard remained unchanged at 15 $\mu g/m^3$. However, the U.S. EPA established a more protective 24-hour standard at 35 $\mu g/m^3$ (average of 98th percentile values for 3 years). The secondary standards were set at levels identical to those for the primary standards. The existing 24-hour PM_{10} standard of 150 $\mu g/m^3$ was retained. However, due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the U.S. EPA revoked the annual PM_{10} standard. The revised standards and related information can be found at <www.epa.gov/ttn/naaqs/standards/pm/s_pm_cr.html>.

A number of parties challenged the 2006 PM standards on the basis that they did not strengthen the annual standard and did not establish a distinct secondary standard for the protection of visibility as recommended by the Clean Air Scientific Advisory Committee. In February 2009, a federal appellate court remanded back to U.S. EPA the 2006 annual $PM_{2.5}$ standard and the $PM_{2.5}$ secondary standard. Despite these legal challenges, U.S. EPA moved forward with implementation of the revised 24-hour $PM_{2.5}$ standard, designating 32 nonattainment areas in 2009-10. Half of these areas had been designated nonattainment for $PM_{2.5}$ in 2005, and the others were new $PM_{2.5}$ nonattainment areas. In contrast to the previous round of nonattainment designations in 2005, a number of the new areas have high concentrations primarily in the cold weather months, with key contributions from wood smoke emissions. State attainment plans for these areas are due in December 2012. Based on 2009 to 2011 air quality data, 20 of the 32 areas now attain the standard. Additional information on the 2009 area designations can be found at: <www.epa.gov/pmdesignations/2006standards>.

As part of its five-year review of the PM NAAQS and in response to the remand from the court, in June 2012 the U.S. EPA proposed revisions to the PM NAAQS, including revisions to the $PM_{2.5}$ annual standard and a distinct $PM_{2.5}$ secondary standard for visibility. After considering public comment, the Agency will finalize any revisions to the PM standards in December 2012 in accordance with the court-ordered schedule. More information on the current PM NAAQS review can be found at: <www.epa.gov/pm/actions.html#jun12>.

New Tier 3 Standards for Mobile Sources

The U.S. EPA is currently developing Tier 3 standards to respond to the critical need to improve air quality, and to enable a harmonized national vehicle emissions control program. The U.S. EPA is designing these standards to reduce emissions of ozone precursors (NO_X and VOC) and other pollutants from motor vehicles, and to help state and local areas attain and maintain the existing health-based NAAQS in a cost-effective and timely way. The standards in this rule would lead to reductions in ozone, PM, NO_2, and mobile source air toxics. The reductions in ozone and PM would avoid premature mortality and other health impacts, including respiratory symptoms in children and exacerbation of asthma. The U.S. EPA is considering more stringent vehicle emission standards as well as reductions in gasoline sulfur content as part of the Tier 3 program. The approach U.S. EPA is taking in developing Tier 3 standards considers the vehicle and its fuel as an integrated system, which would enable technologically feasible and cost-effective emission reductions beyond what would be possible looking at vehicle and fuel standards in isolation.

U.S. Proposed Carbon Pollution Standard for New Power Plants

Power plants are the largest individual sources of carbon pollution in the United States and currently there are no uniform national limits on the amount of carbon pollution that future power plants will be able to emit. Consistent with the U.S. Supreme Court's decision, in 2009, U.S. EPA determined that greenhouse gas pollution threatens Americans' health and welfare by leading to long lasting changes in our climate that can have a range of negative effects on human health and the environment.

On April 13, 2012, U.S. EPA proposed a carbon pollution standard for new power plants. The rule sets national limits on the amount of carbon pollution that new power plants can emit. U.S. EPA is proposing that new fossil-fuel-fired-power plants meet an output-based standard of 1,000 pounds (0.454 metric tons) of CO_2 per megawatt-hour (lb CO_2/MWh gross). The agency's proposal, which does not apply to plants currently operating or that commence construction after April 13, 2012, is flexible and would help minimize carbon pollution through the deployment of the same types of modern technologies and steps that power companies are already taking to build the next generation of power plants. U.S. EPA's proposal would ensure that this progress toward a cleaner, safer, and more modern power sector continues. The proposed rule called "Standards of Performance for Greenhouse Gas Emissions for New Stationary Sources: Electric Utility Generating Units" is posted at <www.epa.gov/carbonpollutionstandard>.

SECTION 4

Fourth Five-year Review and 20-year Retrospective of the United States–Canada Air Quality Agreement

Introduction

Article X, Review and Assessment of the Agreement Between the Government of Canada and the Government of the United States of America on Air Quality, requires Canada and the United States to "conduct a comprehensive review and assessment of [the] Agreement, and its implementation, during the fifth year after entry into force and every five years thereafter, unless otherwise agreed." Article X is intended to ensure that the Parties periodically review and assess the Agreement to determine whether it remains a practical and effective instrument to address shared concerns regarding transboundary air pollution. There have been three Five-Year Reviews so far: in 1996, 2002, and 2006.

This Five-Year Review coincides with the 20th anniversary of the Agreement and therefore presents a 20-year retrospective that celebrates key accomplishments, outlines important challenges, and discusses the prospects for the Air Quality Agreement going forward.

20-Year Retrospective: Accomplishments and Challenges

The U.S.-Canada Air Quality Agreement has been a model of successful bilateral cooperation that has achieved tangible improvements in the environment over its 20-year history.

Addressing Acid Rain:

Signed in 1991 to address "acid rain" or acidification that was damaging aquatic and terrestrial ecosystems in the eastern parts of the United States and Canada, the Air Quality Agreement committed the U.S. and Canada to reduce emissions of SO_2 and NO_X, the pollutants that cause acid rain.

As a result of commitments under Annex 1, achievements include:

- In the U.S., as of 2011, the national Acid Rain Program has reduced emissions of SO_2 by 71 percent from 1990 levels. Power plant emissions of NO_X have decreased by over 69 percent from 1990 to 2011 under the U.S. ARP and other regional programs.
- In Canada, as of 2010, total emissions of SO_2 have declined by 57 percent from 1990 levels, mainly due to the 74 percent reduction in emissions from the nonferrous smelting and refining industry and the 52 percent decrease from fossil fuel-fired electricity generating utilities during the same time period. Total emissions of nitrogen oxides, mainly from transportation sources and power plants, have decreased by 18 percent between 1990 and 2010.

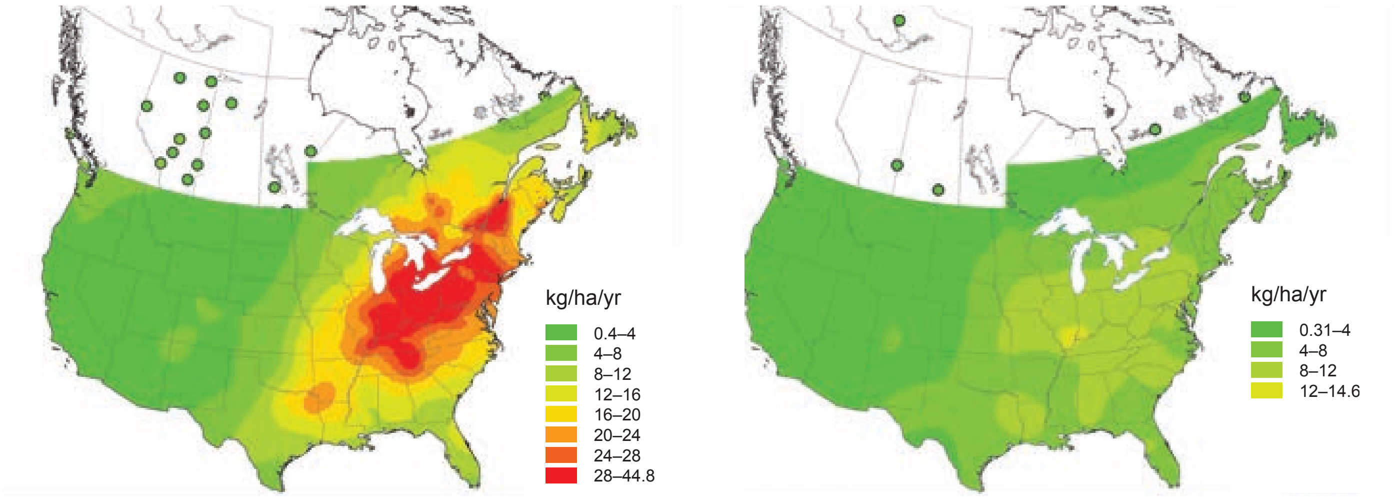
- The extent of the ecosystems damaged by acidification has decreased in response to the emission reductions since 1991 and many of the acidified lakes and streams are recovering. The maps presented in the "Acid Deposition Monitoring, Modeling, Maps, and Trends" section on page 8 and 9 of this report illustrate the large reduction in the amount of acidifying substances received by ecosystems in the 20 years since the Air Quality Agreement was signed.

Figure 36 depicts the vast change in deposition since the Agreement started in 1991.

Figure 36. Changes in Annual Wet Sulfate and Wet Nitrate Deposition, 1990–2010

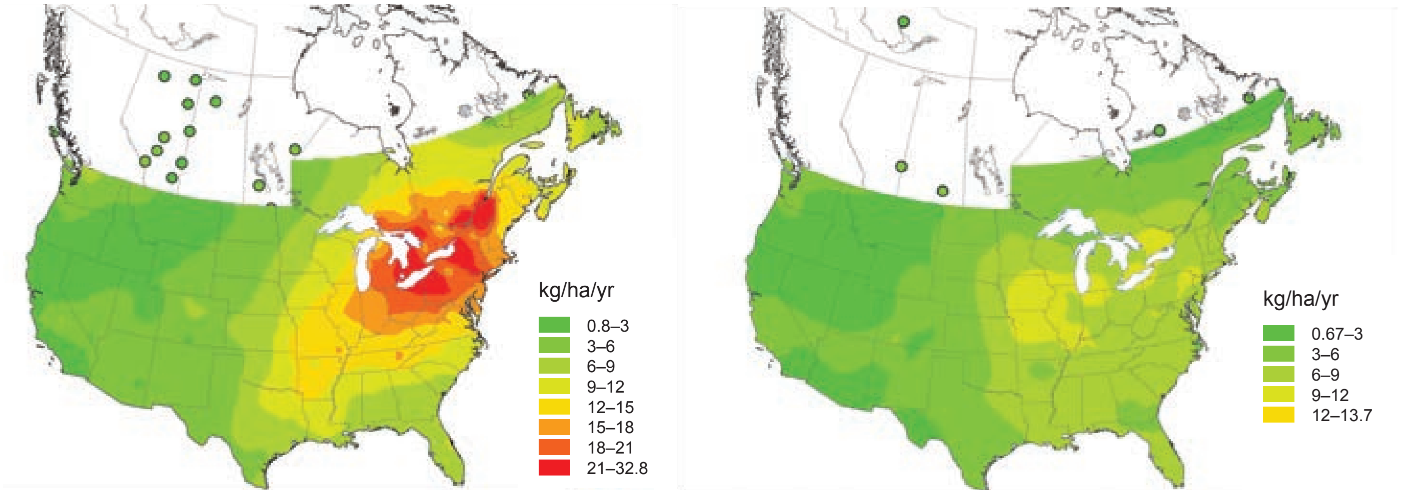
1990 Annual Wet Sulfate Deposition

2010 Annual Wet Sulfate Deposition



1990 Annual Wet Nitrate Deposition

2010 Annual Wet Nitrate Deposition



Source: NAtChem Database (<www.ec.gc.ca/natchem>) and the NADP (<nadp.isws.illinois.edu>), 2012

Addressing Ground-Level Ozone:

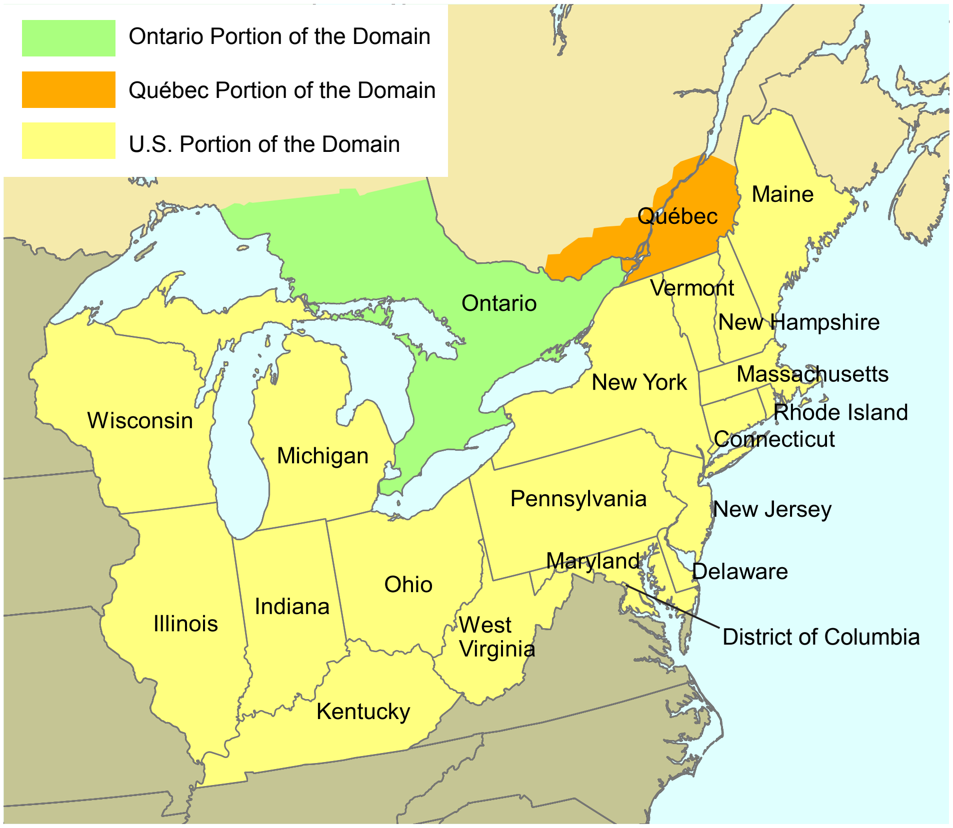
In the late 1990s, ground-level ozone, or summertime smog, was recognized as contributing to thousands of premature deaths across Canada and the U.S. each year, as well as increased hospital visits, doctor visits, and hundreds of thousands of lost days at work and school. The Ozone Annex was added to the Agreement in 2000 to address this problem and reduce transboundary ozone pollution. It calls for reductions in the emissions of NO_X and VOCs, the pollutants that cause summertime smog and affect the health of Canadians and U.S. citizens and their environments.

The Ozone Annex identifies the regions in Canada and the U.S. where decreases in emissions of NO_X and VOCs would reduce transboundary ozone pollution in the other country and it sets out emission reduction requirements within those regions. These transboundary ozone regions or PEMAs (see Figure 37) include parts of southern Quebec and southern and central Ontario in Canada and, in the U.S., 18 midwestern and eastern states, and D.C.

As a result of commitments under the Ozone Annex, achievements since 2000 include:

- Decreased emissions of NO_X and VOCs by 42 percent and 37 percent, respectively, in the U.S. PEMA.
- Reduced emissions of NO_X and VOCs by 40 percent and 30 percent, respectively, in the Canadian PEMA.
- Where ozone levels were being increased by transboundary pollution before 2000, summertime ozone levels in the air within the eastern parts of Canada and the United States have shown measurable decreases over the 1997 to 2006 period coinciding with the large reductions in emissions of NO_X and VOC in the PEMAs defined in the Ozone Annex.

Figure 37. Ozone Annex Pollutant Emission Management Area (PEMA)



Source: United-States Canada Air Quality Agreement, Ozone Annex, 2012

Tracking and Reporting Progress:

The tracking and reporting of results is an important commitment in the Air Quality Agreement. Parties meet annually under the auspices of the Air Quality Committee, the body, along with its subcommittees, responsible for overseeing, administrating, and ensuring implementation of the Agreement. It is within this committee that Canada and the U.S. report to each other on progress and activities under the Agreement. Detailed reports have been consolidated by the U.S. and Canadian governments in the 11 biennial progress reports made publicly available in the twenty years since the Agreement was signed.

The purpose of tracking, under the Agreement, is to provide an early warning system so that if, for example, ozone levels begin to increase outside of the eastern area that has been the Agreement's focus, it is documented and addressed. For this reason, ozone levels within 500 km of the entire length of the U.S.-Canada border are tracked and reported. Ozone levels change as the location of economic activity changes providing the basis for serious discussion and action under the Agreement.

Reporting can be detailed and useful for both Parties. In addition to reporting on emission reduction commitments, for example, the U.S. and Canada report on critical loads for acidification, allowing a comparison between existing deposition levels and the level of deposition that would damage an ecosystem; and on air quality standards for ozone set by the U.S. and Canadian governments so as to facilitate comparisons between the levels of ozone being reported from air quality monitors in both countries. Furthermore, the U.S. and Canada also share information on associated domestic activities as well as regional bilateral efforts such as those of the Eastern Canadian Premiers/Northeastern Governors, and border air quality projects in the Great Lakes Basin and in the Georgia Basin-Puget Sound airsheds. Much of this information is summarized for the public in the biennial progress report.

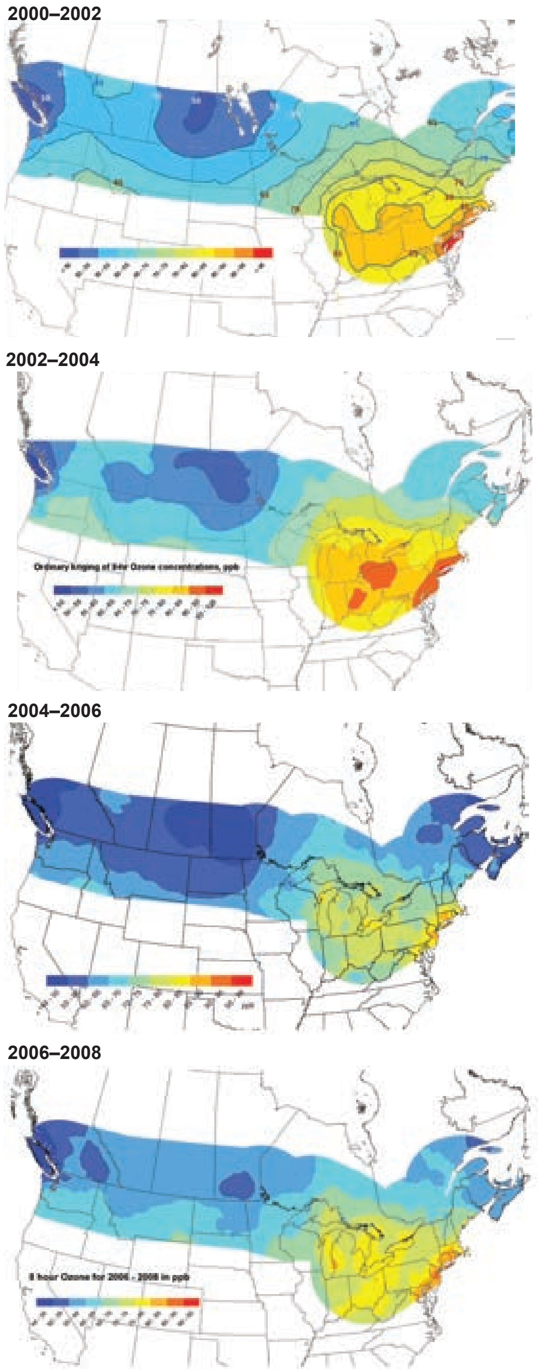
It is important to note that, according to the IJC's syntheses of public comments received in relation to the 2008 and 2010 Progress Reports (the reports produced by the Air Quality Committee since the last Five-Year Review), the public has been satisfied with the progress made by each country to reduce emissions of SO_2, NO_X, and VOCs. Further, the public comments have expressed overall support for the Agreement and its success in fostering cooperation on transboundary air pollution control, monitoring, research, and information exchange.

Figure 38 shows maps from the four Progress Reports since 2004 illustrating how ozone levels are changing across the US-Canada border area, with ozone levels decreasing significantly in the central eastern area and increasing slightly in the western area. This trend continues as evidenced in the most recently updated Ozone Concentrations map (2008 to 2010) in the body of this 2012 Progress Report (see section 1, page 32).

Reporting outcomes also effectively shows where actions by governments have not gone far enough. For instance, it is clear from deposition monitoring that the extent of the acidified ecosystems has decreased in the eastern United States and eastern Canada in response to the large SO_2 and NO_X emission reductions. The Progress Reports clarify, however, that acidification continues to be a problem in certain ecosystems in eastern states and provinces and more will need to be done if these ecosystems are to be restored to their former health. In terms of the Ozone Annex, the Parties agreed that the objective of the Annex was to help "both countries attain their respective air quality goals over time to protect human health and the environment." This agreement means that the Parties can continue to discuss actions to control transboundary ozone where ozone air quality levels that are above the standards are being affected by transboundary flows of ozone and precursor emissions. It also illustrates areas where more work could be done, for example, in reporting human health and environmental effects in response to the decreases in emissions that the Ozone Annex requires.

There have been reporting challenges that, through cooperation, have been overcome. In the 1990s, different approaches and methodologies used in each country required information and data to be provided in a parallel fashion within the Progress Reports. For instance, emissions were not counted in the same way in both countries and were therefore not easily comparable and could not

Figure 38. Ozone Concentrations along the U.S. Canada-Border, 2000–2008



Note: Data contoured are the 2000–2002, 2002–2004, 2004–2006, and 2006–2008 averages of annual fourth highest daily values, where the daily value is the highest running 8-hour average for the day. Sites used had at least 75 percent of possible daily values for these periods.

Source: Environment Canada National Air Pollution Surveillance (NAPS) Network Canada-wide Database <www.ec.gc.ca/rnspa-naps/Default.asp?lang=En&n=5C0D33CF-1)index_e.html> and EPA Aerometric Information Retrieval System (AIRS) Database <www.epa.gov/airdata>, 2012

be used in air quality modeling in both countries. The protocols for air quality monitoring and deposition monitoring were different in each country and it was not possible to demonstrate to Canadians and Americans what was happening across the transboundary region with one map.

Over the past twenty years under the Agreement, however, the dissonance that hampered bilateral performance reporting and air quality research has been smoothed by cooperation among scientists. A review of the Progress Reports since 2000 shows that, despite continuing to use different metrics, harmonized protocols and methodologies for monitoring, measurement, and modeling now create “borderless” maps, tables, and graphics.

Grounded in science, the Air Quality Agreement provides the basis for scientific cooperation and exchange.

The Air Quality Agreement was created to address acid rain at a time when scientists in the United States and Canada had divergent views of acidification. This meant that there was no common evidence on acidification to advise the U.S. and Canadian governments. Seen in the light of these scientific differences, the negotiation and signature of the Air Quality Agreement in 1991 was a significant achievement. An equally important accomplishment was the commitment that the Agreement makes to scientific and technical cooperation and information exchange, enshrined as an annex (Annex 2) to the Agreement.

This cooperative stance had borne fruit by the time of the U.S.-Canada discussions leading to the negotiation of the Ozone Annex. The implementation of the Air Quality Agreement meant that an institutional forum for scientific cooperation on transboundary air pollution had been created and scientists were able to work together to establish common statements of the facts. Under the Agreement, scientific evidence was gathered to demonstrate that ozone was flowing across the border and that it was causing damage to human health. For the first time, both Canadian and U.S. governments recognized that the scientific information they were provided through the bilateral forum was credible and could be the basis for policy recommendations.

Since then, Canada and the United States have advanced their abilities to develop scientific consensus on transboundary air pollution by establishing both common and comparable analytical techniques and atmospheric models to define air quality issues and analyze forecasts that can be the basis for advice to policy makers and government leaders.

In 2004, when the Canada–United States Transboundary Particulate Matter (PM) Science Assessment was completed, it represented the culmination of work undertaken to meet the charge of the Air Quality Committee to its Subcommittee on Scientific Cooperation to "summarize and understand the current knowledge of the transboundary transport of PM and PM precursors between Canada and the United States in a scientific assessment." The Air Quality Committee had recognized the fact that large regions of eastern Canada and the northeastern United States continued to receive acidifying emissions of SO_2 and NO_X and that these emissions also contribute to PM pollution. The Transboundary PM Science Assessment was completed by U.S. and Canadian scientists who brought their knowledge and expertise together to create a fully binational assessment. This achievement was important because it became the basis for a recommendation by the Air Quality Committee to the U.S. and Canadian governments to negotiate a PM Annex to the Air Quality Agreement to address transboundary PM and acidification. It was also important, however, because it demonstrated that what was envisaged for binational cooperation when the Agreement was signed had become a reality.

Binational science carried out at the request of the Air Quality Committee had become, in fact, the basis for the two nations cooperating toward solutions for a common transboundary air quality concern. It is expected that technical and regulatory work to support the consideration of the addition of a PM Annex to the Air Quality Agreement will continue in the coming years. This work will include the updated review and assessment of the science associated with transboundary flows of PM and its precursors which is currently underway.

The Air Quality Agreement provides a basis for cooperation on issues of common interest or concerns.

The Air Quality Agreement was created as an instrument to provide for bilateral cooperation in addition to committing to actions to reduce emissions and carry out scientific and technical exchanges. The Agreement and its administrative arm, the Air Quality Committee, have provided the basis for a number of important bilateral cooperative ventures.

The Agreement's Article V "Assessment, Notification and Mitigation" and Article XI "Consultations" were drafted to deal with one country's concern about pollution coming from a specific industrial source into the other. Under Article V, Parties are required to notify each other when a new or modified emission source is expected to have an impact on the other's air quality through transboundary movement. This up-front open disclosure facilitates cooperation on mitigation before any irritants exist.

A shared objective, a commitment to the Agreement, and a willingness to cooperate is all that is usually needed. For example, in 1998, the concern of residents of Windsor, Ontario about potential pollution from an old coal-fired power plant in Detroit, Michigan, came to the attention of Canadian members of the Air Quality Committee. The Air Quality Committee's coordination of concerned provincial and state governments and U.S. federal regulators was all that was required to address the problem.

In fact, to ensure that any future concerns about specific industrial sources could be handled without confrontation and in a spirit of cooperation, as had been the case with the Detroit power plant, Guidelines for Implementing the Consultation Process under Article XI of the United States-Canada Air Quality Agreement were proposed and approved by the Air Quality Committee at its 1998 Annual Meeting. The Guidelines lay out practical steps on how the two countries could consult informally when one country has concerns about a source of pollution in the other. These guidelines became the basis for discussions that occurred to address pollution crossing the border into North Dakota from the SaskPower Boundary Dam Power Plant in Estevan, Saskatchewan, and also in relation to the Essar Steel Algoma, Inc. facility in Sault Ste. Marie, Ontario. Both of these informal consultations included discussions of abatement programs at the source of the pollution and transboundary air quality monitoring networks with monitors supplied by U.S. and Canadian governments and, in the case of SaskPower, by the power plant. Reporting back to the concerned citizens on the results from the air quality monitors was a key feature of the informal consultations.

The informal consultation related to the SaskPower facility was successfully terminated when SaskPower installed emission abatement technology and the monitoring in Saskatchewan and North Dakota showed that no air quality standards were being exceeded. The discussions around the Essar Steel Algoma, Inc. facility continue but are likely to be concluded in the next year.

Three Border Air Quality Strategy projects offer additional examples of how the Agreement has provided the basis for cooperation that has advanced the transboundary air quality dialogue in flexible and innovative ways. Between 2003 and 2006, two airshed projects — the Georgia Basin-Puget Sound International Airshed Strategy and the Great Lakes Basin Airshed Management Framework — became important sources of practical on-the-ground cooperation. They each focused on assessing air quality issues and programs in those border regions. Another substantial aspect of these two Border Air Quality projects was the research programs carried out between 2003 and 2007 to characterize air pollution exposure and human health issues under the Canadian portion of the Border Air Quality Strategy coordinated with research in the U.S. The results of this research has added significantly to the scientific understanding of the health effects of ozone exposure and assisted in defining how to communicate to people the risks they face from air pollution.

A third study under the Strategy analyzed the feasibility of a cross-border SO_2 and NO_X emission cap and trading program. The Air Quality Agreement had identified in 1991 that market-based mechanisms should be a topic for information exchange. In 2003 to 2005, the Canada-United States Emissions Cap and Trading Feasibility Study was undertaken. The study analyzed the complex issue of emission caps and trading to achieve acid rain and air quality goals using teams of experts in air quality, economic and atmospheric modeling, governance, and law.

The Agreement in the Next 20 Years

Should the Air Quality Agreement Progress Reports be streamlined?

Public comments to the IJC since 1992 in relation to the biennial Progress Reports strongly support the overall scope and nature of the Progress Reports and the valuable information that the Progress Reports are uniquely positioned to provide. Streamlining reporting to take full advantage of the way information can be communicated in the 21st century may, however, be worth considering especially if new methods of reporting can take advantage of communication opportunities offered by digital media.

Should the Air Quality Agreement expand its scope to address new issues and new regions within the U.S.–Canada border area?

The Agreement currently addresses U.S.–Canada acidification and ground-level ozone and is discussing how to address transboundary PM. In 1996, the Air Quality Committee decided that the Agreement should not be used to address persistent toxic pollution (e.g., mercury, PCBs, dioxin) on the basis that, firstly, these pollutants travel long distances in the atmosphere and cross all borders, with the vast majority of emissions globally coming from outside of North America. Secondly, other more suitable international instruments, such as the Stockholm Convention that addresses persistent organic pollutants globally and negotiations under the UNEP to address mercury globally, preclude the need for a bilateral instrument.

In terms of possible future expansion of the Agreement, the Perimeter Security and Economic Competitiveness Regulatory Cooperation Council (RCC), in its 2011 Joint Action Plan for the Canada–United States Regulatory Cooperation Council, stated that “there are significant health and environmental benefits to expanding the [Air Quality] Agreement, with a focus on reducing particulate matter.“ The RCC called for Environment Canada, the U.S. State Department, and the U.S. EPA to consider an expansion of the U.S.–Canada Air Quality Agreement to address PM based on comparable regulatory regimes in the two countries. An expansion of this kind is grounded in the science being updated under the Agreement on transboundary PM. It also complements the work both Canada and the U.S. are doing within the UNECE Long-range Transboundary Air Pollution (LRTAP) Convention where efforts are underway to address long-range transboundary PM and the related issue of black carbon, recognizing the synergies with health, climate change, and biodiversity in North America and the Northern Hemisphere.

The Air Quality Agreement could also focus, in the future, on transboundary air quality issues in the western border area if scientific evidence demonstrates that there are transboundary air issues of concern and clarifies that cooperation would benefit the health and welfare of Canadians and U.S. citizens and their environments. For instance, although it is clear that emission reductions completed on acid rain and ozone under the Air Quality Agreement have already resulted in significant PM emission reductions, the 2004 Transboundary PM Science Assessment demonstrates that in some western provinces and states, PM levels are increasing and the related issue of visibility is degrading as economic activity grows in the energy sector.

The lower mainland of British Columbia has viewed visibility as an instrument for air quality management in part due to the fact that the Canadian air quality standards for PM and ozone have been insufficiently stringent to drive air quality management in that area. The issue of visibility may provide an opportunity under a possible future PM Annex to address transboundary air quality in the western border region of Canada and the U.S., especially if more visibility monitoring is in place to assess changes or if background levels of ambient air are monitored to assess improvements in the region. To date, however, unlike in the U.S., visibility, while arguably an interesting indicator, may not have relevance at a national level. Canada continues to study the issue and its possibilities.

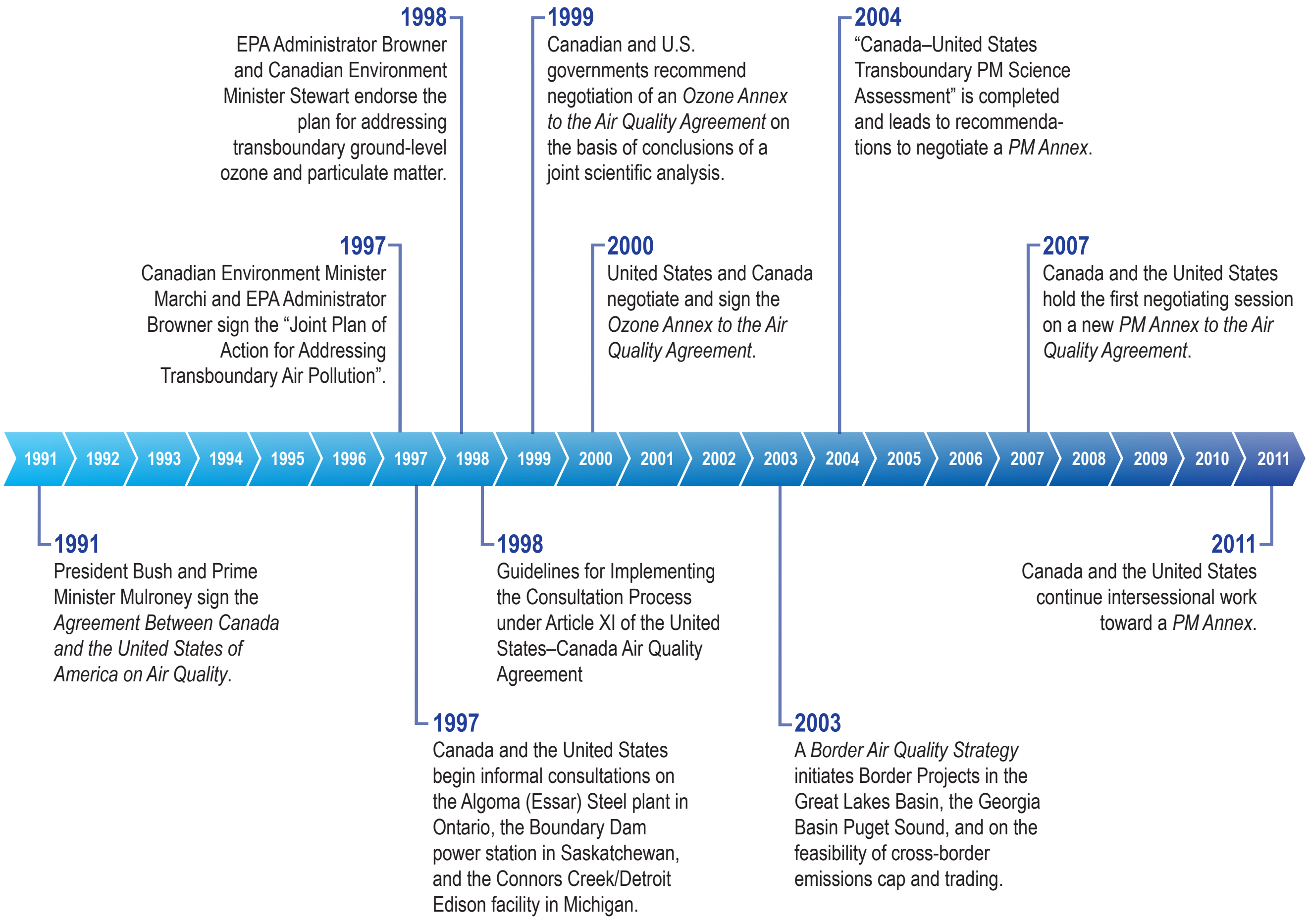
In the north along the U.S.–Canada border (Alaska, Yukon, and Northwest Territories), the Air Quality Agreement could provide the basis for bilateral scientific and technical exchanges and an opportunity to cooperate if development on either side of the border generates concerns. For instance, the Notification provision under the Agreement could be strengthened in a renegotiated Agreement to provide the basis for practical exchanges of information among governments in the North when governments are processing permits for new development that could become potential sources of transboundary pollution. The plans for opening the Arctic region to greater shipping, significant energy extraction, and mining activities are cause for discussion on potentially increased bilateral notification and cooperation.

The Air Quality Agreement will be most effective in the coming years if it continues to concentrate on what it does best, i.e., addressing transboundary air pollution issues of concern through a “made in United States–Canada” vision that is built on the unique nature of the bilateral relationship and takes account of the inherent complexities of national economies and styles of governance that differ in so many ways. At the same time, work under the Agreement should continue to develop and enhance relationships between experts in the U.S. and Canadian governments to ensure that the differences in air quality goals and objectives, governance, program administration, and implementation are the basis for enhancing each others’ points of view rather than hindering cooperation.

Conclusion

In the past 20 years, the Agreement between the Government of Canada and the Government of the United States of America on Air Quality has proven that it is possible to design and implement a bilateral accord in which commitments or obligations recognize and allow for different approaches taken by the Parties in the effort to reduce air pollution. The Agreement required significant changes from major industries with associated costs. It took great political will on the part of both countries at the highest levels; produced dramatic results with huge benefits for human health and the environment; and created a structure that allowed for subsequent agreement (e.g., Ozone Annex) and more dramatic results.

The success of the Agreement over the last 20 years rests on two things: supportive, cooperative, and committed working relationships; and an environment of mutual trust. For the next 20 years to be as successful as the first, these two winning conditions must continue to underpin the implementation of the Air Quality Agreement.



1991
President Bush and Prime Minister Mulroney sign the *Agreement Between Canada and the United States of America on Air Quality*.

1997
Canadian Environment Minister Marchi and EPA Administrator Browner sign the "Joint Plan of Action for Addressing Transboundary Air Pollution".

1997
Canada and the United States begin informal consultations on the Algoma (Essar) Steel plant in Ontario, the Boundary Dam power station in Saskatchewan, and the Connors Creek/Detroit Edison facility in Michigan.

1998
EPA Administrator Browner and Canadian Environment Minister Stewart endorse the plan for addressing transboundary ground-level ozone and particulate matter.

1998
Guidelines for Implementing the Consultation Process under Article XI of the United States–Canada Air Quality Agreement

1999
Canadian and U.S. governments recommend negotiation of an *Ozone Annex to the Air Quality Agreement* on the basis of conclusions of a joint scientific analysis.

2000
United States and Canada negotiate and sign the *Ozone Annex to the Air Quality Agreement*.

2003
A *Border Air Quality Strategy* initiates Border Projects in the Great Lakes Basin, the Georgia Basin Puget Sound, and on the feasibility of cross-border emissions cap and trading.

2004
"Canada–United States Transboundary PM Science Assessment" is completed and leads to recommendations to negotiate a *PM Annex*.

2007
Canada and the United States hold the first negotiating session on a new *PM Annex to the Air Quality Agreement*.

2011
Canada and the United States continue intersessional work toward a *PM Annex*.

APPENDIX A

Canada– United States Air Quality Committee

UNITED STATES MEMBERS ★

United States Co-Chair:

Daniel Reifsnyder
Deputy Assistant Secretary for Environment and Sustainable Development
U.S. Department of State

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U.S. Forest Service
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Richard Artz
Air Resources Laboratory
National Oceanic and Atmospheric Administration

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Christopher Grundler
Office of Transportation and Air Quality
U.S. Environmental Protection Agency

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Air Quality Division
Michigan Department of Environmental Quality

Carol McCoy
Air Resources Division
National Park Service

Stephen Page
Office of Air Quality and Planning Standards
U.S. Environmental Protection Agency

David Shaw
Division of Air Resources
New York State Department of Environmental Conservation

George Sibley
Office of Environmental Quality and Transboundary Issues
U.S. Department of State

Subcommittee on Program Monitoring and Reporting Co-Chair:

Sarah Dunham
Director, Office of Atmospheric Programs
U.S. Environmental Protection Agency

Subcommittee on Scientific Cooperation Co-Chair:

Timothy H. Watkins
Deputy Director
Human Exposure and Atmospheric Sciences Division
Office of Research and Development, U.S. Environmental Protection Agency

CANADIAN MEMBERS

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Mike Beale
Associate Assistant Deputy Minister
Environmental Stewardship Branch
Environment Canada

Members:

Neal Burnham
U.S. Transboundary Affairs Division
Foreign Affairs and International Trade Canada

Daniel Champagne
Direction des politiques de la qualité de l'atmosphère
Ministère du Développement durable, Environnement, Faune et Parcs du Québec

Lawrence Cheng
Policy Evaluation
Air Policy Section
Alberta Environment and Water

John Cooper
Water, Air and Climate Change Bureau
Safe Environments Directorate
Health Canada

David Henry
Energy and Environment Policy Division
Energy Policy Branch
Natural Resources Canada

Mollie Johnson
Americas Directorate
International Affairs Branch
Environment Canada

Tim Karlsson
Emerging Technologies Directorate
Manufacturing and Life Sciences Branch
Industry Canada

Pierre Marin
Environmental Policy
Transport Canada

Kimberly MacNeil
Environmental Science and Program Management Division
Nova Scotia Department of the Environment

Louise Métivier
Industrial Sectors Directorate
Environmental Stewardship Branch
Environment Canada

Glen Okrainetz
Environmental Standards Branch
British Columbia Ministry of the Environment

Adam Redish
Air, Policy and Climate Change Branch
Ontario Ministry of the Environment

Subcommittee on Program Monitoring and Reporting Co-Chair:

Louise Métivier
Director General
Industrial Sectors Directorate
Environmental Stewardship Branch
Environment Canada

Subcommittee on Scientific Cooperation Co-Chair:

Dr. Véronique Bouchet
Manager, Modelling and Integration Research Section
Science and Technology Branch
Environment Canada

Appendix B

List of Acronyms

AIRMoN	Atmospheric Integrated Research Monitoring Network
AMoN	Ammonia Monitoring Network
ANC	acid-neutralizing capacity
ARP	Acid Rain Program
AQA	Air Quality Agreement
AQBAT	Air Quality Benefits Assessment Tool
AQHI	Canadian Air Quality Health Index
AQI	Air Quality Index
AQMEII	Air Quality Model Evaluation International Initiative
AQMS	Air Quality Management System
AQS	(EPA) Air Quality System
AURAMS	A Unified Regional Air quality Modelling System
BACT	best available control technology
BART	best available retrofit technology
BC	black carbon
BCVCC	British Columbia Visibility Coordinating Committee
Bc:Al	base cation to aluminum ratios
BLIERs	Base-Level Industrial Emissions Requirements
Ca^{2+}	calcium ions
CAA	Clean Air Act
CAAA	Clean Air Act Amendments
CAAQS	Canadian Ambient Air Quality Standards
CAIR	Clean Air Interstate Rule
CAPMoN	Canadian Air and Precipitation Monitoring Network
CASTNET	Clean Air Status and Trends Network
CDDs	chlorinated dibenzo-p-dioxins
CDFs	furans
CCME	Canadian Council of Ministers of the Environment
CEMS	continuous emission monitoring system
CEPA 1999	Canadian Environmental Protection Act, 1999
CI	continuous improvement
Cl^-	chlorine
CMAQ	Community Multiscale Air Quality Model
CO	carbon monoxide
CO_2	carbon dioxide
CSAPR	Cross-State Air Pollution Rule
CSN	$PM_{2.5}$ Chemical Speciation Network
CWS	Canada-wide Standards
D.C.	District of Columbia
DISCOVER-AQ	Deriving Information on Surface Conditions from Column and Vertically Resolved Observations Relevant to Air Quality
DOC	dissolved organic carbon
E3MC	economy forecast model
ECA	Emission Control Area
EGU	electric generating unit
EM	Environmental Manager (magazine)

EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency
ER	emergency room
ESAI	Essar Steel Algoma Inc.
EU	European Union
FEM	Federal Equivalent Method
FIPs	Federal Implementation Plans
GEM	gaseous elemental mercury
GHG	greenhouse gas
GOM	gaseous oxidized mercury
GPMP	Gaseous Pollutant Monitoring Program
H^+	hydrogen ion
HAP	hazardous air pollutant
Hg	mercury
hp	horsepower
IADN	Integrated Atmospheric Deposition Network
ICP	International Cooperative Programme
IJC	International Joint Commission
IMPROVE	Interagency Monitoring of Protected Visual Environments
ISA	Integrated Science Assessment
K^+	potassium ion
KCAC	Keeping Clean Areas Clean
kg/ha/yr	kilograms per hectare per year
km	kilometer
kt	kiloton (thousand metric tons)
kW	kilowatts
LAER	lowest achievable emission rate
LFV	Lower Fraser Valley
LRTAP	Long-range Transboundary Air Pollution
LTM	Long-Term Monitoring
MESA Air	Multi-Ethnic Study of Atherosclerosis and Air Pollution

Mg^{2+}	magnesium ion
mg/kg	milligrams per kilogram
MOE	Ministry of the Environment (Ontario)
$\mu g/m^3$	micrograms per cubic meter
MW	megawatt
Na^+	sodium ion
NA	North America
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NATTS	National Air Toxics Trends Station
NADP	National Atmospheric Deposition Program
NAPS	National Air Pollution Surveillance (Network)
NAtChem	National Atmospheric Chemistry Database
NBP	NOx Budget Trading Program
NCore	National Core Monitoring Network
NEI	National Emissions Inventory
NH_3	ammonia
NH_4^+	ammonium
NHTSA	National Highway Traffic Safety Administration
HNO_3	nitric acid
NO	nitrogen monoxide
NOAA	National Oceanic and Atmospheric Administration
NO_2	nitrogen dioxide
NO_3^-	nitrate
NO_X	nitrogen oxides
NPRI	National Pollutant Release Inventory
NPS	National Park Service
NSPS	New Source Performance Standards
NSR	New Source Review
NTN	National Trends Network

OBD	on-board diagnostic
O_3	ground-level ozone
OTC	Ozone Transport Commission
PAH	polycyclic aromatic hydrocarbon
PAMS	Photochemical Assessment Monitoring Stations
Pb	lead
PBM	particulate bound mercury
PCB	polychlorinated biphenyl
PEMA	Pollutant Emission Management Area
PERC	tetrachloroethylene
pH	measure of the activity of the solvated hydrogen ion
PM	particulate matter
$PM_{2.5}$	particulate matter less than or equal to 2.5 microns
PM_{10}	particulate matter less than or equal to 10 microns
ppb	parts per billion
ppm	parts per million
PSD	Prevention of Significant Deterioration
RCC	Regulatory Cooperation Council
REA	Risk and Exposure Assessment
SI	spark-ignition
SIP	State Implementation Plan
SLAMS	State and Local Air Monitoring Stations
SO_2	sulfur dioxide
SO_4^{2-}	sulfate
TCE	trichloroethylene
TIME	Temporally Integrated Monitoring of Ecosystems
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
U.S.	United States
VOC	volatile organic compound

To obtain additional information, please contact:

In Canada:
Air Emissions Priorities
Environment Canada
351 St. Joseph Blvd.
12th Floor, Place Vincent Massey
Gatineau, Quebec K1A 0H3

In United States:
Clean Air Markets Division
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, NW (6204J)
Washington, DC 20460

Environment Canada's website:
<www.ec.gc.ca/Air/default.asp?lang=En&n=83930AC3-1>

U.S. Environmental Protection Agency's website:
<www.epa.gov/airmarkets/progsregs/usca/index.htm>