

United States • Canada
Air Quality Agreement

PROGRESS REPORT 2008

The International Joint Commission Requests Your Comments on This Report

The International Joint Commission (IJC) is responsible for inviting comment on the Air Quality Agreement (AQA) Progress Report and providing a synthesis of the comments to governments to assist them in implementing the agreement. The Air Quality Committee will have the benefit of this synthesis as it implements the agreement and prepares the next progress report. Comments on any aspect of the agreement are appreciated. More information about the IJC and its comment process can be found at <www.ijc.org>.

Written comments on this report should be sent by Friday, April 24, 2009, to:

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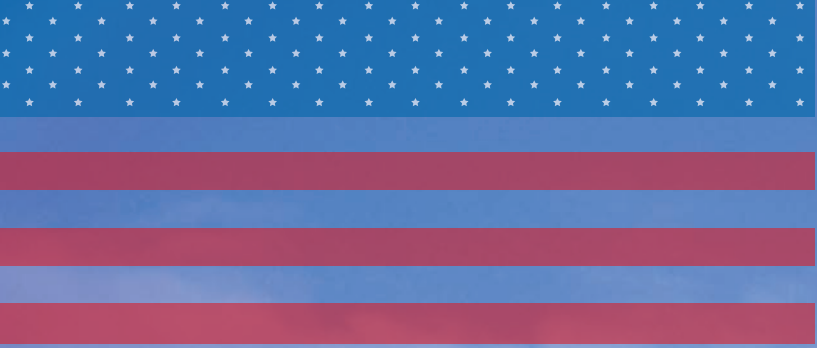
Introduction

In 1991, the United States and Canada committed to reduce the impact of transboundary air pollution through the United States–Canada Air Quality Agreement (AQA). The Acid Rain Annex, negotiated with the original 1991 agreement, established specific objectives related to reducing the emissions of acid rain precursors sulfur dioxide (SO₂) and nitrogen oxides (NO_x). In 2000, the United States and Canada negotiated an Ozone Annex to the Agreement. This annex established commitments related to the reduction of NO_x and volatile organic compounds (VOCs), ozone-forming air pollutants. Currently, negotiations are underway between the United States and Canada to develop an annex that addresses particulate matter (PM).

This 2008 Progress Report, prepared by the bilateral Air Quality Committee, is the ninth biennial report completed under the 1991 United States–Canada AQA. The report discusses 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. Specifically, the report highlights progress made toward meeting the commitments established in the acid rain and ozone annexes of 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 2006 Progress Report. The IJC received 24 comments, more than half of which came from state, provincial, or regional governments representing millions of people. A synthesis of the comments can be found on the IJC Web site at <www.ijc.org/php/publications/pdf/ID1606.pdf>. Almost all of the comments expressed strong support for the agreement and its success in fostering cooperation on transboundary air pollution control, monitoring, research, and information exchange. Additionally, the majority of the comments expressed satisfaction with the progress made by each country toward SO₂, NO_x, and VOC reductions.





SECTION 1:


Commitments

Acid Rain Annex

Overview

The Acid Rain Annex to the 1991 Air Quality Agreement (AQA) established commitments for both countries to reduce emissions of the primary precursors to acid rain, sulfur dioxide (SO₂) and nitrogen oxides (NO_x). The commitments include prevention of air quality deterioration, visibility protection, and continuous emission monitoring. Both countries have been successful in significantly reducing the impact of acid rain on each side of the border. Despite these achievements, studies in each country indicate that although some damaged ecosystems are showing signs of recovery, further efforts are necessary to restore these ecosystems to their pre-acidified conditions.

Key Commitments and Progress: Sulfur Dioxide Emission Reductions

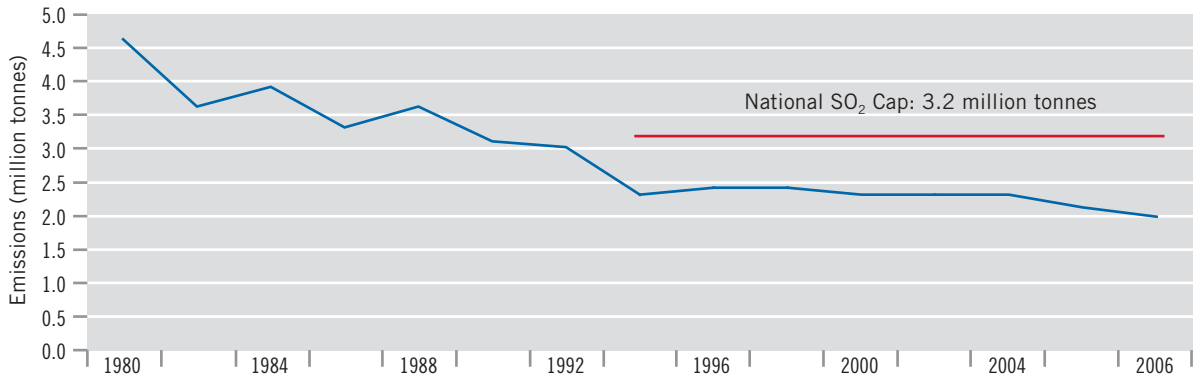

CANADA Canada has been successful in reducing emissions of SO₂, a principal cause of acid rain. In 2006, Canada's total SO₂ emissions were 2 million tonnes, or about 38 percent below the national cap of 3.2 million tonnes.¹ This represents more than a 55-percent reduction from Canada's total SO₂ emissions in 1980 and a

35-percent decrease from the 1990 emission level (see Figure 1). This overall reduction in national SO₂ emission levels can be attributed to the SO₂ emission reductions undertaken as part of the eastern Canada Acid Rain Program. SO₂ emissions in the seven easternmost provinces were 1.4 million tonnes in 2005, or nearly 40 percent below the (now expired) eastern Canada cap of 2.3 million tonnes.

¹ One tonne is equal to 1.1 short tons.



Figure 1. Canadian SO₂ Emissions from Acid Rain Sources, 1980–2006



Source: Environment Canada, 2008

The largest source of SO₂ emissions in Canada continues to be the base metals smelting sector, which accounted for more than 30 percent of national SO₂ emissions in 2006, despite a greater than 50-percent decrease in SO₂ emissions from this sector since 1990.

Canada is committed to further reducing acidifying emissions through the more recent Canada-wide Acid Rain Strategy for Post-2000. This strategy serves as a framework for addressing the country's acid rain problem. The long-term goal of the strategy is to achieve critical loads for acid deposition for aquatic and terrestrial ecosystems. A critical load is the maximum amount of acidifying deposition an ecosystem can tolerate in the long term without being damaged. As part of the Strategy, the provinces of New Brunswick, Nova Scotia, Quebec, and Ontario

set new, stricter SO₂ emission reduction targets that are 50 percent below their 1985 eastern Canada Acid Rain Program targets, to be achieved by 2010 (2015 for Ontario). Provincial measures planned to meet the stricter SO₂ targets include setting caps on emissions from power generating stations, refurbishing industrial and power generating sources with pollution control equipment, and reducing the sulfur content of fuels. All provinces are well on their way to meeting their new SO₂ targets.

Despite these efforts, the control of acidifying emissions has not occurred to the extent necessary to reduce acid deposition below critical loads and ensure the recovery of aquatic and terrestrial ecosystems.



The United States succeeded in meeting its commitment to reduce annual SO₂ emissions by 10 million tons from 1980 levels by 2000. Additionally, in 2007, emissions of SO₂ from the electric power sector in the United

States fell below the 2010 national emission cap of 8.95 million tons for the first time, achieving the U.S. commitment three years early.

Most of the reductions in SO₂ emissions in the United States are due to the Acid Rain Program (ARP) established under Title IV of the 1990 Clean Air Act

Amendments. The ARP requires major reductions of SO₂ and NO_x emissions from the electric power sector, the highest SO₂ emitting sector. Under the ARP, the SO₂ program set a permanent cap on the total amount of SO₂ that may be emitted by electric generation units in the contiguous United States starting in 1995. The reductions are phased in over time, with the final 2010 SO₂ cap set at 8.95 million tons.

To achieve SO₂ emission reductions, the ARP uses a market-based cap and trade program that allows flexibility for individual combustion units to select their own method of compliance. The number of SO₂



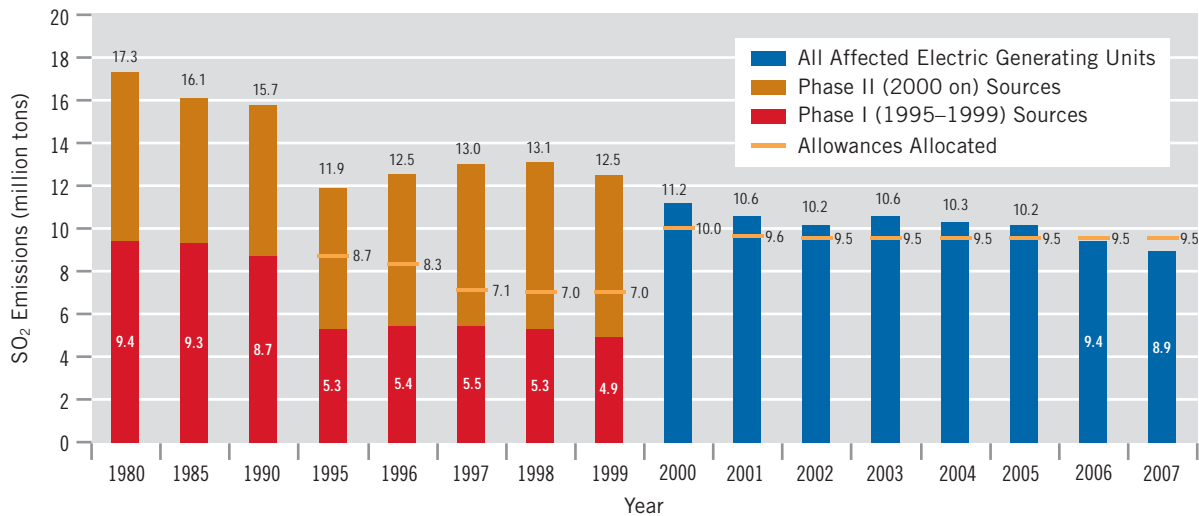
allowances allocated in a given year to a particular unit is determined by Clean Air Act provisions, and the total allowances allocated each year must not exceed the national cap. Every year, each individual source must hold enough allowances to cover its annual emissions. Unused allowances can be sold (traded) or banked (saved) for future use. Banking allowances gives sources the flexibility to determine how they will comply with program requirements over time.

In 2007, the ARP's SO₂ program affected 3,536 electric generating units (EGUs). The U.S. Environmental Protection Agency (EPA) allocated more than 9.5 million SO₂ allowances under the ARP. Actual emissions from affected sources were 8.94 million tons of SO₂ (see Figure 2), down from

9.4 million tons in 2006 and below the 2010 cap of 8.95 million tons. Additionally in 2007, the number of banked allowances grew, from about 6.3 million available for 2007 compliance to approximately 6.7 million available for 2008 and future years.

In addition to the electric power generation sector, emission reductions from other sources not affected by the ARP—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 of annual SO₂ emissions. National SO₂ emissions from all sources have fallen from nearly 26 million tons in 1980 to less than 13 million tons in 2007 (see <www.epa.gov/ttn/chief/trends>).

Figure 2. U.S. SO₂ Emissions from Acid Rain Program Electric Generating Units, 1980–2007



Source: EPA, 2008

Key Commitments and Progress: Nitrogen Oxides Emission Reductions



Canada has surpassed its NO_x emission reduction target at power plants, major combustion sources, and metal smelting operations by 100,000 tonnes below the forecasted level of 970,000 tonnes.

This commitment is based on a 1985 forecast of 2005 NO_x emissions; in 2006, industrial emissions of NO_x totaled 765,480 tonnes. The country is continuing to develop programs to further reduce NO_x emissions nationwide.

Transportation sources contribute the majority of NO_x emissions, accounting for just over half (52 percent) of total Canadian emissions, with the remainder generated by power plants and other sources (see Figure 28: U.S. and Canadian National Emissions by Sector for Selected Pollutants, 2006 on page 40). Additional information on Canadian emissions can be found at <www.ec.gc.ca/pdb/cac/Emissions1990-2015/emissions_e.cfm>. The Canadian government recently passed stringent standards for NO_x emissions from on-road and off-road sources effective from 2004 to 2009.



The United States has achieved and exceeded its goal under the Acid Rain Annex to reduce total annual NO_x emissions by 2 million tons below projected annual emission levels for 2000 without the ARP (8.1 million tons).

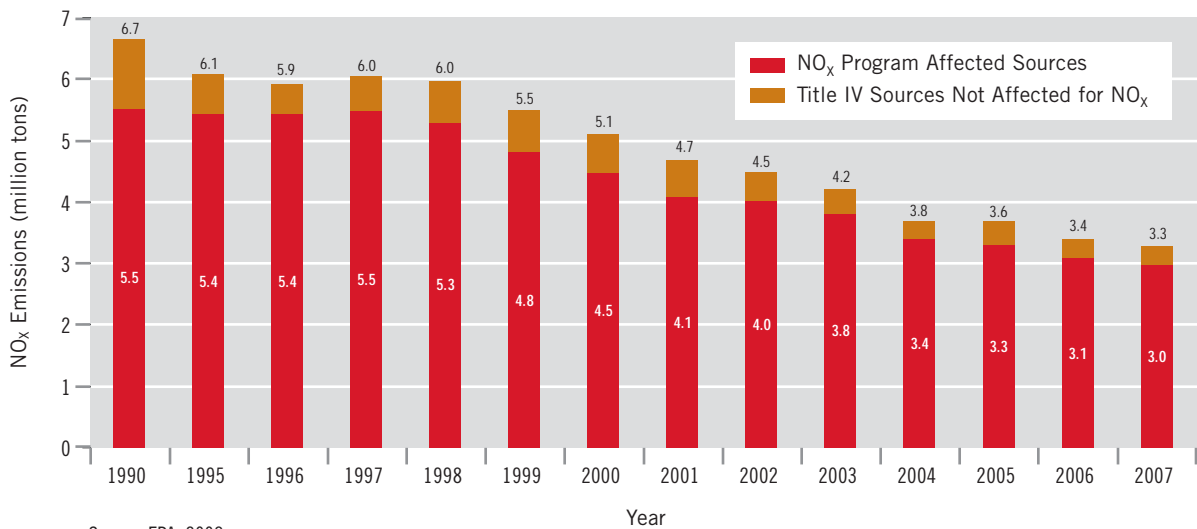
Title IV of the Clean Air Act requires NO_x emission reductions from certain coal-fired EGUs. Unlike the market-based SO₂ program, the NO_x program under the ARP uses rate-based emission limits based on boiler type to achieve reductions.

In 2007, 978 coal-fired units were affected by the NO_x program. Of those units, all 978 met their NO_x emission requirements under the ARP. Emissions

of NO_x from all NO_x program-affected units were 3 million tons, and total NO_x emissions from all sources covered by the ARP were 3.3 million tons (Figure 3). This level is 4.8 million tons less than the projected NO_x levels for 2000 without the ARP, or more than double the NO_x emission reduction goal under the Acid Rain Annex.

While the ARP is responsible for a large portion of these annual NO_x reductions, other programs—such as the Ozone Transport Commission, the NO_x Budget Trading Program (NBP) under EPA’s NO_x State Implementation Plan (SIP) Call, and state NO_x emission control programs—also contributed significantly to the NO_x reductions that sources achieved in 2007.

Figure 3. U.S. Title IV Utility Unit NO_x Emissions, 1990–2007



Source: EPA, 2008

Emissions/Compliance Monitoring



CANADA

Canada has met its commitments to estimate emissions of NO_x and SO₂ from new electric utility units and existing electricity units greater than 25 megawatts (MW) using a method comparable in effectiveness to

continuous emission monitoring systems (CEMS), and to investigate the feasibility of using CEMS by 1995. Continuous emissions monitoring installation in Canada’s electric utility sector has been widespread since the late 1990s. In 2008, almost all new and

existing base-loaded fossil steam plants with high emission rates have operating CEMS. Coal-fired facilities, which are the largest source of emissions from the sector, have SO₂ and NO_x CEMS installed at more than 94 percent of their total capacity.

Under Canada’s Regulatory Framework for Air Emissions, unveiled in April 2007, the government indicated its support for requiring maximum use of continuous emission monitoring technology to ensure effective compliance and enforcement. Details on



the regulatory framework can be found in the New Actions on Acid Rain, Ozone, and Particulate Matter section on page 33 of this report.

Under Canada's National Pollutant Release Inventory (NPRI) mandatory reporting program, electric power generating facilities are required to report their air pollutant emissions annually.



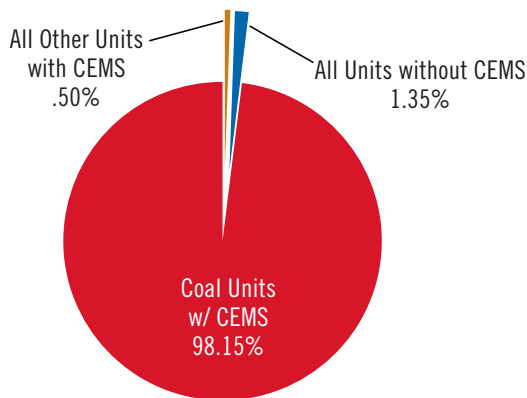
The ARP requires affected units to measure, record, and report SO₂ mass emissions and NO_x emission rates using CEMS or an approved alternative measurement method. The vast majority of emissions are monitored with CEMS, while the alternatives provide a cost-effective means of monitoring mass emissions for smaller and/or cleaner units. Figure 4 shows the percentage of SO₂ emissions monitored using CEMS.

Affected sources are required to meet stringent quality assurance and control requirements and report hourly emission data in quarterly electronic reports to EPA. In 2007, the average percent of monitoring data available (a measure of monitoring systems' reliability) was 98.7 percent for coal-fired units. This number is based on reported monitor data availability for SO₂ monitors (99.1 percent),

NO_x monitors (98 percent), and flow monitors (99 percent).

Using automated software audits, 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 the electronic audits, EPA conducts targeted field audits on sources that report suspect data. In 2007, source compliance with ARP emission monitoring requirements was more than 98 percent, with only 43 units out of 3,526 out of compliance. All 43 units were small units that did not require further follow-up from EPA. All emission data are available to the public within two months of being reported to EPA. Data can be accessed on the Data and Maps Web site maintained by EPA's Clean Air Markets Division at <<http://camddataandmaps.epa.gov/gdm/>>.

Figure 4. Monitoring Methodology for the Acid Rain Program, Total SO₂ Mass



Source: EPA, 2008





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 samplers, and wet sulfate and nitrate deposition are 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).

Figures 5 through 8 show the U.S.–Canada spatial patterns of wet sulfate (sea salt-corrected) deposition for four years: 1990, 1995, 2000, and 2005. Figures 9 through 12 show the patterns of wet nitrate deposition for the same four years. Deposition contours are not shown in western Canada because Canadian experts judged that the locations of the contour lines were unacceptably uncertain due to the paucity of long-term measurement sites in all of the western provinces except Alberta. 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 5. 1990 Annual Sulfate Wet Deposition

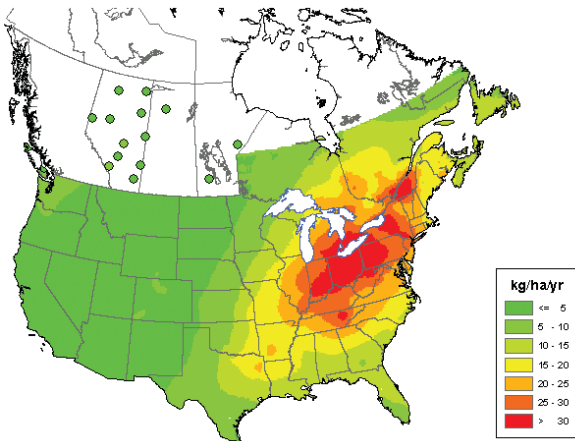


Figure 6. 1995 Annual Sulfate Wet Deposition

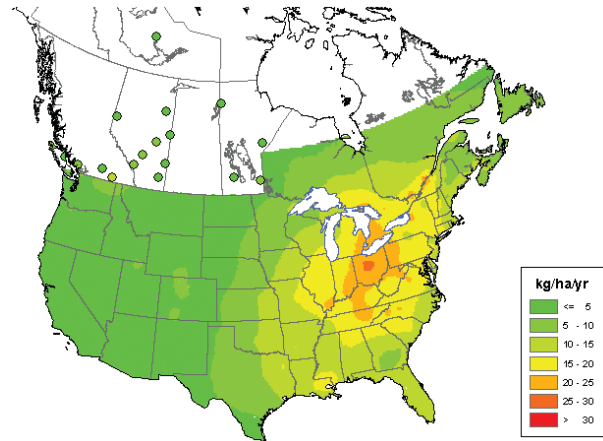


Figure 7. 2000 Annual Sulfate Wet Deposition

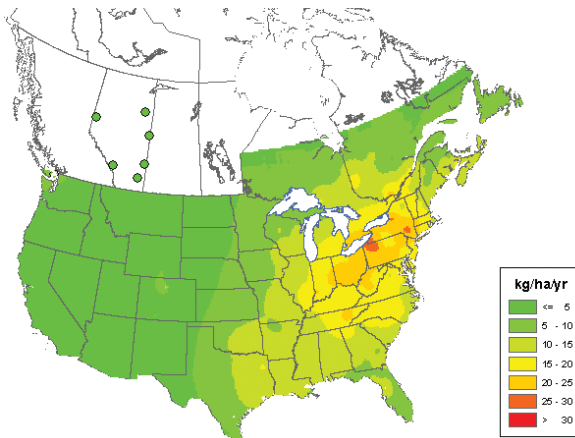
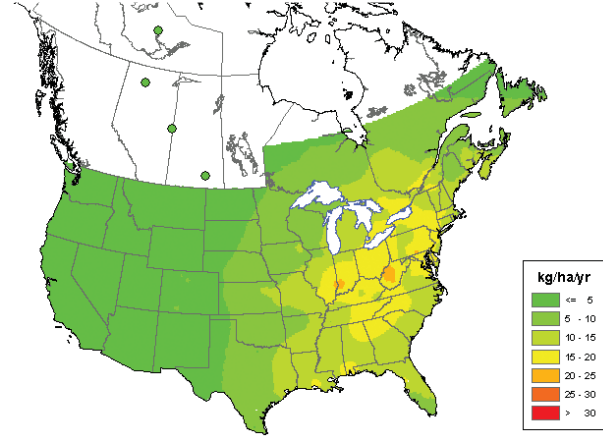


Figure 8. 2005 Annual Sulfate Wet Deposition



Source: National Atmospheric Chemistry (NAtChem) Database (www.msc-smc.ec.gc.ca/natchem/index_e.html) and the National Atmospheric Deposition Program (NADP)



The four maps indicate that wet sulfate deposition is consistently highest in eastern North America around the lower Great Lakes, with a gradient following an axis running from the confluence of the Mississippi and Ohio rivers through the lower Great Lakes. The pattern from 1990 to 2005 illustrates that significant reductions occurred in wet sulfate deposition in both the eastern United States and much of eastern Canada, particularly in the periods from 1990 to 1995 and 2000 to 2005. By 2005, the region receiving more than 20 kilograms per hectare per year (kg/ha/yr) of wet sulfate deposition had essentially disappeared, with the exception of three small areas: at the Illinois–Indiana border, at the

West Virginia–Ohio border, and at the Pennsylvania–Maryland Border. The wet sulfate deposition reductions are considered to be directly related to decreases in SO₂ emissions in both Canada and the United States. The emission reductions are outlined in the Key Commitments and Progress: Sulfur Dioxide Emission Reductions section beginning on page 3.

The patterns of wet nitrate deposition (Figures 9 through 12) show a similar southwest-to-northeast axis, but the highest deposition area is located further north than that of sulfate. Reductions in wet nitrate deposition have generally been more modest than for

Figure 9. 1990 Annual Nitrate Wet Deposition

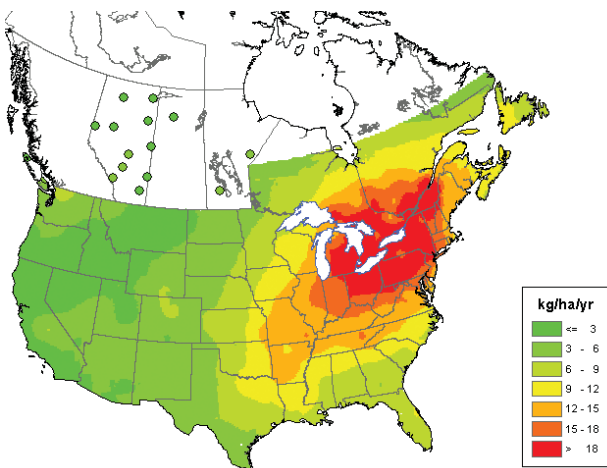


Figure 10. 1995 Annual Nitrate Wet Deposition

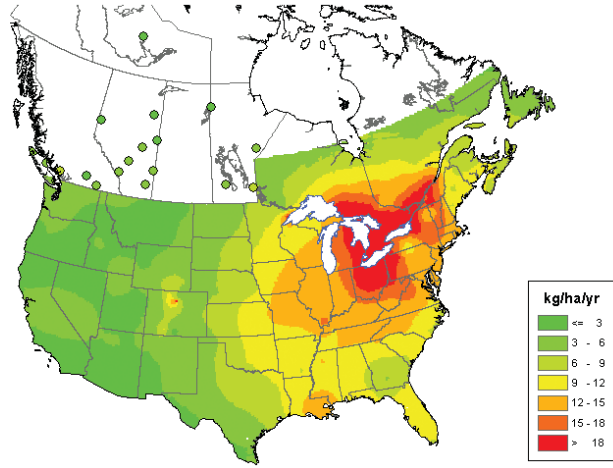


Figure 11. 2000 Annual Nitrate Wet Deposition

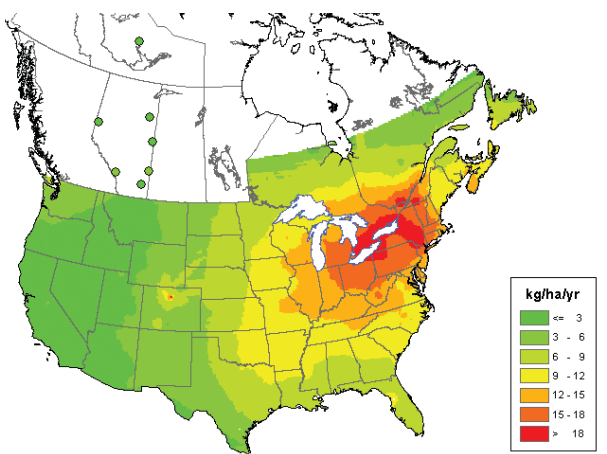
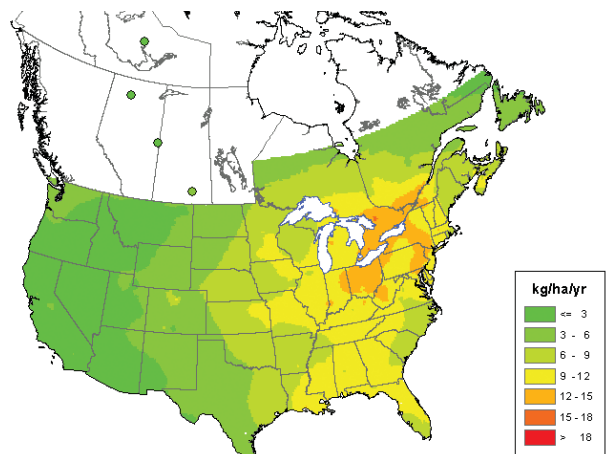


Figure 12. 2005 Annual Nitrate Wet Deposition



Source: National Atmospheric Chemistry (NAtChem) Database (www.msc-smc.ec.gc.ca/natchem/index_e.html) and the National Atmospheric Deposition Program (NADP)



wet sulfate deposition, except during the period from 2000 to 2005, when large NO_x emissions reductions occurred in the United States and, to a lesser degree, in Canada.

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, Northwest Territories, Quebec, New Brunswick, and Nova Scotia. Dry deposition estimates are made at a subset of CAPMoN sites using combined air concentration measurements and modeled dry deposition velocities—the so-called inferential technique. In the United States, wet deposition measurements are made by two coordinated networks: the National Atmospheric Deposition Program/National Trends Network (NADP/NTN), which is a collaboration of federal, state, and nongovernmental organizations (<http://nadp.sws.uiuc.edu/>), and the NADP/Atmospheric Integrated Research Monitoring Network (AIRMoN), which is a sub-network of NADP funded by the National Oceanic

and Atmospheric Administration (<http://nadp.sws.uiuc.edu/AIRMoN/>). 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 EPA, the National Park Service (NPS), and the Clean Air Status and Trends Network (CASTNET) (www.epa.gov/castnet).

Wet deposition measurements in the United States and Canada are comparable, and the data are available from the individual networks and from a binational database accessible to the public at www.msc-smc.ec.gc.ca/natchem/index_e.html. Dry deposition estimates in the two countries, while demonstrating the importance of dry deposition to total deposition in certain areas, are not as comparable. This appears to be due to major differences in the inferential models used to calculate dry deposition velocities and fluxes. The United States and Canada are working collaboratively to reconcile these differences and obtain validation data to evaluate the models.

Preventing Air Quality Deterioration and Protecting Visibility



JOINT EFFORTS

In October 2007, a joint U.S.–Canada visibility workshop was held in Research Triangle Park, North Carolina. EPA, the U.S. Federal Land Managers, and Canadian government representatives came together to review the history of the U.S. visibility program, including visibility impairment monitoring and tracking, and to share information and lessons learned from joint analyses between the two countries, discuss international transport in general, and investigate future collaboration.



CANADA

As reported in previous progress reports, Canada is addressing the commitment to prevent air quality deterioration and ensure visibility protection by implementating the Canadian Environmental Assessment Act, the Canadian Environmental Protection Act (CEPA) of 1999, and the continuous improvement

(CI) and keeping clean areas clean (KCAC) principles that are part of the Canada-wide Standards (CWS) for PM and ozone. The federal government's *Turning the Corner* initiative to regulate air pollution emissions across Canada has the potential to benefit visibility.

Federal and provincial environmental assessment legislation requires that air quality be considered for all major new point sources or modifications to existing sources to ensure that Canadian objectives to protect human health and the environment are met. Mandatory provincial reporting processes require new and existing sources to file notifications, which are reviewed to determine the scale of environmental assessment appropriate to each case. CEPA 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.

There are numerous locations across Canada where ambient levels of PM and ozone are below the CWS.



Actions are required to ensure that levels in these areas do not rise to the CWS, but rather, are reduced over time, and that clean areas are maintained. For example, although Metro Vancouver experiences good regional air quality relative to most other Canadian urban areas, the region adopted a new Air Quality Management Plan (AQMP) in October 2005 to maintain and improve air quality in the Lower Fraser Valley airshed. The new AQMP aims to minimize the risk to human health from air pollution, improve visibility, and reduce metro Vancouver's contribution to global climate change. As the CWS for PM_{2.5} (particulate matter less than or equal to 2.5 microns) is being met throughout the Lower Fraser Valley and the CWS for ozone is exceeded only in the eastern part, the AQMP supports the CI/KCAC provisions of the CWS. Also, visibility degradation in the Lower Fraser Valley occurs at concentration levels of PM_{2.5} well below the CWS. The AQMP's emission reduction actions aim to reduce direct emissions of PM and ozone, as well as PM precursors.

The province of British Columbia has recently taken steps to establish a framework to specifically address visibility. An interagency Visibility Coordinating Committee consisting of representatives from the air quality management agencies was formed in 2007 and is now exploring the development of a visibility management program for urban and rural areas. The early work of the committee involved a multi-stakeholder workshop on visibility management and a report on visibility management options in British Columbia. This report can be viewed at <www.env.gov.bc.ca/air/airquality/pdfs/view_ahead.pdf>.

Current efforts are focused on a review of visibility standards/goals for urban and rural areas in the United States and an assessment of the U.S. Regional Haze Rule. The results of these initiatives will inform a path forward for the development of a visibility management pilot program for the Lower Fraser Valley.



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 Clean Air Act requires major new stationary sources

of air pollution and extensive modifications to major existing stationary sources to obtain permits before construction. The permitting process is called New Source Review (NSR) and applies to both 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 (NAA) 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. BACT is determined on a case-by-case basis and considers energy, environmental, and economic impacts.

NAA permits require the lowest achievable emission rate (LAER). BACT and LAER must be at least as strict as any existing New Source Performance Standard (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 NSR program 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.

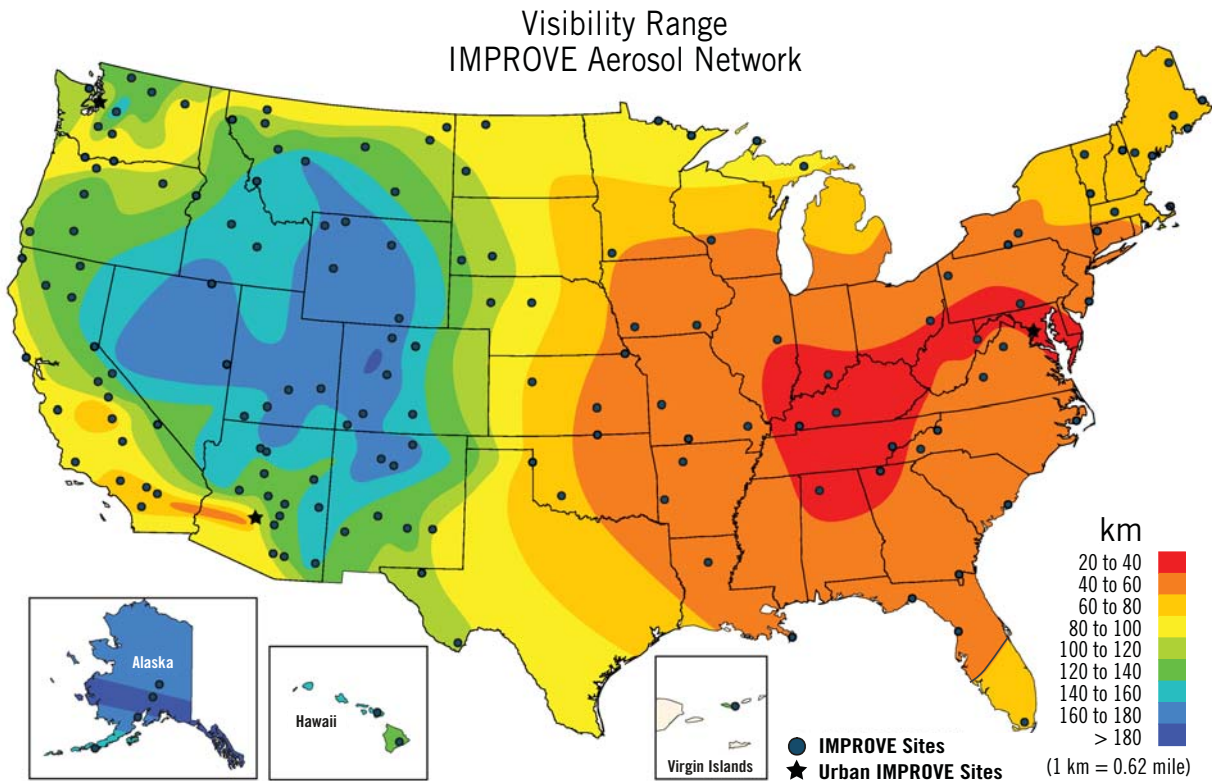
The Clean Air Act established the goal of improving visibility in the nation's 156 Class I areas and returning these areas to natural visibility conditions (visibility that existed before manmade air pollution); the 1999 Regional Haze Rule prescribes the requirements that states must meet to reach that goal by 2064. In July 2005, 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. States were required to submit their Regional Haze SIPs by December 17, 2007. The first planning period establishes an assessment of expected visibility conditions in 2018. The SIPs are revised every 10 years, and states revise their visibility goals accordingly to ensure that reasonable progress is being made to achieve natural visibility conditions. There is also a reporting check every five years, in which states report their interim progress toward reaching the goals. Additional information on EPA's Regional Haze Program can be found at <www.epa.gov/visibility/program.html>.

Figure 13 shows the annual average standard visual range within the United States for the period 2000 to 2004. "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 Interagency Monitoring of Protected Visual Environments (IMPROVE) network. Increased particle pollution reduces the visual range. The visual range under naturally occurring conditions without pollution in the United States is typically 45 to 90 miles (75 to 150 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 <<http://vista.cira.colostate.edu/improve/>>.

Figure 13. Annual Average Standard Visual Range in the Contiguous United States, 2000–2004



Source: Spatial and Seasonal Patterns and Temporal Variability of Haze and Its Constituents in the United States, Report IV, November 2006, IMPROVE, National Park Service



Consultation and Notification Concerning Significant Transboundary Air Pollution



JOINT EFFORTS

Canada and the United States are continuing notification procedures—initiated in 1994—to identify potential new sources and modifications to existing sources of transboundary air pollution within 62 miles (100 km) of the U.S.–Canada border. Additionally, the governments can provide notifications for new or existing sources outside of the 62-

mile region if they believe there is potential for transboundary air pollution. Since publication of the 2006 United States–Canada AQA Progress Report, Canada has notified the United States of eight additional sources, for a total of 52 Canadian notifications. The United States has notified Canada of nine additional sources, bringing the total number of U.S. notifications to 56.

Transboundary notification information is available on the government Web sites of each country at:

Canada:

www.ec.gc.ca/cleanair-airpur/CAOL/canus/canus_applic_e.cfm

United States:

www.epa.gov/ttn/gei/uscadata.html

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

Essar Steel Algoma, Inc.

The ESAI mill is an integrated primary steel producer located on the St. Mary's River in Sault Ste. Marie, Ontario, approximately one mile from the U.S.–Canada border.



The Canada–U.S. 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 monitoring on the U.S. side was initiated by the Intertribal Council of Michigan in 2001. Sampling of fine PM and toxic air pollutants continues on both sides of the border.

During the last two years, 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. In November 2006, the data analysis subgroup of the Algoma informal consultation group completed a report summarizing results of the ambient air monitoring program in the binational area between 2001 and



2003. The executive summary and full technical report are posted on the EPA Region 5 Web site at <www.epa.gov/region5/air/>.

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 particulate matter (i.e., particulate matter less than or equal to 10 microns, or PM₁₀), exceed Ontario air quality criteria in the west end of Sault Ste. Marie, Ontario.

Trend data from the consultation indicate that although emission rates have declined, total steel production at ESAI has increased. The combined impact of these changes on air quality is not yet known, and local agencies are still receiving U.S. citizen complaints.

In 2007, the Intertribal Council of Michigan installed a camera, facing toward Sault Ste. Marie, Ontario, as part of the Midwest Hazecam Network (see

<www.mwhazecam.net>). The Intertribal Council provided the bilateral consultation group with a series of photographs documenting reddish particle plumes emanating from ESAI on multiple dates. The consultation team discussed the photographs in October 2007. Ontario Ministry of the Environment (MOE) staff confirmed that the emissions were coming from a blast furnace at the company's plant. The blast furnace was largely uncontrolled at the time, but ESAI has committed to install a particulate-controlling baghouse on the unit by December 31, 2008.

In September 2008, MOE confirmed that ESAI was in the process of constructing a permanent baghouse and that the company was operating portable baghouse units in the interim. In order to meet the demand for increased steel production, another pre-existing blast furnace at ESAI was restarted in August, 2008. MOE reported that this unit is also operating with temporary particulate controls and that ESAI made a commitment to build a permanent baghouse by December 2009. The ESAI bilateral consultation group will continue to monitor and report on this facility.



Ozone Annex

Overview

The Ozone Annex was added to the AQA in 2000 to address transboundary ground-level ozone. The annex commits both the United States and Canada to 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, and the District of Columbia. The states and provinces within the PEMA are the areas where emission reductions are most critical for reducing transboundary ozone.

Key Commitments and Progress

Vehicles, Engines, and Fuels



CANADA

New stringent NO_x and VOC emission reduction standards for vehicles, including cars, vans, light- and heavy-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 60 percent of the NO_x emissions and more than 30 percent of the VOC emissions in the Canadian portion of the PEMA. To address these emissions, the Ozone Annex commits Canada to controlling and reducing NO_x and VOC emissions from vehicles and fuels by regulating sulfur content in gasoline and on-road diesel fuel and by establishing new emission standards for light-duty vehicles and trucks; heavy-duty vehicles and engines; and motorcycles, recreational marine engines, and small engines (e.g., lawn mowers).

Consistent with its obligations under the Ozone Annex, Canada has implemented a series of regulations to align Canadian emission standards for vehicles and engines with corresponding standards in the United States. By 2020, it is estimated that NO_x and VOC emissions combined from on-road and off-road vehicles and engines in the Canadian portion of the PEMA will be reduced by 41 and 35 percent, respectively, relative to 2005 emissions.

The On-Road Vehicle and Engine 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. The primary purpose of the Regulations Amending the On-Road Vehicle and Engine Emission Regulations (November 15, 2006) is to introduce new requirements for 2006 and later model year on-road motorcycles. The changes will ensure that Canadian emission standards for on-road motorcycles remain aligned with more stringent standards adopted by EPA. In addition, Canada plans to amend the On-Road Vehicle and Engine Emission Regulations to require onboard diagnostic (OBD) systems for on-road heavy-duty engines such as trucks and buses.

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. It is anticipated that these regulations will be amended to extend their scope to include standards to reduce air pollutant emissions from large, off-road spark-ignition (SI) engines, such as forklifts.



The Off-Road Compression-Ignition Engine Emission Regulations were in effect as of January 1, 2006, and 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. Environment Canada plans to amend these regulations to incorporate the more stringent U.S. Tier 4 standards.

The proposed Marine Spark-Ignition Engine and Off-Road Recreational Vehicle Emission Regulations were published in the *Canada Gazette*, Part I, on December 30, 2006. The proposed regulations will introduce new emission standards, aligned with U.S. federal standards, for new outboard engines, personal watercraft, all-terrain vehicles (ATVs), snowmobiles, and off-road motorcycles.

Regulatory initiatives for fuels include the Sulphur in Gasoline Regulations, which limit the level of sulfur in gasoline to 30 milligrams (mg)/kg (equivalent to 30 parts per million [ppm]) as of January 1, 2005; and the Sulphur in Diesel Fuel Regulations, which reduce the level of sulfur in diesel fuel used in on-road vehicles to 15 mg/kg (15 ppm) as of June 1, 2006. Environment Canada amended the Sulphur in Diesel Fuel Regulations to reduce the level of sulfur in diesel fuel used in off-road, rail, and marine engines to 500 mg/kg (500 ppm) as of 2007. Levels will be further limited to 15 mg/kg (15 ppm) beginning in 2010 for off-road and 2012 for rail and marine engines.

Environment Canada and EPA have agreed to work together on integrated vehicle and fuel programs to reduce emissions from the transportation sector, and to work toward harmonized programs for sustainable transport and goods movement.

Stationary Sources of NO_x

Annual caps by 2007 of 39 kilotonnes (kt) of NO_x (as nitrogen dioxide [NO₂]) emissions from fossil fuel power plants in the PEMA in central and southern Ontario, and 5 kt 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's commitment in the Ozone Annex, therefore, focuses on achieving an emission requirement for this sector in the Canadian portion of the PEMA comparable to that in the U.S. portion of the PEMA.

Canada is expected to comply with 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 kt and 5 kt, respectively, for 2007. Emissions from power plants in the Ontario portion of the PEMA were approximately 78 kt in 1990. In 2007, NO_x emissions from Ontario fossil fuel-fired power plants are estimated to be 35.9 kt, or 8 percent below the cap. Annual NO_x emissions for 2007 from Quebec fossil fuel-fired power plants in the PEMA are being assessed.

Ontario's Cessation of Coal Use Regulation (O. Reg. 496/07) under the Environmental Protection Act was in effect as of August 24, 2007. This regulation ensures that coal is not to be used to generate electricity at the Atikokan, Lambton, Nanticoke, and Thunder Bay generating stations after December 31, 2014. Lakeview Generating Station was closed in April 2005 (O. Reg. 396/01), eliminating annual emissions of approximately 4,000 tonnes of NO_x and 15,000 tonnes of SO₂ upwind of the Greater Toronto Area in the PEMA.



Ontario has been engaged in a number of clean energy projects to offset coal-fired electricity generation. On August 27, 2007, the Ministry of Energy announced that the Ontario Power Authority will procure an additional 2,000 MW of renewable energy, which will double the amount of renewable energy acquired by the Ontario government to 4,000 MW. As of June 2008, 522 MW of renewable energy projects were in service.

To ensure that the 5 kt cap is met for the Quebec portion of the PEMA, Quebec's Draft Air Quality Regulation is introducing a specific cap of 2,100 tonnes per year for the Tracy plant. This plant is used mainly during peak periods, and it easily met the caps in 2006 (71 tonnes of NO_x) and 2007 (139 tonnes).

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 is providing national guidance on environmentally preferable electricity products and generation in Canada and is establishing criteria for environmental labeling of qualifying electricity products under the Canadian government's EcoLogo Program. Certification criteria derived from the draft guideline are being used to certify qualifying electricity products.

Canada intends to monitor the application of these criteria as an indicator of improvement in the environmental performance of electricity generation and distribution. Canada intends to review and update these criteria 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 Tetrachloroethylene (Use in Dry Cleaning and Reporting Requirements) Regulations became law on February 27, 2003, and the last provision of these regulations went into effect on August 1, 2005. The regulations phased out the use of older technology dry cleaning machines, which used and released larger quantities of tetrachloroethylene (commonly called perchloroethylene or PERC). The goal of the regulations was to achieve a 71-percent reduction of PERC releases at dry cleaning facilities from 1994 levels by August 2005. Analysis is underway by Environment Canada to determine whether this goal has been achieved.

The Solvent Degreasing Regulations took effect in July 2003 and froze the consumption of trichloroethylene and PERC on cold and vapor solvent degreasing 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.

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. In 2004, the province of Ontario unveiled its implementation plan, which described its approach to reducing smog-causing emissions. As part of this implementation plan, in 2005, Ontario finalized its Industry Emissions—Nitrogen Oxides and Sulphur Dioxide Regulation, which will lead to incremental reductions of NO_x and SO₂ from facilities in seven industrial sectors. Further details on Ontario's implementation plan can be found at <www.ene.gov.on.ca/programs/4708e.htm> and on Ontario's Regulation 194/05 (Industry Emissions—Nitrogen Oxides and Sulphur Dioxide) at <www.ene.gov.on.ca/envision/AIR/regulations/industry.htm>.



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.

Federal actions to reduce ozone-causing emissions from key industrial sectors are being proposed as part of Canada's Regulatory Framework for Air Emissions.

VOC emissions from manufacturing and using consumer and commercial products, such as cleaning products, personal care products, and paints, contribute significantly to the formation of smog. The federal government is therefore taking action to reduce VOC emissions from consumer and commercial products.

Three proposed regulations to limit the concentrations of VOCs in consumer products, architectural coatings, and automotive refinishing products were published in the *Canada Gazette*, Part I, on April 26, 2008. The proposed VOC concentration limits are aligned with a number of current and upcoming regulations in California and other U.S. sectors. The proposed regulations are predicted to result in an average annual reduction in VOC emissions by 28 to 40 percent in the covered sectors. The regulations are expected to be finalized in 2009.

Actions by the Province of Quebec

Quebec has made progress in meeting its Ozone Annex commitments by way of several regulatory actions. The Draft Air Quality Regulation, which is an overhaul of Quebec's current 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. The Draft Air Quality Regulation, published in November 2005, has been revised, taking into consideration the comments received from interested stakeholders, and currently is being finalized. Since the Air Quality Regulation is a multisectoral regulation, the finalization process is lengthy.

With respect to VOC emissions, the amendments to the Regulation Respecting the Quality of the Atmosphere are aimed at reducing emissions from the manufacture and application of surface coatings, commercial and industrial printing, dry cleaning, aboveground storage tanks, petroleum refineries, and petrochemical plants.

Pursuant to its Regulation on 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–Montreal section of the Windsor–Quebec City corridor. Quebec is evaluating the possibility of introducing amendments to the above regulation to address vapor recovery initiatives, including gasoline storage, transfer depots, and service stations supplying both new and existing installations 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 Ontario Emissions Trading Regulation (O. Reg. 397/01), which establishes caps for NO_x and SO₂ emissions from the electricity sector.
- The Ontario Drive Clean Program (O. Reg. 361/98), which is a mandatory inspection and maintenance program for motor vehicles that identifies vehicles that do not meet provincial emission standards and requires them to be repaired. The Vehicle Emissions Enforcement Unit (Smog Patrol) complements the Drive Clean Program by conducting road-side inspections of heavy-duty and light-duty vehicles.
- Stage 1 Recovery of Gasoline Vapor in Bulk Transfers (O. Reg. 455/94), which requires gasoline facility operators to install, maintain, and operate gasoline vapor recovery systems.



- Gasoline Volatility (O. Reg. 271/91, as amended by O. Reg. 45/97), which sets limits for gasoline vapor pressure during the summer.
- Dry Cleaners (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, which sets limits for NO_x and SO₂ 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 and Discharge Monitoring and Reporting Regulation (O. Reg. 127/01), amended in February 2006, which harmonizes Ontario's air emission reporting system with Environment Canada's NPRI.

NO_x and VOC Program Updates



- **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.**
- **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 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.**

NO_x SIP Call: EPA finalized the NO_x SIP Call in 1998. The rule was designed to reduce the regional

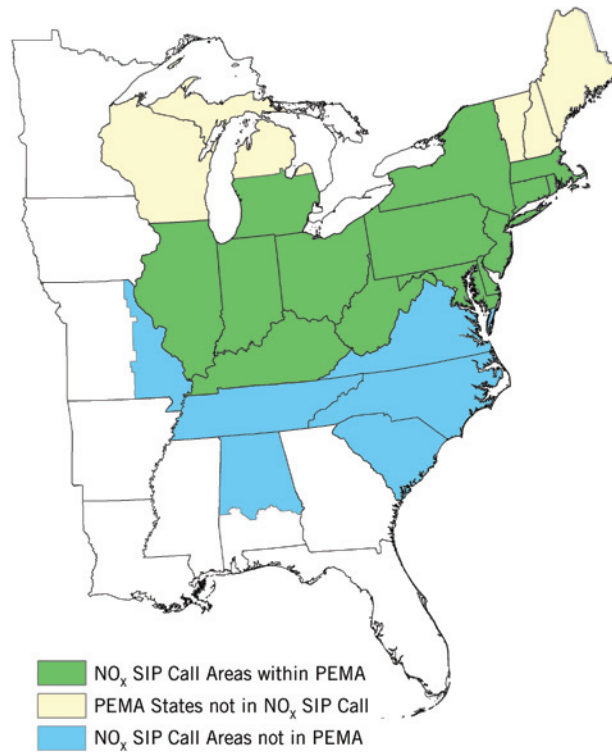
transport of NO_x, one of the precursors of ozone, in the eastern United States. It requires affected states to reduce ozone season NO_x emissions that cross state boundaries and contribute to ozone nonattainment in downwind states.

As of 2007, 20 states and the District of Columbia are affected by the NO_x SIP Call. All affected states and the District of Columbia chose to meet the mandatory NO_x SIP Call reductions primarily through participating in the NBP, a market-based cap and trade program for EGUs and large industrial units. Fourteen of the 20 NBP states plus the District of Columbia are located within the PEMA (see Figure 14).

Further information on the NO_x SIP Call and NBP can be found at www.epa.gov/airmarkets/progsregs/nox/sip.html. Compliance and emission data for all sources participating in the NBP can be found at <http://camddataandmaps.epa.gov/gdm/>.



Figure 14. PEMA Region and NO_x SIP Call States

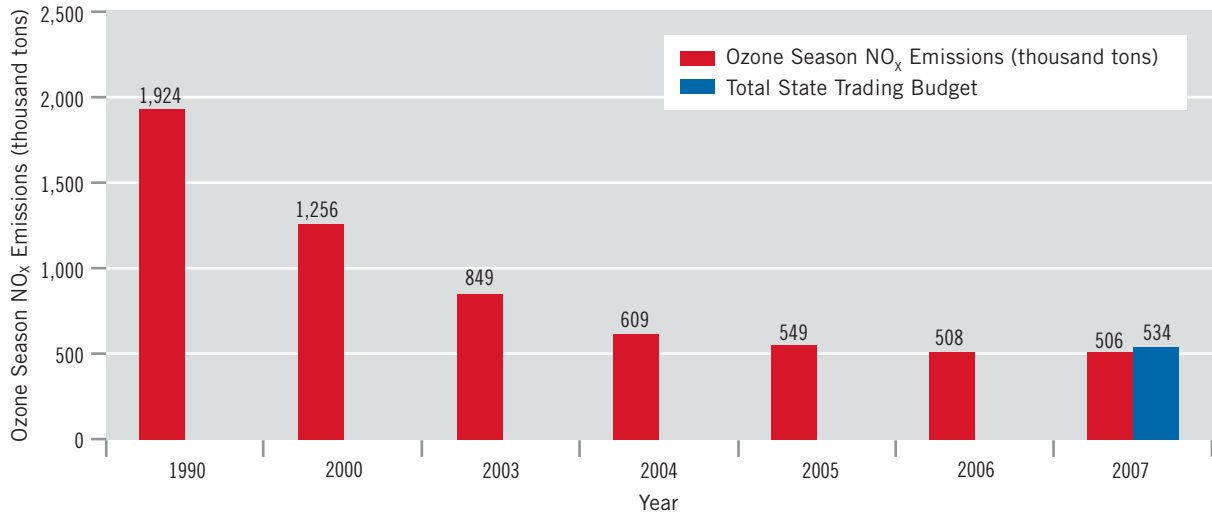


Source: EPA, 2008

Emission Reductions: In the 2007 ozone season, NBP sources emitted 506,312 tons of NO_x. This is almost 28,000 tons, or 5 percent, below the 2007 NO_x budget. Figure 15 shows total ozone season NO_x emissions from all NBP sources. These data include ozone season emissions prior to the start date of

the NBP for some states. For example, the totals in this section include the 2003 to 2007 ozone season emissions for affected units in Missouri, even though those sources were not subject to the NBP emission reduction requirements until 2007.

Figure 15. Ozone Season NO_x Emissions under the NO_x Budget Trading Program



Source: EPA, 2008



Compliance: Under the NBP, affected sources must hold sufficient allowances to cover their ozone season NO_x emissions each year. In 2007, 2,594 units were affected under the NBP. Of those units, only 12 did not hold sufficient allowances to cover 2007 emissions. Overall, affected sources achieved over 99.5 percent compliance in 2007.

New Source Performance Standards: 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, EPA finalized the NSPS for Stationary Compression-ignition Internal Combustion Engines in July 2006, which is helping these sources achieve significant reductions of NO_x and VOC emissions. Furthermore, in December 2007, EPA finalized an additional nationally applicable emission standard—an NSPS for NO_x , carbon monoxide (CO), and VOC emissions from new stationary spark ignited 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, 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. EPA is currently reviewing the NSPS for petroleum refineries and for equipment leaks at chemical plants and petroleum refineries. The equipment leak standards were completed in October 2007, and the petroleum refineries standard was completed in April 2008.

VOC Controls on Smaller Sources: In 1998, 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. Currently, EPA is developing amendments to the consumer products rule and the architectural coatings rule based on the Ozone Transport Commission model rules for these categories. Both amended rules will have a compliance date of January

1, 2009. In addition, EPA had previously scheduled for regulation 15 other categories of consumer and commercial products under section 183(e) of the Clean Air Act. To date, EPA has regulated or issued guidance on 10 of the 15 categories, including 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; and portable fuel containers. Rules for the remaining five categories have been proposed, and final rules for these are scheduled for September 30, 2008. To that end, EPA is developing national rules or guidance on miscellaneous metal products coatings, plastic parts coatings, auto and light-duty truck assembly coatings, miscellaneous industrial adhesives, and fiberglass boat manufacturing materials.

Controls on Hazardous Air Pollutants: EPA has promulgated regulations to control hazardous air pollutant emissions for all of the 40 categories of industrial sources listed in the Ozone Annex. These regulations will help reduce VOC emissions. Most of the sources are either already in compliance or are required to be in compliance with the regulations by the end of 2008, with the exceptions of paint stripping and gasoline distribution facilities, which are not required to be in compliance until January 2011. Most recently, EPA proposed new standards to control hazardous air pollutants from fuel, passenger vehicles, and gasoline cans to further reduce benzene emissions and other mobile source air toxics. By 2030, the proposed Mobile Source Air Toxic Regulations, in addition to fuel and vehicle standards already in place, will reduce toxic emissions from passenger vehicles to 80 percent below 1999 emissions. The proposed Mobile Source Air Toxic Regulations would take effect in 2009 for fuel containers, 2010 for passenger vehicles, and 2011 for fuel requirements.

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 vehicle and engine side, EPA continues to tighten emission standards for vehicles and engines sold in the United States. EPA is implementing much tighter emission standards for highway heavy-duty engines from 2007 to 2010; and Tier 2 exhaust and evaporative standards for light-duty cars and trucks from 2004 to 2009. EPA has also implemented onboard refueling standards and OBD II requirements for these vehicles. In 2004, EPA published new motorcycle emission standards, which take effect in 2006 and 2010.

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

Nonroad Engine Control Program: EPA has applied engine standards in all five nonroad engine categories identified in the Ozone Annex: aircraft, compression-

ignition engines, SI engines, locomotives, and marine engines. Nonroad diesel fuel will align with on-highway diesel fuel at 15 ppm sulfur by 2010. Locomotive and marine diesel fuel has been limited to 500 ppm sulfur since 2007 and will align with on-highway and nonroad diesel fuel at 15 ppm in 2012.

In addition, EPA has promulgated more stringent (Tier 4) standards for nonroad compression-ignition engines and Phase 2 standards for SI engines. The Tier 4 standards for nonroad diesels will phase in through 2014, and the Phase 2 standards for SI engines were fully phased in as of 2007. New locomotive and marine engine standards (for engines less than 30 liters/cylinder) were finalized in March 2008 and will take effect as early as 2008 for remanufactured locomotive and marine engines. Stringent Tier 3 standards will begin as early as 2009 for newly manufactured engines. Even more stringent Tier 4 standards requiring catalytic aftertreatment will phase in for most newly manufactured engines beginning in 2014.

Anticipated Additional Control Measures and Indicative Reductions

National Reductions



CANADA

In addition to measures to regulate emissions from vehicles, off-road equipment, and fuels, the federal government developed an ecoTRANSPORT Strategy to further reduce the environmental impacts of transportation. It includes the following three programs: 1) the ecoTechnology for Vehicles Program involves the purchase and testing of advanced technologies, including hydrogen, advanced electric, hybrid, and fuel cell vehicles; 2) the ecoMOBILITY Program seeks to reduce urban-passenger transportation emissions by encouraging commuters to choose public transit or other sustainable transportation options like carpooling; and 3) the ecoEnergy for Personal Vehicles Program provides decision-making tools to encourage consumers to purchase fuel-efficient vehicles and tips for motorists on driving and maintaining their vehicles to reduce fuel consumption and emissions that cause air pollution.

On October 21, 2006, the federal government published a *Notice of intent to develop and implement regulations and other measures to reduce air emissions*. A key feature of the approach is addressing greenhouse gases, acid rain, and smog-forming pollutants in a coordinated manner, because most of these emissions and pollutants originate from the combustion of fossil fuels from transportation, electricity generation, and other industrial sources.

The resulting reductions in air pollutant emissions and improvements to air quality would occur across the country, including in regions currently in attainment of the CWS for ozone and in the PEMA, where ozone levels still exceed the CWS.

In 2007, the federal government announced *Turning the Corner: An Action Plan to Reduce Greenhouse Gases and Air Pollution* and made public the Regulatory Framework for Air Emissions. The Regulatory Framework operationalizes the government's intention, as conveyed in 2006. More



details are provided in this report in the section, New Actions on Acid Rain, Ozone, and Particulate Matter on page 33.

The federal government also has committed to setting national air quality objectives to complement the emission regulations and support improving air quality across Canada. The objectives could be used to trigger specific actions in areas where they are exceeded. National air quality objectives will initially be set for PM and ozone, the main components of smog.

Area-Specific Reductions

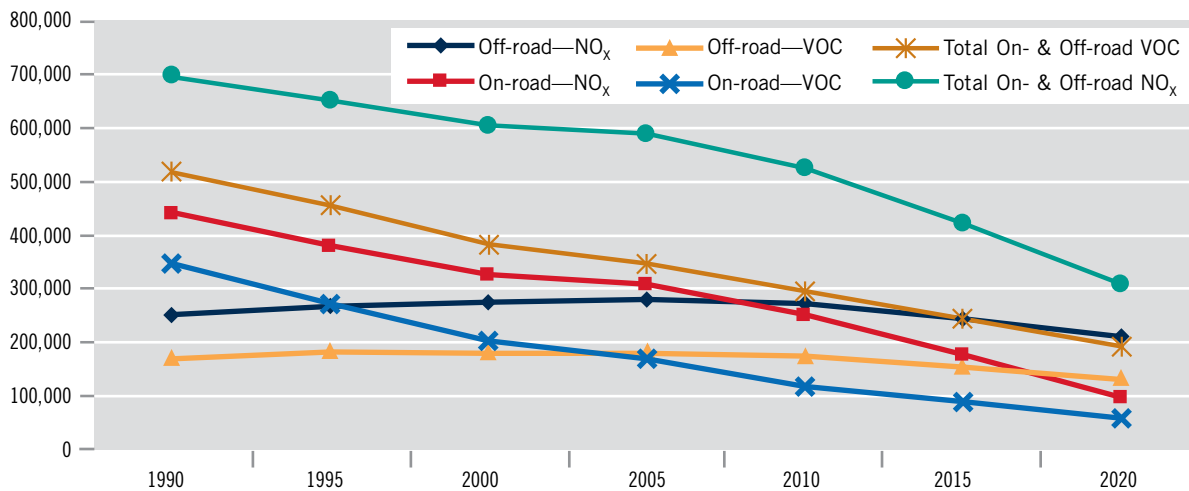
Quebec's Regulation respecting environmental standards for heavy vehicles came into force on June 1, 2006. The regulation sets VOC and CO emission standards for gasoline-powered heavy-

duty vehicles and particulate emission standards for diesel-powered heavy-duty vehicles.

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 16 shows that NO_x and VOC emissions from transportation sources in the PEMA are expected to decrease by 24 percent and 43 percent, respectively, by 2010 from 1990 levels.

Figure 16. Canadian Transportation NO_x and VOC PEMA Emissions and Projections 1990–2020



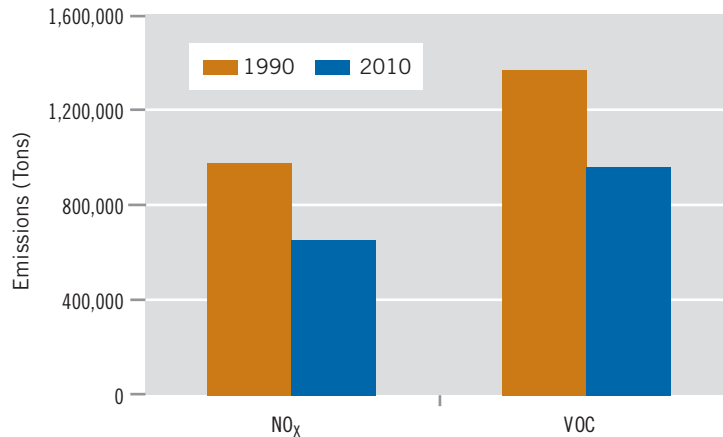
Source: Environment Canada, 2008



Using national emission data and an improved methodology for emission projections, the specific NO_x and VOC emission reduction obligations in the annex are estimated to reduce annual NO_x emissions in the PEMA by 34 percent and annual VOC emissions in the PEMA by 29 percent by 2010,

from 1990 levels (see Figure 17). Canada is currently in the process of finalizing its updated emissions projections based on the 2006 emissions data. These projections will be available later in 2008. The information shown in Figure 17 is the same as that presented in the 2006 progress report.

Figure 17. Canadian NO_x and VOC PEMA Emissions and Projections



Note: 2010 reflects all emission categories including those committed in the specific obligations in Part III of Annex 3 Specific Objectives Concerning Ground-Level Ozone Precursors.

Source: Environment Canada, 2006

National Reductions



In March 2008, EPA published new standards for locomotive and marine engines less than 30 liters per cylinder. These standards will begin to phase in for remanufactured locomotive and marine diesels beginning as early as 2008. Tier 3 standards will begin for newly built locomotive and marine diesels beginning in 2009. Tier 4 standards, which will require exhaust aftertreatment, will begin in 2014 for new marine diesels and 2015 for new locomotives. Tier 4 engines will have 80 percent lower NO_x and 90 percent lower PM than current engines. By 2030, the new locomotive and marine emission standards will reduce annual NO_x emissions by about 800,000 tons and PM emissions by 27,000 tons. Further information about these standards can be found at <www.epa.gov/otaq/locomotv.htm> and <www.epa.gov/otaq/marine.htm>.

EPA began regulating nonroad SI engines in 1997 with its small SI engine rule, which applied 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, EPA has implemented tighter standards covering a wider range of engines. 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. Further information on these rules can be found at <www.epa.gov/otaq/recveh.htm>.

EPA finalized Phase 3 standards for small SI engines and the first ever standards for marine inboard and sterndrive engines in September 2008. Further information can be found at <www.epa.gov/otaq/marinesi.htm>



Area-Specific Reductions

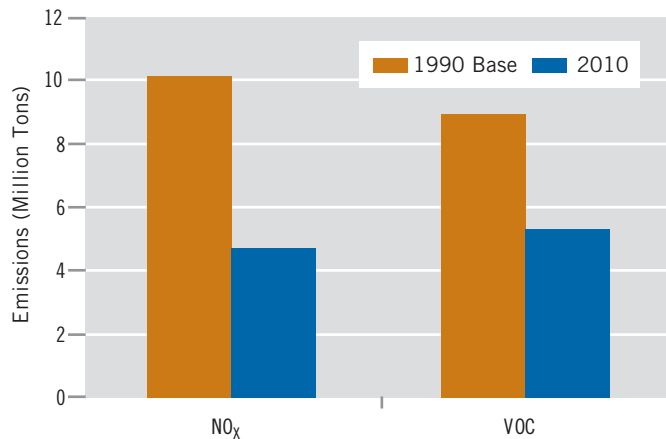
EPA is implementing NO_x and VOC control measures in specific areas, as required by applicable provisions of the Clean Air Act. The measures include NO_x and VOC reasonably available control technology; marine vessel loading; treatment storage and disposal facilities; municipal solid waste landfills; 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. EPA has updated these estimates using national data sets that were completed in late 2007.

The specific emission reduction obligations (see Figure 18) are now estimated to reduce annual NO_x emissions in the PEMA by 53 percent (versus the predicted overall emission reduction rate of 43 percent) and annual VOC emissions in the PEMA by 41 percent (versus the predicted overall emission reduction rate of 36 percent) by 2010, from 1990 levels.

Figure 18. U.S. NO_x and VOC PEMA Emissions and Projections



Note: Emissions projections assume implementation of the Clean Air Interstate Rule (CAIR).

Source: EPA, 2008

Reporting PEMA Emissions



JOINT COMMITMENT

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.
- 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 is a comprehensive air pollutant emissions inventory that contains facility emissions reported under the NPRI mandatory reporting program. Facilities are required to report emissions of ground-level ozone and components of smog, such as NO_x, VOCs, SO₂, total PM, PM₁₀, PM_{2.5}, and CO to Environment Canada. The reported information by facility is publicly available on the Environment Canada Web site at <www.ec.gc.ca/pdb/npri/npri_home_e.cfm>.

The compilation of the comprehensive 2006 air pollutant emissions inventory has been completed, and the emission data have been included in the 2008 Progress Report. The 2006 emissions inventory, along with updates to emission trends (1990 to 2006), are available, and new emission projections (2010 to 2020) will be available in late 2008 on Environment Canada's Web site at <www.ec.gc.ca/pdb/cac/cac_home_e.cfm>.

The air pollutant emissions inventory has been revised to include new 2005 and 2006 emission estimates, as well as updates to the on-road and nonroad transportation sectors and the solvent utilization sector. The new estimates for the nonroad sector include the results of joint Canada–U.S. work on marine transportation sources such as ships and tankers.

The 2002 emissions inventory is the current baseline for joint air quality modeling activities between the two countries. New emissions inventory modeling files for 2005 are available including updated temporal and speciation information.

In the United States, EPA developed 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. The NEI includes both criteria pollutants and hazardous air pollutants. The emissions data in this 2008 Progress Report include 2006 projections based on extrapolations of 2005 NEI data and also represents monitored, source-reported emissions under the U.S. ARP and NBP through 2007. The U.S. regulations require that states report emissions from all sources once every three years; the next comprehensive U.S. emissions inventory will be for 2008 and will be issued in 2010.

Table 1 shows preliminary Canadian and U.S. emissions in the PEMA for 2006 for NO_x and VOCs. Figures 19 and 20 show U.S. emission trends in these areas for 1990 through 2006. 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 utilities. Over this same period, the reductions in VOC emissions are primarily from on-road mobile sources and solvent utilization. VOC emissions from non-industrial fuel combustion increased after 1998 and then returned to a downward trend by 2000, but saw a significant spike upward in 2001. The general rise in VOC emissions from 2001 to 2002 is due to emission changes—including improved characterization—for non-industrial fuel combustion (e.g., commercial and institutional sources such as schools, hospitals, and office buildings), petroleum refining, solvent utilization, nonroad mobile sources, residential wood combustion, and wildfires.



Table 1. PEMA Emissions, 2006

Emissions Category	2006 Annual				2006 Ozone Season			
	NO _x		VOCs		NO _x		VOCs	
	(1000 tons)	(1000 tonnes)	(1000 tons)	(1000 tonnes)	(1000 tons)	(1000 tonnes)	(1000 tons)	(1000 tonnes)
Canadian PEMA Region: Annual and Ozone Season Emissions								
Industrial	149	135	100	91	59	54	45	41
Non-Industrial Fuel Combustion	44	40	96	87	10	9	0	0
Electric Power Generation	52	47	0	0	22	20	0	0
On-Road Transportation	261	238	123	112	118	107	53	48
Nonroad Transportation	292	266	189	172	142	129	91	83
Solvent Utilization	0	0	254	231	0	0	109	99
Other Anthropogenic Sources	4	4	101	92	2	2	43	39
Forest Fires	0	0	0	0	0	0	0	0
Biogenics	-	-	-	-	-	-	-	-
TOTALS	803	730	863	784	353	321	342	311
TOTALS without Forest Fires and Biogenics	803	730	863	784	353	321	342	311
U.S. PEMA States: Annual and Ozone Season Emissions								
Industrial Emissions	627	569	262	238	261	237	109	99
Non-Industrial Fuel Combustion	384	348	791	717	160	145	330	299
Electric Power Generation	1,363	1,236	17	15	568	515	7	6
On-Road Transportation	2,093	1,899	1,359	1,233	872	791	566	514
Nonroad Transportation	1,286	1,167	1,059	960	536	486	441	400
Solvent Utilization	0	0	1,735	1,574	0	0	723	656
Other Anthropogenic Sources	61	55	557	505	25	23	232	210
Forest Fires *	0	0	1	1	0	0	1	1
Biogenics *	151	137	4,605	4,178	0	0	4,017	3,644
TOTALS	5,965	5,412	10,386	9,422	2,423	2,198	6,426	5,830
TOTALS without Forest Fires and Biogenics	5,814	5,275	5,779	5,243	2,423	2,198	2,408	2,185

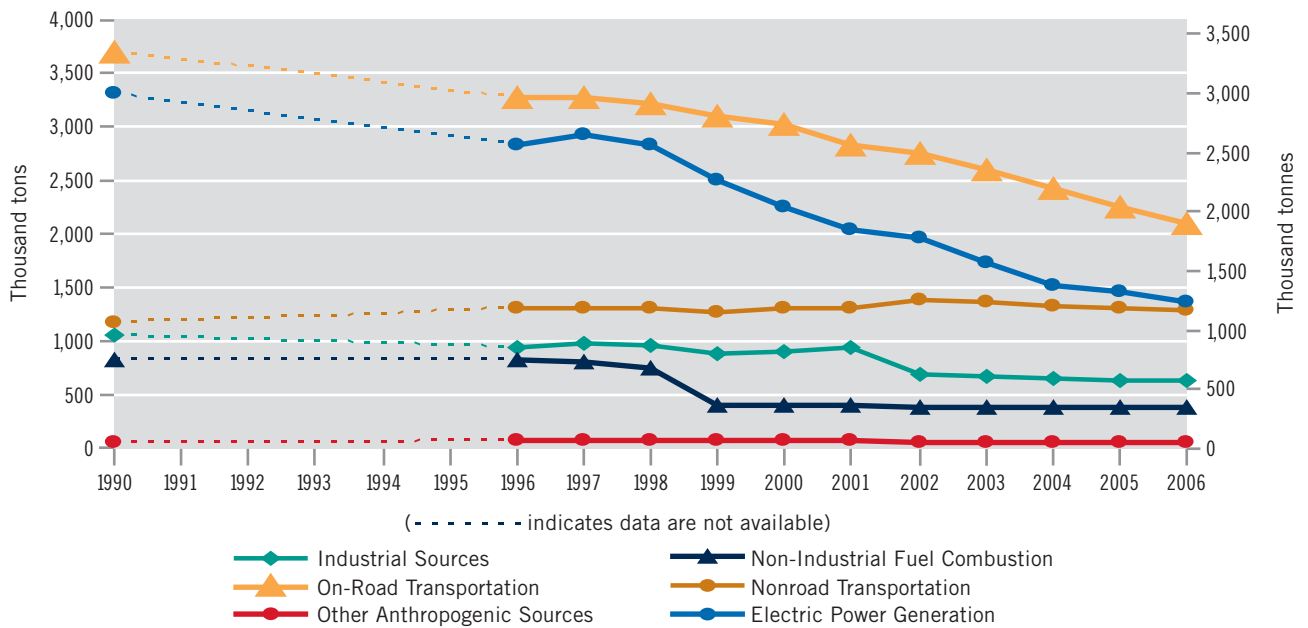
* Data are for 2002

Note: Tons and tonnes are rounded to the nearest thousand. Totals in final rows might not equal the sum of individual columns due to rounding.

Source: EPA, 2008



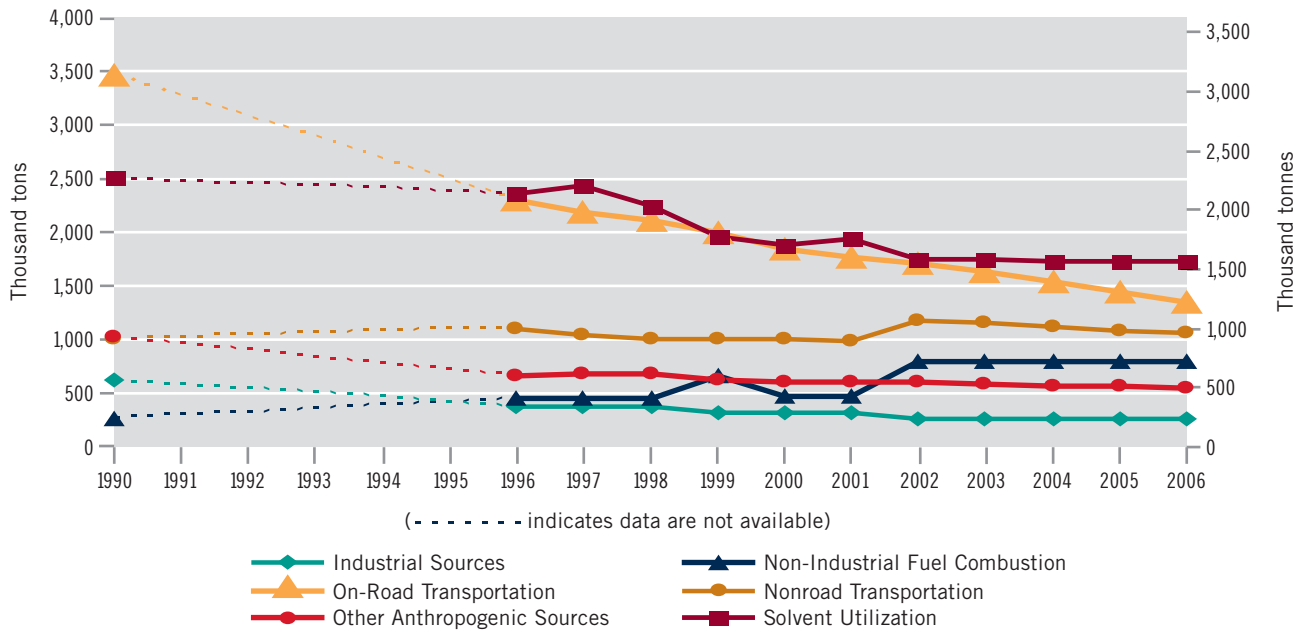
Figure 19. U.S. NO_x Emission Trends in PEMA States, 1990–2006



Note: The scales in Figures 19-20 and 21-22 are significantly different.

Source: EPA, 2008

Figure 20. U.S. VOC Emission Trends in PEMA States, 1990–2006



Note: The scales in Figures 19-20 and 21-22 are significantly different.

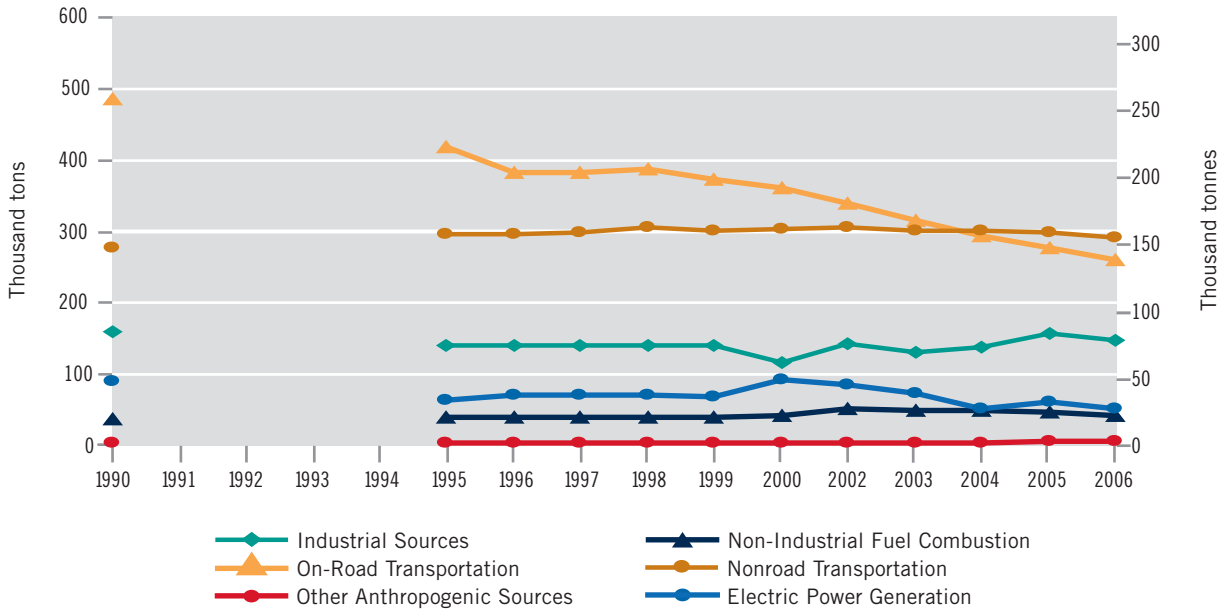
Source: EPA, 2008



Figures 21 and 22 show Canadian NO_x and VOC PEMA emission trends for 1990 through 2006. For NO_x, most of the reductions come from on-road mobile sources and electric power generation, with increases in the non-industrial fuel combustion and nonroad sectors 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, and industrial sources, with increases in non-industrial fuel combustion and nonroad sectors.

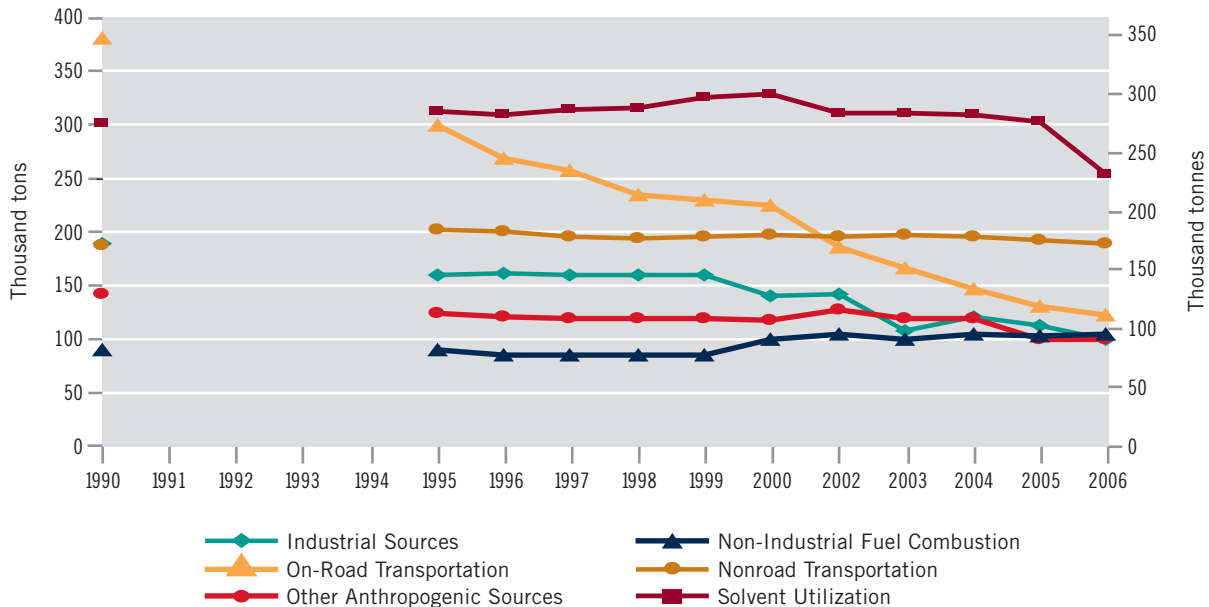
Figure 21. Canada NO_x Emission Trends in the PEMA Region, 1990–2006



Note: The scales in Figures 19-20 and 21-22 are significantly different.

Source: Environment Canada, 2008

Figure 22. Canada VOC Emission Trends in the PEMA Region, 1990–2006



Note: The scales in Figures 19-20 and 21-22 are significantly different.

Source: Environment Canada, 2008



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



JOINT
COMMITMENT

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 for 2006.

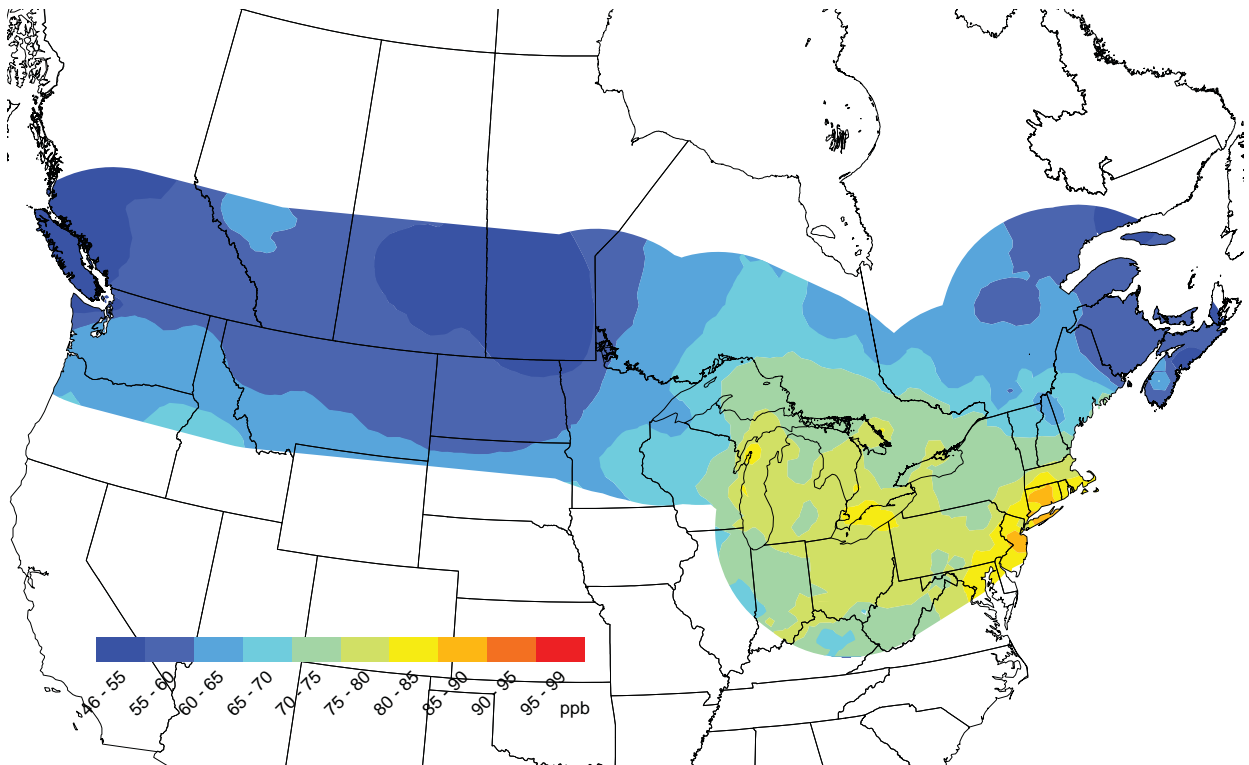
Ambient Levels of Ozone in the Border Region

Figure 23 illustrates ozone conditions in the border region in the metrics of national standards. The reference period is 2004 through 2006. Only data from sites within 500 km (310 miles) of the Canada–

U.S. border that met data completeness requirements were used to develop this map.

Figure 23 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 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 (ppb by volume) be based on 75 percent or more of all possible daily values during the EPA-designated ozone monitoring seasons.

Figure 23. Ozone Concentrations along the Canada–U.S. Border (Three-Year Average of the Fourth Highest Daily Maximum 8-Hour Average), 2004–2006



Note: Data contoured are the 2004–2006 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.

Source: Environment Canada National Air Pollution Surveillance (NAPS) Network Database, 2008 (www.etc-cte.ec.gc.ca/naps/index_e.html); EPA Aerometric Information Retrieval System (AIRS) Database (www.epa.gov/air/data/index.html)



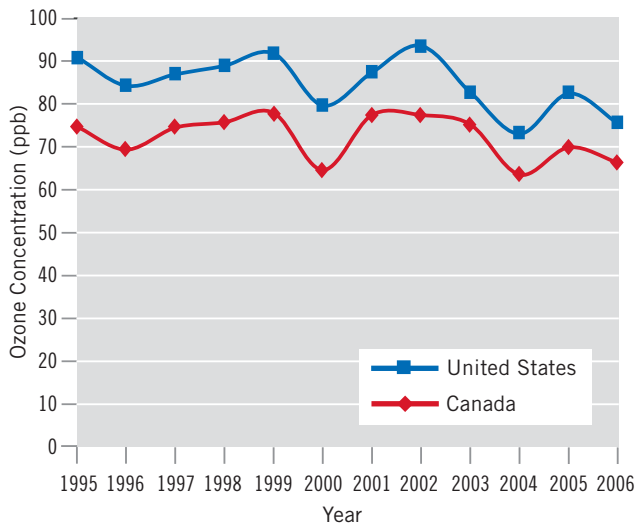
Ambient Concentrations of Ozone, NO_x, and VOCs

Annual ozone levels over time are presented in Figure 24, based on information from longer term eastern monitoring sites within 500 km (310 miles) of the Canada–U.S. border. Ozone levels have decreased over the period with a notable decline in ozone levels since 2002. The lower ozone levels shown for 2004 were due, in part, to the cool, rainy summer 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 24.

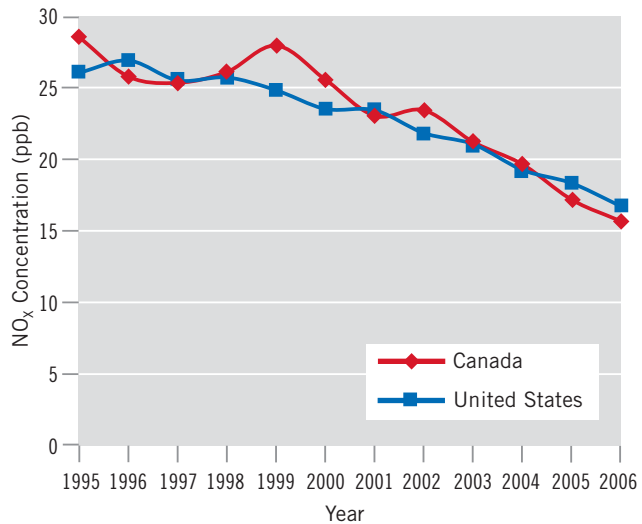
Figures 25 and 26 depict the average ozone season levels of ozone precursors NO_x and VOCs in the eastern United States and Canada. These measurements represent information from a more limited network of monitoring sites than is available for ozone. Figure 27 shows the network of monitoring sites actually used to create the trend graphs in Figures 24 through 26.

Figure 24. Annual Average Fourth Highest Maximum 8-Hour Ozone Concentration for Sites within 500 km of the Canada–U.S. Border, 1995–2006



Source: EPA and Environment Canada, 2008

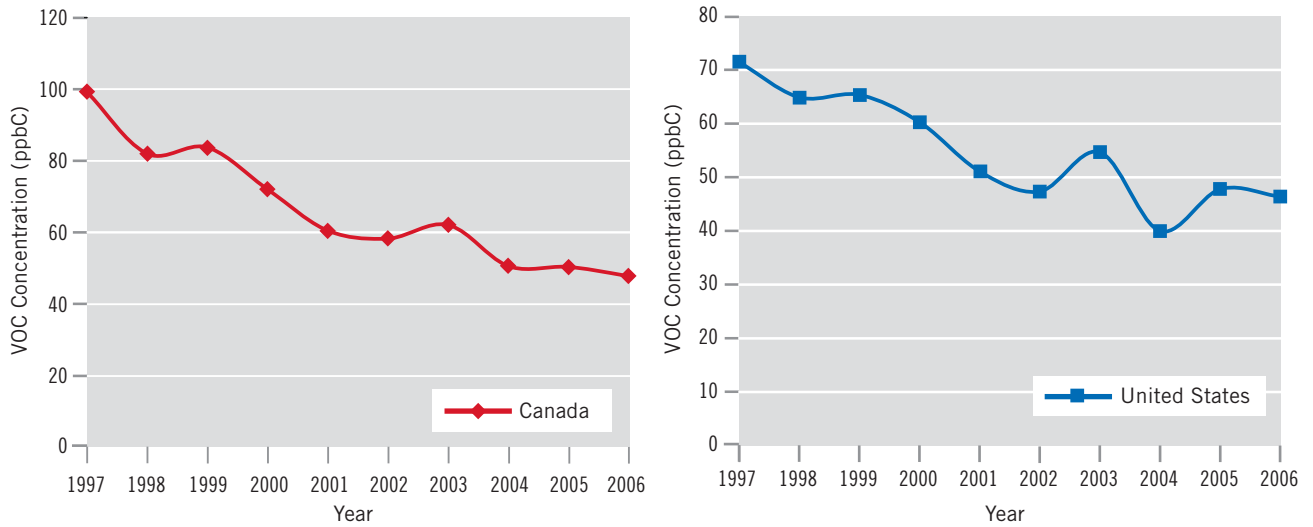
Figure 25. Average Ozone Season 1-Hour NO_x Concentration for Sites within 500 km of the Canada–U.S. Border, 1995–2006



Source: EPA and Environment Canada, 2008



Figure 26. Average Ozone Season 24-Hour VOC Concentration for Sites within 500 km of the Canada–U.S. Border, 1997–2006



Source: EPA and Environment Canada, 2008

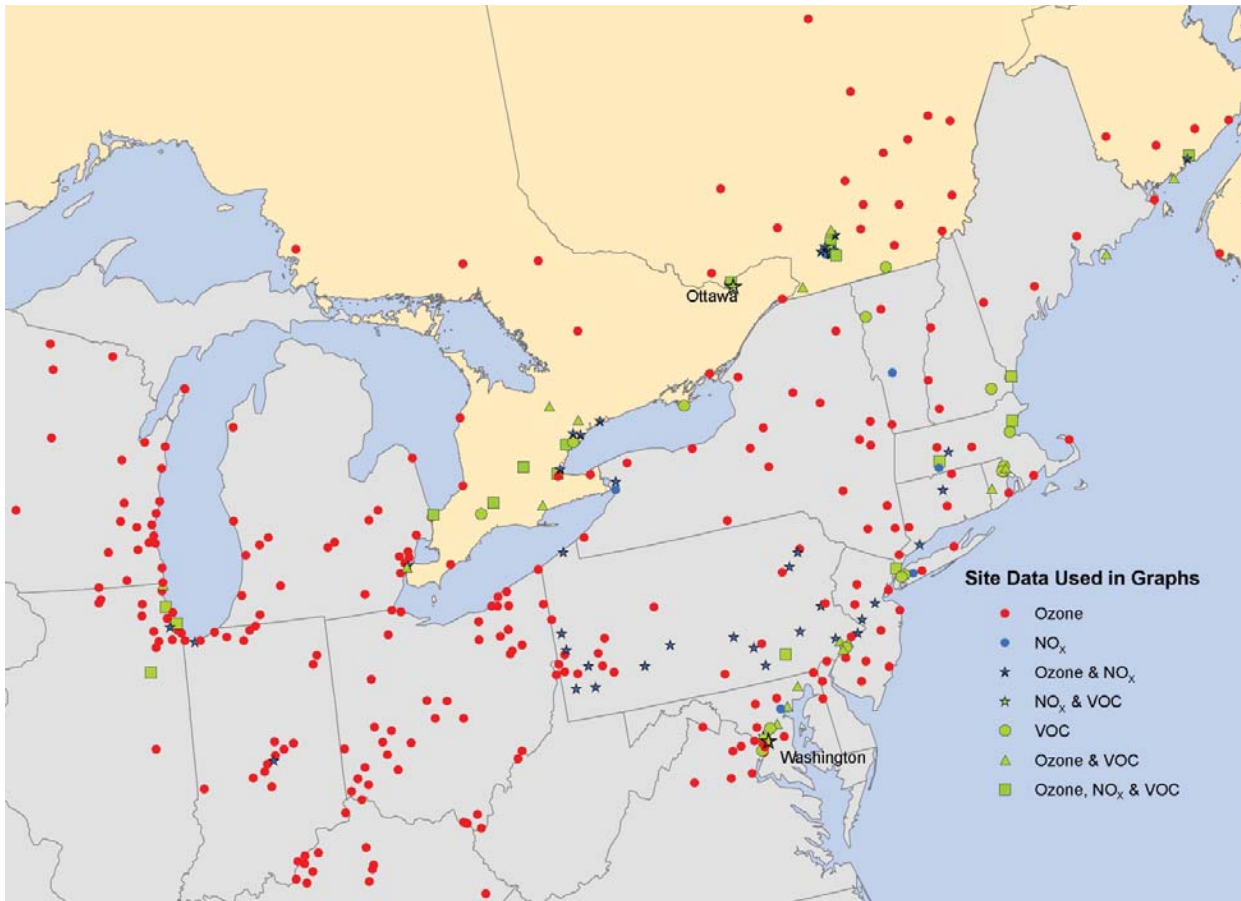
The data in Figures 25 and 26 represent measurements for the ozone season (i.e., May through September). Although NO_x and VOC concentrations have fluctuated over recent years, because VOC concentrations are influenced by temperature, these fluctuations are most likely due to varying meteorological conditions. 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.

Recently in the United States, there has been much investigation into the relationship between NO_x emission reductions under the NO_x SIP Call and

observed concentrations of ambient ozone in the states participating in the NBP. Generally, a strong association exists between areas with the greatest NO_x emission reductions and downwind monitoring sites measuring the greatest improvements in ozone. This suggests that, as a result of the NBP, transported NO_x emissions have been reduced in the East, contributing to ozone reductions that have occurred after implementation of the NBP. More information on the relationship between NO_x emissions and ambient ozone concentrations in the eastern United States is available in the NO_x Budget Trading Program 2007 Program Compliance and Environmental Results report available at www.epa.gov/airmarkets/progress/progress-reports.html.



Figure 27. Network of Monitoring Sites Used to Create Graphs of Ambient Ozone, NO_x, and VOC Levels



Source: EPA and Environment Canada, 2008

New Actions on Acid Rain, Ozone, and Particulate Matter



CANADA

The federal government's clean air initiative, *Turning the Corner: An Action Plan to Reduce Greenhouse Gases and Air Pollution*, includes a regulatory framework for air emissions that sets out proposed mandatory and enforceable reductions in emissions of air pollutants and greenhouse gases from industrial sectors, and sets out regulatory and other actions plans for transportation and consumer and commercial products. In addition to delivering measurable overall health and environmental benefits, the expected reductions in SO₂ and NO_x emissions from industry and transportation will lead to reductions in acid deposition and improvements in visibility.

The industrial component of the regulatory framework included fixed emissions caps for PM, NO_x, SO₂, and VOCs from key industrial sectors, including: base metals smelting; electricity generation; oil and gas; pulp and paper; petroleum refining; iron and steel; iron ore pelletizing; and cement, lime, and chemicals. The proposed targets reflect leading international benchmarks, adjusted for Canadian circumstances where required, and would enter into force in 2012–2015. The validation of the proposed targets with industry, provinces and territories, and other stakeholders, including the exact time of entry into force, is currently ongoing.



The government has also committed to setting national air quality objectives to complement the emission regulations and support improving air quality across Canada. The proposed framework would be reviewed every five years to assess the effectiveness of measures taken to reduce air pollutant emissions relative to the goal of achieving tangible benefits for the health of Canadians and their environment.

For more information on the Regulatory Framework, see <http://www.ec.gc.ca/default.asp?lang=En&n=714D9AAE-1&news=4F2292E9-3EFF-48D3-A7E4-CEFA05D70C21>.

In June 2008, the province of British Columbia released the *BC Air Action Plan*, which directly targets

emission sources that contribute to the formation of ground-level ozone and fine particulate matter in three areas: transportation, industry, and communities. Highlights of the 28 actions in the plan include: promoting a provincewide anti-idling campaign, retrofitting older heavy-duty diesel vehicles, supporting greener ports and marine vessels, eliminating beehive burners, encouraging companies to use cleanest available pollution-control technologies, replacing wood stoves with cleaner alternatives, and implementing a provincial smoke management plan to improve burning practices. Some of the actions have already been initiated, and all are expected to be in place by 2009.

Ozone Standards and Implementation



Due to recent research on health effects from ozone, on March 12, 2008, EPA promulgated a new tighter primary and secondary NAAQS for ozone of 0.075 ppm, with an 8-hour average. The Clean Air Act requires EPA to designate areas as attainment (meeting the standards), nonattainment (not meeting the standards), or unclassifiable (insufficient data to classify) after the Agency sets a new standard or revises an existing standard. For more information on the revised ozone standards please visit www.epa.gov/air/ozonepollution/actions.html.

EPA plans to issue a proposed monitoring rule in late 2008 and final rule in early 2009 to implement the new standards.

Particulate Matter Standards and Implementation

EPA established the NAAQS for PM_{2.5} in 1997 to provide additional protection from the adverse health effects of particles. The Clean Air Act requires EPA to review each air quality standard every five years in light of related new scientific studies. In October 2006, EPA completed another review of the PM standards. The Agency maintained the annual PM_{2.5}

standard at 15 micrograms per cubic meter ($\mu\text{g}/\text{m}^3$) and established a more protective 24-hour standard at 35 $\mu\text{g}/\text{m}^3$ (both with the same three-year form as the 1997 standards). EPA also decided to retain the existing 24-hour PM₁₀ standard of 150 $\mu\text{g}/\text{m}^3$. Due to a lack of evidence linking health problems to long-term exposure to coarse particle pollution, the Agency revoked the annual PM₁₀ standard. The revised standards and related information can be found at www.epa.gov/pm/standards.html.

In April 2005, EPA designated 39 U.S. areas as nonattainment 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 the northwestern United States. States had until April 2008 to submit SIPs (which include strategies and regulations for reducing emissions of PM_{2.5} and its precursors) to EPA. Attainment of the standards is to be as expeditious as practicable, with a presumptive attainment date within five years of designation (April 2010). At the time it approves a state plan, however, EPA can grant an attainment date extension of one to five years if a state provides a demonstration showing that attainment within five years is not practicable based on the severity of the air quality problem or the feasibility of emission controls. The March 2007 Clean Air Fine Particle Implementation Rule provides



guidance to the states for developing their plans and can be found at <www.epa.gov/pm/actions.html>.

Following the revision of the 24-hour PM_{2.5} standard in October 2006, EPA began efforts to designate additional areas as nonattainment for the PM_{2.5} standards. The states submitted recommended “nonattainment” boundaries to EPA in December 2007. Nonattainment area boundaries are established based on several factors, such as emissions and air quality data, population density, traffic patterns, and growth rates. For additional information on the procedures for establishing these boundaries, please visit <www.epa.gov/ttn/oarpg>. On August 19, 2008, EPA sent letters responding to recommendations from the governor of each state explaining EPA’s intended area designations for the revised 24-hour PM_{2.5} standard. EPA plans to finalize the area designations in December 2008, after considering any additional information provided by the states. States with newly designated nonattainment areas will then have three years to develop plans designed to achieve clean air in compliance with the 2006 standards.

A number of programs have been established to reduce emissions of fine particles and precursor pollutants from important sources such as on-road and nonroad vehicle engines and power plants. The Clean Air Nonroad Diesel Rule, finalized in May 2004, is an important federal regulation that will lead to future reductions in particle pollution. Under the Clean Air Nonroad Diesel Rule, Tier 4 standards for new nonroad diesel engines will be phased in from 2008 to 2014, leading to significant public health benefits as older nonroad engines are replaced. The sulfur content in nonroad diesel fuel will be reduced by 99 percent to 15 ppm by 2010.

In 2007, EPA initiated the next review of the current PM NAAQS, which will be completed in 2011. More information, including supporting documents, can be found at <www.epa.gov/ttn/naaqs/standards/pm/s_pm_index.html>.

Clean Air Interstate Rule (CAIR)

Building on the ARP and NBP, CAIR was issued on March 10, 2005. When fully implemented, CAIR would reduce SO₂ emissions across 28 eastern states and the District of Columbia by more than 70 percent and NO_x emissions by more than 60 percent from 2003 levels. CAIR would deliver steep and sustained reductions in air pollution, as well as dramatic health benefits at more than 25 times greater than the cost by 2015.

CAIR is made up of three separate federal cap and trade programs to achieve the required emission reductions: an annual NO_x program, an ozone season NO_x program, and an annual SO₂ program. Each of the programs uses a two-phased approach, with declining emission caps based on highly cost-effective controls on power plants. The first phase was scheduled to begin in 2009 for the NO_x annual and NO_x ozone season programs, and in 2010 for the SO₂ annual program. The second

phase for all three programs was slated for 2015. States affected under the NO_x programs began monitoring in 2008. In 2009, NBP states affected under CAIR would transition to the CAIR ozone season NO_x program. For more information please visit <www.epa.gov/cair/>.

CAIR was challenged in federal court in 2005, and a decision was issued on July 11, 2008, vacating the rule in its entirety. Because of the importance of the case and the complexity of the issues that the decision raises, the U.S. government sought and obtained an extension until September 24 to decide whether to appeal. As of the date of publication of this report, in addition to considering appeal options, the U.S. government is continuing to evaluate alternative ways to achieve the emission reductions and health benefits that CAIR would have provided.



SECTION 2:

Related Air Quality Efforts

New England Governors and Eastern Canadian Premiers

The Conference of New England Governors and Eastern Canadian Premiers (NEG/ECP) is a unique international relationship of six New England state governors (from Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont) and five eastern Canadian premiers (from New Brunswick, Newfoundland and Labrador, Nova Scotia, Prince Edward Island, and Quebec). The conference was created in 1973 and addresses many topics, including the environment, economic development, tourism, energy, fisheries, trade, and agriculture.

At the June 2007 meeting of the NEG/ECP, governors and premiers established a standing committee to draft a regional Transportation and Air Quality Action Plan and to begin implementing the following action items:

- Support development of environmentally friendly biofuels by assessing new technologies and local feedstocks.
- Promote fuel efficiency in all modes of transportation.
- Expand alternative transportation and commuter services.
- Align infrastructure funding with energy and climate goals.
- Seek new opportunities to enhance regional interconnectivity and efficiency of regional freight networks.
- Seek to adopt CO₂ and air quality standards, such as the California standards, for cars throughout the region.

The NEG/ECP developed its Acid Rain Action Plan in 1998, and activities under this plan have been carried out by the Acid Rain and Air Quality Steering Committee. Recent highlights of this work and other work of the NEG/ECP can be found at www.cap-cpma.ca/.



PM Annex Negotiations

Both Canada and the United States have committed to reducing cross-border air pollution and recognize the significant human health and ecosystem effects (including acid rain and regional haze) associated with $PM_{2.5}$ and its precursors. Both countries are committed to negotiating the addition of a Particulate Matter (PM) Annex to the United States–Canada Air Quality Agreement while actively developing and implementing emission reduction programs to reduce fine particle concentrations.

The United States and Canada have held two negotiating sessions on a PM Annex under the United States–Canada Air Quality Agreement: one in November 2007 and one in May 2008. Substantial progress was made during the most recent session, particularly with respect to several elements of the annex such as the:

- Purpose Statement.
- Pollutants of Concern—the annex will address primary $PM_{2.5}$ and two secondary precursors, SO_2 and NO_x .
- Definitions of the PEMAs for both countries—Canada indicated that its PEMA would consist of Canada as a whole, while the U.S. PEMA would include 28 states across the northern part of the country.
- Mobile source commitments that could be included as part of the emission reduction commitments, in recognition of the fact that transportation is a major contributor to particulate matter.

Intersessional work is continuing in preparation for the next negotiating session. This includes:

- Finalizing the Purpose Statement.
- Developing annex language on mobile source commitments with emphasis on temporal alignment.
- Assessing ambient monitoring networks for PM and visibility in both countries.
- Sharing information about emissions monitoring and reporting requirements for stationary sources, including measurement of condensable $PM_{2.5}$ emissions.
- Collaborating on visibility issues (e.g., U.S. participation in the July 2008 Environment Canada visibility monitoring workshop in British Columbia; Canadian participation in a planned U.S. workshop on urban visibility issues).

Discussions continued as part of the November 2008 United States–Canada Air Quality Committee meeting.



SECTION 3: Scientific and Technical Cooperation and Research

Emission Inventories and Trends



JOINT
EFFORTS

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. The inventories and projections are available at www.epa.gov/ttn/chief/eiinformation.html. These emission inventories were also processed for U.S. and Canadian air quality models to support the technical

assessment of air quality problems. In the United States, the most recent complete emission inventory data are for the year 2005. The 2006 emission data in this 2008 Progress Report were developed as an interpolation between the 2005 NEI and a 2009 projection inventory. The 2009 projection inventory was originally prepared for possible inclusion with the emissions processing and air quality modeling in support of future EPA regulatory analyses (available at www.epa.gov/ttn/chief/emch), see CAP 2002-Based Platform, Version 3).

Both countries were active participants in the NARSTO (formally known as North American Research Strategy for Tropospheric Ozone) emission inventory assessment, which was completed in summer 2005. The final report is titled, *Improving Emission Inventories for Effective Air Quality Management Across North America*. This report

includes recommendations for the long-term improvement of the emission inventory programs in both Canada and the United States, as well as in Mexico, the third participant in NARSTO.

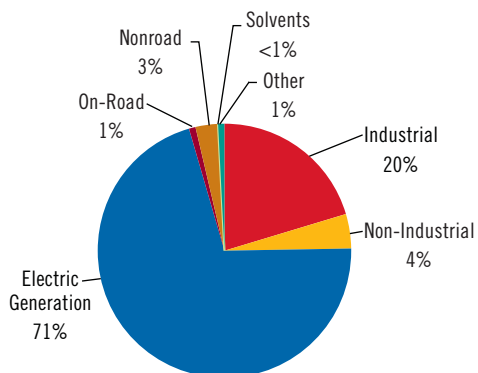
Emission data for both countries for 2006 are presented in Figures 28, 29, 30, and 31. Figure 28 shows the distribution of emissions by source category grouping for SO_2 , NO_x , and VOCs. The following observations can be made from this figure:

- SO_2 emissions in the United States stem primarily from coal-fired combustion in the electric power sector. Canadian SO_2 emissions come mostly from smelters in the industrial sector, with lower emissions from the electric power sector, due to the large hydroelectric and nuclear capacity in Canada. 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 (35 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, solvents contribute the highest percentage (26 percent) of VOCs.

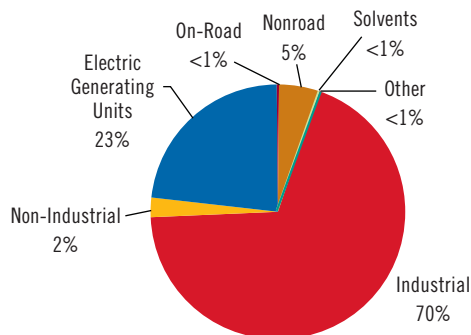


Figure 28. U.S. and Canadian National Emissions by Sector for Selected Pollutants, 2006

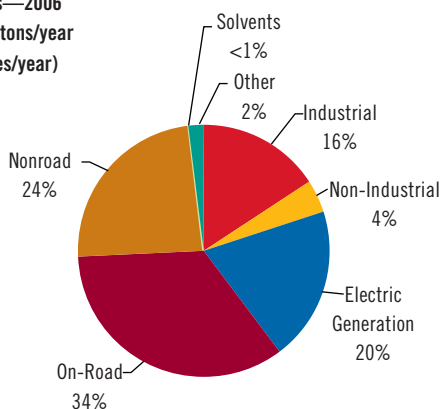
U.S. SO₂ Emissions—2006
 Total: 13.3 million tons/year
 (12.0 million tonnes/year)



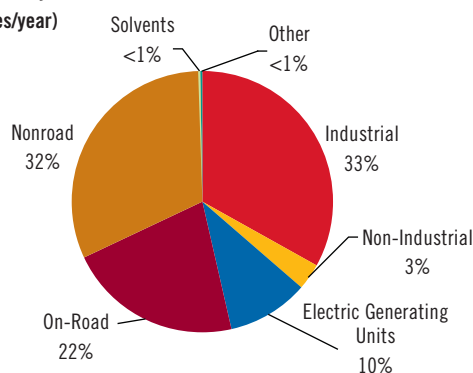
Canadian SO₂ Emissions—2006
 Total: 2.0 million tons/year
 (2.2 million tonnes/year)



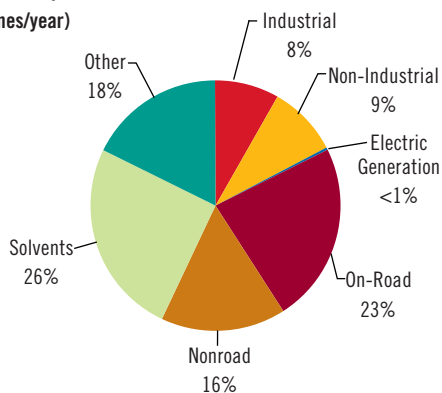
U.S. NO_x Emissions—2006
 Total: 17.4 million tons/year
 (15.8 million tonnes/year)



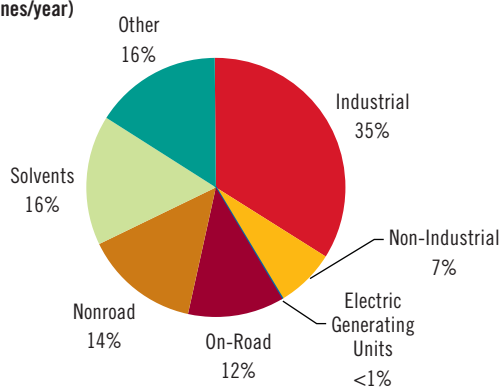
Canadian NO_x Emissions—2006
 Total: 2.4 million tons/year
 (2.6 million tonnes/year)



U.S. VOC Emissions—2006
 Total: 16.7 million tons/year
 (15.2 million tonnes/year)



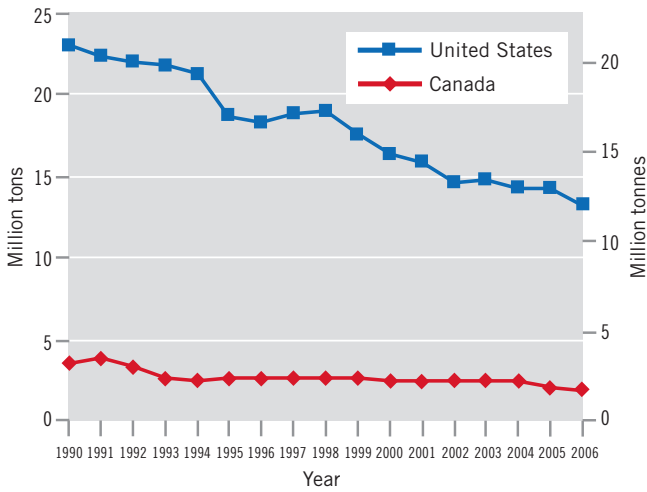
Canadian VOC Emissions—2006
 Total: 2.7 million tons/year
 (2.9 million tonnes/year)



Source: EPA and Environment Canada, 2008

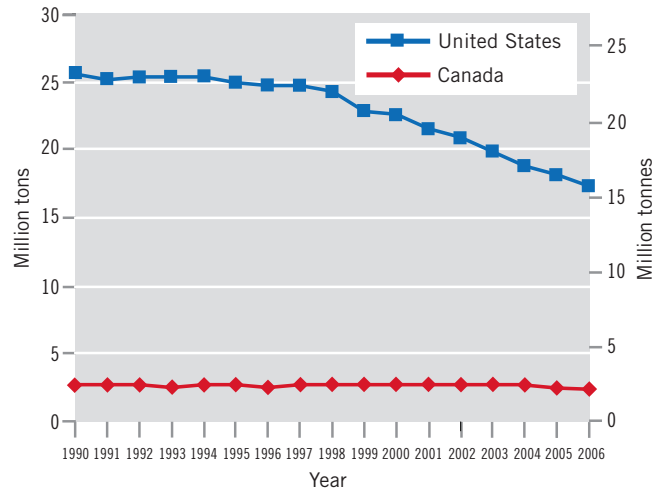


Figure 29. National SO₂ Emissions in the United States and Canada from All Sources, 1990–2006



Source: EPA and Environment Canada, 2008

Figure 30. National NO_x Emissions in the United States and Canada from All Sources, 1990–2006

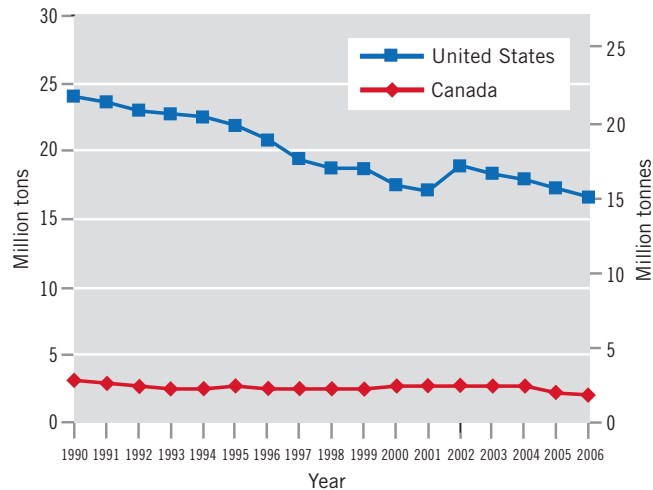


Source: EPA and Environment Canada, 2008

The emission trends reflected in Figures 29, 30, and 31 for SO₂, NO_x, and VOCs, respectively, show emissions from 1990 through 2006. In the United States, the major reductions in SO₂ emissions came from electric power generation sources. For NO_x, the reductions came from on-road mobile sources and electric power generation sources. For VOCs, the reductions were from on-road mobile sources, waste disposal and recycling, and chemical and allied products manufacturing and use.

Both countries have seen major reductions in SO₂ emissions. In Canada, the reductions in SO₂ emissions came from base metal smelters in the industrial sector. For NO_x, the reductions were from on-road mobile sources, electric power generation sources, and industrial sources. For VOCs, the reductions came from electric power generation sources, on-road mobile sources, and solvent utilization.

Figure 31. National VOC Emissions in the United States and Canada from All Sources, 1990–2006



Source: EPA and Environment Canada, 2008



Air Quality Mapping, Monitoring, and Reporting

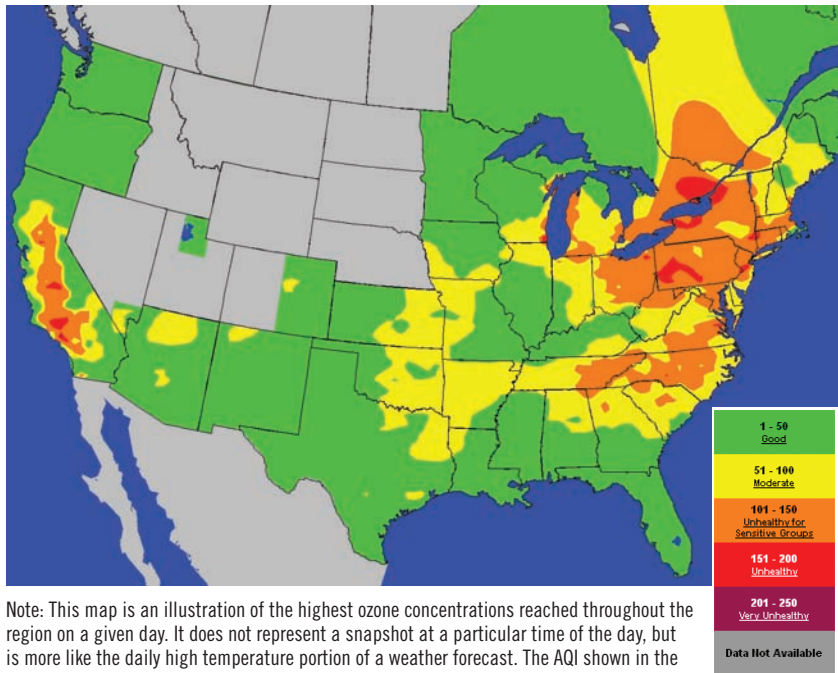


JOINT EFFORTS

Each country is responsible for ensuring instrument calibration and comparability of measurements of ozone and PM. Since 2001, the jurisdictions in the United States and Canada have collaborated to contribute to the EPA-led AIRNow program (www.airnow.gov). In 2004, the Web site was expanded to provide information on PM and ozone measurements on a continental scale year-round. Figure 32 is an example of the Air Quality Index (AQI) based on

ozone concentration data available for portions of the United States and Canada on the AIRNow Web site. Canadian and U.S. efforts continue to improve air quality characterization by combining measurements with numerical forecasts from the operational air quality forecasting model. Each country is improving air quality forecasting services. In addition, the two countries are continuing to develop national air quality forecast models. Jurisdictions consult in preparing routine forecasts for border regions and in developing communication materials for the public.

Figure 32. 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: EPA, 2008



CANADA

Environment Canada continues to expand and refurbish federal and provincial/territorial networks of monitoring stations across the country. Canada maintains two national ambient

air quality monitoring networks—the NAPS Network and the CAPMoN. Information about these networks can be found at www.etc-cte.ec.gc.ca/NapsStations/Default.aspx and www.msc-smc.ec.gc.ca/capmon/index_e.cfm.



Between 2002 and 2007, \$10.9 million was invested in new and replacement monitoring equipment. There also were significant investments in the associated laboratories. There are currently 231 ozone monitors and 242 continuous PM_{2.5} monitors reporting to NAPS. In addition, there are 41 filter-based samplers reporting PM_{2.5} on a one-in-three-day basis. Environment Canada has developed a chemical speciation network to characterize PM_{2.5}. Seventeen sites are now operating across Canada.

CAPMoN currently operates 18 ozone monitors, eight of which are within 500 km (310 miles) of the Canada-U.S. border, to characterize regionally representative air quality. Integrated PM_{2.5} and PM₁₀

mass measurements, as well as PM speciation measurements on a one-in-three-day schedule, were initiated at five monitoring sites between 2004 and 2005. VOCs are also being measured at the same five CAPMoN sites. Reactive nitrogen compounds, including nitric oxide (NO), total oxidized nitrogen (NO_y), and NO₂, are being measured at three sites—the Centre for Atmospheric Research, Egbert, Ontario; Kejimikujik, Nova Scotia; and Saturna Island, British Columbia.

The ozone monitors at the 18 CAPMoN sites also continue to gather data in real time, in support of the Air Quality Prediction Program, and for distribution to the EPA-led AIRNow program.

Existing Networks



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 categories 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 (EPA, NPS, the National Oceanic and Atmospheric Administration, 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 (SLAMS).
- Human exposure assessment for health research studies.

- Public air quality reporting and forecasting (AQI/AIRNow).
- Accountability of control strategies (ARP, NO_x SIP Call, and NBP).
- Model evaluation.
- Determination of source receptor relationships.
- Characterization of regional air masses, 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, research.

A summary of monitoring networks is provided in Table 2.



Table 2. U.S. Air Quality Monitoring Networks

MAJOR ROUTINE OPERATING AIR MONITORING NETWORKS: State / Local / Tribal/ Federal Networks				
Network ¹	Sites	Initiated	Measurement Parameters	Source of Information and/or Data
Urban/Human-Health Monitoring				
NCore ² —National Core Monitoring Network	75 planned	2008	O ₃ , NO/NO ₂ /NO _y , SO ₂ , CO, PM _{2.5} /PM _{10-2.5} ³ , PM _{2.5} speciation, NH ₃ , HNO ₃ , Surface Meteorology ⁴	www.epa.gov/ttn/amtic/monstratdoc.html
SLAMS—State and Local Ambient Monitoring Stations	~3000	1978	O ₃ , NO _x /NO ₂ , SO ₂ , PM _{2.5} /PM ₁₀ , CO, Pb	www.epa.gov/ttn/airs/airsaqs/aqsweb/aqswebhome.htm
CSN—PM _{2.5} Chemical Speciation Network	300	1999	PM _{2.5} , PM _{2.5} speciation, Major Ions, Metals	www.epa.gov/ttn/airs/airsaqs/aqsweb/aqswebhome.htm
PAMS—Photochemical Assessment Monitoring Network	75	1994	O ₃ , NO _x /NO _y , CO, Speciated VOCs, Carbonyls, Surface Meteorology ⁴ , Upper Air	www.epa.gov/ttn/airs/airsaqs/aqsweb/aqswebhome.htm
Rural/Regional Monitoring				
IMPROVE—Interagency Monitoring of Protected Visual Environments	110 plus 67 protocol sites	1988	PM _{2.5} /PM ₁₀ , Major Ions, Metals, Light Extinction, Scattering Coefficient	http://vista.cira.colostate.edu/IMPROVE/
CASTNET—Clean Air Status and Trends Network	80+	1987	O ₃ , weekly concentrations of SO ₂ , HNO ₃ , SO ₄ ²⁻ , NO ₃ ⁻ , Cl ⁻ , NH ₄ ⁺ , Ca ²⁺ , Mg ²⁺ , Na ⁺ , K ⁺ for Dry and Total Deposition, Surface Meteorology ⁴	www.epa.gov/castnet/
GPMP—Gaseous Pollutant Monitoring Program	33	1987	O ₃ , NO/NO/NO ₂ , SO ₂ , CO, Surface Meteorology ⁴ , 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#data
NADP/NTN—National Atmospheric Deposition Program/ National Trends Network	250+	1978	Precipitation Chemistry and Wet Deposition for Major Ions (SO ₄ ²⁻ , NO ₃ ⁻ , NH ₄ ⁺ , Ca ²⁺ , Mg ²⁺ , Na ⁺ , K ⁺ , H ⁺ as pH)	http://nadp.sws.uiuc.edu/
NADP/MDN Mercury Deposition Network	100+	1996	Mercury measured in precipitation and Wet Deposition	http://nadp.sws.uiuc.edu/mdn/
IADN—Integrated Atmospheric Deposition Network	20	1990	PAHs, PCBs, and organochlorine compounds are measured in air and precipitation	www.epa.gov/glnpo/monitoring/air/
Air Toxics Monitoring				
NATTS—National Air Toxics Trends Stations	23	2005	VOCs, Carbonyls, PM ₁₀ metals ⁵ , Hg	www.epa.gov/ttn/airs/airsaqs/aqsweb/aqswebhome.htm
State/Local Air Toxics Monitoring	250+	1987	VOCs, Carbonyls, PM ₁₀ metals ⁵ , Hg	www.epa.gov/ttn/airs/airsaqs/aqsweb/aqswebhome.htm
NDAMN—National Dioxin Air Monitoring Network	34	1998 - 2005	CDDs, CDFs, dioxin-like PCBs	http://cfpub2.epa.gov/ncea/cfm/recordisplay.cfm?deid=22423

Notes:

1. 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.
2. NCore is a network proposed to replace NAMS, as a component of SLAMS; NAMS are currently designated as national trends sites.
3. PM_{10-2.5}—proposed new NAAQS.
4. Surface Meteorology includes wind direction and speed, temperature, precipitation, relative humidity, and solar radiation.
5. PM₁₀ metals may include arsenic, beryllium, cadmium, chromium, lead, manganese, nickel, and others.



Recent Developments

EPA has developed a National Ambient Air Monitoring Strategy for state, local, and tribal agencies and introduced a new multipollutant monitoring network referred to as NCore. Monitors at NCore sites will measure particles ($PM_{2.5}$, speciated $PM_{2.5}$, $PM_{10-2.5}$, speciated $PM_{10-2.5}$), ozone, SO_2 , CO, NO_x ($NO/NO_2/NO_y$), and basic meteorology. It is anticipated that ammonia and nitric acid measurements will also be made after further methods development. Sites will be placed in broadly representative urban (about 55 sites) and rural (about 20 sites) locations throughout the country. EPA will collaborate on site selection with individual state and local agencies and multistate organizations. Where possible, states will locate urban NCore sites next to existing monitoring operations, including PAMS or National Air Toxic Trends Stations (NATTS) sites, to leverage existing resources. Similarly, EPA will coordinate with states and other existing monitoring network programs (i.e., IMPROVE, CASTNET) to establish rural-based NCore sites. The objective of this network is to gather additional information needed to support emissions and air quality model development, air quality program accountability, and future health studies. On October 17, 2006, EPA finalized revisions to the ambient air monitoring regulations that included requirements to reflect the NCore network, which is scheduled to be fully operational by January 1, 2011. Information on the NCore network is available at www.epa.gov/ttn/amtic/ncore/index.html.

EPA currently is transitioning the carbon measurement at CSN-speciated $PM_{2.5}$ stations to the IMPROVE protocol to support better comparability between the

CSN and IMPROVE networks. This effort is expected to be completed in 2009.

EPA is supporting two new initiatives in collaboration with NADP to help further characterize air quality and deposition. One involves implementing a pilot network of 20 sites that sample ammonia concentrations on a half-week basis using passive samplers. The second initiative complements NADP's Mercury Deposition Network (MDN) and involves supporting development of an ambient speciated mercury network that will provide information on status and trends in mercury concentrations, dry deposition estimates, and information for model development and validation. Both efforts aim to utilize the NADP committee structure as a platform for initiation and continued growth. The NADP Web site contains data, maps, and program information (<http://nadp.sws.uiuc.edu>).

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 currently is evaluating monitoring methods that provide highly time-resolved (i.e., hourly) measurements of both gaseous (SO_2 , nitric acid, ammonia) and aerosol (sulfate, ammonium, nitrate, chloride, and other base cations) components. EPA is investigating a denuder-filterpack measurement method for integrated (24-hour interval) routine ammonia measurements. The Web site for CASTNET includes program information, data and maps, annual network reports, and quality assurance information, (see www.epa.gov/castnet).



Health Effects

Between 2003 and 2007, Health Canada carried out two research programs to characterize air pollution exposure and human health issues under the Canadian portion of the Border Air Quality Strategy, coordinated with research in the United States. Health Canada also continues to develop an air health indicator (AHI) for tracking the changes in health outcomes over time due to changing air quality. The Air Quality Health Index (AQHI) has completed its development phase and is being implemented across the country as a new index that presents the public with information on health risk in real time and as an air quality forecast.

Research in the Great Lakes Basin Airshed

The results of health-related research activities in the Great Lakes basin region included the following:

- **Windsor Children's Respiratory Health Study:** This three-phase study, conducted during 2004 and 2005, evaluated lung function in children exposed to a relatively high level of air pollution. Results indicate that neighborhood roadways, the majority of which are smaller local roads, might adversely influence respiratory symptoms and airway inflammation. Among children with a history of asthma, elevated pollutants in ambient air might contribute to decreased lung function and increased airway oxidative stress.
- **Windsor Exposure Assessment Study:** For this project, researchers performed a spatial assessment of air pollution in the Windsor region and monitored personal exposure to indoor and outdoor air pollution by healthy and non-smoking adults and asthmatic school children. The spatial analysis portion of the study was completed in 2006, and the results show that the spatial variability of air pollution in Windsor is dependant primarily on the local sources that emit the specific pollutants (e.g., NO₂ variation is primarily the result of local traffic emission sources).² The personal exposure portion of the study was completed in 2007, and the results suggest that



when increased air pollution occurs due to a smog episode, personal exposure and indoor air pollution levels also increase. Personal exposures to VOCs, such as benzene, are more likely to be a result of indoor sources than outdoor air pollution.

- **Long-term Exposure to Air Pollutants and Mortality and Morbidity Rates, Including Cancer:** This study compared mortality and morbidity rates for Windsor, Sarnia, and London since the late 1970s with the overall rates in Ontario province. Because of the availability of long-term air monitoring data in Windsor, the analysis on associations with air pollution focused on data from Windsor, Ontario. Results show that among adults in the Windsor area, mortality rates of circulatory diseases (including coronary heart disease), respiratory diseases (including bronchitis and emphysema), and lung cancer were statistically significantly higher in both men and women compared to Ontario average rates. Mortality rates for circulatory diseases, including coronary heart disease, and for chronic obstructive pulmonary disease and asthma in adults were statistically significantly higher in the high-SO₂ study area compared to the low-SO₂ study area. Among women, mortality rates for lung cancer were significantly higher in the high SO₂ study area than in the low SO₂ area. Total suspended particles were significantly associated with mortality rates, mainly for cardiovascular diseases. These results were presented at a public forum in Windsor, Ontario, in 2007. A more refined study is underway to adjust for the confounding effects of cigarette smoking and occupational exposure.

² Wheeler et al., 2008. Environmental Research, 106 (1): 7-16.



Research in the Georgia Basin–Puget Sound International Airshed

The University of British Columbia, the University of Victoria, and the University of Washington conducted health research in the Georgia Basin–Puget Sound International Airshed, coordinated through a partnership between Health Canada and the British Columbia Centre for Disease Control. The research included the following studies:

- **Establishing a Childhood Disease Cohort:** A birth cohort of 120,000 children born in the Georgia Basin airshed was established to evaluate the relationship between air pollution exposure and respiratory disorders. Analyses show that lifetime exposure to PM_{10} and NO_2 was significantly associated with an increased risk of bronchiolitis hospitalization; traffic as a source of air pollution appears to play an important role in elevated bronchiolitis hospitalization. The study found that male gender, aboriginal ethnicity, maternal smoking during pregnancy, and the existence of older siblings were significant risk factors for inflammation of the middle ear.
- **Birth Outcomes in the Greater Vancouver Regional District:** The British Columbia Perinatal Database Registry and the British Columbia Linked Health Database were used to relate maternal air pollution exposure during pregnancy and adverse birth outcomes. Results show that CO , NO , NO_2 , $PM_{2.5}$ and black carbon in ambient air, as well as distance to highway traffic, contributed to inter-uterus growth retardation and pre-term birth.³
- **Personal Exposures and Activity Patterns of Pregnant Women and Infants:** Data were collected on personal exposure, activity information, and traffic exposure for 62 pregnant women as a function of stage of pregnancy and season. Results showed that the pregnant women spent most of their time at or near home. Activities of women in the study support the use of home exposures as a proxy for their personal exposure. Modeled exposure generally underestimates personal exposure and

variability, and therefore, land-use regression models are unlikely to overestimate exposure in cohort studies. Gas stove presence in the home was significant in explaining the relationship between personal and predicted exposures for NO and NO_2 . Including work location information in the exposure assessment could improve estimates, because results suggest that primary air pollutant exposures occur both at home and at work.⁴

- **Walkability Study:** This geographic information system study integrated land use and transportation network information to link walkability and emissions exposure for eventual application to Vancouver and Seattle. This study provided a better understanding of the interface between air pollution exposure and the physical activity outcomes in relation to community design to more effectively implement healthy urban environments.
- **Particulate Matter Exposure and Infant Health in Puget Sound:** This study involved monitoring a birth cohort for traffic and wood smoke pollution using individualized geospatial exposure estimates to relate birth outcomes and air pollution. Results suggest that there is an increased risk of bronchiolitis hospitalization with increasing exposure to $PM_{2.5}$. Effect estimates were somewhat higher for longer term exposure windows than for acute exposure. Traffic as a source of air pollution appears to play an important role in elevated bronchiolitis hospitalization.

Canadian Air Quality Health Index

The AQHI, developed by Health Canada and Environment Canada, in collaboration with the provinces and key health and environment stakeholders, is a new public information tool that helps Canadians protect their health from the negative effects of air pollution on a daily basis. The AQHI is intended to replace AQIs currently in use for public reporting of air quality.

The new AQHI, which is based on epidemiological studies that relate air pollution to acute health outcomes, employs a linear, no-threshold

³ Brauer et al., 2008. *Environmental Health Perspectives*, 110: 680-686.

⁴ Nethery et al., 2007. *Occupational and Environmental Medicine*. Published online December 2007 as article doi:10.1136/oem.2007.035337 at <http://www.oem.bmj.com>.



concentration-response relationship of short-term health risks of the smog mixture, using three pollutants (NO_2 , ground-level ozone, and $\text{PM}_{2.5}$) as a surrogate for the complex mixture of air pollutants in the typical urban atmosphere. The index is expressed on a 1 to 10+ scale, where higher values represent a greater health risk.

Separate health advisories for general and “at risk” populations have been developed for these different health risk categories. Environment Canada will make current (hourly) and forecasted (today and tomorrow) AQHI values and their associated health advisories publicly available on its Weatheroffice Web site at <www.weatheroffice.gc.ca> and in regular weather reports on television and radio broadcasts. This information will allow people to make informed choices to protect themselves and those in their care from short-term health impacts of exposure to air pollution.

To date, the AQHI has been successfully piloted in communities in British Columbia (2005, 2006) and Nova Scotia (2006), and in the city of Toronto (2007 to present). The AQHI is now available in 14 communities in British Columbia and in the Greater Toronto Area and Saint John, New Brunswick. Additional communities across the country will gain access to the AQHI over the next three years. Additional information on the AQHI is available at <www.airhealth.ca>.

Canadian Air Health Indicator

The AHI, proposed in May 2005, is defined as the percentage of the number of daily deaths attributable to exposure to the pollutant of interest. The AHI is proportional to the level of risk, estimated using an appropriate statistical model, and the level of the pollutant of interest. The AHI can be used to evaluate spatial and temporal trends of air pollution and the related health risk in Canada starting in 1981 and also can provide a measure of progress in air quality management over time. More analyses are being conducted to refine the methodology. The AHI is included in the 2008 Canadian Environmental Sustainability Indicators Annual Report and is comprised of the spatial-temporal risk of ozone-related mortality from 1990 to 2005 in several Canadian cities.



U.S. Report on Health Effects of Ozone and PM

The health and welfare effects of ozone are documented and critically assessed in the EPA Ozone Criteria Document and EPA Ozone Staff Paper, finalized and released to the public in February 2006 and July 2007, respectively. These documents can be found at <<http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=149923>> and <http://epa.gov/ttn/naaqs/standards/ozone/s_o3_cr_sp.html>.

The purpose of the revised EPA Ozone Criteria Document, titled *Air Quality Criteria for Ozone and Other Photochemical Oxidants*, was to critically evaluate and assess the latest scientific information published since the last review of the ozone criteria document in 1996. The 2006 review focused on useful new information that emerged in the last decade, and is pertinent in evaluating health and environmental effects data associated with ambient air ozone exposures. The EPA Ozone Staff Paper is based on key findings and conclusions from this document, together with other analyses, and presents options for the EPA Administrator’s consideration regarding review, and possible revision, of the ozone NAAQS.

The new research published in the staff paper suggested additional health effects beyond those that had been known when the 8-hour ozone standard was set in 1997. Since 1997, more than 1,700 new health and welfare studies related to ozone have been published in peer-reviewed journals. Many of these studies have investigated the impact of ozone exposure on health effects such as changes in lung structure and biochemistry,



lung inflammation, asthma exacerbation and causation, respiratory illness-related school absence, hospital and emergency room visits for asthma and other respiratory disorders, and premature mortality.

Aggravation of existing asthma resulting from short-term ambient ozone exposure was reported prior to setting the 1997 ozone standard and has been observed in studies published subsequently. In addition, a relationship between long-term ambient ozone concentrations and the incidence of recent-onset asthma in adult males (but not females) was reported. An additional study suggested that incidence of new diagnoses of asthma in children is associated with heavy exercise in southern California communities with high ozone concentrations. A study in Toronto reported a significant relationship between 1-hour maximum ozone concentrations and respiratory hospital admissions in children under the age of two. Given the relative vulnerability of children in this age category, there is particular concern about these findings. Increased rates of illness-related school absenteeism have been associated with 1-hour daily maximum and 8-hour average ozone concentrations in studies conducted in Nevada. These studies suggest that higher ambient ozone levels might result in increased school absenteeism.

The air pollutant most clearly associated with premature mortality is PM. Repeated ozone exposure, however, is a possible contributing factor for premature mortality, causing an inflammatory response in the lungs that could predispose elderly and other sensitive individuals to become more susceptible to other stressors, such as PM. The findings of other recent analyses provide evidence that ozone exposure is associated with increased mortality. Most recently, new analyses of the 95 cities in the National Morbidity, Mortality, and Air Pollution Study data sets showed associations between daily mortality and the previous week's ozone concentrations, which were robust against adjustment for PM, weather, seasonality, and long-term trends. Other recent epidemiological studies have reported associations between acute ozone exposure and mortality, as summarized in the Ozone Criteria Document.

Exposure to PM has been associated with premature mortality as well as indices of morbidity, including respiratory hospital admissions and emergency department visits, school absences, lost work days, restricted activity days, effects on lung function and symptoms, morphological changes, and altered host defense mechanisms. Recent epidemiologic studies have continued to report associations between short-term exposures to fine particles and effects such as premature mortality, hospital admissions or emergency department visits for cardiopulmonary diseases, increased respiratory symptoms, decreased lung function, and physiological changes or biomarkers for cardiac changes. Long-term exposure to fine particles has also been associated with mortality from cardiopulmonary diseases and lung cancer and effects on the respiratory system, such as decreased lung function and chronic respiratory disease.

There are several sensitive or vulnerable subpopulations that appear to be at greater risk to PM-related effects. These include individuals with preexisting heart and lung disease, older adults, and children.



Review of U.S. Ozone and Particulate Matter Air Quality Standards

Based on the results of recent research on the health effects from ground-level ozone, on March 12, 2008, EPA promulgated tighter primary and secondary NAAQS for ozone of 0.075 ppm, with an 8-hour average (see “New Actions on Acid Rain, Ozone, and Particulate Matter” on page 33). For more information on the revised ozone standards please visit www.epa.gov/air/ozonepollution/actions.html.

In 2007, EPA initiated the next review of the current PM NAAQS, which will be completed in 2011. More information, including supporting documents, can be found at www.epa.gov/ttn/naaqs/standards/pm/s_pm_index.html.

U.S. Health and Exposure Research

EPA conducts human health and exposure research as part of the Clean Air Research Program. The research conducted in this program is described in the recently updated Clean Air Research multiyear plan found at www.epa.gov/ord/htm/multi-yearplans.htm. The Clean Air Research multiyear plan has two long-term goals (LTGs):

LTG 1—Reduce uncertainty in standard setting and air quality management decisions.

LTG 2—Reduce uncertainties in linking health and environmental effects to air pollution sources.

These two LTGs reflect a balanced research program that directly supports developing and implementing NAAQS and other air quality regulations (LTG 1), while also conducting multidisciplinary research to strengthen the understanding of the relationships among sources of air pollution, ambient air concentrations, human and ecological exposures, and health outcomes (LTG 2). Within LTG 2, there is particular emphasis on three research themes that represent a strategic change in EPA’s Clean Air Research Program. These three themes are:

- 1) Launching a multipollutant research program.
- 2) Identifying specific source-to-health outcome linkages, with initial emphasis on “near roadway” impacts.
- 3) Assessing the human health and environmental improvements due to past regulatory actions.

In recent years, human health and air pollution exposure research at EPA has focused primarily on PM. While PM will continue to be a significant focus, the introduction of LTG 2 will support research that investigates relationships between air quality and health from an integrated, multidisciplinary, and multipollutant perspective.

EPA’s Clean Air Research Program includes several health and exposure research studies focused on the Detroit–Windsor area. These studies are described below.

- **The Detroit Exposure and Aerosol Research Study (DEARS)** is evaluating the relationship between ambient levels, residential levels, and personal exposures for air toxics, PM, PM components, and PM from specific sources. Field data collection for DEARS was conducted from 2004 through 2007. Analysis and modeling studies using collected data are currently in progress. The DEARS coordinates with similar Canadian research efforts.
- **The Detroit Children’s Health Study** is applying exposure modeling data for PM and select criteria pollutant gases from the DEARS, as well as school-based exposure monitoring to assess the impact of ambient-based pollutants on the health of children ages seven through 12 in the Detroit and Dearborn areas. One focus will be the impact of potential automotive emission exposures on the exacerbation of asthma.
- **The Mechanistic Indicators of Childhood Asthma** is an epidemiologic study that is being conducted to advance our current understanding of various risk factors and triggers of childhood asthma. This study is gathering and analyzing information



from 2006 through 2009 on biological markers of exposure, early effect, and susceptibility (including gene expression data) from 100 asthmatic and 100 non-asthmatic children recruited from the Detroit, Michigan Metropolitan area.

- **The Detroit Cardiovascular Health Study** is being conducted by the University of Michigan as a parallel study to the DEARS. Personal exposure

data from the DEARS will be integrated with cardiovascular findings associated with brachial artery dilation. Clinical findings have shown this to be a sensitive marker for potential exposures to some pollutant classes, like PM, using ambient-based monitoring. Use of personal exposure data potentially will provide a more sensitive analysis.

- **The Detroit PM Toxicology Study** will link PM source characterization data from the DEARS to ultrafine and other select size fractions of PM. Toxicological assessment of each fraction combined with source apportionment information will provide insight as to the toxic properties of PM attributed to specific ambient sources.

More information about the studies above can be found at www.epa.gov/dears/ and www.epa.gov/dears/studies.htm.

Ecological Effects

Aquatic Effects Research and Monitoring

Both the United States and Canada, along with 18 European countries, participate in the United Nations Economic Commission for Europe's International Cooperative Program on Assessment and Monitoring of Acidification of Rivers and Lakes (i.e., ICP Waters). The ICP Waters program started in 1985 to assess, on a regional basis, the effects of acid rain and air pollution on water and water courses such as rivers and lakes. As part of this program, participants contribute water chemistry data from their respective countries to a central database. One of the goals of the ICP Waters program is to use the central database to provide a joint understanding of the impacts of long-range transboundary air pollutants.

In 2005 an ICP representative from the United Kingdom noted the widespread observed trend of increasing surface water dissolved organic carbon (DOC) concentrations, which is a potential sign of recovery from acid deposition. The ICP Waters

program evaluated this trend by using the central database to identify factors causing increases in DOC, and to assess the effect of this trend on acidification recovery. As part of the evaluation, the central water chemistry database was expanded to include 522 remote lakes and streams from Nordic countries, the United Kingdom, the United States, and Canada. In addition to information on DOC concentrations, the database included information on other acidification-related chemical variables.

Taking advantage of the data compiled for the analysis of regional DOC trends in Europe and North America, U.S. and Canadian scientists examined trends for other acidification-related variables in surface water for lakes and streams in the northeastern United States and southeastern Canada. The scientists analyzed eight regional subsets: 31 lakes in New England, 49 lakes in the Adirondacks, nine streams in the northern Appalachians, 71 streams in the southern Appalachians, 88 lakes in Atlantic Canada, 28 lakes in Quebec, 72 lakes in the Sudbury region of Ontario, and 80 lakes in the remainder of Ontario. They examined the trends for a given lake or stream over a 15-year period from 1990 to 2004, which approximately parallels the existence of the U.S.–Canada AQA. The scientists determined

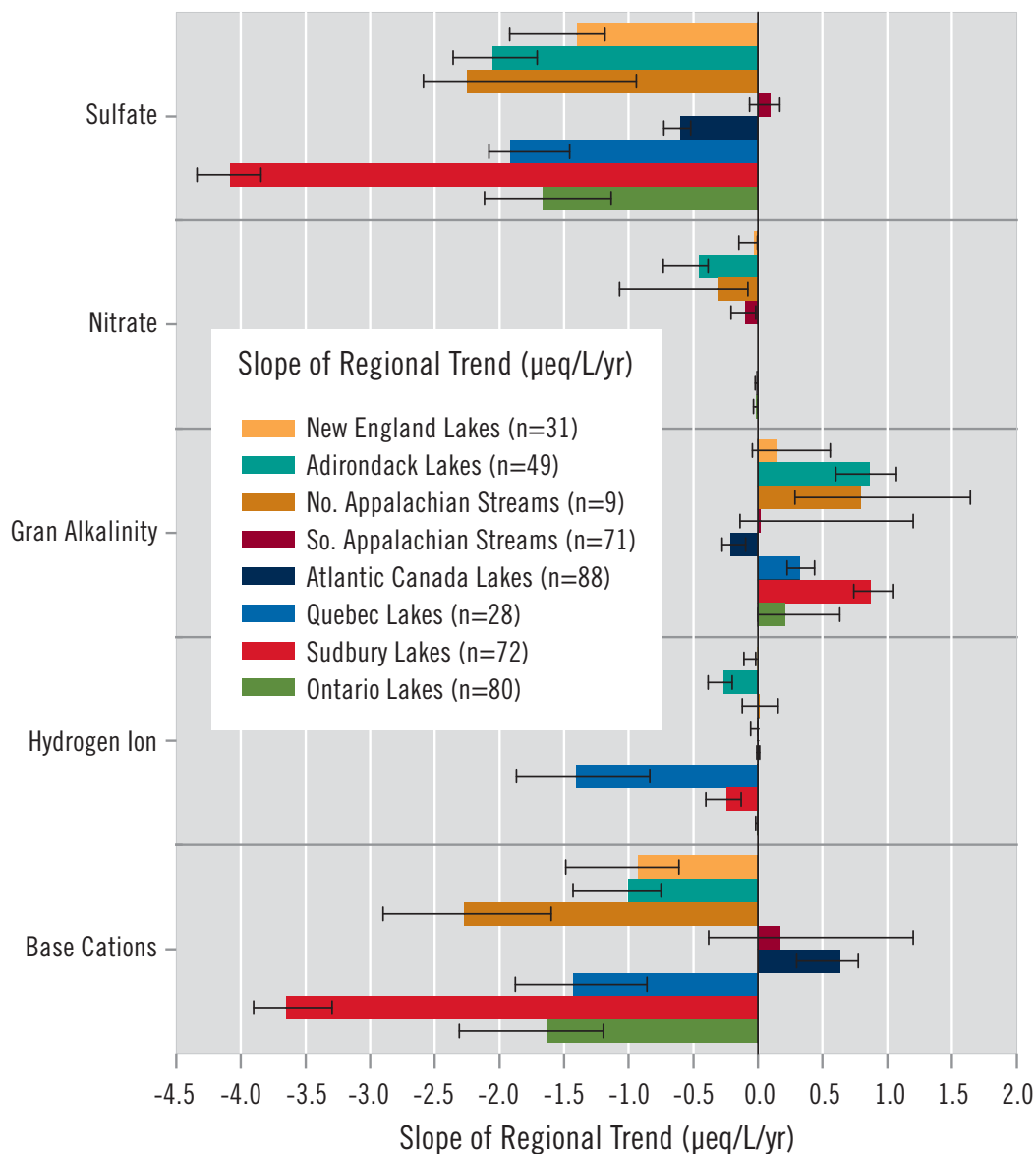


trends for the following acidification-related variables: sulfate (SO_4^{2-}), nitrate (NO_3^-), Gran alkalinity (measure of the amount of acid-neutralizing bases in water), hydrogen ion (H^+), and the sum of base cations (calcium + magnesium + sodium + potassium).

The results of these regional trend analyses are shown in Figure 33. The trends were calculated as the change in the concentration of each of the variables per year (e.g., change in concentration of

sulfate per year). A negative value for the slope of a regional trend indicates that the concentration of the variable is declining in that region, while a positive slope value means it is increasing. Movement toward recovery is indicated by a positive trend in Gran alkalinity and by negative trends in sulfate, nitrate, base cations, and hydrogen ions. Monteith et al. (see Figure 33 source information below) analyzed and reported regional DOC trends in the ICP Waters program DOC paper.

Figure 33. Regional Surface Water Concentration Trends ($\mu\text{eq/L/yr}$) for Eight Regions of Northeastern North America, 1990–2004



Note: Both positive and negative concentration trends are displayed. The length of the bar represents the median trend slope for that regional subset, and the error bars are the 95 percent confidence limits around the median. The indicated regional trend is statistically significant if the error bars do not overlap zero micron equivalents per liter per year ($\mu\text{eq/L/yr}$). Movement toward recovery is indicated by a positive trend in Gran alkalinity and by negative trends in sulfate, nitrate, base cations, and hydrogen ions.

Source: Monteith, D.T., Stoddard, J.L., Evans, C.D., de Wit, H.A., Forsius, M., Høggåsen, T., Wilander, A., Skjelkvåle, B.L., Jeffries, D.S., Vuorenmaa, J., Keller, W., Kopáček, J. and Vesely, J. 2007. Rising dissolved organic carbon in surface waters due to changes in atmospheric deposition chemistry. *Nature* 450: 537-541.



U.S. and Canadian SO_2 emission reductions included in the AQA commitments have resulted in obvious, significant, and substantial declining SO_4^{2-} trends in the surface waters of all regions except the southern Appalachian region. The regions with declining SO_4^{2-} trends have soils that absorb little of the atmospherically deposited SO_4^{2-} , so much of the SO_4^{2-} input is released to nearby lakes or streams, leading to acidification of surface waters. In these regions there is a direct relationship between the declining atmospheric deposition of SO_4^{2-} and the decrease in SO_4^{2-} concentration in surface waters. The lack of response recorded in southern Appalachian streams occurs because the soils of this region adsorb most of the atmospherically deposited SO_4^{2-} ; therefore less SO_4^{2-} is leached to nearby surface waters. Lakes in the Sudbury region of Ontario show by far the greatest rate of SO_4^{2-} concentration reductions, probably because it reflects the cumulative effect of reduced deposition and declining leaching from the larger soil pool of sulfur that accumulated during past periods of localized high SO_4^{2-} deposition.

Small negative NO_3^- trends were detected in the U.S. regions only. This is the reverse of trends observed prior to 1990; however, the influence of NO_3^- on acidification recovery (i.e., increasing alkalinity) is relatively small compared to SO_4^{2-} .

An observed chemical trend that demonstrates the ecological response of decreasing atmospheric inputs of SO_4^{2-} , is the decline in base cation concentration in surface water. As SO_4^{2-} is deposited to soils, it can mobilize base cations, resulting in base cations leaching from the soil into nearby surface waters. A negative trend in base cations in surface waters is expected to occur in response to declining SO_4^{2-} deposition. Reduced rates of base cation leaching into surface waters might indicate declining soil acidification, but surface water monitoring data alone cannot be used to confirm soil recovery. Almost all the ecosystem response to reduced SO_4^{2-} deposition in the New England and Ontario regions is reflected in declining base cation concentrations, except for the Sudbury region, where the declining release of sulfur from the soil pool also plays a role.

Surface water recovery from acidification is indicated by increasing Gran alkalinity concentrations and/or declining H^+ concentrations (i.e., increasing pH). When the decline in deposition of acidifying anions, like SO_4^{2-} and NO_3^- , is not completely compensated by base cation declines in surface water, the residual difference is usually expressed as increasing alkalinity and/or decreasing H^+ , and this is exactly the case here. The four regions with the greatest difference between SO_4^{2-} and base cation declines showed the largest positive trends in alkalinity (Adirondack lakes, northern Appalachian streams, and Sudbury lakes) or the largest H^+ decreases (Quebec lakes).

Atlantic Canada lakes were an exception to the above. Atlantic Canada was also the exception in the Monteith et al. trends paper, as it was the only North American region that showed statistically significant negative DOC trends. Increasing sodium ion inputs from sea salt might account for the statistically significant positive base cation trends observed here. The decreasing DOC trend in Atlantic Canada lakes might also be a causal factor in their small, but statistically significant, negative alkalinity trend. This is a demonstration of how the interaction of forcing factors (declining SO_4^{2-} deposition and increasing sea salt deposition) can lead to unexpected results.

Critical Loads and Exceedances

A critical load is a quantitative estimate of exposure to a pollutant(s) below which significant harmful effects on specific sensitive elements of the environment do not occur, according to present knowledge. The critical load of acid deposition is defined as the maximum deposition that an ecosystem can assimilate without significant long-term harmful effects. Deposition of both nitrogen and sulfur compounds can contribute to a critical load exceedance.



In the *2004 Canadian Acid Deposition Science Assessment*, for the first time in North America, new and combined critical load estimates were generated for sulfur and nitrogen acid deposition for both sampled surface waters and upland forest soils using steady-state models.⁵ Because

⁵ Jeffries, D.S., and Ouimet, R. (2005) Chapter 8: Critical loads: Are they being exceeded? In: 2004 Canadian Acid Deposition Science Assessment [CD ROM]. Available from Environment Canada.



sulfur and nitrogen have different atomic weights, the combined critical load cannot be expressed in mass units (kg/ha/yr); instead, it is expressed in terms of ionic charge balance as equivalents per hectare per year (eq/ha/yr).

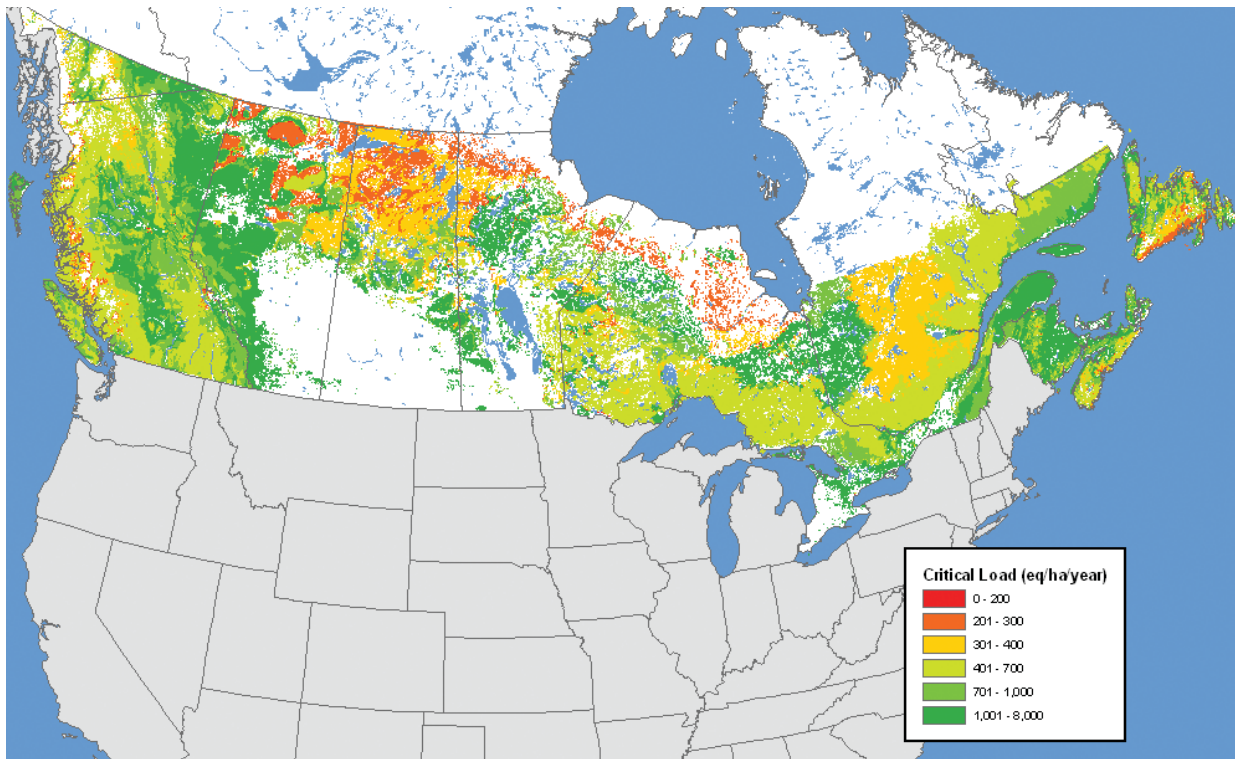
Since the *2004 Acid Deposition Science Assessment*, significant work has been done to expand critical load development and estimate critical load exceedances for upland forest soils.^{6, 7, 8, 9} Until recently, efforts in Canada were focused on developing critical loads and exceedances for forest soils and lakes in eastern Canada, but concern over rising emissions of acidifying pollutants has broadened the focus to include western Canada.

Figure 34 presents recently developed estimates of sulfur plus nitrogen critical loads for upland forest soils in Canada. These critical loads were developed

using the protocol established by the NEG/ECP Environmental Task Group on Forest Mapping for all of Canada, with the exception of British Columbia and northern Ontario, where preliminary estimates of critical loads are based on base cation weathering rates as deposition data are unavailable for these regions.

Critical loads below 400 eq/ha/yr (red to yellow in Figure 34) occur along high-elevation areas and the coast of British Columbia and over large areas in northern Alberta, Saskatchewan, Manitoba, and Ontario; south-central Quebec; and southeastern Nova Scotia and Newfoundland. The 1983 eastern Canada Acid Rain Program established a target load for sulfur deposition equivalent to approximately 400 eq/ha/yr to protect moderately sensitive lakes in eastern Canada; the new science shows that for many regions, the critical load for sulfur and nitrogen is significantly lower than the 1983 target.

Figure 34. Sulfur Plus Nitrogen Critical Loads for Upland Forest Soils across Canada



Source: Carou, S., Dennis, I., Aherne, J., Ouimet, R., Arp, P.A., Watmough, S.A., DeMerchant, I., Shaw, M., Vet, R., Bouchet, V., and M. Moran (2008). A National Picture of Acid Deposition Critical Loads for Forest Soils in Canada, Report Prepared by Environment Canada for CCME.

⁶ Ouimet, R., P.A. Arp, S.A. Watmough, J. Aherne, I. Demerchant (2006). Determination and mapping critical loads of acidity and exceedances for upland forest soils in eastern Canada. *Water, Air and Soil Pollution* 172: 57-66.
⁷ Aherne, J., Watmough, S. (2006) Calculating Critical Loads of Acid Deposition for Forest Soils in Manitoba and Saskatchewan: Data Sources, Critical Load, Exceedance and Limitations. Final Report prepared for CCME. Environmental and Resource Studies, Trent University, Peterborough, ON.
⁸ Aherne, J. (2008a). Calculating Critical Loads of Acid Deposition for Forest Soils in Alberta: Critical load, exceedance and limitations. Final Report, Environmental and Resource Studies, Trent University, Peterborough, Ontario.
⁹ Aherne, J. (2008b). Calculating Critical Load and Exceedance Estimates for Upland Forest Soils in Manitoba and Saskatchewan: Comparing Exceedance Outputs of Different Models. Final Report, Environmental and Resource Studies, Trent University, Peterborough, Ontario.



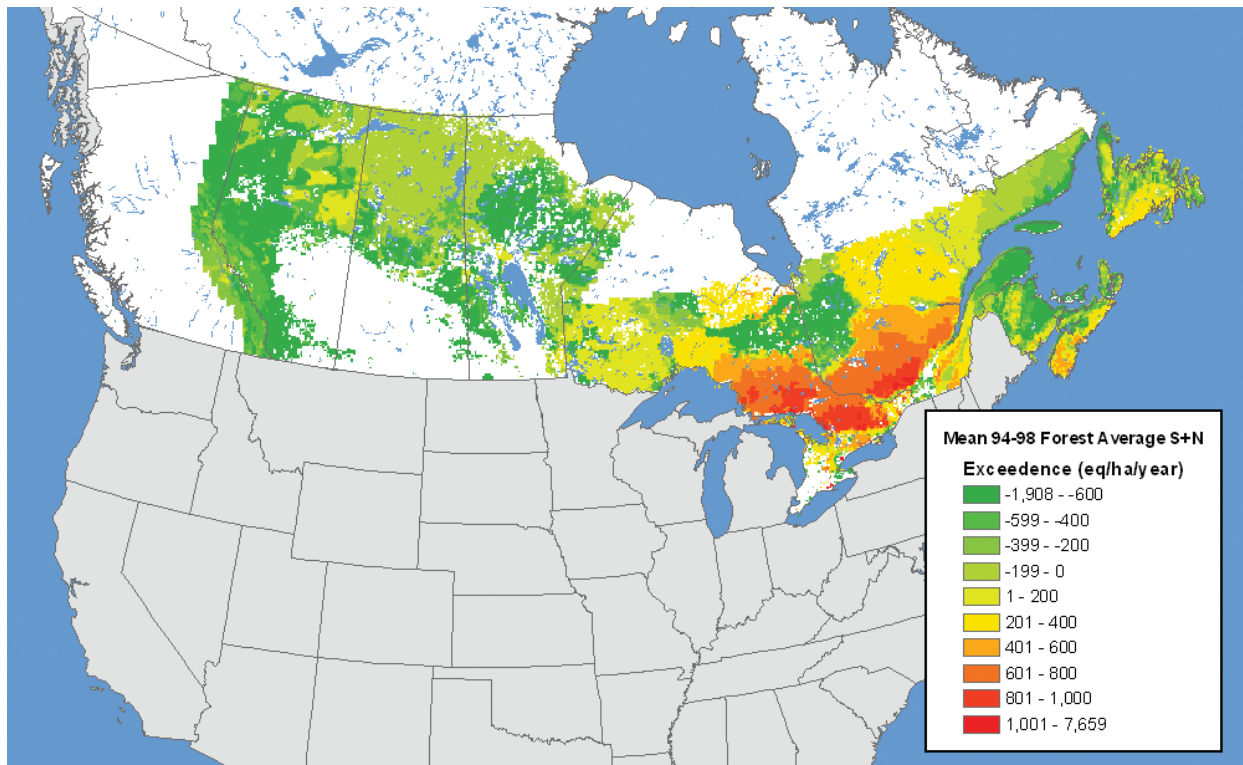
Figure 35 presents exceedances of sulfur plus nitrogen critical loads for upland forest soils across Canada based on measured wet deposition plus inferential dry deposition (using combined air concentration measurements and modeled dry deposition velocities) of sulfur and nitrogen over forested areas from 1994 to 1998. During that period, approximately 38 percent of the mapped upland forest area in Canada received acid deposition in exceedance of the critical loads. Critical load exceedances in western Canada were relatively low compared to eastern Canada.

For comparative purposes, a second critical load exceedance map (Figure 36) was developed based on a one-year model simulation of 2002 sulfur and nitrogen deposition levels using Environment Canada's AURAMS model (A Unified Regional Air Quality Modeling System). Overall, the results are consistent with those shown in Figure 35, although

substantial differences can be observed in the magnitude of the exceedances. In eastern Canada a decline in sulfur and nitrogen deposition and the corresponding critical load exceedances has occurred since the 1994–1998 measurement period and is not captured in Figure 35. The critical load exceedance hotspots near major emissions sources (e.g., Lower Fraser Valley, Athabasca oil sands, Manitoba smelters, and Sudbury), reflected in Figure 36, are not well-represented in the deposition data used to develop Figure 35 because the monitoring stations are located in regions remote from large emission sources.

Overall, this recent evaluation of acid deposition sensitivity shows that in every Canadian province there are upland forest soils that currently receive acid deposition levels greater than their long-term critical loads. In southeastern Canada, in particular, the risk for continued ecosystem damage exists, despite past reductions in acidifying emissions.

Figure 35. Exceedances of Sulfur Plus Nitrogen Critical Loads for Upland Forest Soils across Canada Based on Average (1994–1998) Measured Deposition

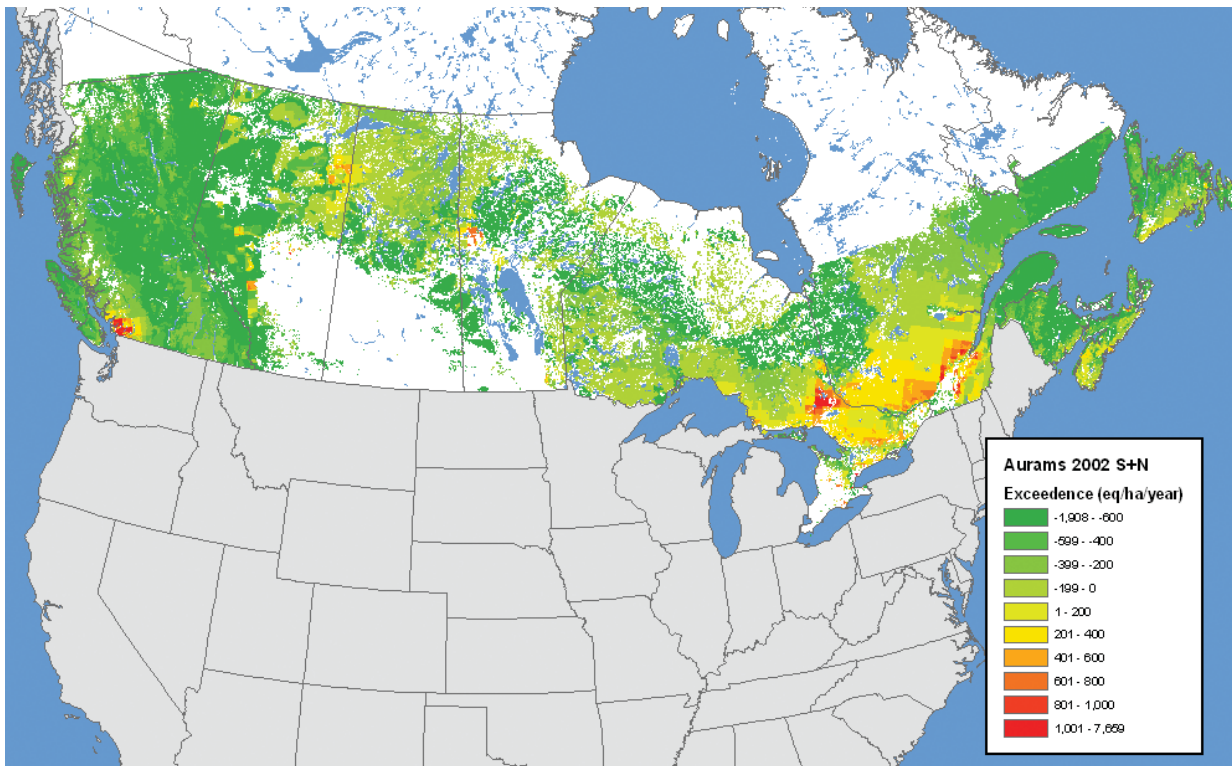


Note: No deposition estimates were available for British Columbia and northern Ontario.

Source: Carou, S., Dennis, I., Aherne, J., Ouimet, R., Arp, P.A., Watmough, S.A., DeMerchant, I., Shaw, M., Vet, R., Bouchet, V., and M. Moran (2008). A National Picture of Acid Deposition Critical Loads for Forest Soils in Canada, Report Prepared by Environment Canada for CCME.



Figure 36. Exceedances of Sulfur Plus Nitrogen Critical Loads for Upland Forest Soils across Canada Based on Preliminary Estimates of Current Deposition (2002) from the AURAMS Model



Source: Carou, S., Dennis, I., Aherne, J., Ouimet, R., Arp, P.A., Watmough, S.A., DeMerchant, I., Shaw, M., Vet, R., Bouchet, V., and M. Moran (2008). A National Picture of Acid Deposition Critical Loads for Forest Soils in Canada, Report Prepared by Environment Canada for CCME.



In the United States, the critical loads approach is not an officially accepted approach to ecosystem protection. For example, language specifically requiring a critical loads approach does not exist in the Clean Air Act. Nevertheless, the critical loads approach is being explored as an ecosystem assessment tool with great potential to simplify complex scientific information and effectively communicate with the policy community and the public. The critical loads approach can provide a useful lens through which to assess the results of current policies and programs and to evaluate the potential ecosystem-protection value of proposed policy options.

Recent activities within federal and state agencies, as well as the research community, in the United States indicate that critical loads might be emerging as a useful ecosystem protection and program assessment tool. In 2004, the National Research Council

recommended that EPA consider using critical loads for ecosystem protection. In 2005, EPA included a provision in its Nitrogen Dioxide Increment Rule that individual states may propose the use of critical loads information as part of their air quality management approach, in order to satisfy requirements under Clean Air Act provisions regarding “prevention of significant deterioration.” Between 2002 and 2006, several federal agencies convened conferences and workshops to review critical loads experience in other countries, discuss critical loads science and modeling efforts, and explore the possible future role of a critical loads approach in air pollution control policy in the United States. More recently, a new ad hoc critical loads committee was formed within the NADP (<http://nadp.sws.uiuc.edu/clad/>). This committee will promote information sharing, scientific advances, and applied projects in an effort to explore the potential uses of critical loads in policy development and program implementation in the United States.

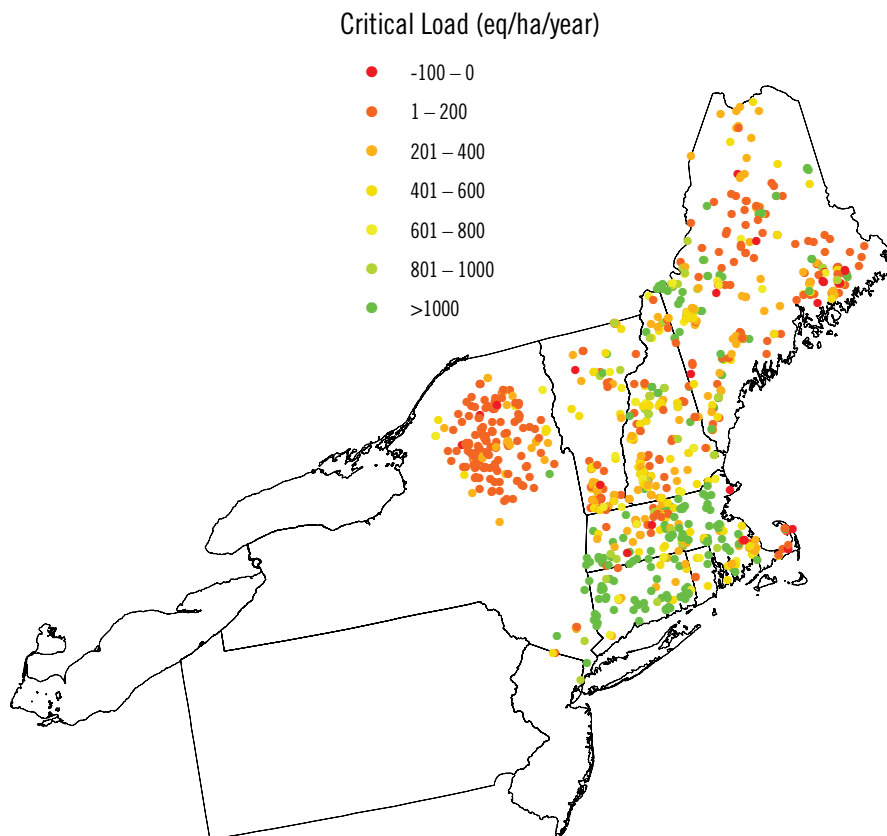


As a result of these developments, agencies such as the NPS and the U.S. Forest Service developed specific recommendations for using the critical loads approach as a tool to assist in managing federal lands. Several federal agencies are now employing critical loads approaches to protect and manage sensitive ecosystems. For example, in Rocky Mountain National Park in Colorado, NPS has entered into a Memorandum of Understanding (MOU) with the Colorado Department of Public Health and Environment (CDPHE) and EPA to address harmful impacts to air quality and other natural resources occurring in the park, and to reverse a trend of increasing nitrogen deposition. The MOU requires NPS to develop a resource management goal to protect park resources and requires the CDPHE to develop an air management strategy that will help to meet park goals. Based on research results that indicate deleterious effects on natural resources from current levels of atmospheric nitrogen deposition, NPS has established a resource management goal,

linked to a critical load for wet nitrogen deposition of 1.5 kg/ha/yr for high elevation aquatic ecosystems. The Colorado Air Quality Control Commission has also established a “Rocky Mountain National Park Initiative Sub-committee” to involve stakeholders, review the research, identify information needs, and discuss options for improving conditions in the park.

In addition to activities within federal and state agencies, the peer-reviewed scientific literature on critical loads in the United States has increased in recent years. Figure 37 illustrates recently developed estimates of critical loads for sulfur plus nitrogen in acid-sensitive lakes in the northeastern United States (DuPont et al., 2005 and others). Additional critical loads estimates were calculated using the model employed in the peer-reviewed literature, combined with data from two EPA-administered surface water monitoring programs: the Temporally Integrated Monitoring of Ecosystems (TIME) program and the Long-Term Monitoring (LTM) program.

Figure 37. Estimated Sulfur Plus Nitrogen Critical Loads for Lakes in Northeast United States



Source: EPA, 2008 and DuPont J., T.A. Clair, C. Gagnon, D.S. Jeffries, J.S. Kahl, and S.J. Nelson, and J. M. Peckenham. (2005). Environmental Monitoring and Assessment 109: 275-291.



The LTM program consists of a subset of lakes and streams that are located in areas most impacted by acid deposition. The LTM lake and stream sites are monitored three to 15 times per year, with some site records dating back to the early 1980s. In New England, the LTM project collects quarterly data from lakes in Maine, Vermont, and the Adirondack region of New York.

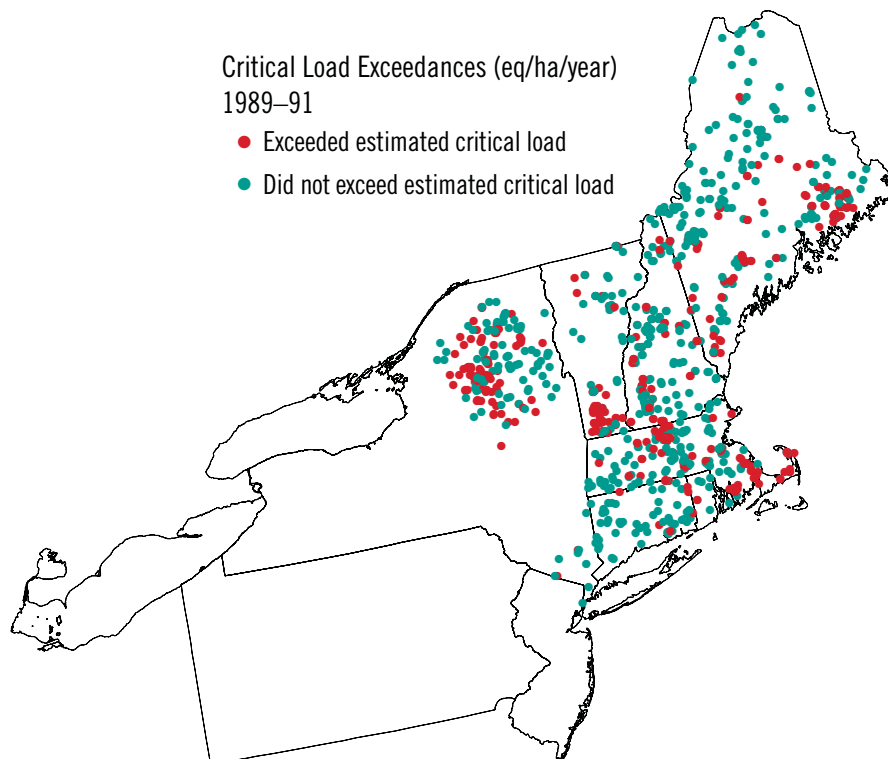
The TIME program employs probability sampling; each monitoring site was chosen statistically from a predefined target population. In New England, the target populations include lakes likely to be responsive to changes in acidic deposition. TIME lakes in Maine, Vermont, and the Adirondack region of New York are monitored annually.

Both the literature-estimated critical load values and critical load estimates calculated using the TIME and LTM data were developed using the Steady-State Water Chemistry model with the same underlying

assumptions. For both sets of estimates, the critical load represents the combined deposition load of sulfur and nitrogen to which the lake could be subjected and still have an acid neutralizing capacity of 50 $\mu\text{eq/L}$. Critical loads of combined total sulfur and nitrogen are expressed in terms of ionic charge balance as equivalents per hectare per year (eq/ha/yr).

Figures 38 and 39 relate critical loads estimates to total wet and dry sulfur and nitrogen deposition estimates for two periods: 1989 to 1991 and 2004 to 2006. In these figures, estimates of wet and dry deposition for the two periods are based on measured values from the NADP network combined with modeled values based on the Community Multiscale Air Quality (CMAQ) model, respectively. Comparing Figures 38 and 39 provides insight into the improvements resulting from implementing the SO_2 and NO_x emission reduction commitments in the U.S.–Canada AQA.

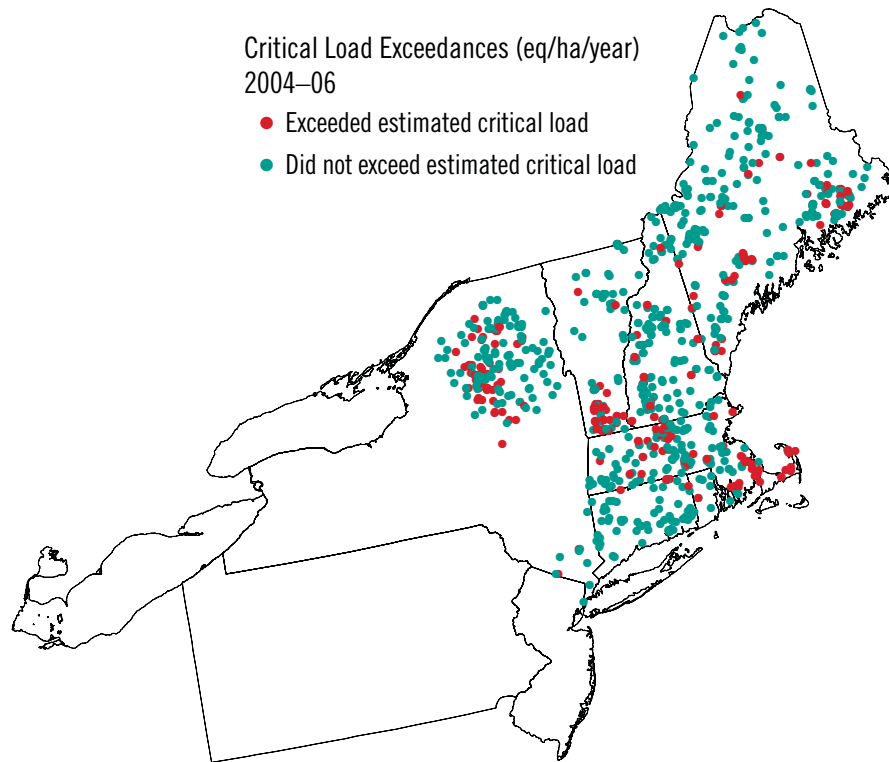
Figure 38. Eastern U.S. Lakes Exceeding the Estimated Critical Load (Sulfur + Nitrogen) for Total Nitrogen and Sulfur Deposition for the Period 1989–1991



Source: EPA, 2008 and DuPont J., T.A. Clair, C. Gagnon, D.S. Jeffries, J.S. Kahl, and S.J. Nelson, and J. M. Peckenham. (2005). Environmental Monitoring and Assessment 109: 275-291.



Figure 39. Eastern U.S. Lakes Exceeding the Estimated Critical Load (Sulfur + Nitrogen) for Total Nitrogen and Sulfur Deposition for the Period 2004–2006



Source: EPA, 2008 and DuPont J., T.A. Clair, C. Gagnon, D.S. Jeffries, J.S. Kahl, and S.J. Nelson, and J. M. Peckenham. (2005). *Environmental Monitoring and Assessment* 109: 275-291.

Approximately 28 percent of the lakes for which critical load estimates were calculated (Figure 37) in the northeastern United States currently receive acid deposition greater than their estimated critical load (Figure 39). This is an improvement when compared to the period from 1989 to 1991, during which 41 percent of those lakes received acid deposition greater than their estimated critical load (Figure 38). Areas with the greatest concentration of lakes where acid deposition currently is greater than—or exceeds—estimated critical loads include the Adirondack Mountain region in New York, southern New Hampshire and Vermont, northern Massachusetts, and northeast Maine (Figure 39).

Reductions in acidic deposition have occurred over the past decade, as demonstrated by the wet deposition maps in Figures 5 through 12 on pages 8 and 9. However, this comparison of past and current total deposition estimates with critical loads estimates from the scientific literature indicates that acid-sensitive ecosystems in the northeastern United States might still be at risk of acidification at current deposition levels. As a result, additional reductions in acidic deposition from current levels might be necessary to protect these ecosystems, a conclusion supported by other recent analyses, such as the 2005 National Acid Precipitation Assessment Report to Congress (www.ostp.gov/pdf/napap_report_2005.pdf).



Conclusion

The United States and Canada continue to meet the commitments set forth in the 1991 AQA. Both countries have made significant progress in reducing acid rain and controlling ground-level ozone in the transboundary region. The following are key achievements from 2006 through 2008:

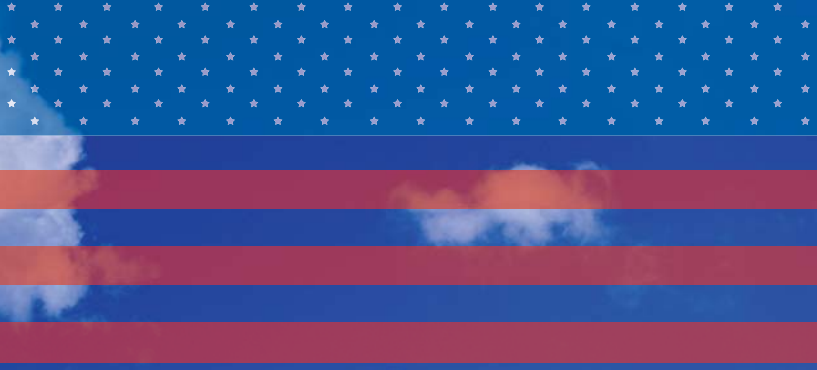
- Preliminary analyses indicate that Canada has met its 2007 Ozone Annex commitment to cap total annual emissions of NO_x from fossil fuel-fired power plants within the PEMA at 39 kilotonnes in Ontario and 5 kilotonnes in Quebec.
- In 2007, the United States met its Acid Rain Annex commitment to lower its annual emissions of SO_2 for electric generating utilities to 8.95 million tons by 2010.

The AQA addresses transboundary air pollution for the benefit of the health and welfare of our citizens, in particular through implementation of the Acid Rain and Ozone Annexes.

Both Canada and the United States are committed to reducing cross-border air pollution and recognize the significant human health and ecosystem effects (including acid rain and regional haze) associated with $\text{PM}_{2.5}$ and its precursors. Both countries are committed to negotiating the addition of a Particulate Matter (PM) Annex to the United States–Canada Air Quality Agreement while actively developing and implementing emission reduction programs to reduce fine particle concentrations.

The United States and Canada have held two negotiating sessions on a PM Annex under the United States–Canada Air Quality Agreement: one in November 2007 and one in May 2008. Discussions continued as part of the November 2008 United States–Canada Air Quality Committee meeting.

The countries remain committed to the AQA based on historic precedent and mutual respect. As the sense of our shared future expands, the AQA offers a model of dynamic cooperation.



APPENDIX A: U.S.–Canada Air Quality Committee



Canadian Members

Canada Co-Chair:

Cécile Cléroux
Assistant Deputy Minister
Environmental Stewardship Branch
Environment Canada

Jeffrey Heynen
U.S. Relations Division
Foreign Affairs and International Trade Canada

Members:

Randy Angle
Air Policy Business Unit
Strategic Policy Branch
Alberta Environment

Glenn MacDonell
Environmental Industries Directorate
Service Industries and Consumer Products Branch
Industry Canada

Mike Beale
Strategic Priorities Directorate
Environmental Stewardship Branch
Environment Canada

Kimberly MacNeil
Environment and Natural Areas Management Division
Nova Scotia Department of Environment and Labour

Ross Ezzeddin
Environment Policy Division
Energy Policy Branch
Natural Resources Canada

Robert Noël de Tilly
Air Policy Branch
Quebec Department of Sustainable, Development,
Environment and Parks

Paul Glover
Healthy Environments and Consumer Safety Branch
Health Canada

Hu Wallis
Environmental Quality Branch
British Columbia Ministry of Environment

Jim Whitestone
Air Policy and Climate Change Branch
Ontario Ministry of the Environment



Subcommittee on Program Monitoring and Reporting Co-Chair:

Kerri Timoffee
Manager, Canada–U.S.
Air Emissions Priorities
Environmental Stewardship Branch
Environment Canada

Subcommittee on Scientific Cooperation Co-Chair:

Keith Puckett
Director, Air Quality Research
Science and Technology Branch
Environment Canada



United States Members

United States Co-Chair:

Daniel Reifsnyder
Deputy Assistant Secretary for the Environment
U.S. Department of State

Bruce Polkowsky
Air Resources Division
National Park Service

Members:

Brian J. McLean
Office of Atmospheric Programs
U.S. Environmental Protection Agency

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

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

G. Vinson Hellwig
Air Quality Division
Michigan Department of Environmental Quality

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

Subcommittee on Program Monitoring and Reporting Co-Chair:

Brian J. McLean
Director, Office of Atmospheric Programs
U.S. Environmental Protection Agency

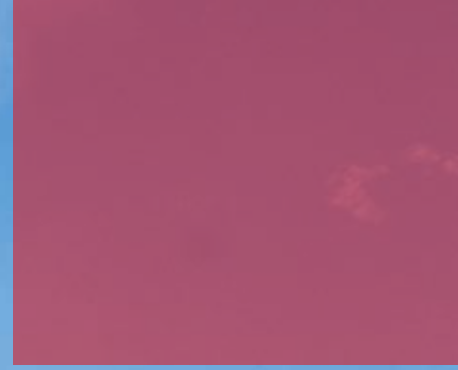
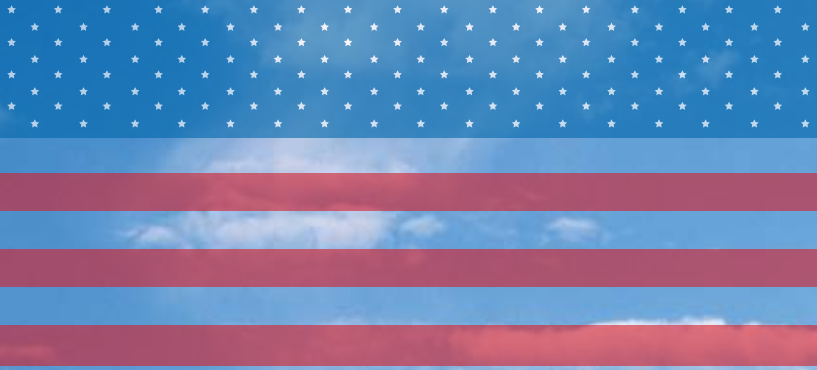
Daniel Fantozzi
U.S. Department of State

Subcommittee on Scientific Cooperation Co-Chair:

Richard S. Artz
Air Resources Laboratory
National Oceanic and Atmospheric Administration
(NOAA)

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

Mitchell Baer
Office of Policy and International Affairs
U.S. Department of Energy



APPENDIX B: List of Acronyms

AHI	Air Health Indicator	CEMS	continuous emission monitoring system
AIRMoN	Atmospheric Integrated Research Monitoring Network	CEPA	Canadian Environmental Protection Act
AQA	Air Quality Agreement	CI	continuous improvement
AQHI	Air Quality Health Index	CO	carbon monoxide
AQI	Air Quality Index	CO ₂	carbon dioxide
AQMP	Air Quality Management Plan	CSN	Chemical Speciation Network
ARP	Acid Rain Program	CWS	Canada-wide Standards
ASI	Algoma Steel, Inc.	DEARS	Detroit Exposure and Aerosol Research Study
ATVs	all-terrain vehicles	DOC	dissolved organic carbon
AURAMS	A Unified Regional Air Quality Modeling System	EGU	electric generating unit
BACT	best available control technology	hp	horsepower
BART	best available retrofit technology	ICP Waters	International Cooperative Program on Assessment and Monitoring of Acidification of Rivers and Lakes
CAIR	Clean Air Interstate Rule	IJC	International Joint Commission
CAPMoN	Canadian Air and Precipitation Monitoring Network	KCAC	Keeping Clean Areas Clean
CASTNET	Clean Air Status and Trends Network	kg	kilogram
CCME	Canadian Council of Ministers of the Environment	km	kilometer
CDPHE	Colorado Department of Public Health and Environment	kt	kilotonne
		kw	kilowatt



LAER	lowest achievable emission rate	NPS	National Park Service
LTG	long-term goal	NSPS	New Source Performance Standard
LTM	Long-Term Monitoring	NSR	New Source Review
MDN	Mercury Deposition Network	NTN	National Trends Network
mg	milligram	OBD	onboard diagnostics
MOU	Memorandum of Understanding	PAMS	Photochemical Assessment Monitoring Stations
MW	megawatt	PEMA	Pollutant Emission Management Area
NAA	Nonattainment Area	PERC	perchloroethylene
NAAQS	National Ambient Air Quality Standards	PM	particulate matter
NADP	National Atmospheric Deposition Program	PM _{2.5}	particulate matter less than or equal to 2.5 microns
NAMS	National Air Monitoring Stations	PM ₁₀	particulate matter less than or equal to 10 microns
NAPS	National Air Pollution Surveillance	ppm	parts per million
NARSTO	(formerly) North American Research Strategy for Tropospheric Ozone	ppb	parts per billion
NATTS	National Air Toxics Trends Stations	ppbC	parts per billion carbon
NBP	NO _x Budget Trading Program	PSD	Prevention of Significant Deterioration
NEG/ECP	New England Governors and Eastern Canadian Premiers	SI	spark-ignition
NEI	National Emissions Inventory	SIP	State Implementation Plan
NO	nitric oxide	SLAMS	State and Local Air Monitoring Stations
NO ₂	nitrogen dioxide	SO ₂	sulfur dioxide
NO _y	total reactive oxidized nitrogen	TIME	Temporally Integrated Monitoring of Ecosystems
NPRI	National Pollutant Release Inventory	VOC	volatile organic compound
NO _x	nitrogen oxides		

NOTES



To obtain additional information, please contact:

In the United States:

Clean Air Markets Division
U.S. Environmental Protection Agency
Mail Code 6204J
1200 Pennsylvania Avenue, NW
Washington, DC 20460

U.S. Environmental Protection Agency's Web site:
www.epa.gov/airmarkets/progsregs/usca/index.htm

Environment Canada's Web site:

www.ec.gc.ca/cleanair-airpur/Pollution_Issues/Transboundary_Air/Canada-_United_States_Air_Quality_Agreement-WS83930AC3-1_En.htm

In Canada:

Air Emissions Priorities
Environment Canada
351 St. Joseph Boulevard
11th Floor, Place Vincent Massey
Gatineau, Quebec K1A 0H3



United States Environmental Protection Agency
Office of Air and Radiation (6204J)
1200 Pennsylvania Avenue
Washington, DC 20460

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