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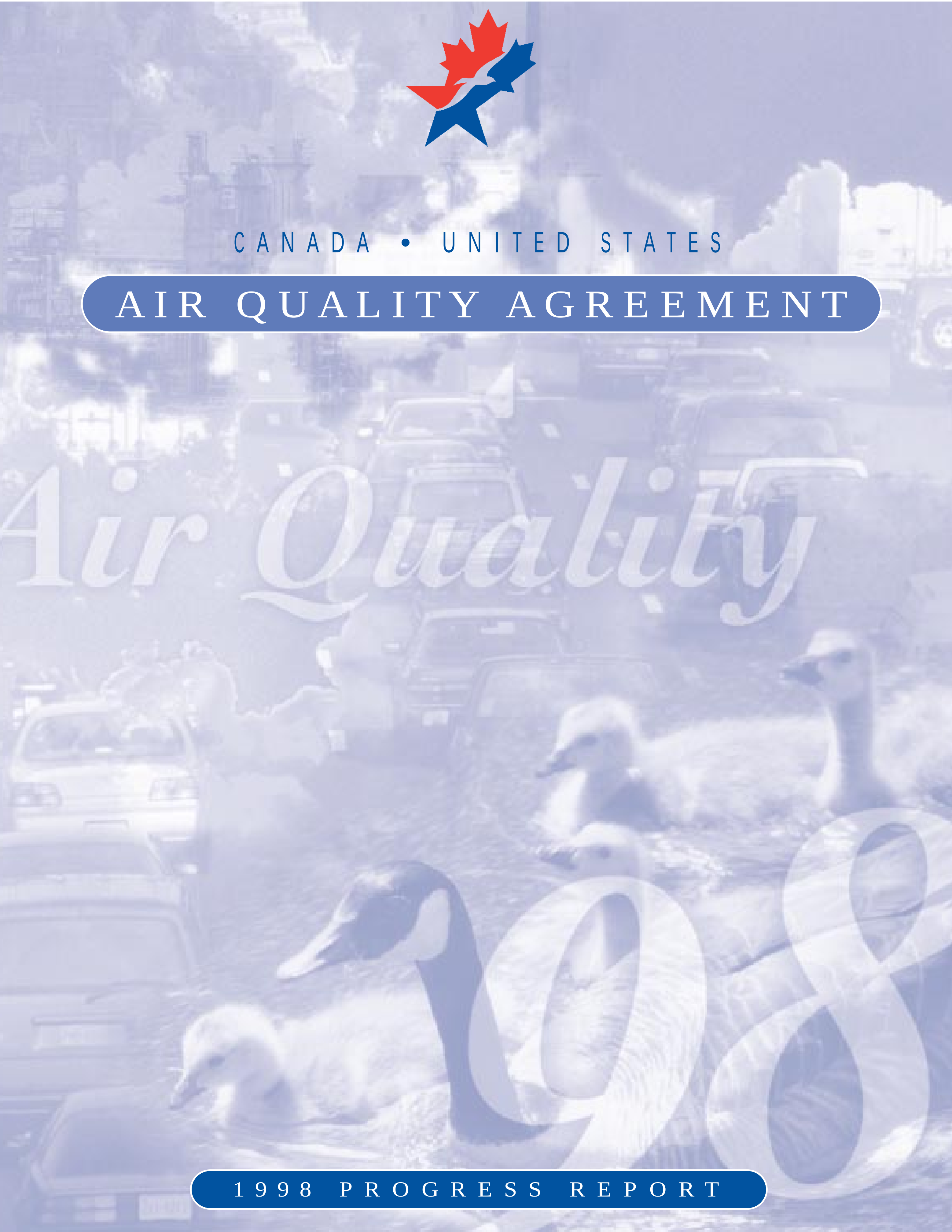
AIR QUALITY AGREEMENT



1998 PROGRESS REPORT

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1998 PROGRESS REPORT

YOUR COMMENTS ON THIS REPORT WOULD BE APPRECIATED BY FEBRUARY 26, 1999:

The International Joint Commission (IJC) is responsible for inviting public comment on Air Quality Agreement Progress Reports and for distributing comments received on request. Written comments on this report should be sent to one of the following offices on or before February 26, 1999:

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INTRODUCTION

Under the 1991 Air Quality Agreement, Canada and the United States have committed to addressing transboundary air pollution. To date, work under the Agreement has focused on acid rain issues. The two governments have made significant reductions in emissions of the two major acid rain pollutants — sulphur dioxide (SO_2) and nitrogen oxides (NO_x).

Over the past two years, the Federal governments' close cooperation with State and Provincial governments and other stakeholders has demonstrated that, in addition to the importance of continuing joint work on common concerns to reduce acid deposition, the two countries have substantial common interests in the problems of ground-level ozone and particulate matter pollution, particularly due to their impacts on human health.

This fourth report on the Air Quality Agreement focuses on progress since 1996 to meet commitments in the Agreement, key scientific and technical trends related to air pollution, and the results of the acid rain control programs in each country. The report also considers the increasing cooperation of both countries in addressing the emerging transboundary issues of ground-level ozone and particulate matter (PM).

During April 1997 meetings in Washington between the Prime Minister and the President, U.S. Environmental Protection Agency (EPA) Administrator Carol Browner and the former Canadian Minister of the Environment signed the Program to Develop a Joint Plan of Action for Addressing Transboundary Air Pollution. The Joint Plan's focus was on ground-level ozone and particulate matter. In June 1998, Administrator Carol Browner and Minister of the Environment Christine Stewart endorsed a report from the Canada–U.S. Air Quality Committee outlining a strategy that will lead, by April 1999, to recommendations on negotiation of an ozone annex pursuant to the Air Quality Agreement and on a joint plan for transboundary inhalable fine particles.

Note: Canadian spelling is used throughout. Future reports will alternate the use of Canadian and American spelling. Dollars are $ U.S. unless otherwise indicated.

COMMITMENTS AND PROGRESS

This section focuses on Canadian and U.S. progress in meeting key commitments under Annex I of the Air Quality Agreement.

REDUCTIONS IN EMISSIONS OF SULPHUR DIOXIDE

CANADIAN COMMITMENT

- *SO_2 emissions reduction in 7 easternmost provinces to 2.3 million tonnes[1] by 1994*
- *Maintenance of 2.3-million tonne annual cap for eastern Canada through December 1999*
- *Permanent national cap for SO_2 emissions of 3.2 million tonnes by 2000*

Canada has surpassed its international and domestic commitments to reduce emissions of sulphur dioxide (SO_2) both in the seven easternmost provinces and nationally. In 1997, national emissions were approximately 2.6 million tonnes, or 18% below the cap of 3.2 million tonnes. In eastern Canada, emissions were approximately 1.7 million tonnes, or 24% below the cap of 2.3 million tonnes. Furthermore, forecasts of emissions of SO_2 up to the year 2010 indicate that Canadian emissions will remain well below these caps.

Despite meeting and exceeding its commitments, Canada remains concerned about acid rain in eastern Canada. Environment Canada is working with the provinces and territories to develop a Canada-Wide Acid Rain Strategy for Post-2000 that would lead to the establishment of new SO_2 targets and reduction schedules for the provinces of Ontario, Quebec, New Brunswick, and Nova Scotia. The strategy, expected to be submitted to provincial and Federal Energy and Environment Ministers for approval in 1998, is based on a 1997 report issued by the multi-stakeholder Acidifying Emissions Task Group. The report, *Towards a National Acid Rain Strategy*, concluded that emissions reductions of up to 75% beyond current commitments would be required in targeted regions of eastern Canada and the United States to prevent damage to sensitive ecosystems in Canada.

U.S. COMMITMENT

- *SO_2 emissions reduction of 10 million tons[2] from 1980 levels by 2000[3]*
- *Permanent national cap of 8.95 million tons of SO_2 per year for electric utilities by the year 2010*
- *National cap of 5.6 million tons for industrial source emissions beginning in 1995*

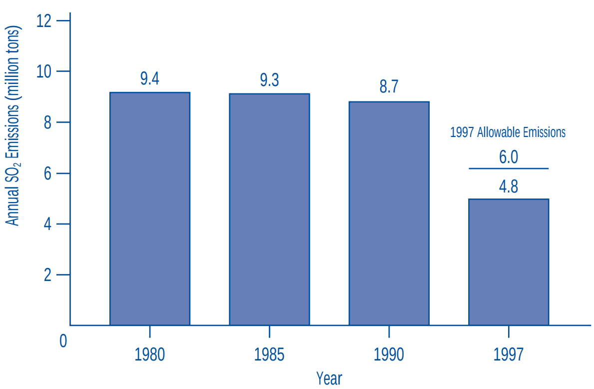
Since implementation of the U.S. Acid Rain Program in 1995, utility units targeted under Phase I (1995–1999) have continued to show a 50% reduction in SO_2 emissions from 1980 levels. These Phase I units, which include the highest emitting plants, have exceeded their prescribed annual emissions reductions, reducing SO_2 emissions significantly below allowed annual levels. In 1997, SO_2 emissions for all affected Phase I units were 5.5 million tons, which is 23% (or 1.7 million tons) below the 7.1 ton allowable level determined by 1997 allowance allocations. All affected Phase 1 units include the highest emitting 263 original units and 160 other participating units in 1997. SO_2

1. One Tonne is equal to 1.1 short tons
2. One (short) ton is equal to 0.9 tonnes.
3. With the exception of sources re-powering with a qualifying clean coal technology, sources receiving bonus allowances as part of the Allowance Trading Program and sources using allowances earned for early reduction efforts prior to the year 2000.

emissions for the original units were 4.8 million tons in 1997. For the first three years of the program (1995–1997), SO_2 emissions from all Phase I units have been 30% below allowable levels.

As part of the Acid Rain Program, all affected utility units (which account for more than 99% of utility SO_2 emissions) are allocated a specific number of emissions allowances, with one allowance equalling one ton of SO_2 emissions. Allowances are tradable, and utilities are free to buy, sell, or bank them for future use. In Phase II (to begin in the year 2000), the total number of allowances allocated is set at half the 1980 emissions level, providing a legally binding cap on national utility SO_2 emissions.

U.S. SO_2 Emissions Reductions at Original Phase 1 Utility Units



Note: Original utility units include the 263 highest emitting Phase 1 units.

The SO_2 Allowance Trading Program is the first large-scale emissions trading program in the United States. The flexibility of this program and other compliance options has resulted in significantly lower than expected costs for reducing emissions.

REDUCTIONS IN EMISSIONS OF NITROGEN OXIDES

CANADIAN COMMITMENT

- *By 2000, reduce stationary source emissions 100,000 tonnes below the forecast level of 970,000 tonnes*
- *By 1995, develop further annual national emissions reduction requirements from stationary sources to be achieved by 2000 and/or 2005*
- *Mobile sources: implement NO_x control program*

In Canada, nitrogen oxide (NO_x) emissions have decreased from 2.1 million tonnes in 1990 to 2.0 million tonnes in 1995, largely as a result of industrial process changes, retrofitting of fossil-fuelled power plants, and provincial and Federal programs targeting mobile sources.

The largest contributor of NO_x in Canada is the transportation sector, which accounts for about 60% of all emissions. Improvements are expected by 2010, with an anticipated decline in NO_x emissions of 10% from 1990 levels, primarily as a result of improved standards for on-road vehicles. In 1997, Transport Canada adopted new regulations under the Motor Vehicle Safety Act that harmonized Canadian light-duty vehicle emissions standards with those of the United States. The new regulations apply to light-duty vehicles, light-duty trucks, engines, and motor cycles manufactured after September 1, 1997, which are fuelled by gasoline, methanol, compressed natural gas (CNG), and liquefied natural gas (LNG). Additional new regulations apply to diesel-fuelled on-road heavy-duty vehicles manufactured after January 1, 1998. Regulations are pending for diesel construction vehicles and certain off-road vehicles, which will likely be harmonized with U.S. standards. A Memorandum of Understanding signed in 1995 with the Railway Association of Canada restricts NO_x emissions to 115 kilotonnes (kt) per year for the railway industry.

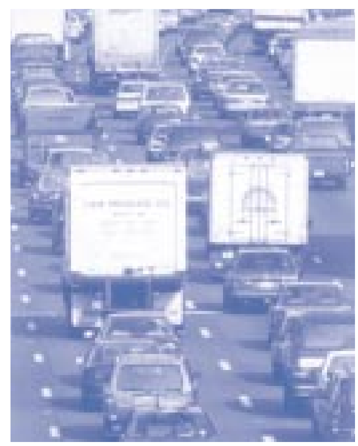


Photo by Steve Delaney, U.S. EPA

For stationary source sectors, Canada is on target to meet its commitment to reduce national stationary source NO_x emissions by the year 2000, with expected reductions well in excess of the required 100 kt. Reductions are in place at major combustion sources, power plants, and metal smelting facilities. Stricter emissions limits for reducing NO_x emissions from new power plants have been established for 1995, and further tightening of the emissions limits for post-2000 is in progress. New guidelines have also been developed for reducing NO_x emissions from new and modified commercial and industrial boilers, process heaters and cement kilns, combustion turbines, and gas-fired reciprocating compressor engines.

Ontario, Quebec, the Lower Fraser Valley of British Columbia, and the Atlantic provinces are completing action plans to reduce NO_x emissions as part of their acid rain or smog programs. These include actions to reduce vehicle emissions and cut NO_x emissions at large stationary sources such as power plants.

U.S. COMMITMENT

- *By 2000, reduce total annual emissions of NO_x by 2 million tons*
- *Implement stationary source control program for electric utility boilers*
- *Implement mobile source control program*

The United States continues to address NO_x emissions from stationary and mobile sources under the 1990 Clean Air Act Amendments (CAAA), which has mandated a two million ton reduction in NO_x emissions by the year 2000. The Acid Rain Program and the motor vehicle source control program together are expected to exceed this goal.

In 1996, the first year that NO_x reductions were implemented under the Acid Rain Program, affected utility units reduced emission rates by an average of 40% below 1990 levels, emitting 33% less NO_x (a reduction of 340,000 tons) and achieving an average of 18% overcompliance with required emission rate levels.

The number of utility units required to make reductions in 1997 was 10% greater than in 1996. These units reduced emission rates by an average of 41% below 1990 levels, emitting 32% less NO_x (a reduction of 409,000 tons) and achieving 16% overcompliance with required emission rate levels.

Beginning in the year 2000, NO_x emissions from electric utility units are expected to be reduced by an additional 1.7 million tons per year as a result of regulations issued in December 1996 for virtually all coal-fired utility boilers.

EPA continues to implement regulations established under the CAAA for passenger cars and trucks, heavy-duty trucks, locomotives, aircraft, and nonroad engines. The National Low Emission Vehicle (NLEV) Program, promulgated in March 1998, will achieve substantial nationwide NO_x emissions reductions. NLEV vehicles will be as much as 70% cleaner than current vehicles. Emissions reduction estimates are based on a start date of May 1999 in the Northeast and May 2001, nationwide.

In October 1997, EPA adopted more stringent emissions standards for heavy-duty diesel engines, which will be used in trucks and buses beginning in the model year 2004. This new combined standard for NO_x and hydrocarbons (HC) represents a 50% reduction in NO_x emissions from the existing 1998 NO_x standard. In September 1997, EPA proposed stringent new standards for diesel engines used in a wide range of nonroad construction, agricultural, and industrial equipment, and some marine applications.

In December 1997, EPA finalized emissions standards for NO_x, HC, carbon monoxide (CO), PM, and smoke for newly manufactured and remanufactured diesel-powered locomotives and locomotive engines. The standards will take effect in 2000 and will result in an approximate two-thirds reduction in NO_x emissions. In April 1997, EPA finalized new emissions standards for NO_x and CO for commercial aircraft engines. Aircraft engines contribute about 2% of the total U.S. mobile source NO_x and CO emissions but can account for up to 4% of mobile source NO_x emissions in some airport areas.

EPA has also undertaken to reduce NO_x emissions under the ground-level ozone nonattainment provisions of the Clean Air Act. In November 1997, EPA proposed the ozone transport reduction rulemaking to establish budgets for NO_x emissions for various states. By the summer of 2007, the rulemaking is expected to result in NO_x reductions of more than 1.1 million tons annually beyond those achieved through the acid rain and mobile source control programs. To assist the states in meeting their NO_x budgets, EPA proposed a voluntary NO_x trading program in May 1998. Final regulations on the NO_x budgets and the voluntary NO_x trading program are expected in the fall of 1998.

MONITORING OF EMISSIONS

Canada and the United States differ in the compliance monitoring systems that they use to measure emissions of SO_2, NO_x, and other pollutants from utilities.

CANADIAN COMMITMENT

- *By 1995, estimate emissions of NO_x and SO_2 from new electric utility units and existing electric utility units greater than 25 MWe (megawatts electric) using a method of comparable effectiveness to Continuous Emissions Monitors (CEMs)*
- *By 1995, investigate feasibility of using CEMs*
- *Other major stationary sources: work towards comparably effective methods of emission estimation for SO_2 and NO_x emissions*

Continuous Emissions Monitoring (CEM) systems are not yet fully utilized in Canada as a tool for tracking emissions at all major sources. However, either CEM or mass balance methods are used to estimate SO_2 emissions in both utility and nonutility installations because emissions from these sources are regulated to reduce acid rain. Since NO_x emissions are more difficult to estimate in equipment such as utility boilers, almost all of Canada's base-loaded utility units now have CEMs to measure NO_x. Some of the large gas turbine cogeneration facilities also have CEM systems for NO_x monitoring. Small cogenerators, pipeline compressors, and peaking units, however, still depend upon alternative methods with comparable effectiveness to CEM, such as annual sampling, fuel/steam/water flow measurement, or parametric performance analysis. New cement plants will be required to use CEM systems, although more flexible approaches will continue to be accepted for existing plants.

As part of the NO_x/VOC Management Program, the *National Emission Guidelines for Commercial/Industrial Boilers and Heaters* has been published. The guideline references a range of emissions measurement options that can be used to evaluate NO_x emissions and calls for some form of continuous verification from sources with an input capacity greater than 250 million British thermal units per hour [MMBtu/hr; i.e., >73 megawatts (MW) thermal].

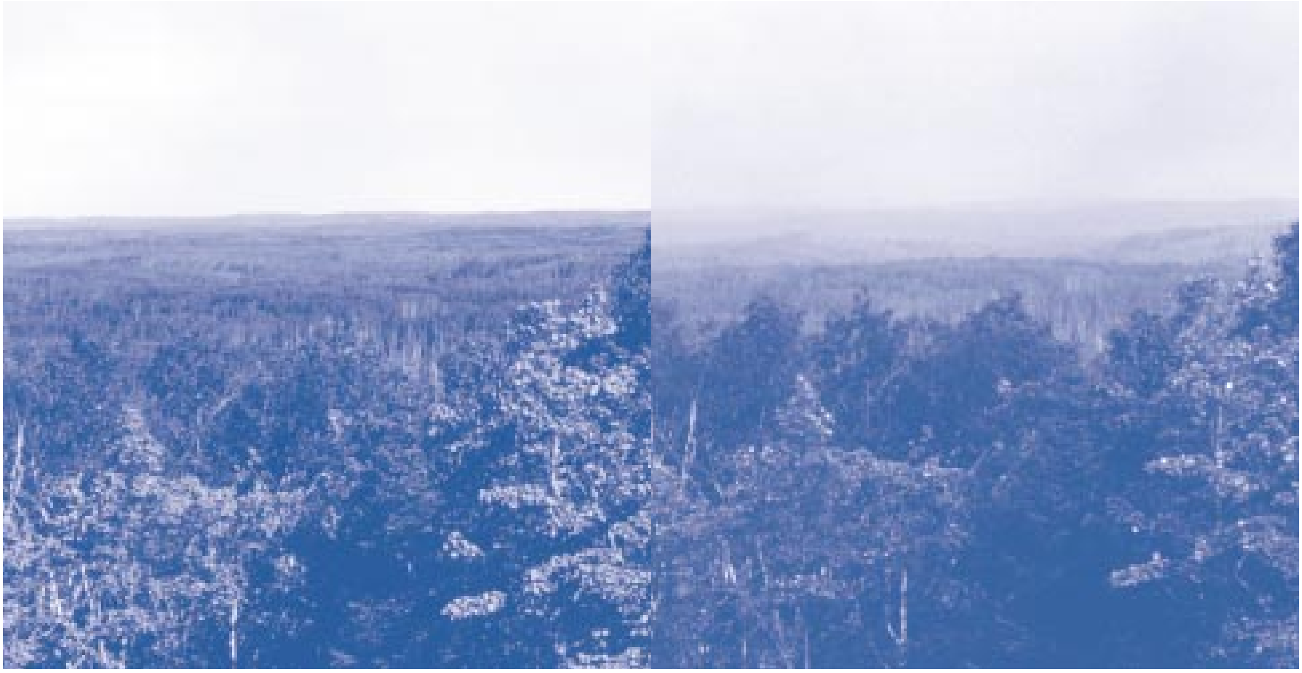
U.S. stack testers perform measurements to improve quality assurance requirements for flow CEMs which measure stack gases

CEMs at Homer City, PA, plant

U.S. COMMITMENT

- *By 1995, new electric utility units and existing units greater than 25 MWe operate CEM systems*

CEMs are used by all utilities affected under the Acid Rain Program and are critical to the success of the program, providing some of the most accurate data ever collected by EPA. CEM data establish the basis for the SO_2 allowance trading program and are used to determine compliance with the NO_x reduction program.



Courtesy of the U.S. Forest Service

Visibility on good (left) and bad (right) day at Boundary Waters Canoe Area Wilderness, Minnesota

Any new or existing utility units greater than 25 MW must use CEMs that measure gaseous pollutants. Coal units must use volumetric flow monitors. Some natural gas and oil-fired units have alternative monitoring requirements. Each regulated unit must account for each ton of emitted SO_2, NO_x, and carbon dioxide (CO_2) and provide this and other operating data quarterly to EPA's Emissions Tracking System, which then analyzes the data. Utility quarterly reports are available on the Internet (http://www.epa.gov/acidrain).

PREVENTION OF AIR QUALITY DETERIORATION AND VISIBILITY PROTECTION

CANADIAN COMMITMENT

- *By 1995, develop and implement means affording levels of prevention of significant air quality deterioration and visibility protection comparable to those in the United States for sources that could cause significant transboundary air pollution*

Environmental management in Canada includes a range of measures for prevention of significant air quality deterioration (PSD) and visibility protection. A compilation of all of the abatement requirements for new sources across the country is currently being completed to demonstrate the means Canada uses to prevent air quality deterioration.

In addition, Federal and provincial environmental assessment legislation requires that air quality be considered for all major new point sources or modifications to existing sources. 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.

The development of Canada-Wide Standards for particulate matter and ozone, which will set air quality targets and establish implementation plans to meet the targets, will also contribute to efforts to address Canada's obligations related to PSD and visibility protection under the Air Quality Agreement.

U.S. COMMITMENT

- *Maintain means for preventing significant air quality deterioration and protecting visibility as required under the Clean Air Act for sources that could cause significant transboundary air pollution*

The U.S. PSD program has three key goals: protecting the public health and welfare from any adverse effects that might occur — even at air pollution levels lower than the National Ambient Air Quality Standards (NAAQS); preserving, protecting, and enhancing the air quality in Class I areas, such as large national parks and wilderness areas; and ensuring that economic growth occurs in harmony with the preservation of existing clean air resources.

The PSD program sets maximum air quality degradation limits that can ensure that the air quality in many areas of the country remains better than that mandated by the NAAQS. The program also requires best available control technology for all new sources.

In July 1997, EPA proposed regulations that expand the scope of existing 1980 visibility rules to include regional haze problems. The proposed rules will improve visibility or visual air quality at specially protected “Class I” national parks and wilderness areas including the Grand Canyon, Yosemite, Yellowstone, Mount Ranier, Shenandoah, the Great Smokies, Acadia, and the Everglades. The proposed regulations set targets for each Class I area allowing for improvement of visibility on the most impaired days and prevention of further degradation on the least impaired days. Visibility beyond these areas would also be improved. Under the proposal, states must implement a planning process to attain the new ambient air quality standards for ozone and PM and improve visibility problems caused by regional haze. Final regulations are expected in the fall of 1998. As a result of the proposed regulations, and in an effort to achieve greater consistency among Federal land managers on permit review issues, the U.S. National Park Service, the U.S. Forest Service, and the U.S. Fish and Wildlife Service have initiated a process to undertake the following: provide a list for the public of the different species sensitive to air pollution within Class I areas; determine critical loads and criteria for adverse impacts; and standardize their requests for analyses that should be performed by permit applicants.

In other program activities, EPA proposed revised New Source Review regulations in July 1996 in an effort to streamline its permitting procedures. Among other things, the proposed regulations would clarify and codify the procedures for reviewing the impact of major new sources (or major modifications of existing sources) for Class I areas. Final regulations are expected in December 1998.

NOTIFICATION OF SIGNIFICANT TRANSBOUNDARY AIR POLLUTION

CANADIAN AND U.S. COMMITMENT

- *Each Party shall notify the other concerning a proposed action, activity, or project that would be likely to cause significant transboundary air pollution*

Canada and the United States are continuing notification procedures initiated in the fall of 1994 to identify possible new sources or modifications to existing sources of transboundary air pollution within 100 kilometres [62 miles] of the border, as well as any new sources or modifications of concern beyond the 100-km limit. Canada has notified the United States of 12 sources to date, and the United States has notified Canada of 6 sources. Transboundary notification information is available to the public on the Internet (see box). Both governments are making an effort to improve their notification procedures.

INTERNET SITES

Canada: http://www.doe.ca/pdb/can_us/applic_e.html

U.S.: http://www.epa.gov/ttn/gei/uscadata.html

Canadian and U.S. officials discuss monitoring in Sault Ste. Marie, Ontario, at the Algoma Steel consultation meeting (June 1998).

Canada and the United States are involved in specific discussions on the Algoma Steel plant in Ontario, the Boundary Dam power station in Saskatchewan, and the Connors Creek/Detroit Edison facility in Detroit, Michigan.

ASSESSMENT AND MITIGATION OF TRANSBOUNDARY AIR POLLUTION

CANADIAN AND U.S. COMMITMENT

- *Each Party shall, as appropriate and as required by its laws, regulations, and policies, assess those proposed actions, activities, and projects within the area under its jurisdiction that, if carried out, would be likely to cause significant transboundary air pollution*

Despite different interpretations of the commitment to assess and mitigate under the Agreement, Canada and the United States have made progress in finding ways to cooperate. For example, in 1996, Canada formally raised its concern to the United States that the Federal Energy Regulatory Commission (FERC) decision to allow open-access transmission of U.S. electric power generation could potentially increase transboundary flows of emissions due to possible changes in the locations of power generation as a result of competition in electricity markets.

Following FERC's adoption of an open access transmission policy, President Clinton proposed the Comprehensive Electricity Competition Plan, which recommends a number of measures to improve energy efficiency and reduce emissions of air pollutants, including NO_x. Under this plan, Federal agencies are committed to coordinating their air emissions data and reporting annually to the President. EPA is developing analytical tools to assist in monitoring power plant emissions and analyzing electricity markets as the electricity industry becomes more competitive. EPA is developing a comprehensive data system comparing environmental attributes of all generating plants and companies in the United States. EPA has agreed to share the results of the monitoring and tracking of emissions with Canada.

ADDITIONAL AIR QUALITY PROGRAMS AND INITIATIVES

In recognition of the harmful effects of ground-level ozone and inhalable particles, Canada and the United States are now undertaking cooperative efforts on these issues.

COOPERATION ON GROUND-LEVEL OZONE AND PARTICULATE MATTER

Joint Plan of Action for Addressing Transboundary Air Pollution

In April 1997, EPA Administrator Carol Browner and the former Canadian Minister of the Environment signed an agreement calling on both governments to develop a Joint Plan of Action for Addressing Transboundary Air Pollution focusing on ozone and particulate matter (PM).

In June 1998, EPA Administrator Carol Browner and Canadian Minister of the Environment Christine Stewart signed a Progress Report on the Joint Plan that sets targets and schedules for governments toward a negotiated ozone annex to the Air Quality Agreement and a joint plan on inhalable particles. The Progress Report identifies the following strategy:

April 1998: Deliver to the Canadian Minister of the Environment and the U.S. EPA Administrator a progress report on work plans to develop the Joint Plan of Action [completed];

December 1998: Review by the Canada–U.S. Air Quality Committee of possible elements of a new ozone annex to the Canada–U.S. Air Quality Agreement and of possible next steps on fine inhalable particles; and

April 1999: Deliver to the Canadian Minister of the Environment and the U.S. EPA Administrator a recommendation on negotiation of an ozone annex pursuant to the Air Quality Agreement and on a joint work plan for transboundary fine inhalable particles.

The delivery of the Progress Report on the Joint Plan of Action to the U.S. EPA Administrator and the Canadian Minister of the Environment fulfilled the first step of the strategy. The report outlines the work that Canada and the United States will undertake by April 1999 to support a recommendation regarding development of an ozone annex and a joint work plan for transboundary fine inhalable particles.

DOMESTIC PROGRAMS TO ADDRESS OZONE AND PM

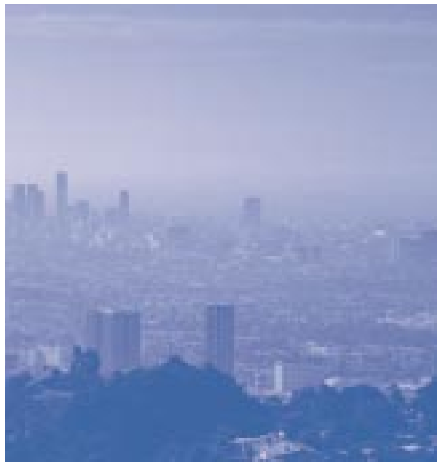
The following subsection identifies the increasing program efforts of both the Canadian and U.S. governments to address ground-level ozone and PM issues.

CANADA

Air Quality Objectives and Standards

The current Canadian national air quality objective for ground-level ozone is 82 parts per billion (ppb) averaged over one hour. This objective has been translated into standards in many provinces. At present, there are no national objectives for PM other than total suspended particulate matter (TSP); however, British

Columbia and Newfoundland have each set an air quality criterion for particulate matter with a diameter of 10 µm (PM_{10}) at 50 micrograms per cubic metre (µg/m^3) averaged over 24 hours. Ontario has set an interim criterion at the same level. Newfoundland has set a $PM_{2.5}$ criterion of 25 µg/m^3 (averaged over 24 hours).



In view of recent research findings linking serious adverse health impacts to ground-level ozone and fine PM, Canada is conducting a scientific review of the PM and ozone objectives.

Building on this work, the Federal and Provincial governments are developing Canada-Wide Standards (CWS) for ground-level ozone and PM (PM_{10} and $PM_{2.5}$). The CWS will set achievable targets for these pollutants that all Canadian jurisdictions will formally agree to meet. The recommendations on CWS for PM and ozone, with accompanying jurisdictional implementation plans, are expected to be presented to the Canadian Council of Ministers of the Environment in the fall of 1999.

Smog Management (Ground-level Ozone and PM)

The Phase 1 NO_x/VOC Management Plan, in place since 1990, includes a wide range of Federal and provincial initiatives and measures to reduce NO_x and VOCs. Complementing the Phase 1 Federal initiatives, the Phase 2 Federal Smog Management Plan, published in 1997, outlines further initiatives to be taken at the Federal level to reduce NO_x and VOC emissions and broadens the issue to consider PM.

Provinces are also developing smog management plans. These initiatives incorporate substantial reductions of NO_x and VOC emissions in the Windsor–Quebec City Corridor, the Southern Atlantic Region, and the Lower Fraser Valley of British Columbia. In British Columbia, the Greater Vancouver Regional District has enacted a stringent program of regulatory limits for VOC and NO_x emissions for a wide range of industrial and commercial point sources as well as Canada's first mandatory vehicle inspection and maintenance (I&M) program.

Following more than a year of intensive consultations, Ontario published a smog plan in January 1998 that includes a wide range of specific industrial commitments to reduce NO_x and VOC emissions. Ontario is putting in place its own mandatory in-use vehicle I&M program ("Drive Clean"), which includes heavy-duty vehicles. In addition, Ontario is developing a particulate strategy as part of its smog plan commitments.

Work has begun on a Phase 3 Federal smog management program, which will include an increased focus on inhalable particles as an important component of smog, and will link measures more strongly with other air quality programs, including the acid rain program.

UNITED STATES

Revised Ozone and PM Standards

In 1997, EPA revised the National Ambient Air Quality Standards (NAAQS) for ozone and PM. EPA is phasing out the previous 1-hour primary (health-based) standard for ozone and replacing it with a new 8-hour standard of 0.08 parts per million (ppm). To ensure a smooth, legal, and practical transition, EPA will not revoke the 0.12 ppm 1-hour standard in a given area until that area has achieved three consecutive years of air quality data meeting the 1-hour standard. EPA has also replaced the previous secondary standard for ozone (to protect the environment, including crops, national parks, and forests) with a standard identical to the new primary standard.

For PM, EPA revised the primary (health-based) standards by adding a new annual $PM_{2.5}$ standard of 15 µg/m^3 and a new 24-hour $PM_{2.5}$ standard of 65 µg/m^3. EPA is retaining the current annual PM_{10} standard of 50 µg/m^3 and adjusting the PM_{10} 24-hour standard of 150 µg/m³ by changing the form of the standard. EPA revised the secondary (welfare-based) standards by making them identical to the primary standards. Secondary standards must specify the level of air quality necessary to protect the public welfare from any known or anticipated adverse effects associated with the pollutant in ambient air.

EPA $PM_{2.5}$ monitors at the North Carolina training site.

EPA believes that the $PM_{2.5}$ and PM_{10} standards, combined with the Acid Rain Program and Regional Haze Program, will provide protection against the major PM-related welfare effects, including visibility impairment, soiling, and materials damage. For the new $PM_{2.5}$ standards, several years of monitoring and planning will be undertaken before EPA will require local control measures. The first priority will be to establish a comprehensive monitoring network (comprising over 1,000 sites) to determine ambient fine particle concentrations across the country. The network will help EPA and the states determine which areas do or do not meet the new air quality standards, the major sources of $PM_{2.5}$ in various regions, and what action is needed to clean up the air. Components of this monitoring network will help provide subsequent support for scientific research on PM.

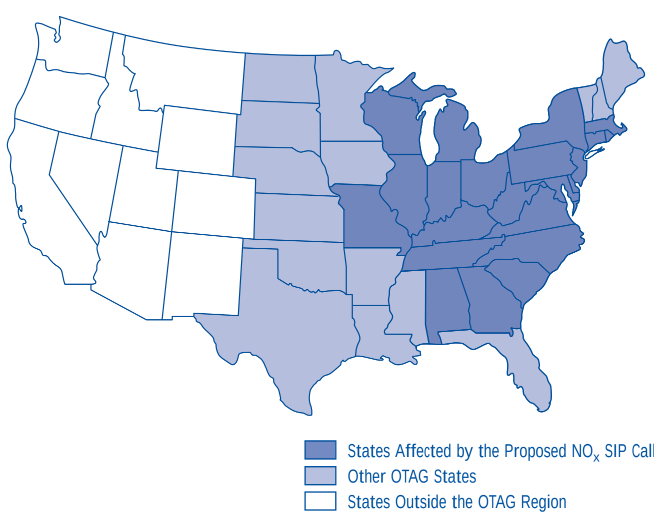
Three years of acceptable monitoring data from the PM network will be available from the monitors by the spring of 2001 at the earliest, and three years of data will be available from all monitors in 2004. The first determinations about nonattainment status will not occur before 2002. States will then have three years from a designation of nonattainment to submit, to EPA, State Implementation Plans (SIPs) for attaining the standards. The next review of the PM standards will be completed in 2002, before the SIPs are developed.

The Ozone Transport Reduction Rule

EPA's strategy for implementing the new ozone standard will build on work conducted over the past two years by the Ozone Transport Assessment Group (OTAG), which is made up of environmental commissioners from the 37 easternmost states and the District of Columbia. In accordance with the Presidential directive issued with the new NAAQS, EPA intends to adopt a regional strategy to reduce ozone in the eastern United States.

In November 1997, EPA proposed an ozone transport reduction rule requiring states in the OTAG region that are significantly contributing to nonattainment or interfering with maintenance of attainment in downwind states to submit revised SIPs to reduce interstate pollution. Twenty-three jurisdictions are affected by the proposed NO_x SIP call. The final rulemaking is expected in the fall of 1998. In the proposal, EPA estimates that the vast majority of the 96 "new" counties (counties that violate the new 8-hour standard but not the old 1-hour standard) in the 23 jurisdictions are projected to come into attainment as a result of implementation of the regional NO_x reductions included in the OTAG modelling results.

Ozone Transport Assessment Group (OTAG) States



OTHER COOPERATIVE AIR QUALITY EFFORTS

In a spirit of bilateral cooperation, some Canadian provinces and American states have established partnerships and developed initiatives to address transboundary air quality issues.

New England Governors and Eastern Canadian Premiers

The Conference of New England Governors and Eastern Canadian Premiers announced resolutions containing action plans for acid rain and mercury at its June 1998 annual meeting. The resolutions include commitments to expand deposition and effects monitoring and analysis for SO_2, NO_x, and mercury. The governors and premiers also committed to establishing new SO_2 reduction targets for 2010 in each of their jurisdictions and called on the Federal governments to reduce annual SO_2 emissions in each country by a further 50% below the current commitments. For mercury, they agreed to further specific emissions reductions within the region. The resolutions were an outgrowth of a February 1998 workshop held in Portland, Maine. These issues will remain on the agenda for several years.

Partnerships for Protected Areas

A regional air quality partnership in the northeastern United States and Atlantic Canada has been established to preserve and enhance the air quality of protected national parks and wilderness areas, as well as other areas in the region. Known as the Northeast Regional Air Quality Committee (NERAQC), it is made up of international, Federal, provincial, and state agencies. The Committee provides a vehicle for information exchange on air pollution research, monitoring, and mitigation efforts among member agencies. The Committee also develops jointly sponsored projects that enhance the understanding of the importance of clean air and supports efforts to maintain or improve air quality in protected areas. Among NERAQC's achievements have been the installation and operation of a continuous monitor for ozone at Roosevelt Campobello International Park, preparation of a regional air quality assessment, and a letter of support regarding EPA's proposed regional haze regulations. More information is available on the Internet (http://capita.wustl.edu/NEARdat/transflo/NERAQC/NERAQC.HTM).

The Great Lakes Clean Air Partnership (GLCAP) is being organized with states, provinces, and native Canadians and Americans in the Great Lakes region to focus on sources of air pollution affecting protected areas in the United States and Canada in the Great Lakes ecosystem. GLCAP recently finalized its Memorandum of Understanding and established an executive secretariat composed of Canadian and U.S. co-chairs and two additional members from each country.

A third international partnership is being organized in the Pacific Northwest (British Columbia, Washington, and Oregon) to deal with air pollution impacts on protected areas in that region. The group is made up of Federal, state, provincial, and local land management and air regulatory agencies.

The NAFTA Commission for Environmental Cooperation (CEC) Transboundary Ozone Report

A report entitled *Long-Range Transport of Ground-level Ozone and Its Precursors: Assessment of Methods to Quantify Transboundary Transport Within the Northeastern United States and Eastern Canada* (1997) was prepared by the NAFTA Commission for Environmental Cooperation (CEC) Secretariat together with the Northeast States for Coordinated Air Use Management (NESCAUM) and the Eastern Canada Transboundary Smog Issue Group (ECTSIG). The report showed that transboundary transport of these pollutants exists in North America, particularly where pollutants from upwind regions with high levels of precursor emissions flow into downwind regions experiencing high ozone levels. Findings also indicated that when local pollution is factored in with long-range transport, ground-level ozone can be a regional problem over an area of more than 600 kilometres [about 400 miles] and for periods of several days. The report is available from the Commission for Environmental Cooperation, 393 St. Jacques West, #200, Montreal, Quebec, Canada H2Y 1N9 or NESCAUM, 129 Portland Street, Boston, MA 02114, USA.

Canada–U.S. Georgia Basin Ecosystem Initiative

Canada and the United States are moving to implement integrated, inter-agency airshed management plans to improve air quality within the Georgia Basin, which encompasses parts of Washington State and the Province of British Columbia. Analysis of air and precipitation samples, meteorological patterns, and output from computer models indicates the transborder flow of pollutants between Washington State and the Canadian portion of the Lower Fraser Valley, with windflow patterns moving pollution in both directions across the border. Computer models clearly show the transborder flow of air pollution during smog episodes in the Lower Fraser Valley.

Canadian Public Smog Forecasts – Air Quality Prediction Pilot Project

During the summer of 1997, a pilot project in New Brunswick tested the concept of providing "smog forecasts" to the public. Daily predictions of ozone concentrations, along with public health and educational messages, were prepared for the Greater Saint John Region. Issuing the forecast required continual exchanges of information with the State of Maine Department of Environmental Protection. Environment Canada is considering the feasibility of expanding this service to other urban centres.

U.S. Air Quality Prediction Pilot Projects

Several states are actively developing a credible air quality forecasting system to issue warnings when public health might be threatened. The focus is most often on urban areas (e.g., in southern states and in the West), but is sometimes regional. As a step in the development process, the National Oceanic and Atmospheric Administration (NOAA) is making experimental air quality forecasts for the Northeast available via the Internet. A select number of states will be evaluating the accuracy of predictions, and the results will guide future projects.

EMPACT Project

Under the "Right to Know Initiative," EPA created the Environmental Monitoring for Public Access and Community Tracking (EMPACT) project which includes an ozone mapping project developed in cooperation with the states. The project uses real-time data from more than 400 monitoring stations in 21 eastern and mid-western states to provide colour-coded, animated images of ozone levels throughout the day. The maps allow local media to deliver accurate and timely health messages about ozone pollution to interested areas including Canada. EPA will generate animated movies and peak daily concentration maps for different subsets of the 21-state region. Ozone maps are available on EPA's website (http://www.epa.gov/airnow).

Great Lakes Binational Toxics Strategy

In April 1997, Canada's Minister of the Environment and the EPA Administrator signed the Great Lakes Binational Toxics Strategy. The strategy, developed in close cooperation with the eight Great Lakes States, the Province of Ontario, and key stakeholders, includes goals for reducing or virtually eliminating certain persistent toxic substances in the Great Lakes ecosystem. Work is still under way to reduce the deposition of air toxics from sources both within and outside the Great Lakes Basin.

SCIENTIFIC AND TECHNICAL ACTIVITIES

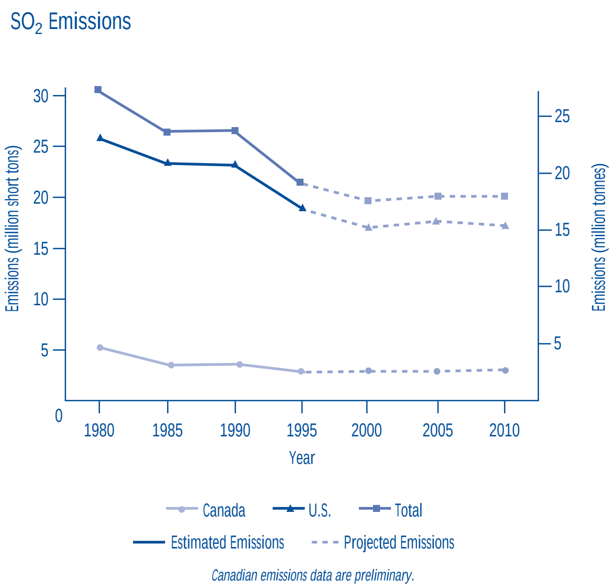
This section presents the progress of both countries in meeting the commitments in Annex 2 of the Air Quality Agreement, which addresses coordination and cooperation on air quality modelling, monitoring, and effects research.

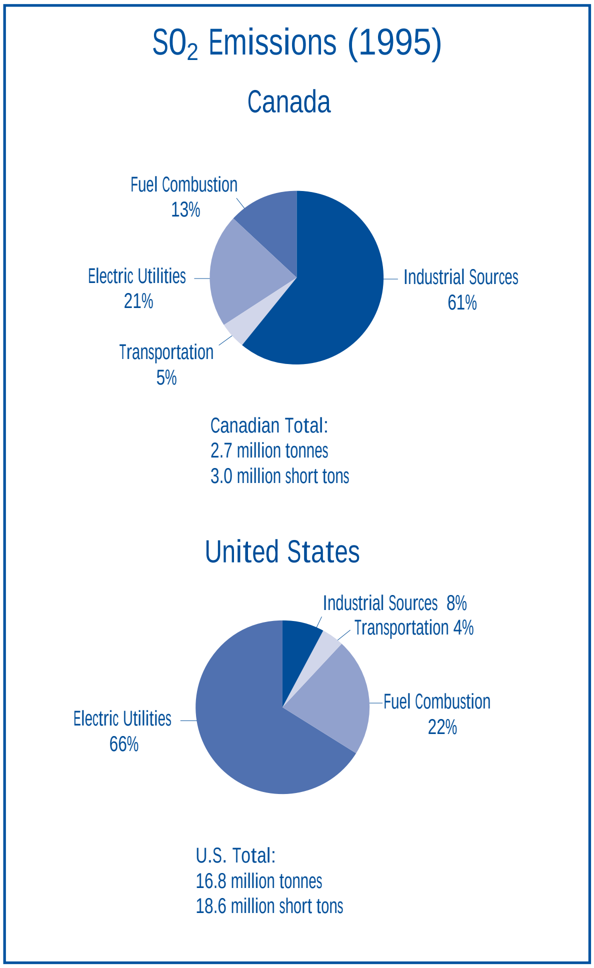
EMISSIONS INVENTORIES

SO_2, NO_x, and VOCs are the main pollutants addressed in this subsection. SO_2 and NO_x emissions are the dominant precursors of acidic deposition; NO_x and VOCs are primary contributors to the formation of ground-level ozone; and all three pollutants contribute to PM formation. Methodologies to determine emissions estimates for SO_2, NO_x, and VOCs have been revised in both Canada and the United States since the 1996 Progress Report was published, and methods continue to change as new models and data (e.g., CEM data) are introduced.

SO_2

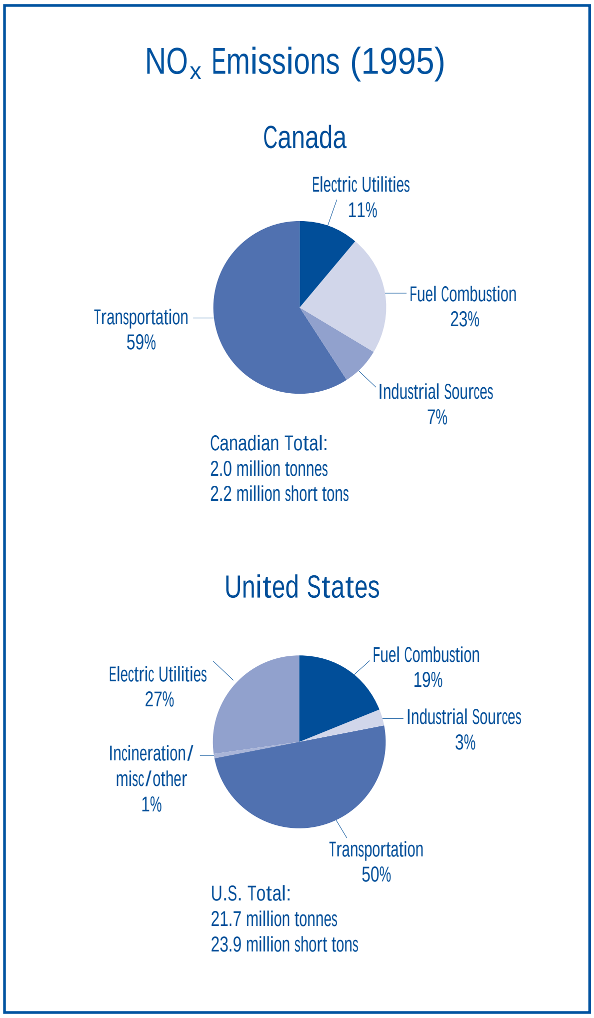
The principal anthropogenic sources of SO_2 are coal and oil combustion, smelting, and a few industrial processes. SO_2 emissions are declining in Canada and the United States. Overall trends in emissions levels from 1980 to 2010 are shown below.

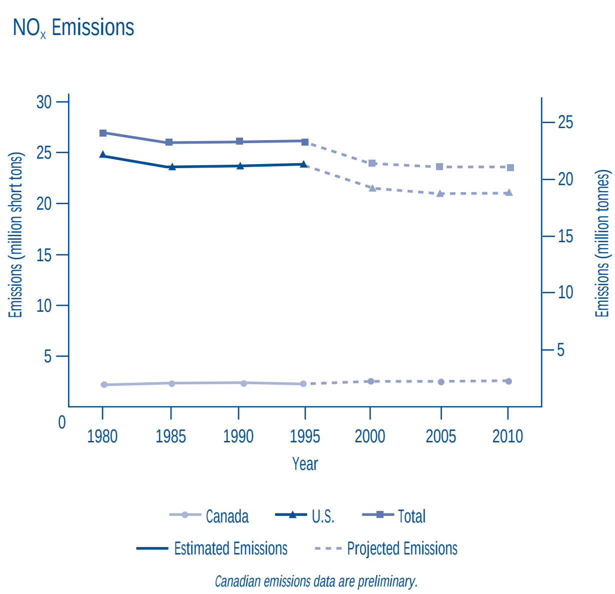




NO_x

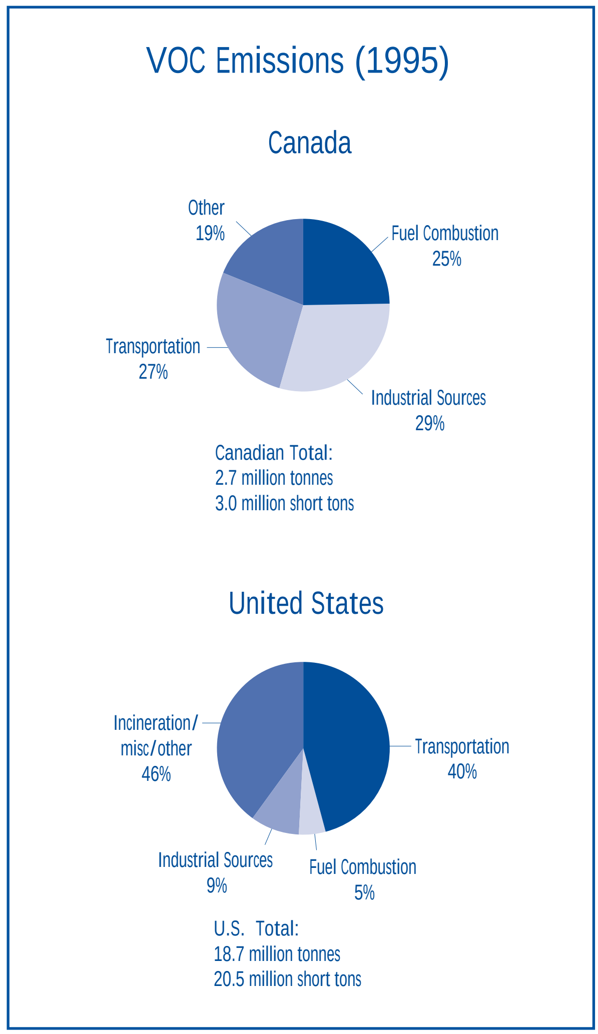
The principal anthropogenic source of NO_x emissions is combustion of fuels in stationary and mobile sources. This occurs in motor vehicles, residential and commercial furnaces, industrial and electric utility boilers and engines, and other equipment. Overall estimated trends for anthropogenic emissions of NO_x in Canada and the United States from 1980 to 2010 are shown on page 15.



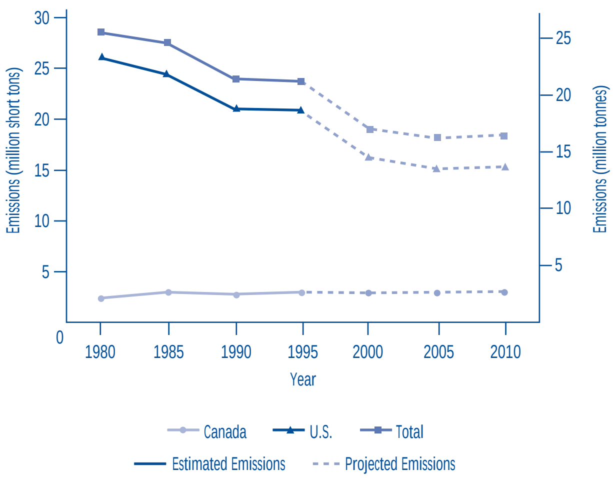


VOCs

VOCs contribute to the formation of ground-level ozone. Anthropogenic emissions of VOCs come from a wide variety of sources, such as mobile sources and industrial processes (e.g., chemical manufacturing and production of petroleum products). Electric utilities produce negligible amounts of VOCs. There are also important natural sources of VOCs. VOC emissions in both countries are expected to decline by the year 2000 and then remain stable through 2010. Overall estimated trends in anthropogenic VOC emissions from 1980 to 2010 for Canada and the United States are shown on page 16.



VOC Emissions



Canadian emissions data are preliminary.

ACID DEPOSITION MONITORING

There has been substantial interaction between Canada and the United States relating to deposition monitoring. Future collaborative efforts may include steps towards network integration, coordinated analyses, and assessment to examine the extent of impacts on transboundary deposition resulting from changes in emissions.

CANADA

In 1997, Canada completed a major review of acid deposition and its effects in Canada: the *1997 Canadian Acid Rain Assessment.* The assessment builds on the contribution of its predecessor (1990) by asking two key questions: “What progress has there been to date?” and “Is that enough to protect Canada’s forests and the health of its citizens from continuing damage by acid rain and other forms of acidic deposition?” Some of the findings are summarized in this report.

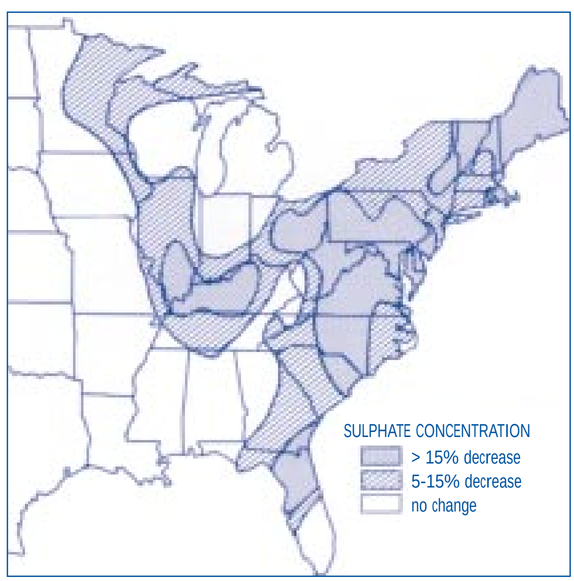
In Canada, reductions in SO_2 emissions have been matched by a corresponding decline in concentrations of sulphates in air and precipitation. These declining concentrations are also reflected in reductions of sulphate deposition on the ground. Between the early 1980s and the early 1990s, there was a noticeable decrease in the area of eastern North America receiving more than 20 kg per hectare per year of sulphate from precipitation. In Canada, this area declined by 46% from 1980 to the early 1990s.

Surprisingly, however, emissions reductions have not yet been matched by a similar reduction in the acidity of precipitation because concentrations of base ions (e.g., calcium, magnesium, and potassium), which normally neutralize the effects of acid deposition, have decreased at the same time as sulphur dioxide emissions. The reasons for the decrease in base ions are not yet fully understood.

UNITED STATES

Acid deposition is measured as both wet deposition (rain, snow, fog) and dry deposition (particles and gases). The National Atmospheric Deposition/National Trends Network (NADP/NTN) is a national long-term wet deposition network made up of 200 sites. An analysis using results from NADP/NTN reported that, in 1995, the sulphate concentration in wet deposition decreased by as much as 25% in the eastern United States compared to the period between 1983 and 1994, particularly in some of the most sensitive areas. This decrease was accompanied by a reduction in the acidity of the precipitation.

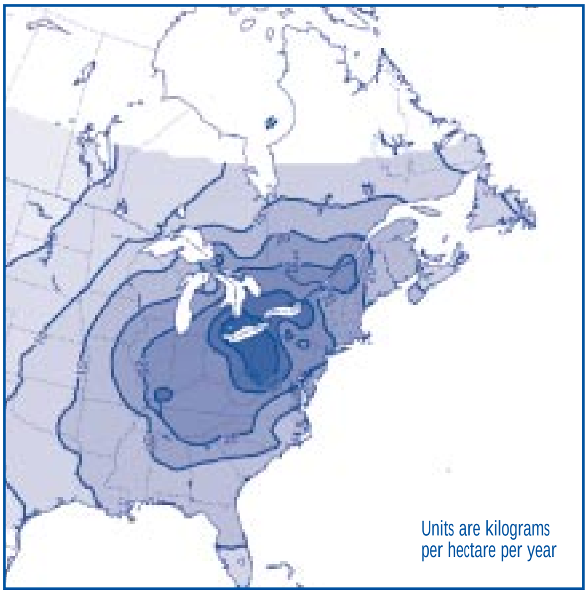
Percent Change of 1995 Sulphate Concentrations in Precipitation (from 1983–1994) following Major Reductions in Sulphur Emissions



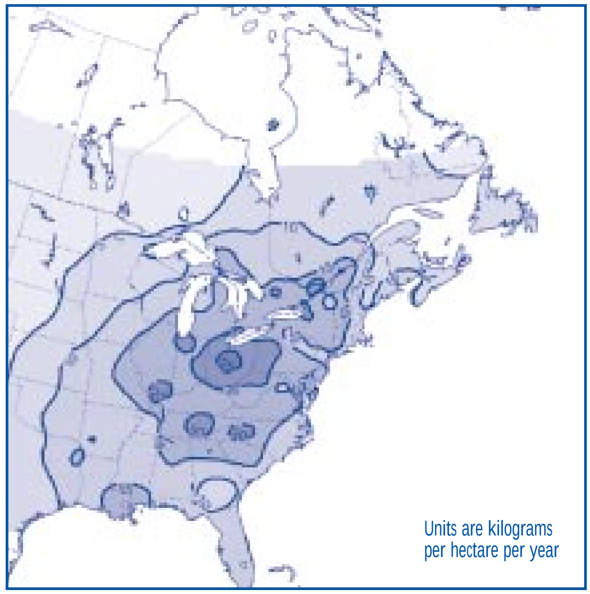
Adapted in the *Illinois State Water Survey Annual Report,* July 1, 1996–June 30, 1997, from J. A. Lynch, V. C. Bowersox and J. W. Grimm (see Bibliography, page 26)

Wet Sulphate and Wet Nitrate Deposition in 1980–1984 and 1995

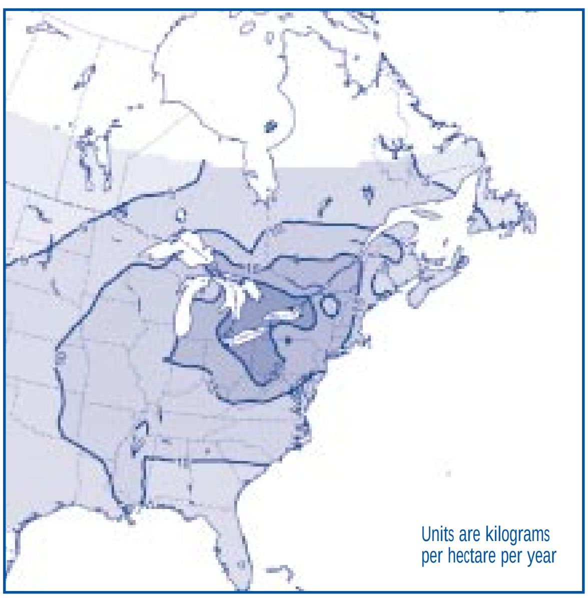
Wet deposition in 1995 can be compared to the average during 1980 to 1984. Comparing (a) and (b) shows that wet sulphate deposition has decreased during the period, generally corresponding to the decrease in SO_2 emissions. On the other hand, wet nitrate deposition — panels (c) and (d) — has remained essentially unchanged. Units are kilograms per hectare per year (kg/ha/yr). These analyses are based on measurements of precipitation chemistry from the NADP/NTN and CASTNeT in the USA, and from Federal and provincial monitoring networks in Canada. Wet sulphate deposition has been adjusted for the sea-salt contribution of sulphate.



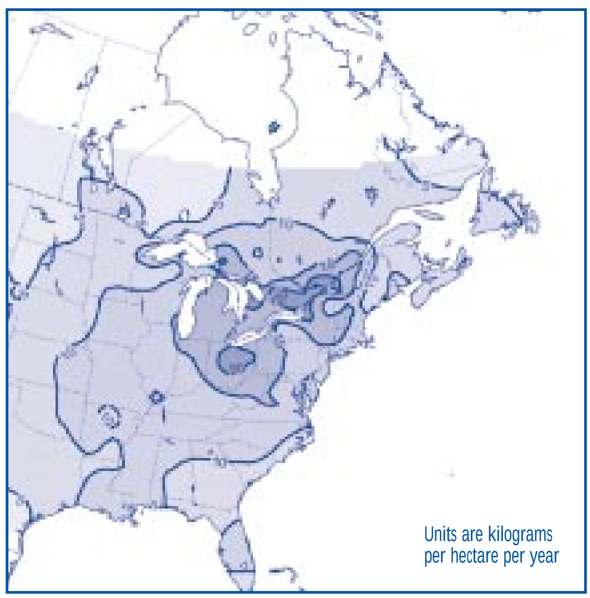
(a) 1980–84 Wet Sulphate Deposition



(b) 1995 Wet Sulphate Deposition

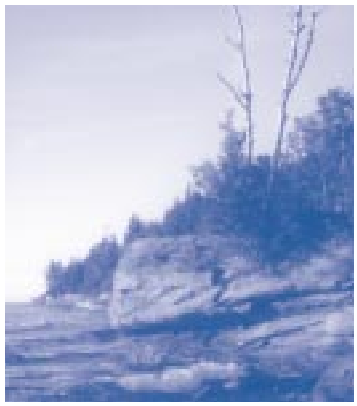


(c) 1980–84 Wet Nitrate Deposition



(d) 1995 Wet Nitrate Deposition

The Clean Air Status and Trends Network (CASTNet) is a long-term dry deposition network made up of 70 sites with a data record starting in 1989. An analysis of CASTNet data completed in 1997 reported that sulphate and sulphur dioxide concentrations in air at the 31 eastern sites decreased by 25% to 30% between 1989 and 1995. A longer record is available at the similar (but substantially fewer) sites of the NOAA Atmospheric Integrated Assessment Monitoring Network (AIRMoN). The AIRMoN data also reveal a decrease in air concentrations of sulphur species in 1995 to levels substantially below those of the early 1990s and apparently returning to levels of the mid-1980s. Further interpretation of available data continues to be fully explored.



There is no consensus regarding trends in nitrate data. Unlike sulphate, wet deposition data for nitrate do not show a reduction in 1995. The dry deposition and air concentration data are relatively inconclusive. Additional data are necessary to assist in detecting trends. The importance of maintaining a dry deposition network has been underlined by recent analyses.

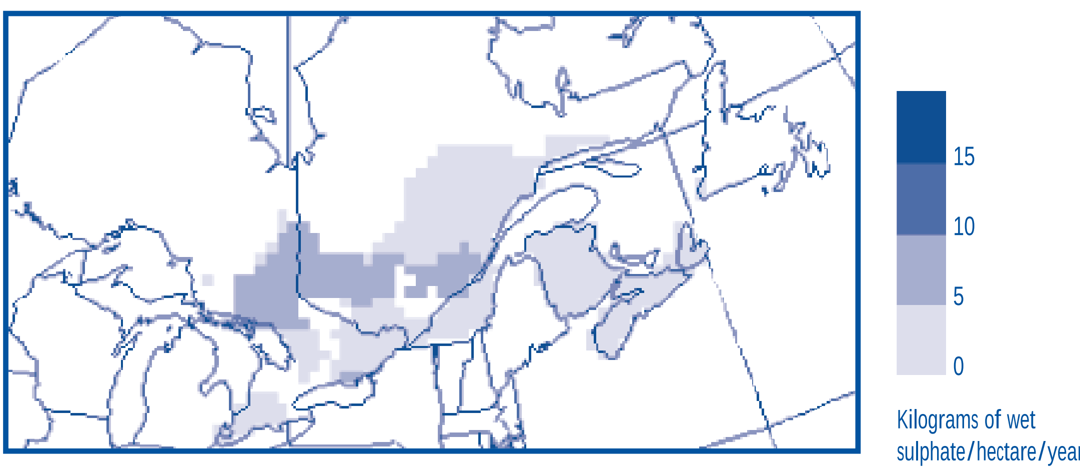
AQUATIC EFFECTS AND RESEARCH MONITORING

Assessing the effectiveness of acid rain control programs and characterizing the continuing effects of acid deposition are important efforts in both Canada and the United States. Research and monitoring activities are necessary to assess whether the control programs and resulting changes in emissions and subsequent deposition are having the desired ecological results.

CANADA

Despite acid rain control programs, a large area of southeastern Canada continues to receive twice as much sulphate as the lakes and wetlands can tolerate without suffering long-term damage. The maximum amount of acidic deposition an ecosystem can tolerate — an amount known as its critical load — depends principally on its local geology.

Projected sulphate deposition exceedances of critical loads in eastern Canada in the year 2000



This figure represents the difference between the critical loads and the expected sulphate deposition after both Canadian and U.S. controls are in place. It shows that a large area (791,000 km^2) of southern and central Ontario, southern Quebec, New Brunswick, and Nova Scotia will continue to receive mean annual sulphate deposition amounts that exceed their critical loads. The critical load will be exceeded by up to 10 kg/ha/yr of wet sulphate in parts of central Ontario and in southern Quebec. As a result, approximately 95,000 lakes will remain damaged by acid rain.

In response to declining sulphate deposition, surface water quality is improving gradually. Sulphate concentrations have declined in the majority of monitored lakes in Ontario and Quebec, but this is not the case in the Atlantic provinces. Corresponding reductions in lake acidity have been modest, however, since the concentrations of base ions have also declined.

An Integrated Assessment Model has been used to predict the acidification status of clusters of Canadian lakes as a function of SO_2 emissions. The model projects that once all the emissions controls established under the legislation of both countries are in place, aquatic ecosystems in a large area of eastern Canada will continue to receive sulphate deposition amounts that exceed their critical loads. As a result, the model predicts that approximately 11% to 25% of the lakes will remain chemically damaged (i.e., with a pH below 6), while approximately 6% to 15% of fish species will continue to be lost. Models indicate that further emissions reductions of as much as 75% in targeted regions of eastern Canada and the United States will be needed to protect sensitive areas in Canada.

UNITED STATES

Trends in surface water chemistry have been reported for 36 sensitive lakes [i.e., low to moderate acid neutralizing capacity (ANC)] as they relate to trends reported for 15 deposition monitoring stations in the northeastern United States for the period 1982–1994. In apparent response to significant declines in sulphate deposition, all lakes had strong decreases in sulphate concentrations. Lakes in New England appeared to have reacted differently from lakes in the Adirondacks: New England lakes showed some recovery (i.e., increased ANC), whereas lakes in the Adirondacks did not show a trend in ANC or experienced further acidification.

The United States will continue annual monitoring of a representative set of 100 lakes in the Northeast and 100 streams in the Mid-Atlantic states that are appropriate for estimating changes in acidification in surface waters in these two regions (the TIME Program). More frequent monitoring and data analysis will be conducted on 30 lakes in the Northeast and 15 streams in the Mid-Atlantic (the LTM Program).

The United States will also conduct watershed modelling to evaluate the effect of controls on responses of watersheds and surface waters to forms and levels of acidic deposition and to help explain and predict possible future responses. Of particular interest are efforts to model the dynamic impacts of nitrogen and sulphur deposition on surface waters and to further characterize the role and rate of watershed response to deposition levels. Previous modelling conducted by EPA projected that in a sensitive population of lakes (such as the Adirondacks, N.Y., area), a range of 11% to 43% of sensitive lakes may continue to be acidic with full implementation of the Clean Air Act.

FOREST EFFECTS

There is increasing evidence that decades of acid deposition have depleted the natural reserves of basic ions such as calcium and magnesium from forest soils that are naturally poor in bases. Such acidified soils can no longer protect downstream ecosystems from acid rain; waters that drain these forests carry both acids and toxic aluminum into streams, lakes, and rivers. The decrease in atmospheric deposition of bases is also contributing to depleting the ecosystems of their store of minerals, which are essential nutrients for most plants. Some effects have been observed at research sites in sensitive areas of eastern North America. It is extremely difficult to predict how ecosystems will respond to this challenge over the next decades; however, further investigation will help characterize the extent and magnitude of the problem.

CANADA

As a result of acidic deposition, soil nutrients are declining in certain Canadian forest ecosystems. In Ontario, ambient levels of sulphate and nitrate deposition have accelerated the loss of base ions from soils that support sugar maple-dominated hardwood forests. Studies in Quebec indicate that the nutrient status of sugar maple seedlings declines as soil acidification increases and basic ions are lost from the soil. Trees in nutrient-depleted areas initially show reduced growth, with more visible signs of damage, such as defoliation, appearing later. These effects will likely be sustained or increased at current deposition levels, resulting in a long-term decline in forest ecosystem productivity.

Critical loads of acidic deposition have been estimated for certain Canadian forest soils. They are derived, in large part, from the inherent capacity of soils to buffer incoming acidity. Theoretically, when combined amounts of sulphur and nitrogen fall below these loads, forest ecosystems will be buffered against adverse effects. If critical loads are exceeded for long periods, nutrient imbalances will develop in acidified soils and forest productivity will decline. Critical loads are consistently being exceeded for large portions of south and central Ontario and Quebec as well as portions of Atlantic Canada. Preliminary analyses indicate that exceeding critical loads by an acid deposition rate of 500 acid equivalents per hectare per year (eq/ha/yr) — currently the case for some sensitive forest soils — is associated with a loss of 10% in annual productivity.

Laboratory research on tree seedlings indicates that Canadian forests, particularly in areas of high episodic events (Atlantic Canada, southern Ontario and Quebec, and the Fraser Valley in British Columbia) are susceptible to damage and decline from ground-level ozone. The Canadian Forest Service is establishing a network of passive ozone monitors in representative forest ecosystems across the country to measure ambient levels of ozone. This network will allow determination of ozone injury risk for the various forest types.

UNITED STATES

The Forest Health Monitoring Program (a joint effort of the U.S. Department of Agriculture Forest Service, State foresters, and universities) continues to show that there is no evidence of broad regional-scale forest decline in the northeastern United States due to acidic deposition.

The eastern North American hardwood forest is generally in good health. However, sensitive, high-elevation forests and certain types of forest soils may be showing continuing signs of vulnerability. Some dieback and mortality of northern hardwoods were reported in several high-elevation localities in the southern Appalachian mountains, with a total affected area of between 500 and 1,000 acres (1% of national forest lands of the northern hardwood type).

The United States maintains three mountain cloud chemistry sites in the northern and southern Appalachians to better quantify the contribution of clouds to total deposition at high elevations. These sites are located where high-elevation forest effects are a concern. Researchers are conducting surveys of some 300,000 acres of northern hardwood forest to determine the cause and extent of regional die back and mortality. The annual monitoring program uses a permanent plot system to establish a baseline to track forest health. The grid currently covers 60% of the forest lands across all ownerships in the continental United States.

Ozone damage to plants in the United States has been documented for at least 30 to 40 years. The Forest Health Monitoring Program is expected to provide 100% coverage by 2003. The program continues to find evidence of ozone injury on sensitive tree, shrub, and herb plant species in forested areas of the Northeast, Great Lakes, and Middle Atlantic States. Evidence of ozone injury also continues to be found in forests in southern and central California. The direction of the trend in ozone effects on forests is uncertain. Once fully implemented, the Forest Health Monitoring Program is expected to provide a statistical trend on the impacts of ozone on forests.

EFFECTS ON MATERIALS

UNITED STATES

The National Park Service continues to sponsor and promote research on the effects of anthropogenic air pollution on cultural resources through the Materials Research Program (MRP) of the National Center for Preservation Technology and Training (NCPTT), located in Natchitoches, Louisiana. Most of the studies under way focus on the effects of gaseous SO_2 pollution on buildings and monuments and stone decay. A 1997 report of field studies on the Cathedral of Learning in Pittsburg, Pennsylvania, shows the interaction of various processes, including deposition velocity, wind patterns, and erosion on the soiling of the building. In another project, MRP sponsored a state-of-the-art literature review, which is available on request from the National Center for Preservation Technology and Training at NSU, Box 5682, Natchitoches, LA 71497. Efforts are under way to make this review more widely available by publishing it as a monograph through an academic press. Since the 1996 Progress Report, MRP has expanded its in-house research on stone decay processes and its work on cooperative research projects.

Acid rain and other pollutants can damage statues.

HEALTH EFFECTS

CANADA

Canadian scientific efforts have focused specifically on evaluating the impacts of relatively low levels of air pollution. Epidemiological studies have shown a strong association between episodes of elevated PM concentrations in ambient air and increased rates of hospitalization due to cardio-respiratory problems, as well as increased rates of mortality. These studies are based on large databases and are consistent with several studies reported in the United States and Europe. PM has also been linked to reduced lung function in children, increases in asthma symptom-days, and restricted activity days in both children and adults.

Similar risks result from exposure to elevated ambient levels of ozone; the major health effects in exposed populations are also an increased rate of hospitalization and mortality.

The identification of independent health effects of pollutants such as SO_2 and NO_x should provide a strong basis for a more comprehensive ozone and particulate strategy that would emphasize both particles and precursor gases.

Overall, the amount of research on the human health impacts of air pollutants has decreased substantially in Canada in the past two years; however, two studies will continue. Data collected for the past several years in Saint John, New Brunswick, will be analyzed to determine the specific exposure-response relationships in individual patients who visit the hospital for an emergency condition or an admission. No further data collection is planned. A follow-up study to the 1987–1994 joint study conducted by Health Canada and the Harvard School of Public Health began this year and will be completed in 2002. Its purpose is to determine whether the effects of the reduced lung function observed among children in the original study persist into adolescence and young adulthood.

Particulate Matter

Continuing epidemiological studies have shown an association between air pollution (especially particulate matter) and acute increases in mortality and morbidity. Fine particles penetrate deeply into the lungs and are more likely than coarse particles to contribute to adverse health effects, including premature death and increased hospital admissions and emergency visits, primarily for the elderly and persons with respiratory and cardiopulmonary disease.

Research continues to identify and characterize the specific components of PM responsible for these effects and causal mechanisms. EPA scientists have examined some of the mechanisms by which inhaled pollutants, especially ozone and PM, damage lung cells. Transition metals (such as iron) in PM can induce significant lung injury and inflammation via the formation of free radicals, which can lead to cardiopulmonary stress. This research will lay the groundwork for further studies to determine if particles and gaseous pollutants (which coexist in the atmosphere) have additive or synergistic effects. Devices capable of concentrating ambient air particles have received considerable attention, and scientists from both the United States and Canada have collaborated with scientists from Harvard University in developing a fine particle concentrator for use in human studies.

Components of the national $PM_{2.5}$ network will provide subsequent support for scientific research on PM (see Section III, page 11, for details).

Ozone

A new EPA study shows that some changes in lung function, symptoms, and inflammatory markers, seen on acute exposure, are no longer evident in humans after exposure to ozone for five consecutive days, although indicators of lung injury persist. This may indicate that ozone-induced lung injury can continue despite the absence of symptoms. In healthy, nonsmoking joggers exposed to ozone in the New York City metropolitan area during the course of a summer season, scientists found evidence of lung injury

Courtesy of the Asthma Society of Canada

Child taking asthma medication

and reduction in host defence capability but no evidence of inflammation at the end of the summer. These data suggest that humans naturally exposed to low levels of ozone for an extended period of time can develop potentially adverse health effects. Human response to a particular exposure is often difficult to quantify, since variables such as exposure concentration, exposure duration, and breathing volume must be taken into account. A mathematical model that quantifies the relationships among these variables has been used as a part of an ozone health risk assessment.

Assessments

EPA's National Center for Environmental Assessment (NCEA) will be conducting its five-year review of air quality criteria for both PM and ozone. These assessments form the scientific basis for the National Ambient Air Quality Standards (NAAQS). In addition, EPA's Ecological Risk Assessment Guidelines should be finalized in the near future to provide guidance for environmental risk assessors. NCEA has published *Particulate Matter Research Needs for Human Health Risk Assessment* to provide guidance on health and environmental research issues needed to support future reviews of the NAAQS. A similar document outlining ozone health and environmental research needs is expected in the future.

Recognizing that NO_x emissions contribute to multiple public health and environmental problems, the United States has initiated efforts to coordinate activities and assess an integrated approach to achieving decreases in NO_x emissions. In August 1997, EPA released *Nitrogen Oxides: Impacts on Public Health and the Environment*, which represents a step toward coordinated research, monitoring, and assessment activities as well as better integration of emissions reduction efforts. The report is available (http://www.epa.gov/ttn/oarpg/t1ria.html).

The National Acid Precipitation Assessment Program (NAPAP) released, in August 1998, its four-year integrated assessment report on the costs, benefits, and effectiveness of the Acid Rain Program. The report concluded that the market-based emissions trading system has been a cost-effective mechanism to achieve significant emission reductions. The report documented the measured reductions in acid rain, particularly in the northeastern United States. However it also concluded that while recovery of ecosystems is becoming evident in certain regions, it is not yet occurring in some of the most sensitive areas, such as the Adirondack Mountains in New York. Further reductions in acid deposition may be necessary to protect these areas and continued monitoring is required to assess ecological response. The report summary is available (http://www.nnic.noaa.gov/CENR/NAPAP/NAPAP_96.htm).

OZONE MONITORING, RESEARCH, AND ASSESSMENT

CANADA

Assessment

In 1997, Canada published the results of its first NO_x/VOC science assessment. The seven-volume assessment draws together a wide range of scientific tools and knowledge in support of resolving the ground-level ozone problem. The reports cover health and vegetation effects; ambient air monitoring and data analysis; mathematical modelling for emissions control scenario evaluation; and emissions inventories for ozone and its precursors.

The NO_x/VOC science assessment was undertaken expressly to respond to the needs of policy makers for defensible, high-quality, scientific information upon which to design and implement future emissions reduction strategies in Canada. There are five major policy-relevant findings:

- There is no discernible human health threshold for ground-level ozone. The current 82-ppb one-hour Canadian ozone objective is not fully protective of human health and vegetation. The apparent continuum of adverse health effects indicates that any improvements in ambient ozone concentrations are expected to result in public health benefits. Therefore, strategies for ozone management should focus on continuous improvement.
- The design of emissions reduction strategies will be different for each of the ozone problem areas (the Lower Fraser Valley, the Windsor–Quebec City Corridor, and the Southern Atlantic Region). Reductions in both NO_x and VOC emissions will benefit large urban areas, whereas on a regional basis, NO_x reductions may be more effective in lowering widespread ozone concentrations, benefiting nonurban areas. In all areas, however, large emissions reductions will be required to meet the current 82-ppb one-hour ozone objective.
- In eastern Canada, transboundary transport plays a major role during smog episodes. Therefore, air quality improvements will depend on concurrent U.S. emissions reductions.
- Responsible agencies should maintain the air monitoring network as a minimum at the density recommended in the Ambient Air Monitoring Working Group's report and implement the network enhancements identified in the Working Group's Implementation Plan. Agencies should also cooperate to improve the timeliness and accuracy of emissions inventories.

- Responsible agencies should maintain their support for research to answer the remaining scientific uncertainties and policy and scientific questions in support of Canadian smog policy development. Sound policy is dependent on a sound scientific basis.

Over the past several years, the Science Program has answered some important policy questions that provide directional guidance and strengthen decision making on the optimal emissions reductions leading to resolution of the ground-level ozone problem in Canada. The completion of the science assessment is the starting point for the collaborative process between the Canadian policy and scientific communities that is necessary to resolve some outstanding ground-level ozone issues.

Canadian involvement in trilateral scientific research efforts, such as the North American Research Strategy for Tropospheric Ozone, and participation in international programs, such as the United Nations Economic Commission for Europe's Convention on Long-range Transboundary Air Pollution, are expected to yield long-term benefits in understanding the ground-level ozone problem and in reducing precursor concentrations.

UNITED STATES

Monitoring

The United States continues its ozone monitoring program, which principally comprises three related networks: State and Local Air Monitoring Stations (SLAMS), which are used for a variety of purposes, including describing compliance with the NAAQS for ozone; National Air Monitoring Stations (NAMS), which conduct long-term national monitoring for urban area-oriented ambient monitoring; and Photochemical Assessment Monitoring Stations (PAMS), which monitor all ozone nonattainment areas classified as serious, severe, or extreme.

Research

Research continues under the North American Research Strategy for Tropospheric Ozone (NARSTO). NARSTO is a public/private partnership that includes the United States, Canada, and Mexico and has the goal of determining efficient and effective strategies for local and regional ozone management across the North American continent. NARSTO coordinates research on the atmospheric processes involved in ozone and ozone precursor accumulation, transformation, and transport in the continental troposphere. The NARSTO State-of-the-Science Assessment Report, scheduled for release in early 1999, will address tropospheric ozone and ozone precursor transboundary issues, emissions, monitoring trends, modelling, and methods development.

Quality assurance and data management guidelines and assistance are available to all NARSTO researchers at the Oak Ridge National Laboratory in Oak Ridge, Tennessee. A permanent NARSTO data archive is maintained by the NASA EOSDIS Distributed Active Archive Center at the Langley Research Center in Langley, Virginia.

PARTICULATE MATTER MONITORING AND RESEARCH

CANADA

PM levels are monitored throughout Canada by the National Air Pollution Surveillance (NAPS) network in cooperation with the provinces and municipalities. Ambient levels of particulate matter across Canada are affected by a number of factors, including local sources of PM and precursor gases as well as contributions from long-range atmospheric transport. PM levels at a given site are usually quite low, but this predominance of low levels is contrasted by periodic episodes during which concentrations of PM can be significantly higher. PM is a public health concern and an important cause of reduced atmospheric visibility.

Data from the NAPS network have shown that the highest PM_{10} concentrations are found at sites in the Windsor–Quebec City Corridor and Winnipeg, Calgary, Regina, and Edmonton. Prairie sites are noted for elevated levels of coarse particles that are predominantly from windblown soil. Sites in the Windsor–Quebec City Corridor and Vancouver have the highest concentrations of fine particles (known as $PM_{2.5}$ because of their diameter of 2.5 microns or less). A significant proportion of these fine particles are formed in the atmosphere through chemical reactions from the burning of fossil fuels and other industrial processes. The smaller the particle, the more likely it is to be transported long distances with the winds.

PM concentrations in Canada appear to be decreasing, based on measurements from ten urban sites across Canada for the 1984–1993 period. Trend analyses have shown that annual average PM_{10} (fairly coarse particles with a diameter of 10 microns or less) concentrations have decreased by an average of 2% per year on a national basis and $PM_{2.5}$ concentrations by 3.3% (1984–1993). However, recent (1991–1996) PM_{10} results from six Ontario sites show no consistent trend.

Canada is developing a model that will simulate the atmospheric chemistry and transport of PM. The model will assist in the formulation of effective control strategies for PM, and it will estimate the improvements in PM levels that will result from current strategies to reduce emissions of SO_2, NO_x, VOCs, and toxic substances.

UNITED STATES

PM monitoring efforts are discussed in Section III, page 11, in connection with revision of the PM standard.

SECTION V

CONCLUSION

Considerable success is being achieved in Canada and the United States in reducing emissions of SO_2 and NO_x. Both pollutants contribute to acid rain, which was the initial focus of efforts under the Air Quality Agreement.

Over the past two years, the Federal governments' close cooperation with State and Provincial governments and other stakeholders has demonstrated that, in addition to the importance of continuing joint work on common concerns to reduce acid deposition, the two countries have substantial common interests in focusing on the problems of ground-level ozone and particulate matter, particularly due to their impacts on human health.

The April 1997 signing of the Agreement to develop a Joint Plan of Action for Addressing Transboundary Air Pollution by U.S. EPA Administrator Browner and the former Canadian Minister of the Environment inaugurated a new era of binational cooperation on transboundary air issues. EPA Administrator Browner and Environment Minister Stewart endorsed, in June 1998, a timetable and strategy for addressing ground-level ozone and particulate matter. The stage has now been set for increased cooperation on these two additional pollutants of concern.

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