CANADA ◆ UNITED STATES

AIR QUALITY AGREEMENT

2000

Progress Report

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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 28, 2001:

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Acronyms and Abbreviations

AIRMoN	Atmospheric Integrated Research Monitoring Network
AIRS	Aerometric Information Retrieval System
AQC	Air Quality Committee
AQI	Air Quality Index
ARNEWS	Acid Rain National Early Warning System
AURAMS	A Unified Regional Air Quality Modeling System
BAT	best available techniques
BC	British Columbia
CAAA	Clean Air Act Amendments
CAPMoN	Canadian Air and Precipitation Monitoring Network
CASTNet	Clean Air Status and Trends Network
CEM	continuous emission monitoring or monitors
CEPA	Canadian Environmental Protection Act
CFS	Canadian Forest Service
CL	critical loads
CO	carbon monoxide
CO_2	carbon dioxide
CMAQ	Community Multi-Scale Air Quality Model
CUTA	Canadian Urban Transit Association
E-GRID	Emissions & Generation Resource Integrated Database
EPA	U.S. Environmental Protection Agency
eq	equivalence
FHM	Forest Health Monitoring
FIGCP	Forest Indicators of Global Change Project
FRM	Federal Reference Method
g/bhp-hr	grams per brake horsepower hour
g/mi	grams per mile

IMPROVE	Interagency Monitoring of Protected Visual Environments
km	kilometers
kt	kilotonnes
LRTAP	Long-Range Transboundary Air Pollution Protocol
mm	millimeter
MOU	Memorandum of Understanding
MRP	Materials Research Program
MWe	megawatts electric
NAAQS	National Ambient Air Quality Standards
NADP/NTN	National Atmospheric Deposition Program/National Trends Network
NAMP	North American Maple Project
NAMS	National Air Monitoring Stations
NAPS	National Air Pollution Surveillance
NARSTO	North American Research Strategy for Tropospheric Ozone
NCPTT	National Center for the Preservation of Technology and Training
NEG/ECP	New England Governors and Eastern Canadian Premiers
NERAQC	Northeast Regional Air Quality Committee
NESCAUM	Northeast States for Coordinated Air Use Management
NH_3	ammonia
NMHC	nonmethane hydrocarbons
NO	nitrogen oxide
NO_x	nitrogen oxides
NO_2	nitrogen dioxide
OTC	Ozone Transport Commission
PAMS	Photochemical Assessment Monitoring Stations
PM	particulate matter
PM_{10}	particulate matter less than or equal to 10 microns
$PM_{2.5}$	particulate matter less than or equal to 2.5 microns
ppb	parts per billion
ppm	parts per million
PSD	Prevention of Significant Deterioration

REMSAD	Regional Modeling System for Aerosols and Deposition
RESEF	Quebec Forest Intensive Monitoring Network
SIP	State Implementation Plan
SLAMS	State and Local Air Monitoring Stations
SMB	simple mass-balance
SO_2	sulfur dioxide
SPM	special purpose monitors
SUV	sport utility vehicle
TRS	total reduced sulfur
USFS	U.S. Department of Agriculture Forest Service
VOC	volatile organic compound
μm^3	cubic micrometers

Introduction

This is the fifth Progress Report highlighting the commitments Canada and the United States made under the 1991 Air Quality Agreement to address transboundary air pollution. The report details the continued progress of both governments in addressing acid rain. The report also focuses on the most recent developments of both governments in expanding cooperative efforts to reduce ground-level ozone and particulate matter (PM) pollution, which have significant impacts on human health. The bilateral Canada-U.S. negotiations held this year to develop an ozone annex to the Agreement signal the importance both governments are placing on this effort.

In this report, Canada and the United States cite significant emissions reductions of major pollutants that cause acid rain—sulfur dioxide (SO_2) and nitrogen oxides (NO_x). Canada's national cap of 3.2 million tonnes for SO_2 emissions will become fully operational in 2000. Currently, Canada's SO_2 emissions are at 2.7 million tonnes, and they are projected to remain below the cap in the future. As the United States ended Phase I of the SO_2 program and began Phase II in 2000, Phase I utility units reported SO_2 emissions of 4.9 million tons, which was 28 percent below allowable levels for 1999 and a reduction of more than 50% from 1980 levels. Full implementation in 2010 will result in a 10-million ton reduction of SO_2 emissions, which will be approximately 40% below 1980 levels. Canada reduced its year 2000 stationary source NO_x emissions by more than 100,000 tonnes below the forecast level of 970,000 tonnes. In the United States, NO_x emissions from power generation are expected to be reduced by more than 2 million tons below forecast levels. NO_x emissions from all source categories are expected to be 2 million tons below 1980 levels.

The report also provides information on progress since 1998 in meeting other key commitments in the Agreement. Updates are included on emissions forecasts, acid deposition monitoring, scientific research, and the air quality programs of both governments.

In 1997, the Canadian and U.S. environmental ministers signed a Joint Plan of Action for Addressing Transboundary Air Pollution on ground-level ozone and PM, and in 1998 the ministers issued a follow-up Joint Plan Report. The 2000 Progress Report considers cooperative efforts in data analyses, modeling, monitoring, and information sharing leading to development of an ozone annex to the Air Quality Agreement and existing and planned efforts to develop a joint work plan for transboundary PM.

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

Progress and Commitments

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

Sulfur Dioxide Reductions

CANADIAN COMMITMENT

- Sulfur dioxide (SO_2) emissions reduction in seven 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's commitment to reduce acid rain remains a priority in air pollution management. In 1998, total Canadian SO_2 emissions were less than 2.7 million tonnes, which is below the national cap of 3.2 million tonnes. Emissions in the seven easternmost provinces were 1.8 million tonnes below the eastern Canada cap of 2.3 million tonnes. Forecasts[2] from the *1999 Annual Progress Report on the Canada-Wide Acid Rain Strategy for Post-2000* indicate that emissions will remain below all applicable caps well into the future. Significant reductions of SO_2 and/or nitrogen oxides (NO_x) could result from reduction initiatives that come into effect after 1998. These initiatives were not included in the forecasts. Examples of these initiatives include new SO_2 targets under the Canada-Wide Acid Rain Strategy, reductions under Phase 3 of the Federal Smog Management Plan and provincial or territorial smog initiatives, and Canada-Wide Standards for $PM_{2.5}$ (PM less than or equal to 2.5 microns) and ozone.

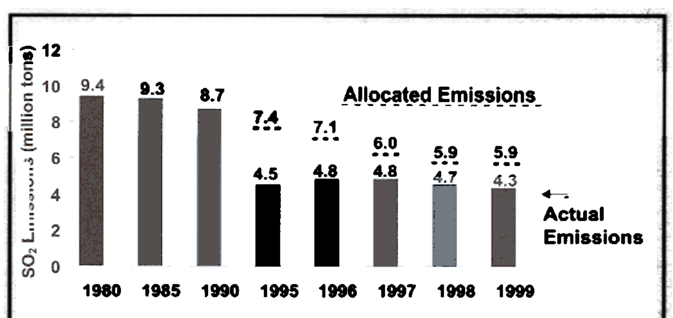
The permanent national cap of 3.2 million tonnes per year by 2000 is currently being implemented through the Eastern Canadian Acid Rain Program using bilateral agreements between each respective province and the Federal Government. This program, which will be fully implemented in 2000, is being succeeded by the Canada-Wide Acid Rain Strategy for Post-2000. The strategy's next step, described in Section III, p. 10, targets sulfur, striving for SO_2 emissions reductions that achieve critical loads (CL)[3] for acidity throughout the country.

UNITED STATES COMMITMENT

- SO_2 emissions reduction of 10 million tons[4] from 1980 levels by 2000, taking into account credits ("allowances") earned for reductions from 1995 to 1999.
- Permanent national cap of 8.95 million tons of SO_2 per year for electric utilities by the year 2010.
- National SO_2 emissions cap of 5.6 million tons for industrial sources beginning in 1995.

As the U.S. Acid Rain Program entered Phase II in January 2000, data showed that SO_2 emissions in 1999 were 670,000 tons lower than 1998 levels as sources prepared to meet their Phase II reduction obligations. The U.S. Environmental Protection Agency's (EPA's) annual review reported SO_2 emissions from Phase I affected units were 4.9 million tons, or 28 percent below the 1999 allowable emissions level for SO_2. In 1999, the total number of participating units was 398. Of that number, 263 were the highest-emitting units, and 135 were units electing to participate early.

U.S. SO_2 Emissions From 263 Phase I Units



Figure

[1]One tonne is equal to 1.1 short tons.

[2]Forecast emissions are interim emissions estimates using 1998 values reported by the provinces and territories. The forecasts are projected with growth factors calculated from total provincial changes in emissions found in the National Emissions Inventory and Projections Task Group Consensus National Base Case Forecast, 1996.

[3]Critical loads are estimates of the maximum pollutant loadings that environmental resources can absorb on a sustained basis without experiencing measurable degradation.

[4]One (short) ton is equal to 0.9 tonnes.

By the end of five years of Phase I implementation, affected units showed an overall reduction in SO_2 emissions of more than 50% from 1980 levels. In Phase II, the program expands from 400 fossil-fired electric generating units in 25 states to more than 2,000 units in 48 states. All major power plants in the contiguous 48 states are now covered by the Acid Rain Program. Reductions in Phase I were greater than required in almost every affected state, with major reductions in the highest-emitting areas (i.e., the Midwest). Sources achieved 100% compliance with regional emission reductions in every year of Phase I. Full implementation of the program in 2010 will achieve a 10-million-ton reduction of SO_2 emissions, about 40% below 1980 levels.

During Phase I, under the SO_2 Allowance Trading Program—the centerpiece of the Acid Rain Program—allowance market activity steadily increased among all participants, contributing to the lower than expected costs for reducing emissions. Through the SO_2 Allowance Trading Program, all affected utility units are allocated a specific number of emissions allowances, with one allowance authorizing the emission of one ton of SO_2. Allowances are tradable, and utilities may buy, sell, or bank them for future use. On an annual basis, a source must hold allowances that equal or exceed its annual SO_2 emissions.

Industrial SO_2 emissions from stationary sources that are not commercial or residential continue to remain below the 5.6-million-ton cap. These emissions are projected to remain below the cap for at least the next 10 years. Should emissions from these sources exceed the cap, EPA is authorized to establish regulations to reduce emissions to below 5.6 million tons.

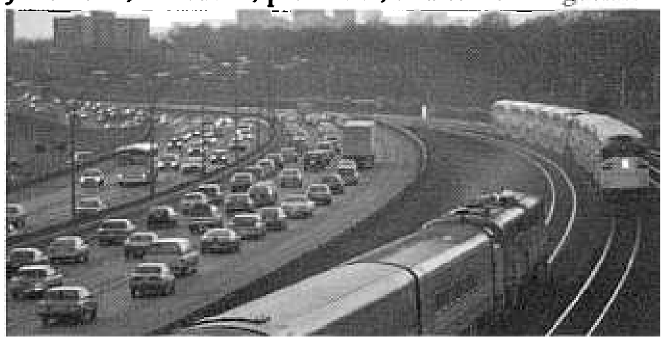
Nitrogen Oxides Reductions

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.
- Implement a NO_x control program for mobile sources.

NO_x emissions have been reduced by more than 100,000 tonnes below the forecast level of 970,000 tonnes at power plants, major combustion sources, and metal smelting operations.

Canada is developing programs to further reduce NO_x emissions. (For additional details, see Section III, pp. 10-11.) All provinces are currently discussing plans and progress jointly with the Federal Government to reduce stationary source emissions of NO_x. For example, Ontario's Anti-Smog Action Plan sets an air quality goal to reduce the average number of ozone exceedance hours by 75% by the year 2015. This translates into a 45% reduction of NO_x emissions and volatile organic compounds (VOCs) in Ontario from 1990 levels. In June 2000, all federal, provincial, and territorial governments agreed to a Canada-Wide Standard for ozone of 65 parts per billion (ppb) to be achieved by 2010. Joint initial actions for reducing NO_x and VOC emissions, necessary to meet the standard for ozone, were agreed on and will target industry sectors, including pulp and paper and electric power, that are among the large stationary source emitters of NO_x emissions. (For additional details, see Section III, p. 9.)



Regulations have steered on-road engines, which contribute approximately 35% of Canada's total NO_x emissions, toward newer, cleaner technology and reduced emissions. Canadian on-road vehicle emissions standards are harmonized with those of the United States. (For additional details, see Section III, pp. 10-11.)

UNITED STATES 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.

By the end of 2000, EPA's Acid Rain Program and the mobile source control program are expected to reduce stationary and mobile source NO_x emissions by more than 2 million tons below 1980 levels, exceeding the mandate under the 1990 Clean Air Act Amendments (CAAA).

From 1996 to 1999, NO_x emissions from coal-fired utility boilers were approximately 400,000 tons per year below projections for what emissions would have been without the Acid Rain Program. In 1999, actual NO_x emissions were slightly below 1998 levels and decreased by approximately 424,000 tons (32 percent) compared to 1980 levels. Beginning in 2000, NO_x emissions from electric utility units are expected to be reduced by an additional 1.7 million tons each year.

EPA also has undertaken efforts to reduce NO_x emissions under the ground-level ozone provisions of the CAAA. In September 1998, EPA finalized a rule to establish mandatory NO_x emission budgets for 22 eastern states.[5] By 2007, this rule-making is expected to result in approximately 1 million tons of additional NO_x emission reductions each summer beyond those achieved by acid rain and mobile source control programs. In a separate but related rule-making, EPA granted petitions filed under Section 126 of the CAA, identifying specific NO_x sources that contribute to ozone in the petitioning states. As a result, beginning in 2003, a total of 392 facilities in 12 states must reduce annual emissions by about 500,000 tons from expected 2007 levels, or about half the emission reductions under the 22-state program.

In other actions, EPA is working with nine northeastern states to implement a trading program for NO_x in the Ozone Transport Region. In 1999, the initial year of operation, the first eight participating states reduced NO_x emissions by more than 50% from 1990 levels (20% below allowable levels) due to the trading program.

In December 1999, under continuing implementation of CAAA requirements for mobile sources, EPA announced more protective tailpipe emissions standards for all passenger vehicles, including sport utility vehicles, vans, and pickup trucks. Simultaneously, EPA announced more stringent standards for sulfur in regular gasoline. The standards will ensure the effectiveness of low-emission control technologies in vehicles and are the clean-air equivalent of removing 164 million cars from the road. The new standards will require passenger vehicles to be 77% to 95% cleaner than those on the road today, decreasing gasoline's sulfur content by 90% to 30 parts per million (ppm).

In addition, in June 2000, EPA proposed a major program to significantly reduce emissions from heavy-duty engines and vehicles. This comprehensive 50-state control program proposal for heavy-duty engine and vehicle standards and highway diesel fuel sulfur control treats the heavy-duty vehicle and its fuel as a single system. The proposed rule will cap the sulfur content in diesel fuel sold to consumers at 15 ppm. Diesel fuel's sulfur content is currently about 500 ppm. The proposal for tailpipe emission reductions reduces NO_x to 0.2 grams per brake horsepower hour (g/bhp-hr) and emissions of PM to .01 g/bhp-hr. (For more information on NO_x mobile source efforts, see Section III, pp. 13-14).

Monitoring of Emissions

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 megawatts electric (MWe) using a method of comparable effectiveness to Continuous Emissions Monitors (CEMs).
- By 1995, investigate feasibility of using CEMs.
- Work toward comparably effective methods of emission estimation for SO_2 and NO_x emissions from other major stationary sources.

An important tool, CEMs provide information that can improve emissions estimation methodologies. CEMs also facilitate automatic emissions monitoring and reporting, and establish a "common currency" in emissions trading regimes.

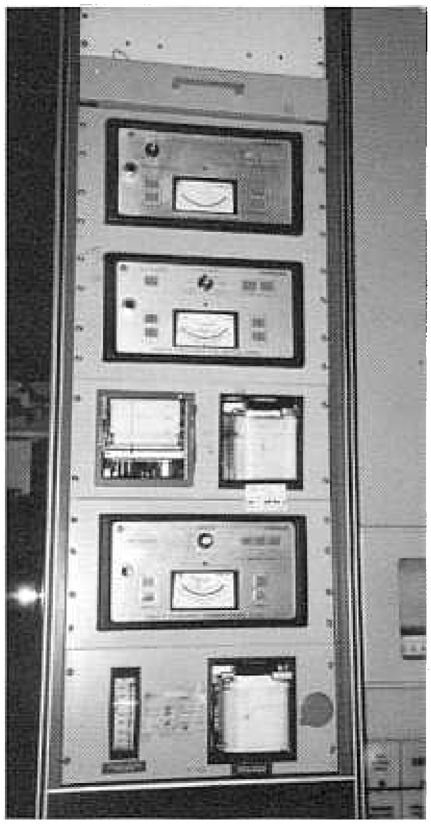
Permitting of CEMs is under provincial jurisdiction, and the type of in situ, extractive, or dilution CEM system used is site-specific to each application. By 1995, CEM installation in Canada's utility sector was widespread, with SO_2 CEMs installed in more than 87% of the coal generation capacity (67 units) and more than 52% of the oil generation capacity (22 units). With respect to NO_x CEMs, 72% of the oil generation capacity (14 units), more than 78% of the gas generation capacity (10 units), and more than 85% of the coal generation capacity (43 units) had CEMs installed.

By 2000, this situation had not changed significantly because almost all base-loaded fossil steam plants with high emission rates had operating CEMs. Few flow monitors are used, and not all systems have the accuracy and reliability required for emissions trading purposes. The fact that Canada has no interprovincial emissions

[5]EPA's final action was subject to legal challenge by a number of parties. In March 2000, the U.S. Court of Appeals for the DC Circuit issued a 2-to-1 ruling in favor of EPA on all major issues associated with the NO_x State Implementation Plan (SIP) Call. The court remanded issues—including those relating to Wisconsin, Georgia, and Missouri—to EPA. In June 2000, the court ordered SIP revisions addressing requirements upheld by the Court due by October 30, 2000.

trading regime, however, provides little incentive for improvement for accuracy and reliability. Monitoring systems across sectors are designed with less stringency and more flexibility. For example, exhaust gas volume and mass emission rates are often determined by estimation from several choices of standard calculation methods.

CEMs have been installed in the nonutility sector to monitor emissions of either SO_2 or NO_x in various jurisdictions across the country. In Quebec, CEMs are required on acid plants used to control SO_2 in the base metal sector. Acid plants account for approximately 60% of the province's nonutility SO_2 emissions. In Ontario, CEMs for SO_2, NO_x, and other pollutants are recommended for municipal solid waste, biomedical waste incinerators and base metal smelters. Other requirements for CEMs are for pulp and paper recovery boilers that monitor concentrations of total reduced sulfur (TRS) and hydrogen sulfide, and wood waste boilers to monitor temperature. Because of recent publication of an emissions guideline for cement kilns, several cement plants are installing CEM systems for emissions measurements and process control functions. Most new gas turbine cogeneration systems have very low emissions of all pollutants and are able to accurately estimate NO_x emissions using other methods, such as predictive monitoring or periodic sampling.


SO_2 and NO_x CEM machine.

Ontario's major SO_2 emitters (i.e., INCO, Falconbridge, and Ontario Hydro) are required to undertake annual audits to verify SO_2 emissions. Alberta requires CEMs for various nonutility sources, including sour gas plants[6], pulp and paper, petroleum refining, fertilizer, chemical, oil sands, waste incinerators, and wood waste nonutility generators. In 1999, Alberta published new CEM performance guidelines that will soon be applicable to most industrial sources. British Columbia, through a decentralized provincewide permitting system, requires installation and operation of CEMs for SO_2 and NO_x on a case-by-case basis. In the Greater Vancouver Regional District, the data from installed NO_x and SO_2 CEMs are used in the emissions inventory.

UNITED STATES COMMITMENT

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

By 1995, all required CEMs were installed by utilities under the Acid Rain Program. They continue to provide some of the most accurate and complete data ever collected by EPA. All coal-fired units must use CEMs to measure concentrations of SO_2 and NO_x, as well as volumetric flow, to determine hourly mass emissions of SO_2 and NO_x. Those natural gas and oil-fired units that do not use CEMs use fuel flow meters and frequent fuel sampling and analysis to determine mass SO_2 emissions for conservative emission factors. These units also use CEMs with volumetric flow to determine NO_x mass emissions.

Statistics reflect high accuracy and availability of all CEMs at Phase I and Phase II units. In 1999, relative accuracy standards were met by 96.2, 94.5, and 99.4 percent of the SO_2, NO_x, and volumetric flow CEMs, respectively. In 1999, the availability of these data exceeded 98 percent. By the end of 2000, nearly 100 percent of the affected sources will be reporting hourly emissions and heat input data electronically, allowing immediate quality assurance analyses by EPA's Emissions Tracking System, feedback to utilities, and verification of quarterly data compiled from hourly data on SO_2, NO_x, and carbon dioxide (CO_2.) Quarterly emissions reports for every affected unit are available to the public on the Internet at www.epa.gov/acidrain. CEMs data provide the foundation for the SO_2 Allowance Trading Program as well as the NO_x Budget Trading Program. These data are used to determine compliance with both the SO_2 and NO_x reduction programs.

[6]Sour gas is raw natural gas with a relatively high concentration of sulfur compounds such as hydrogen sulfide.

Prevention of Air Quality Deterioration and Visibility Protection

CANADIAN COMMITMENT

- By 1995, develop and implement means (comparable to those implemented in the United States) to prevent air quality deterioration and to ensure visibility protection for sources that could cause significant transboundary air pollution.

Canada uses an approach to new sources (e.g., addressing major new and existing sources, examining various reduction measures, and applying similar technologies) that it considers comparable to the U.S. approach. Since Canada is a federation, the federal and provincial/territorial, and some municipal governments each share in the responsibility of air quality management and pollution prevention. The report, *Canadian Mechanisms to Prevent the Deterioration of Air Quality: An Analysis of Requirements for New Sources of Air Pollution and Modifications to Existing Sources*, provides an overview of the requirements at each level of government across the country.

In addition to existing measures, the new Canadian Environmental Protection Act (CEPA) of September 1999 focuses on pollution prevention as the preferred approach to environmental protection. The Canadian government will use the new act to reduce the impacts of toxic substances. Implementation of similar principles—pollution prevention, continuous improvement, and keeping clean areas clean—is also part of the Canada-Wide Standards. The latter principle recognizes that polluting "up to a limit" is not acceptable and that the best strategy to avoid future problems is keeping clean areas clean. Continuous improvement applies in areas with ambient levels below the levels of the standards but still above the levels associated with observable health effects. Jurisdictions are encouraged to take remedial and preventative actions to reduce emissions from anthropogenic sources to the extent practicable.

Federal, provincial, and territorial governments will work with stakeholders during the next several years to establish implementation plans and programs for $PM_{2.5}$ and ozone Canada-Wide Standards that apply pollution prevention and best management practices. These practices could include ensuring that new facilities and activities incorporate the best available, economically feasible technologies to reduce PM and ozone levels. They could also include reviewing new activities that might contribute to PM and ozone level increases.

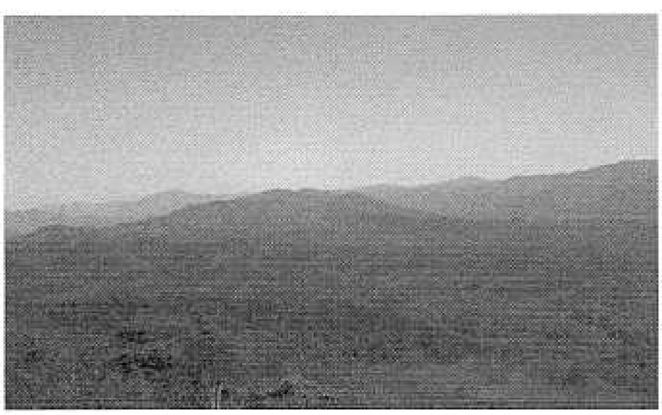
UNITED STATES COMMITMENT

- Maintain means for preventing significant deterioration and protecting visibility as required under the CAA for sources that could cause significant transboundary air pollution.

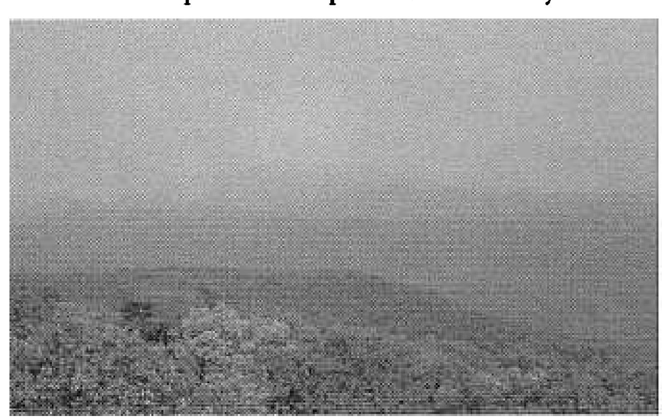
The U.S. Prevention of Significant Deterioration (PSD) Program has three key goals: (1) protecting public health from any adverse effects that might occur—even at air pollution levels lower than the National Ambient Air Quality Standards (NAAQS); (2) preserving, protecting, and enhancing the air quality in Class I areas such as large national parks and wilderness areas; and (3) ensuring that economic growth occurs in harmony with the preservation of existing clean air sources.

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

In April 1999, EPA issued the final regional haze regulations that expand the scope of 1980 visibility rules.



Good visibility day in Great Smokey Mountains. Visual range is 100 miles.



Bad visibility day at same location. Visual range is 20 miles.

Source: National Park Service

The regulations will improve visibility at specially protected Class I national parks and wilderness areas, addressing visibility impairment caused by numerous sources located over broad regions. The program establishes the basis from which states can work together to develop implementation plans designed to achieve "reasonable progress" toward the national visibility goal of no human-caused impairment in the 156 mandatory Class I federal areas nationwide.

States are required to establish goals to improve visibility on the 20% worst days and to allow no degradation on the 20% best days for each Class I area in the state. In establishing any progress goal, states must analyze the progress rate for the next 10- to 15-year implementation period that would, if maintained, achieve natural visibility conditions by 2064. States will need to show reasonable progress. In addition to identifying goals, state plans must include the following: (1) emissions reduction measures to meet these targets in combination with other state measures; (2) requirements for Best Available Retrofit Technology on certain large, existing sources or an alternative emissions trading program; and (3) visibility monitoring representative of all Class I areas.

State regional haze plans are due in the 2003 to 2008 timeframe. Due to common precursors and the regional nature of the PM and haze problems, the haze rule includes specific provisions for states working together in regional planning groups to assess these problems and develop coordinated, regional emission reduction strategies. One provision allows nine Grand Canyon Visibility Transport Commission States (i.e., Arizona, California, Colorado, Idaho, Nevada, New Mexico, Oregon, Utah, and Wyoming) to submit initial plans in 2003 to implement their past recommendations within the framework of the national regional haze program. Another provision allows certain states to develop coordinated strategies for regional haze and PM until 2008, contingent upon future participation in regional planning groups.

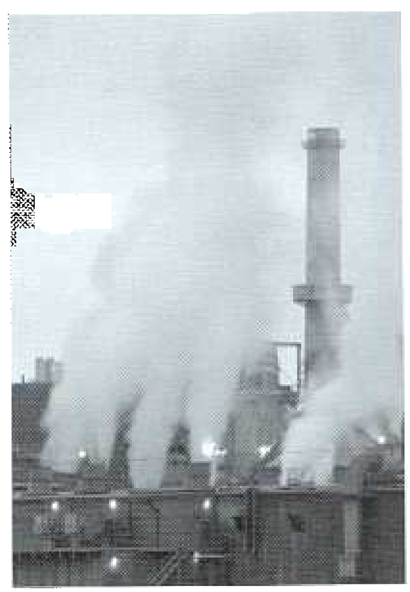
The new regional haze regulations require ambient monitoring representative of each of the Class I areas to track progress toward the U.S. national visibility goal. Required regional haze trend assessments will be based on changes in visibility expressed in deciviews[7]. To facilitate these assessments, the aerosol portion of the Interagency Monitoring of Protected Visual Environments (IMPROVE) visibility monitoring network is being expanded from 30 to 110 sites during the year 2000. The expanded network will now represent all Class I areas where monitoring can be practically implemented.

Implementation of the PM and Ozone NAAQS, in conjunction with the regional haze program, is expected to improve visibility in urban as well as rural areas nationwide. Other air quality programs are expected to reduce emissions and improve visibility in certain regions of the country. The Acid Rain Program is expected to reduce sulfate haze, particularly in the eastern United States, by achieving significant regional reductions in SO_2 emissions. In addition, visibility impairment in Class I and other areas should improve because of a number of regulatory activities, including the NO_x State Implementation Plan (SIP) Call, mobile source emissions and fuel standards, certain air toxics standards, and the implementation of smoke management and wood stove programs to reduce fuel combustion and soot emissions.

Notification, Assessment, and Mitigation of Significant Transboundary Air Pollution

JOINT EFFORT COMMITMENT

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



Notification

Canada and the United States are continuing notification procedures, initiated in fall 1994, to identify possible new sources and modifications to existing sources of transboundary air pollution within 100 kilometers (km)—62 miles—of the border. The countries are also notifying one another of new sources or modifications

[7]A measure of visibility that captures the relationship between air pollution and human perception of visibility. When air is free of particles that cause visibility degradation, the Deciview Haze Index is zero. The higher the deciview level, the poorer the visibility.

of concern beyond the 100-km limit. Canada has notified the United States of 20 sources, and the United States has notified Canada of 14 sources. Transboundary notification information is available on the Internet sites of both governments at:
Canada: www.ec.gc.ca/pdb/can_us/applic_e.html
U.S.: www.epa.gov/ttn/gei/uscadata.html.

Since the last Progress Report, Canada and the United States have sustained successful, ongoing consultations on sources of concern. Consultations on the Boundary Dam power station in Saskatchewan and the Algoma Steel Plant in Ontario have led to joint air quality monitoring efforts. A binational consultation group composed of federal, state, provincial, and Boundary Dam power station authorities has developed a 5-year monitoring plan for the area around the power station on both sides of the border. Beginning in 2000, monitoring is designed to characterize air quality in the area, with five samplers set up within 60 km of the local community of Estevan (see Figure 2 below). Forums on air quality such as the one held in the summer of 2000 provide information to concerned citizens and the general public about existing efforts and future plans.

A similar plan, also developed by a joint consultation group, is being implemented in the area surrounding the Algoma Steel Plant. Dust fall monitoring sites have been established in Sault Ste. Marie, Michigan. Snow sampling has been conducted at a number of sites there, as well as in Sault Ste. Marie, Ontario. A $PM_{2.5}$ monitoring network consisting of two monitoring stations is scheduled to begin in summer 2000. Ongoing consultations on the Connors Creek Detroit Edison Power Plant were resolved to the satisfaction of all parties involved.

Saskatchewan-North Dakota PM Monitoring Network

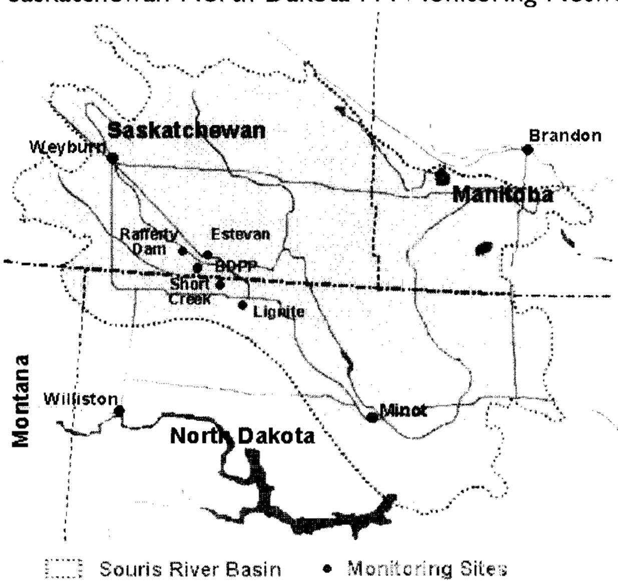


Figure 2

Saskatchewan-North Dakota public meeting.

The plant, which went back into operation in the summer of 1999, is now using natural gas instead of coal. The plant is using CEMs as well.

Assessment and Mitigation

Canada and the United States have continued to make progress in assessment and mitigation despite different interpretations of the commitment under the Air Quality Agreement. In response to the Federal Energy Regulatory Commission's adoption of the open access transmission policy and Canada's concerns about possible increased transboundary flows of emissions, EPA has established an electronic database—the Emissions & Generation Resource Integrated Database (E-GRID). E-GRID reports publicly available emissions and generation data for virtually every power plant and company that generates electricity in the United States. EPA has demonstrated the operation of E-GRID to Canada and shared emissions monitoring and tracking results. The second E-GRID provides 1997 data and includes new information on company, owner type, and fossil-only emission rates for utilities.

The next version, E-GRID 2000, scheduled for release before the end of the year, will include actual emissions and resource mix data for 1998 and preliminary data for 1999 for all plants, including nonutility generators. The data will be configured according to industry and power grid structure in 2000 reflecting the latest corporate mergers, power plant sales, and grid reconfigurations. In addition to emission profiles for SO_2, NO_x, and CO_2, E-GRID 2000 is expected to report plant-specific emissions and emission rates for mercury for the first time. A database of power interchange between regions of the grid is also under development for future versions. (The E-GRID Web site is at www.epa.gov/acidrain/egrid.)

Additional Air Quality Programs

This section focuses on the expanding cooperative efforts and progress Canada and the United States have undertaken on ground-level ozone and particulate matter. Other air quality efforts undertaken internationally, through provincial-state cooperation, and through public/private partnerships are also reported.

Cooperation on Ground-Level Ozone and Particulate Matter

Ozone

Since the last Progress Report, Canadian Minister of the Environment David Anderson and EPA Administrator Carol Browner have supported the April 1999 recommendation of the Air Quality Committee (AQC) to proceed with ozone annex negotiations. The first three negotiating meetings were held February 2000 in Ottawa, June 2000 in Washington, DC, and August 2000 in Ottawa. Additional meetings are taking place, with a goal of completing an ozone annex by the end of 2000.

The move to develop an ozone annex was an outgrowth of the initiative on ground-level ozone and particulate matter (PM)—the Program to Develop a Joint Plan of Action for Addressing Transboundary Air Pollution—signed by the environmental heads of both governments in April 1997. The recommendation to support negotiation of an ozone annex also was based in part on a March 1999 report, *Ground-Level Ozone: Occurrence and Transport in Eastern North America,* developed by the AQC Subcommittee on Program Monitoring and Reporting.

The report contains modeling and air quality analyses and features the following conclusions: (1) long-range transport of ozone and its precursors significantly influence the magnitude and persistence of high ozone concentration; (2) due to relative amounts of emissions in each country and the prevailing winds during summer ozone seasons, more ozone and precursors flow north-northeast from the United States into Canada than south-southeast from Canada into the United States; (3) there are substantial transboundary regional benefits to controlling NO_x emissions both in Canada and the United States; and (4) there is clear evidence of the rationale for discussing an effective binational approach for management of ozone and its precursors in eastern North America. (The report can be found at:
Canada: www.ec.gc.ca/smog/transport/cda_us99.htm
U.S.: www.epa.gov/oar/oaqps/publicat.html#uscanaq)

Particulate Matter

As an outgrowth of the Joint Plan of Action and the June 1998 report by the environmental ministers on the progress of both governments, Canada and the United States are proceeding with technical analyses to develop a work plan for addressing transboundary PM issues. These analyses include modeling, monitoring, and data analysis. (For more details on PM work plan development and cooperative analyses, see Section IV, pp. 23-25.)

Domestic Programs to Address Ozone and Particulate Matter

CANADA

Federal/Provincial/Territorial Initiatives

PM and ozone Canada-Wide Standards were finalized by the Canadian Council of Ministers of the Environment in June 2000. The standard for PM, which focuses on the fine fraction $PM_{2.5}$, is a 30 cubic micrometers (μm^3) 24-hour average, 98th percentile ambient measurement annually averaged over 3 consecutive years, to be achieved by 2010. Jurisdictions can continue to apply their existing air quality objectives or guidelines for PM less than or equal to 10 microns (PM_{10}). The Canada-Wide Standard for ozone is 65 ppb 8-hour average, 4th highest measurement annually averaged over 3 consecutive years, to be achieved by 2010.

Accompanying the standards are a set of joint initial actions to be undertaken by all Canadian jurisdictions and completed in 2005. Federal, provincial, and territorial governments will work together, in consultation with stakeholders, to identify and develop comprehensive, national multi-pollutant emissions reduction strategies. Initially, the strategies target the following sectors: electric power, pulp and paper, iron and steel, base metal smelting, concrete and asphalt plants, and lumber and allied wood products. These sectors, based on current emission inventories, are significant emitters of the precursor pollutants that cause PM and ozone. The pollutants are common to most jurisdictions and affect many communities across Canada.

The Canada-Wide Acid Rain Strategy for Post-2000 calls for a number of actions, including new emissions reduction targets in Ontario, Quebec, New Brunswick, and Nova Scotia and the pursuit of further SO_2 emissions reduction commitments from the United States. Ontario, Quebec, New Brunswick, and Nova Scotia made a commitment at the Canadian Council of Ministers of the Environment meeting in November 1999 to announce new targets before the end of 2000. Ontario has since announced its target of a 50% reduction from 1990 levels by 2015. Quebec has committed to a preliminary target of 40% from 1990 levels by 2002.

Federal Initiatives

Based on scientific recommendations, the ministers of environment and health announced PM_{10} as toxic under the new 1999 Canadian Environmental Protection Act (CEPA).

Under CEPA 1999, a concrete timeframe to bring a toxic substance under effective control is required. Key industrial sectors will be required to set emission reduction targets and timetables to meet those targets. The Government of Canada's action on PM_{10} is one of a number of immediate and long-term actions on clean air. Official notification was published in the *Canada Gazette* for a 60-day public comment period.

To effectively reduce the ambient concentrations of PM, management strategies must address the pollutants that are emitted as precursors to PM. In that regard, the Federal Government announced its intention to recommend to the Governor in Council that the principal precursors to PM (SO_2, NO_x, VOCs, and ammonia) be added to Schedule 1 of CEPA's list of toxic substances. The announcement launched a 60-day comment period during which interested parties have the opportunity to provide the ministers of environment and health with comments regarding this proposal. These comments will be considered by the ministers prior to finalizing their recommendation to the Governor in Council.

In fall 2000, the Federal Government is releasing Phase 3 of the Federal Smog Management Plan, continuing the effort begun in 1990 with the Phase 1 NO_x/Volatile Organic Compound (VOC) Management Plan and the subsequent 1997 Phase 2 Federal Smog Management Plan. The Phase 3 Plan provides for initiatives to reduce emissions from transportation and petroleum fuels as well as stationary sources. The plan also provides for further scientific research and analysis of the smog problem, better ambient air monitoring and reporting, and public education. The plan addresses key industrial sectors, including electric power, iron and steel, base metal smelting, pulp and paper, and lumber and allied wood products.

The Phase 3 Smog Plan and its initiatives are developed using multi-stakeholder consultation processes, in cooperation with other interested levels of government. Phase 3 initiatives will be implemented in a multi-pollutant approach, considering not only ozone and PM, but also initiatives already underway to address toxics, acid rain, and climate change.

As a sector, on-road vehicles are the largest contributor to NO_x and carbon monoxide (CO) emissions in Canada, and the second largest contributor to VOC emissions. Given the integrated nature of the North American market, Canadian motor vehicle emission standards generally mirror those in the United States. The current Tier 1 standards establish limits on hydrocarbons, CO, NO_x, and PM emissions. In 1997, harmonization with the United States was written into the Motor Vehicle Safety Regulations. The federal emission standards were previously established under the Motor Vehicle Safety Act but are now found under CEPA 1999.

The CEPA provisions also create new authorities to set national emission standards for vehicles and engines used in a variety of off-road applications (e.g., agricultural and construction equipment) and nonroad applications (e.g., lawn mowers, generators, and chain saws). Under CEPA, Canada plans to continue aligning its emission standards for new vehicles and engines with corresponding U.S. federal programs. Environment Canada also plans to consult with stakeholders to develop a multi-year agenda for implementing an effective emission control program for vehicles, engines, and fuels.

Restrictions from mobile sources also will reduce SO_2 levels. Beginning in July 2002, through regulations under CEPA, gasoline's sulfur content must not exceed an average of 150 parts per million (ppm). This limit is further restricted to 30 ppm by January 2005. The reduction in gasoline sulfur levels is expected to reduce ambient concentrations of SO_2 and sulfate particles, as well as VOC, CO, and NO_x emissions from gasoline vehicles equipped with catalytic converters. Sulfur in diesel regulations, effective since January 1, 1998, limit the sulfur content of diesel fuel used in on-road vehicles to a maximum of 500 ppm. Benzene in gasoline regulations, effective since July 1999, limit the content of benzene in gasoline to below 1% by volume.

To fill the regulatory gap until CEPA 1999 provided the necessary new authorities, Environment Canada announced a Memorandum of Understanding (MOU) with members of the Canadian Marine Manufacturers Association. Under this voluntary MOU, outboard engines and personal watercraft sold in Canada will be designed to comply with U.S. federal emission standards beginning in the 2001 model year. Environment Canada also has engaged in dialogue with industry associations and engine manufacturers representing the utility engine and off-road diesel sectors to implement similar programs.

Environment Canada is working closely with the Canadian Urban Transit Association (CUTA), Bombardier, and other private sector partners to deliver a major nationwide sustainable transportation campaign. Running in 61 Canadian cities, the campaign is supported by board advertisements on buses and public service announcements. The campaign focuses on alternatives to single-occupancy vehicles and highlights the role of public transit in creating cleaner and healthier communities.

Provincial/Regional Emission Reduction Plans

Ontario

Ontario has developed an Anti-Smog Action Plan, which covers a wide variety of sectors, to reduce 1990 NO_x and VOC emissions levels 45% by the year 2015. The action plan has currently identified, planned, or implemented reduction opportunities. These opportunities are expected to assist Ontario in achieving up to 80% of the targeted NO_x reductions and 60% of the targeted VOC reductions. Other opportunities and actions are being identified by a team of stakeholders from industry, nongovernmental organizations, ministry staff, and other levels of government.

The Ontario government addresses air quality problems using a mix of regulatory and voluntary tools. On January 24, 2000, Ontario announced new actions to improve air quality, including a commitment to reduce the province's SO_2 emissions 50% beyond the Countdown Acid Rain Program cap of 885 kilotonnes (kt) per year, by 2015. New regulations will cap NO_x and SO_2 emissions and will require mandatory emissions monitoring and reporting. These regulations will first apply to the electricity sector, then extend to other industrial and commercial sectors. In 2001, annual SO_2 and NO_x emissions (as nitrogen oxide) from coal and oil-burning power plants greater than 25 megawatts electric (MWe) will be limited to 157.5 kt and 36 kt net—more than 19% and 28% below the levels emitted in 1990. The province also announced emissions performance standards for Ontario, as well as U.S.-based generators wishing to sell to the Ontario market.

At the same time, the province proposed a "Cap, Credit, and Trade" emissions reduction trading program. A new environmental assessment regulation has also been announced for Ontario that would specify environmental assessment requirements for electricity sector activities. Drive Clean, initiated in 1999, is a program for inspection and maintenance of passenger vehicles, trucks, and buses to reduce emissions from existing vehicles. When fully implemented, this program will eliminate 62,000 tonnes of smog-causing pollutants per year. The province's gasoline volatility regulation has been updated and requires gasoline refiners and blenders to reduce the smog-causing fumes emitted from summer-grade gasoline.

More than 100 air quality standards will have been reviewed and revised or updated by the end of fiscal year

1999/2000 to ensure that the environment is protected. Ontario also established an interim air quality standard for PM_{10}. Currently, the province is developing a PM reduction strategy. The ministry also launched the Partners in Air Program, a partnership of high schools, government, business, and industry. The program will include in-class instruction for students on reducing smog and monitoring air quality. Provincewide results are posted for students on a Partners in Air Internet Web site at www.partnersinair.org

British Columbia

British Columbia (BC) has been the leader in a number of clean transportation initiatives. BC is the only province to regulate beyond federal tailpipe emission standards for new vehicles. After a review of the relative benefits of U.S. Tier 2 and California Low Emission Vehicle Standards II standards, BC announced in March 2000 that it will follow the U.S. Tier 2 standards because they will provide the best air quality improvements. A fuel tax exemption is provided to encourage the use of natural gas, propane, and high-level alcohol blends to reduce emissions related to smog, fine particle formation, and greenhouse gases. A new exemption was created for low-level ethanol blends in the 1999 provincial budget.

BC's AirCare Program has regulated the emissions of existing vehicles since 1992. A number of improvements will take effect when AirCare2 testing begins later in 2000 or early 2001. BC also began mandatory testing of heavy vehicle emissions in 1999. BC has Canada's only program to provide financial incentives to take older polluting vehicles off the road. The program was relaunched in November 1998 with a wider range of incentives. BC has also supported fuel cell commercialization through the purchase of three Ballard hydrogen fuel cell buses, used since fall 1999.

The Lower Fraser Valley is an international air shed bordered by seacoast and mountains. The Canadian portion is shared by the Fraser Valley Regional District and the Greater Vancouver Regional District. Both areas have management plans aimed at improving air quality or preventing further deterioration. (Detailed information on air quality management efforts in both regions can be found at: www.gvrd.bc.ca/services/air/index.html and www.fvrd.bc.ca/home.html.)

UNITED STATES

Revised Ozone and PM Standards

In July 1997, EPA established an 8-hour primary ozone standard to protect against longer exposure periods that are of concern for both human health and the environment. The level of the national 8-hour primary and secondary ambient air quality standards for ozone is an 0.08 ppm daily maximum, 8-hour average, over 3 years. The standards are met when the 3-year average of the annual fourth-highest daily maximum 8-hour ozone concentration is less than or equal to 0.08 ppm.

The 8-hour ozone standard was subject to legal challenge. In May 1999, the U.S. Court of Appeals for the DC Circuit remanded the case back to EPA for further consideration. The court has since agreed to review the decision.

EPA is taking other actions to protect against the risks of ozone pollution while litigation continues over its more protective 8-hour standard. EPA is retaining the 1-hour ozone standard where it currently applies and has reinstated it in areas where it was previously revoked. These areas will continue monitoring for ozone, and some will need to take action to prevent or eliminate ozone violations. Once the 8-hour standard has become fully enforceable and is subject to no further legal challenge, EPA will take action to evoke the 1-hour standard in areas where air quality meets that standard.

Regarding PM standards, the last review of the standards concluded that further protection from adverse health effects is needed. Based on this review, the primary (health-based) PM standards were revised in July 1997, adding two new $PM_{2.5}$ standards that offer protection from fine particles. The new $PM_{2.5}$ standards were set at 15 μm^3 and 65 μm^3, respectively, for the annual and 24-hour standards. The secondary (welfare-based) $PM_{2.5}$ standards were made identical to the primary standards and will be implemented in conjunction with a revised visibility protection program to address regional haze in mandatory federal Class I areas. In May 1999, the U.S. Court of Appeals for the DC Circuit vacated the revised PM_{10} standards, remanding them back to EPA for further consideration. The Supreme Court has since agreed to review the decision in May 2000. EPA is currently reviewing the PM standards, scheduled for completion by 2002.

In other efforts, EPA began deployment of a new monitoring network in early 1999 to assess fine PM data with respect to the new $PM_{2.5}$ standards (see Section IV, p. 24 for more details).

The Ozone Transport Reduction Rule and Related Actions

In September 1998, EPA finalized the Ozone Transport Reduction Rule, known as the NO_x State Implementation Plan (SIP) Call, requiring 22 states[8] and the District of Columbia to submit SIPs addressing the regional transport of ground-level ozone. By improving air quality and reducing NO_x emissions, the actions directed by these plans will decrease the transport of ozone across state boundaries in the eastern half of the United States. The rule requires emissions reduction measures to be in place by May 2004. The final rule does not mandate which sources must reduce pollution. States will have the ability to meet the rule's requirements by reducing emissions from the sources they choose. Utilities and large nonutility point sources, however, would be one of the most likely sources of NO_x emissions reductions. The final rule includes a model NO_x Budget Trading Program that will allow states to achieve more than 90% of the required emissions reductions in a highly cost-effective way. This rule will reduce total summertime NO_x emissions in the affected states and the District of Columbia by about 25% (approximately 1 million tons) beginning in 2003. EPA projects that these regional NO_x reductions, in combination with existing local controls, will bring the vast majority of all new ozone nonattainment areas into attainment with the 8-hour ozone standard. They also will help reduce ozone levels in the remaining nonattainment areas east of the Mississippi River.

In 1997, in a separate but related action, Connecticut, Maine, Massachusetts, New Hampshire, New York, Pennsylvania, Rhode Island, and Vermont filed petitions with EPA under Section 126 of the Clean Air Act Amendments (CAAA) to reduce the transport of ground-level ozone. The petitions identified 30 states, plus the District of Columbia, as containing sources that significantly contribute to the regional transport of ground-level ozone. The petitions asked EPA to find that certain utilities and other NO_x emissions sources significantly contribute to these states' ozone problems.[9]

In April 1999, EPA issued a final rule determining that four of the eight petitions could be approved based solely on technical considerations under the 1-hour standard. In January 2000, EPA granted these four petitions.[10] As a result, 392 facilities will have to reduce annual emissions about 510,000 tons from 2007 levels.

Tier 2 Standards for Auto Tailpipe Emissions and Low Sulfur in Gasoline

In December 1999, EPA announced more protective tailpipe emissions standards for all passenger vehicles, including sport utility vehicles (SUVs), minivans, vans, and pickup trucks. Simultaneously, EPA announced more stringent standards for sulfur in gasoline, which

will ensure the effectiveness of low-emission control technologies in vehicles and reduce harmful air pollution. The implementation of the new tailpipe and sulfur standards will equate to removing 164 million cars from the road. These new standards require passenger vehicles to be 77% to 95% cleaner than those on the road today and to reduce gasoline's sulfur content by up to 90%.

The new tailpipe standards are set at an average of 0.07 grams per mile (g/mi) of NO_x emissions for all classes of passenger vehicles, beginning in 2004. This regulation marks the first time that SUVs and other light-duty trucks—even the largest passenger vehicles—are subject to the same national pollution standards as cars. Vehicles weighing less than 6,000 pounds will be phased into this standard between 2004 and 2007.

[8] EPA's final action was subject to legal challenge by a number of parties. In March 2000, the U.S. Court of Appeals for the DC Circuit issued a 2-to-1 ruling in favor of EPA on all major issues associated with the NO_x SIP Call. The court remanded issues—including those relating to Wisconsin, Georgia, and Missouri—to EPA. In June 2000, the court ordered SIP revisions addressing requirements upheld by the Court due by October 30, 2000.

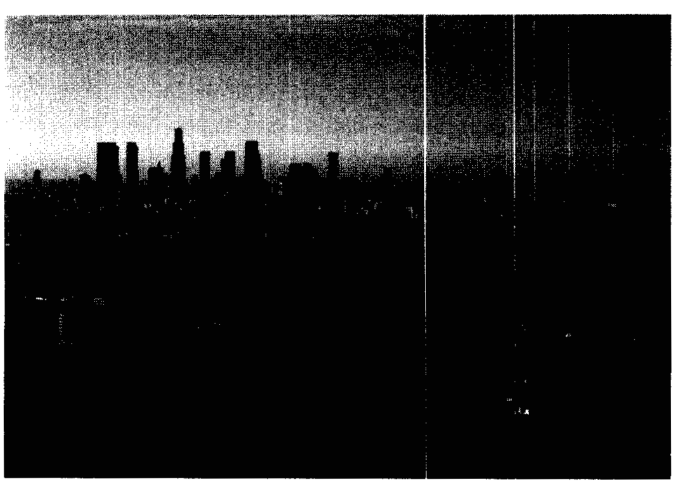
[9] All eight petitioning states requested findings under the 1-hour ozone standard; five also requested findings under the 8-hour standard. For each petition, EPA made separate technical determinations for the 1-hour and 8-hour ozone standards.

[10] EPA denied petitions for the 1-hour standard filed by Maine, New Hampshire, Rhode Island, and Vermont because these states no longer had areas that were not attaining the 1-hour standard.

For the heaviest light-duty trucks, the program provides a three-step approach to reducing emissions. First, in 2004, vehicles must not exceed 0.6 g/mi—a more than 60% reduction from current standards. Second, these vehicles are required to achieve an interim standard of 0.2 g/mi to be phased in between 2004 and 2007—an 80% reduction from current standards. In the final step, half of these vehicles will meet the 0.07 standard by 2008, and the remaining will comply in 2009. Vehicles weighing between 8,500 and 10,000 pounds can take advantage of additional flexibility during the 2004 to 2008 interim period.

Beginning in 2004, the nation's gasoline refiners and importers will have the flexibility to manufacture gasoline with a range of sulfur levels, as long as all their production is capped at 300 ppm and their average annual corporate sulfur levels are capped at 120 ppm. In 2005, the refinery average will be set at 30 ppm, with a corporate average of 90 ppm and a cap of 300 ppm. Both the average standards can be met by using credits generated by other refiners that reduce sulfur levels early. Finally, in 2006, refiners will meet a 30-ppm average sulfur level with a maximum cap of 80 ppm. Gasoline produced for sale in parts of the western United States will be allowed to meet a 150-ppm refinery average and a 300-ppm cap through 2006 but will have to meet the 30-ppm average/80-ppm cap by 2007.

Small refiners (i.e., those that have no more than 1,500 employees and a corporate crude oil capacity of no more than 155,000 barrels per day) will be required to comply with less stringent interim standards through 2007, when they must meet the final sulfur standards. If necessary, small refiners that demonstrate a severe economic hardship can apply for an additional extension of up to two years.



Proposed Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements

In June 2000, EPA proposed a major program to significantly reduce emissions from heavy-duty engines and vehicles. This comprehensive 50-state control program regulates the heavy-duty vehicle and its fuel as a single system. Under the proposal, new emission standards will begin to take effect in 2007 and will apply to heavy-duty highway engines and vehicles operated on any fuel. As proposed, this program will reduce emissions of NO_x and nonmethane hydrocarbons (NMHC)—key ingredients in ground-level ozone—by 2.8 million and 305,000 tons per year in 2030, respectively. Particulate emissions from these vehicles would be reduced by 110,000 tons per year in 2030.

The proposed PM emissions standards for new heavy-duty engines of 0.01 g/bhp-hr would take effect in the 2007 model year. Standards for NO_x and NMHC are 0.20 g/bhp-hr and 0.14 g/bhp-hr, respectively. These NO_x and NMHC standards would be phased in together for diesel engines between 2007 and 2010. Proposed standards for complete heavy-duty vehicles would be implemented on the same schedule as for engine standards. For vehicles between 10,000 and 14,000 pounds, the proposed standards are 0.4 g/mi for NO_x, 0.02 g/mi for PM, and 0.23 g/mi for NMHC. Proposed standards for diesel fuel specify that fuel sold to consumers for use in highway vehicles have a sulfur content no greater than 15 ppm, beginning in June 2006. Current sulfur content in fuel is about 500 ppm.

State Efforts

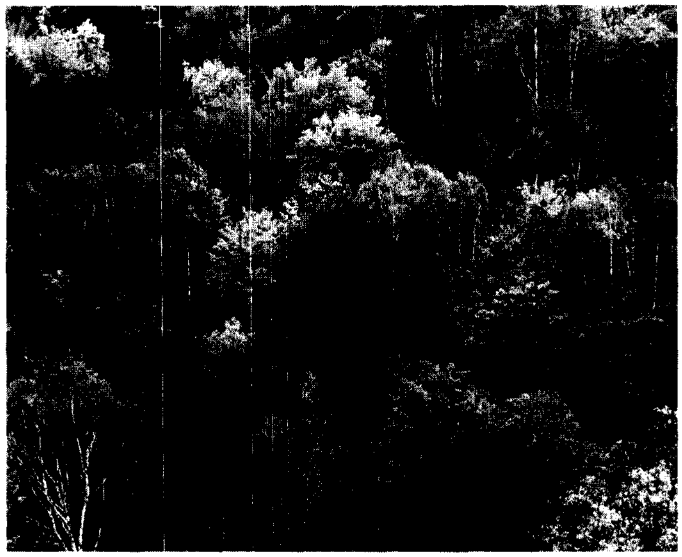
Attainment Demonstrations

The CAAA requires each state containing an area designated nonattainment for ozone to submit an attainment demonstration plan to meet the ozone standard. EPA has recently proposed action on attainment demonstrations for 10 major urban areas: Atlanta, Baltimore, Houston, New York, Philadelphia, Chicago, Milwaukee, western Massachusetts, greater Connecticut, and Washington, DC. Attainment demonstrations for these areas will involve 13 states and the District of Columbia.

The CAAA specifies certain measures that must be adopted in nonattainment areas—reasonably available control technology on major sources, and vehicle inspection and maintenance, for example. However, each state can choose the additional measures needed for attainment. The rule-making action for each plan provides details of the control measures the plans rely upon.

Northeast Ozone Transport Region

The CAAA established the Northeast Ozone Transport Region and the Ozone Transport Commission (OTC) in recognition of long-standing regional ozone problems in the northeastern United States. The OTC comprises the governors or their designees and an air pollution control official from Connecticut, Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, Virginia, and the District of Columbia. Administrators for three northeastern EPA regions also participate.



The OTC states decided on a number of steps to reduce regional air pollution. For example, they agreed to significantly reduce NO_x emissions throughout the region from large stationary sources such as power plants and other large fuel combustion sources using market-based approaches. This program is expected to reduce 1990 baseline emissions by 52 percent.

Other Cooperative Air Quality Efforts

United Nations Long-Range Transboundary Air Pollution Protocol

The United Nations Economic Commission for Europe's Convention on Long-Range Transboundary Air Pollution Protocol (LRTAP), signed in 1979, was the first international agreement recognizing environmental and health problems caused by the flow of air pollutants across borders and the need for regional solutions. On LRTAP's 20th anniversary in December 1999, Canada and the United States signed the Protocol to Abate Acidification, Eutrophication, and Ground-Level Ozone. The signing of this agreement initiates a new phase within LRTAP to increase emphasis on implementation, compliance, review, and extension of existing protocols.

To accommodate the domestic (acid rain) and bilateral (acid rain and ozone) agreements in place or currently underway in both countries, Canada and the United States will incorporate their emissions reduction commitments for SO_2, NO_x, and VOCs into the new protocol at the time of ratification. This will enable inclusion of the bilateral initiative to complete negotiations of an ozone annex to the Air Quality Agreement in 2000. Emissions reduction commitments in the protocol relate to emission limit values for new and existing stationary sources and new mobiles sources; application of best available techniques (BAT); and measures to reduce VOC emissions associated with the use of products. There are no Canadian or U.S. commitments related to ammonia. (For more information on the LRTAP Convention and protocols, see www.unece.org/env/lrtap.)

New England Governors and Eastern Canadian Premiers

The Conference of New England Governors and Eastern Canadian Premiers (NEG/ECP) announced resolutions containing action plans for acid rain and mercury at its July 1998 annual meeting. In 1999, the NEG/ECP Acid Rain Steering Committee called on the Federal Governments to reduce SO_2 emissions 50% and annual NO_x emissions 30% beyond current commitments. State and provincial implementation of the NEG/ECP Acid Rain Action Plan has led to the formation of focused work groups on forest mapping, surface water quality, fine particle monitoring, public outreach, and data exchange. (For details on scientific activities and NEG/ECP projects, see Section IV, pp. 27 and 28.)

Canada-U.S. Georgia Basin Ecosystem Initiative

In January 2000, Canadian Minister of the Environment David Anderson and EPA Administrator Carol Browner signed a British Columbia-Washington Environmental Cooperation Agreement. This cooperative initiative builds on several years of conservation and protection work at the state/provincial/regional levels, strengthening the governments' partnership in addressing the region's transboundary and global environmental challenges. As part of this initiative, Canada and the United States will establish a joint Environment Canada-EPA work group of senior-level officials to develop annual action plans. The plans will share scientific information on the ecosystem, develop joint research initiatives, ensure coordination of environmental management initiatives, and jointly consider longer term planning issues. Enhanced cooperation on air quality issues is expected to be one of the first action items.

North American Research Strategy for Tropospheric Ozone

The North American Research Strategy for Tropospheric Ozone (NARSTO) is a public/private partnership that includes Canada, the United States, and Mexico. It coordinates research on atmospheric processes involved in ozone and ozone precursor accumulation, transformation, and transport in the continental troposphere, as well as on fine particles. NARSTO's report, *An Assessment of Tropospheric Ozone Pollution: A North American Perspective*, is expected to be released by fall 2000. The report will address tropospheric ozone and ozone precursor transboundary issues, emissions, monitoring trends, modeling, and methods development. Research continues under NARSTO to determine efficient and effective strategies for local and regional ozone management across the North American continent. NARSTO also is preparing a PM science assessment expected to be completed by the end of 2002.[11]

Northeast Regional Air Quality Committee

The Northeast Regional Air Quality Committee (NERAQC), established in response to Prevention of Significant Deterioration (PSD) and visibility protection under Annex 1, is focused on protected areas in New England and Atlantic Canada. NERAQC is made up of federal, state, and provincial representatives. The committee holds meetings and conferences to exchange information about air pollution research, air monitoring, and mitigation efforts that impact parks and protected areas. (For more information on NERAQC, see http://capita.wustl.edu/NEARdat/transflo/NERAQC/NERAQC.htm.)

[11]Quality assurance and data management guidelines and assistance are available to all NARSTO researchers at the Oak Ridge National Laboratory in Oak Ridge, Tennessee.

Scientific Information Exchange

This section focuses on Canadian and U.S. progress under Annex 2 of the Air Quality Agreement to cooperate and to exchange scientific information related to transboundary air quality issues. This cooperation and exchange of data is essential for comparing atmospheric and ecosystem changes related to variations in emissions of pollutants. It is also important for publishing results in common formats. The emissions graphics and acid deposition maps presented in this section are examples of cooperative data sharing. Throughout the 1990s, cooperative efforts focused primarily on acid rain. In recent years, the two governments have undertaken joint analyses and shared data in the areas of ground-level ozone and fine particulates.

Emissions Inventories

Emissions inventories provide the foundation for air quality management programs. They are used to identify major sources of air pollution, provide data to input into air quality models, and track the progress of control strategies. In this section, SO_2, NO_x, and VOCs are the main pollutants addressed. 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.

In this section, emissions trends estimates for SO_2, NO_x, and VOCs for both Canada and the United States (Figures 3, 6, and 7) are presented reflecting new methodologies for determining total estimates and using new models and results (e.g., the NONROAD model). In addition to the joint emissions trends data, the latest available data (1998) on sources of emissions by sector are presented in Figures 4, 5, and 8. Canadian emissions data are preliminary

Canada-U.S. SO_2 Emissions, 1980-2010

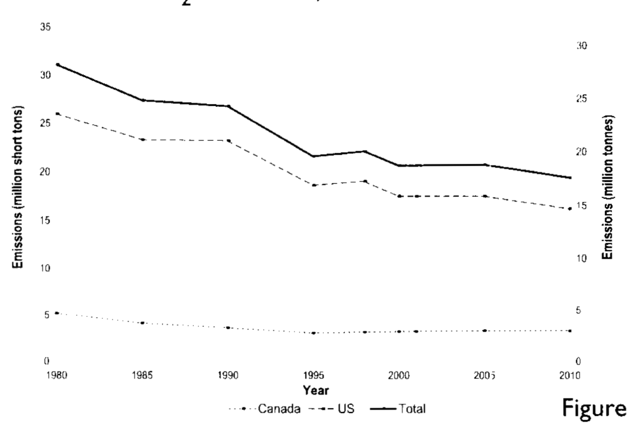


Figure 3

No data were available in 1980 to estimate emissions from U.S. nonroad diesel and gasoline vehicles. For purposes of consistency, these emissions have been removed from all other years.

Sulfur Dioxide

Coal and oil combustion, smelting, and a few industrial processes continue to be the principal anthropogenic sources of SO_2. Overall, a 39% reduction in SO_2 emissions is projected in Canada and the United States from 1980 to 2010.

Canada-U.S. SO_2 Emissions By Sector

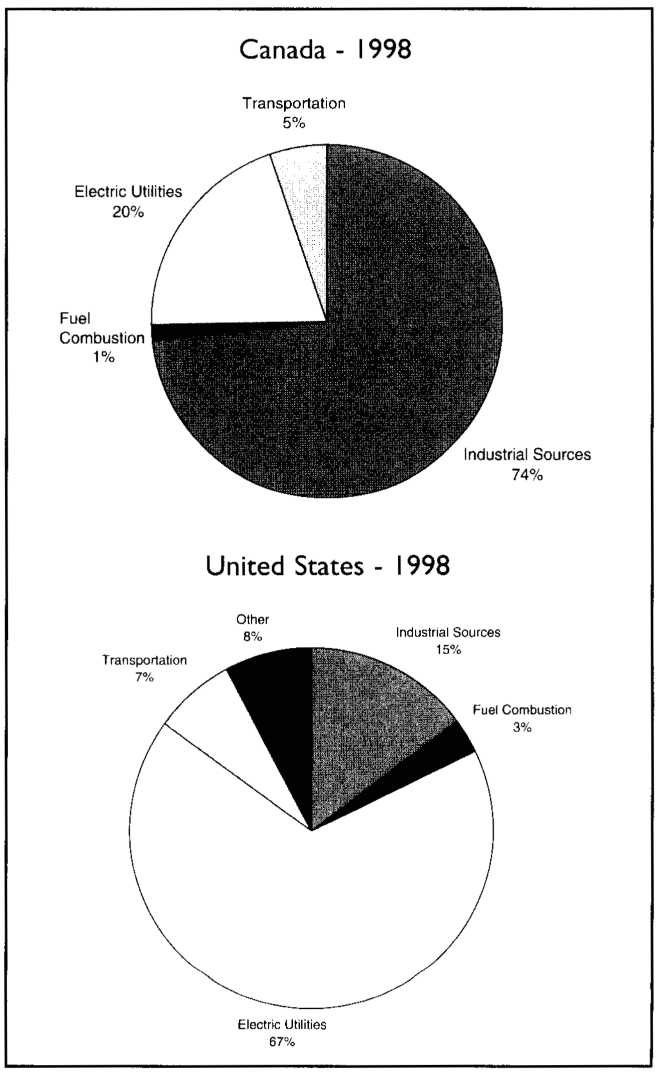


Figure 4

Nitrogen Oxides

The principal anthropogenic source of NO_x emissions remains the combustion of fuels in stationary and mobile sources. Motor vehicles, residential and commercial furnaces, industrial and electric utility boilers and engines, and other equipment contribute to this category. U.S. reductions in NO_x emissions are attributed to controls in electric utilities under the Acid Rain Program, the estimated controls associated with EPA's Regional Transport NO_x State Implementation Plan (SIP) Call, and the Tier 2 Tailpipe Standard. Overall estimated trends for anthropogenic emissions of NO_x in Canada and the United States from 1990 to 2010 are shown below.

Canada-U.S. NO_x Emissions By Sector

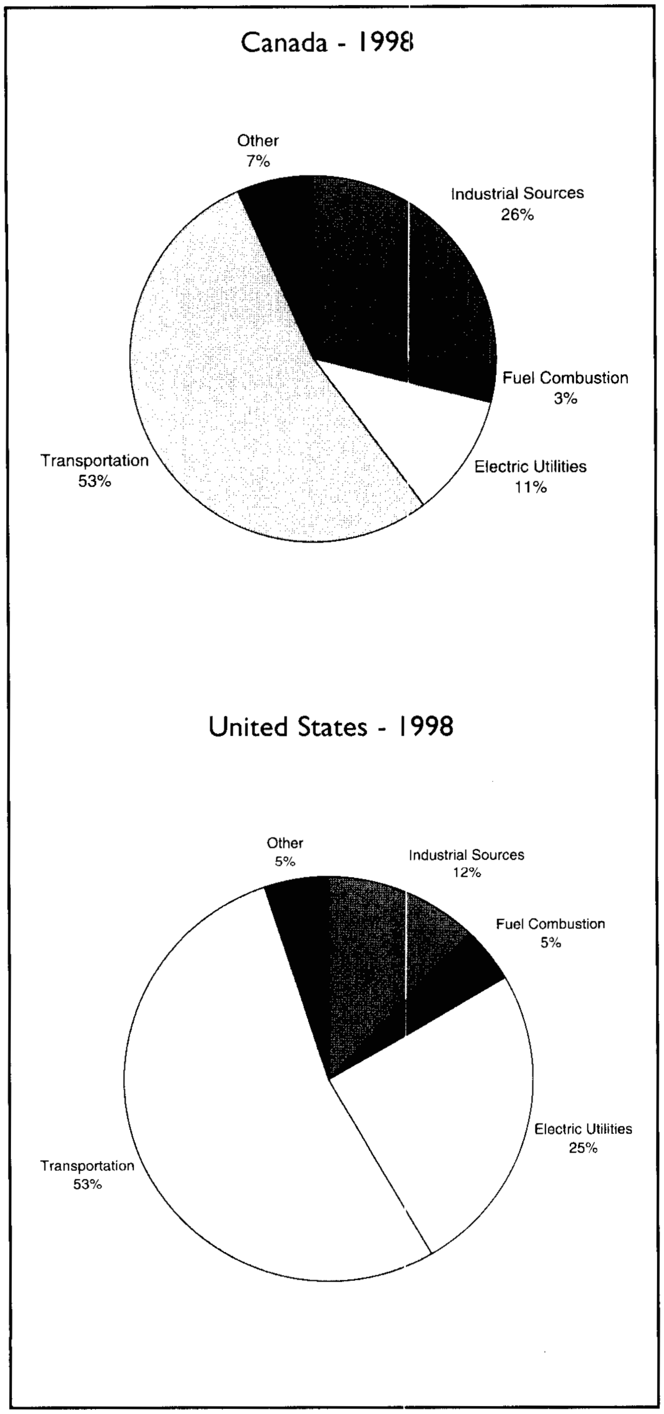


Figure 5

Canada-U.S. NO_x Emissions, 1990-2010

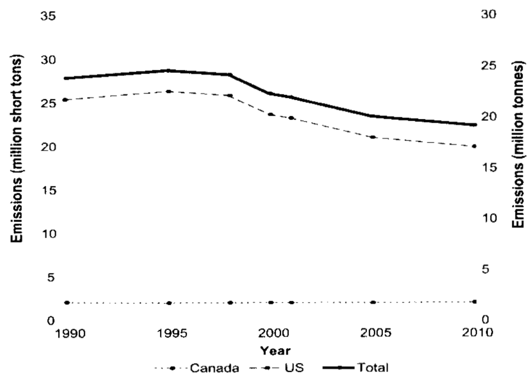


Figure 6

Volatile Organic Compounds

Anthropogenic emissions of VOCs come from a wide variety of sources, including mobile sources and industrial processes (e.g., chemical manufacturing and the production of petroleum products). Emissions in the United States are expected to decline by the year 2000 and then remain stable through 2010. Overall estimated trends in anthropogenic VOC emissions for Canada and the United States from 1980 to 2010 are shown below.

Canada-U.S.VOC Emissions, 1980-2010

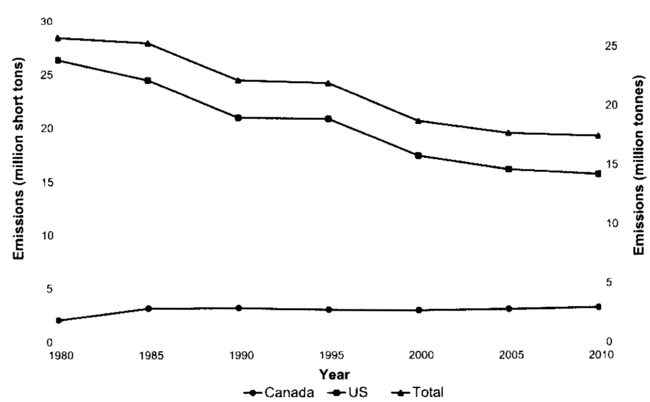


Figure 7

Canada-U.S. VOC Emissions By Sector

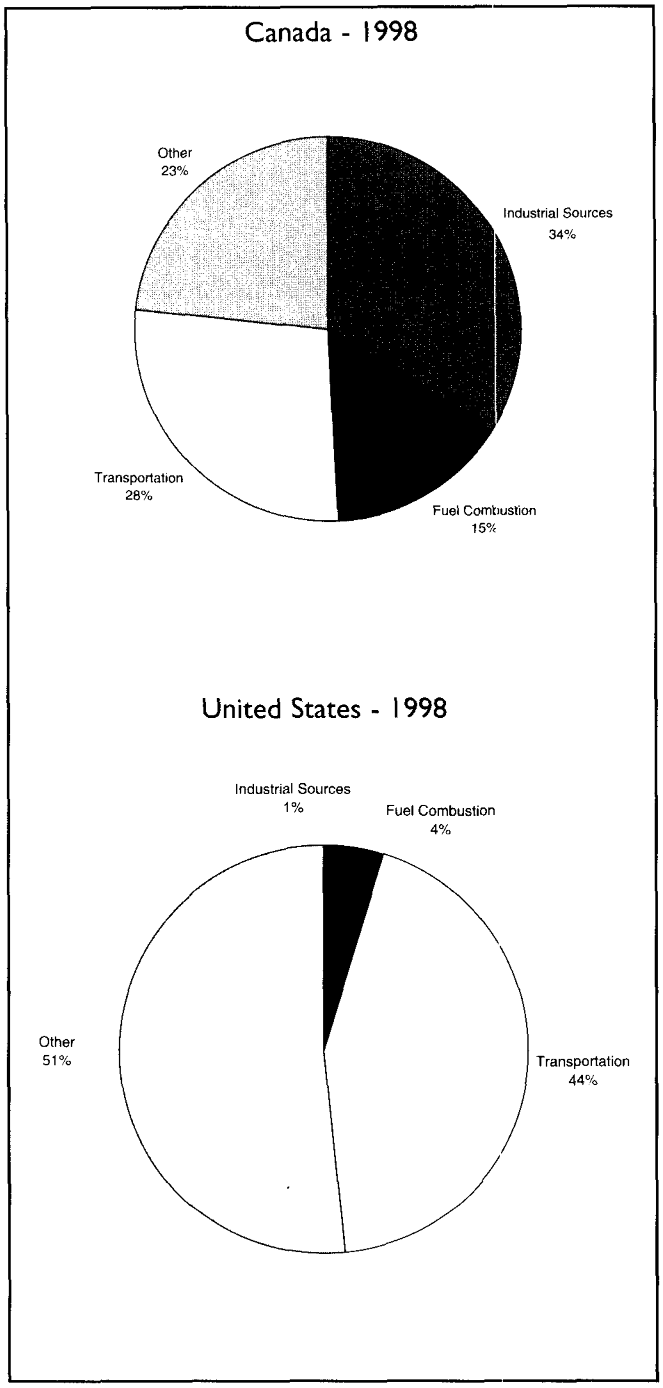


Figure 8

Acid Deposition Monitoring

Acid deposition monitoring is measured both as wet deposition in the form of rain, snow, and fog, and dry deposition through analyses of particles and gases. Canada and the United States have well-established networks that measure wet and dry deposition. Both countries contributed to an integrated data set used for the maps on page 20 that show North American deposition trends.

Status and Trends

Following implementation of Phase I of the Acid Rain Program, analyses of National Atmospheric Deposition Program/National Trends Network (NADP/NTN) data for 1995 to 1998 showed a dramatic and unprecedented sulfate deposition reduction of up to 25% over a large area of the eastern United States. The greatest reductions were in the northeastern United States, where many sensitive ecosystems are located.

In eastern Canada, sulfate concentrations in precipitation did not exhibit the same sudden decrease in 1995 as seen in the United States. While the Canadian concentration trends generally moved downward in 1995, the decrease appeared as a continuation of a slow decline begun several years earlier. The magnitude of the slow decline between the 1986 to 1989 period and the 1993 to 1996 period ranged from 12% to 30% at most Canadian Air and Precipitation Monitoring Network (CAPMoN) sites.

A 10-year trend analysis for the 1988 to 1998 period at 34 eastern U.S. Clean Air Status and Trends Network (CASTNet) sites shows significant declines in SO_2 and sulfate concentrations in ambient air. The average SO_2 reduction was 38 percent; for sulfate, the reduction was 22 percent. In the early 1990s, ambient SO_2 concentrations in the rural eastern United States were highest in western Pennsylvania and along the Ohio Valley in the vicinity of Chicago and Gary, Indiana. Large SO_2 air quality improvements can be seen by comparing the 1990 to 1991 period with the 1997 to 1998 period. The largest decrease in concentrations are noted in the vicinity of Chicago and throughout states bordering the Ohio Valley (Illinois, Indiana, Ohio, Pennsylvania, Kentucky, and West Virginia). The highest SO_2 concentrations in the rural parts of the eastern United States are concentrated in southwestern Pennsylvania.

In eastern Canada, SO_2 and sulfate concentrations in air exhibited similar trends to those in the eastern United States. At most CAPMoN sites, SO_2 and sulfate concentrations decreased from highs in the 1988 to 1991 period until 1995, after which they leveled off. As with the U.S. CASTNet measurements, the sulfate decline tended to be slower than that of SO_2. Highest SO_2 and sulfate concentrations occurred in the southernmost parts of Ontario and Quebec, in close proximity to the northern areas of the United States that experienced the highest concentrations.

Analyses of Atmospheric Integrated Research Monitoring Network (AIRMoN) wet and dry deposition sites

Wet Sulfate and Wet Nitrate Deposition in 1980-1984 and 1995-1998

Wet depostion before (1980-1984) and after (1995-1998) the implementation of the Phase 1 CAAA controls can be compared in Figures 9 through 12. Wet sulfate deposition decreased substantially from the early 1980s to the post-implementation period. Nitrate wet deposition, on the other hand, showed minor changes between these periods. Units are kilograms per hectare per year. These analyses are based on measurements of precipitation chemistry from the NADP/NTN and CASTNet in the United States and from federal and provincial monitoring networks in Canada. Wet sulfate deposition has been adjusted for the sea-salt contribution of sulfate. Contours are not shown in figures 11 and 12 in Ontario and Quebec because provincial data were not available; values shown in those provinces are for federal sites only.

1980-1984 Wet Sulfate Deposition

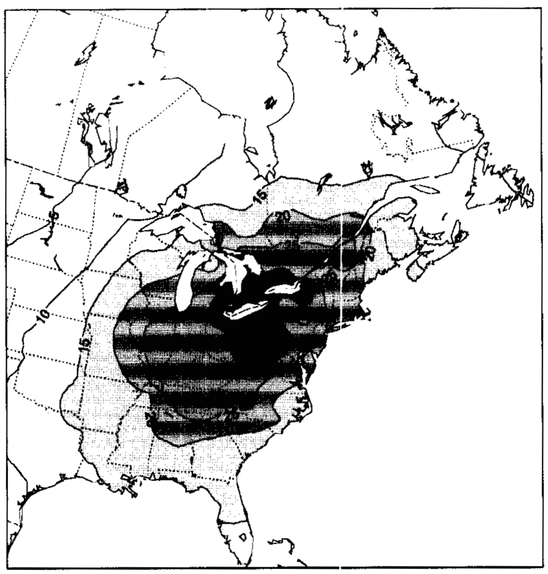


Figure 9

1980-1984 Wet Nitrate Deposition

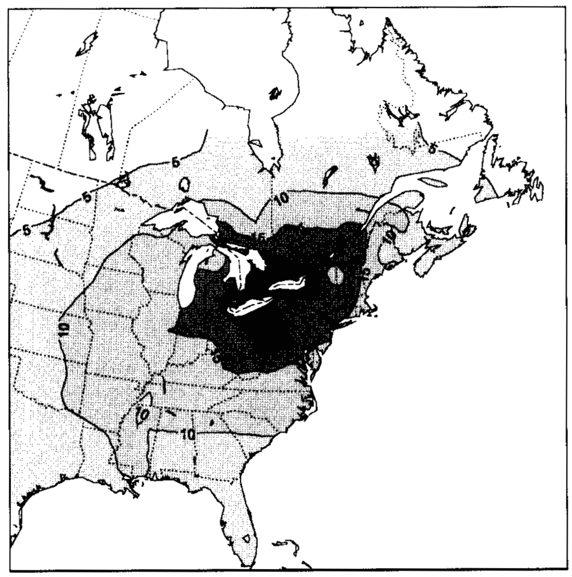


Figure 10

1995-1998 Wet Sulfate Deposition

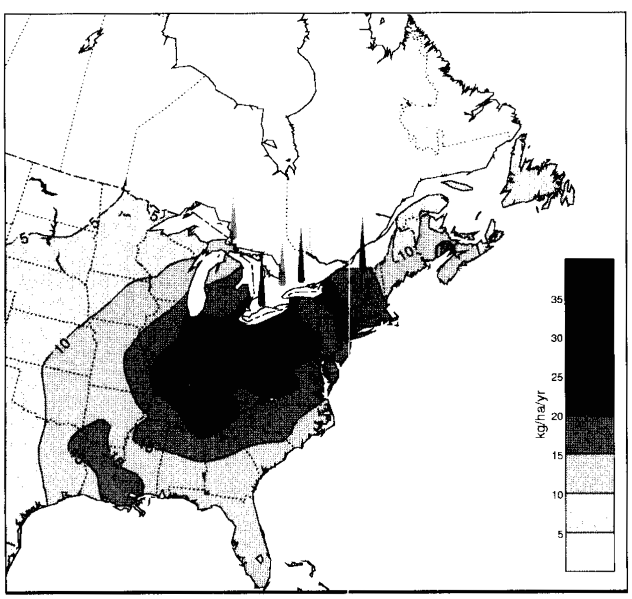


Figure 11

1995-1998 Wet Nitrate Deposition

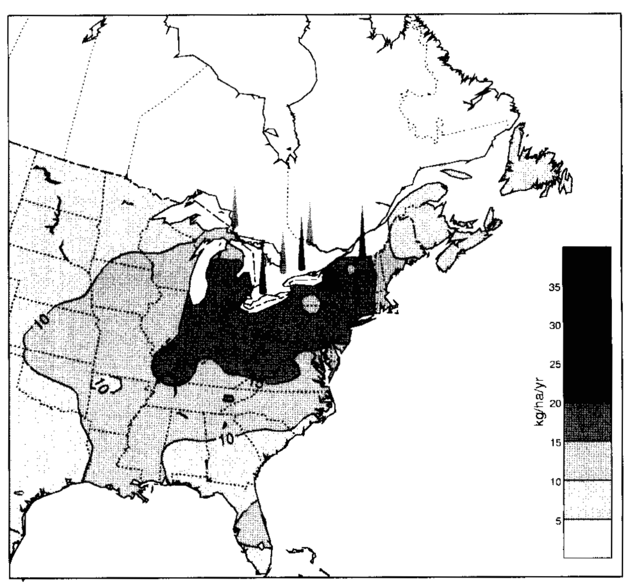


Figure 12

focusing primarily in the Northeast showed sulfate concentrations dropping as utility SO_2 emissions decreased. There was a one-to-one change in total sulfur concentrations reduced (SO_2 and sulfate) to SO_2 emissions reduced.

Nitrate concentration in precipitation remains unchanged when comparing NADP/NTN nitrate data collected from 1983 to 1984 with data collected from 1995 to 1998. CASTNet data also showed no change in total nitrate concentrations. The highest nitrate concentrations were found in Ohio, Indiana, and Illinois.

In eastern Canada, the concentrations of nitrate in precipitation, as measured by CAPMoN, showed different trends depending on the location. In Ontario, the majority of sites did not exhibit an obvious trend throughout the 1980s and up to 1997; in Quebec and the Atlantic regions, most sites showed increases in the last few years of the 1980s or the first few years of the 1990s, followed by decreases until early 1997. This behavior is consistent with the trend in NO_x emissions in eastern North America.

Canada

Wet deposition in Canada is measured by various federal and provincial/territorial governments. Environment Canada operates 19 federal sites in Canada under the auspices of CAPMoN. Three additional sites will be added in 2000/2001. Provincial wet deposition monitoring networks, comprising 77 sites, are operated by the governments of British Columbia, Alberta, Quebec, New Brunswick, Nova Scotia, Newfoundland, and the Northwest Territories. Ontario closed its monitoring network of approximately 20 sites in April 2000, leaving only 7 CAPMoN sites operating in that province.

Dry deposition is determined at 10 of Environment Canada's CAPMoN sites using a technique known as the inferential method (a similar approach is used in the United States). Two more sites will be added in 2000/2001. No dry deposition measurements are made by the provinces or territories.

United States

The United States has three acid deposition monitoring networks: NADP/NTN; AIRMoN, which is part of NADP; and CASTNet. NADP/NTN has more than 200 wet deposition monitoring sites, including 15 collocated dry deposition sites monitored on a weekly basis. Nine AIRMoN sites monitor wet deposition on a daily basis, and 15 sites monitor dry deposition on a weekly basis. CASTNet has 74 sites monitoring dry deposition and rural ozone concentrations.

Information and Data Exchange

EPA and Environment Canada have broadened their coordination on comparability issues, sharing of information on quality control, and data management. An EPA workshop held in May 2000 focused on challenges facing the operation of dry deposition monitoring networks in both countries. During the next few years, research efforts will be directed at developing better estimates of dry deposition, emphasizing nitrogen.

Ozone Concentrations Over Eastern North America, 1996-1998

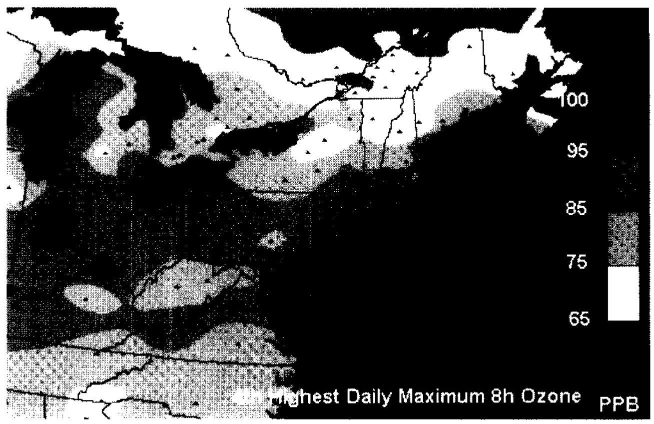


Figure 13

Ground-Level Ozone Monitoring and Mapping

Ground-level ozone (the primary constituent of smog) continues to be a pervasive pollution problem throughout many areas of the United States and southern Canada. Ozone is not emitted directly into the air, but is formed by the reaction of VOCs and NO_x in the presence of heat and sunlight. Ground-level ozone forms readily in the atmosphere, usually during hot summer weather. As reported in Section III, p. 9, the Air Quality Committee produced a joint transboundary ozone report including modeling and air quality analyses.

Status and Trends

Figure 13 (above) shows the fourth highest daily maximum 8-hour ozone concentration for the northeastern portion of North America, averaged over the years 1996 to 1998. This figure was created for Environment Canada using the EPA-sponsored Map Generator Program. The figure incorporates data from 271 ozone monitoring sites that had at least two years of observations in the 1996 to 1998 period.

Distribution of 4th Highest Daily 8h Maximum Ozone (ppb) for Regional Sites, 1994-1996 (Median, 5th, 25th, 75th, and 95th Percentiles)

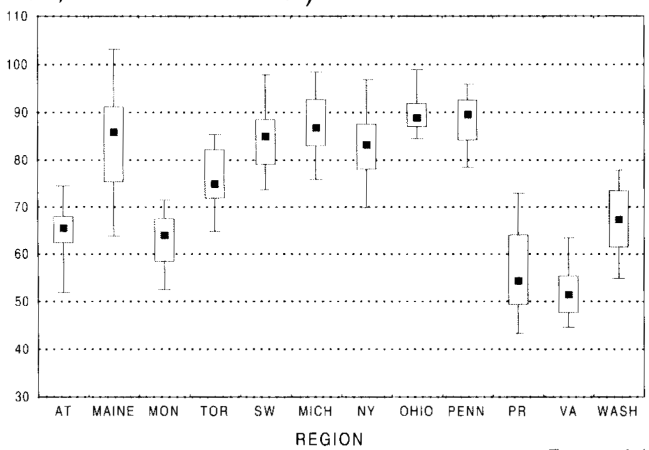


Figure 14

Figure 14 shows the distribution of the fourth highest daily maximum 8-hour ozone concentration at sites in the Canada-U.S. border region using data for 1994 to 1996. The highest values are recorded at the U.S. sites and at the southwestern Ontario sites; the lowest values are recorded at sites in the Prairies and the Vancouver area.

Concentrations of combined nitrogen oxide (NO), nitrogen dioxide (NO_2) and NO_x decreased in urban sites from 1989 to 1996 in Montreal, the Toronto area, southwestern Ontario, and Vancouver-Lower Fraser Valley. About half of this change was recorded between 1989 and 1990. In contrast, there has been little or no detectable change in mean VOC concentrations during the same period.

Ozone Monitoring

Both governments have extensive ground-level ozone monitoring programs.

Ambient monitoring of ground-level ozone and NO_x is performed throughout Canada under the National Air Pollution Surveillance (NAPS) network. The NAPS network is a joint program of the federal and provincial governments for monitoring and assessing the ambient air quality at 150 air monitoring stations in 52 urban centers across Canada. Air quality data for the criteria pollutants (SO_2, carbon monoxide (CO), NO_2, ozone, and PM) and for other pollutants such as particulate lead, sulfate, and nitrate are collected, validated, and archived in the NAPS database.

Data records for ozone and NO_2 go back to the early 1980s. Special VOC measurements have been collected since 1989. Most monitoring of ground-level ozone and precursors is focused in the country's densely urbanized regions. In addition, Environment Canada operates CAPMoN, which is representative of most nonurban regions of the country.

The national ambient air quality monitoring program—the State and Local Air Monitoring Stations (SLAMS) network—is implemented by state and local air pollution control agencies. The SLAMS network consists of three major categories of monitoring stations: (1) those that are SLAMS only; (2) National Air Monitoring Stations (NAMS); and (3) Photochemical Assessment Monitoring Stations (PAMS). PAMS measure a variety of criteria and noncriteria pollutants. EPA also operates CASTNet, which provides ozone levels in rural areas, as well as dry acidic deposition levels and trends (see pages 19 and 21).

Currently, there are 578 SLAMS for ozone, which are used for SIP support, state/local data, and EPA regional office oversight. There are 208 NAMS sites for ozone, which are used for national policy support, national trends development, measurement of maximum concentrations and population exposures, and EPA headquarters oversight. Additionally, the state and local agencies operate 265 special purpose monitors (SPM) for ozone. These are generally used for special state- or local-level studies and state/local oversight.

The PAMS networks measure ozone precursors (i.e., approximately 60 volatile hydrocarbons and carbonyl) as required by the 1990 Clean Air Act Amendments (CAAA) to monitor the most severe ozone nonattainment areas. The PAMS requirements were designed to provide information on the roles of ozone precursors, pollutant transport, and local meteorology in the photochemical process, and to assist in information gathering for proposed ozone control strategies. In 2000, approximately 83 PAMS will be in operation.

Ozone Mapping

AIRNOW Expansion

AIRNOW, EPA's real-time air quality program, will expand into Canada in 2000 to cover the Atlantic provinces and Quebec. The AIRNOW animated Ozone Map shows ozone concentrations within categories ranging from "Good" to varying degrees of "Unhealthy." (For more information, see www.epa.gov/airnow.)

The expansion into eastern Canada is a cooperative venture involving New England states, eastern Canadian provinces, the Northeast States for Coordinated Air Use Management (NESCAUM), EPA, and Environment Canada. Ontario has been invited to join the project. In May 2000, the partners initiated efforts to begin transfer of the real-time ozone data. The resulting map is expected to be available to the general public in 2000. The project, in reaching out to the public, will complement existing smog advisory programs and the developing smog forecasting program. Currently, 32 states participate in AIRNOW.

Air Quality Index

In 1999, EPA finalized revisions to the Air Quality Index (AQI), formerly known as the Pollutant Standards Index. Significant revisions were made, including: (1) changes to better reflect the continuum of health risks associated with increased pollutant concentrations; (2) the addition of pollutant-specific health and cautionary statements to inform the public of effective risk reduction behaviors; (3) an AQI update for use in the media (i.e., television and newspapers); and (4) specific revisions to add an ozone subindex in terms of 8-hour average concentrations, as well as a new subindex for fine PM ($PM_{2.5}$). (For more information, see www.epa.gov/airnow/publications.html.)

Particulate Matter Monitoring, Data Analysis, and Modeling

Canada and the United States are conducting cooperative analyses and developing a joint work plan for transboundary inhalable particles as an outgrowth of the Joint Plan of Action signed in 1997 and the Joint Plan Report of the environmental ministers in 1998. The work plan will include both data analysis and atmospheric modeling efforts to quantify the impacts of transboundary PM and precursors transport across the region.

The first workshop on ambient data analysis and air quality modeling activities was held in September 1999. The workshop participants recommended developing a 3- to 4-year plan, taking advantage of the first generation of PM models to assess transboundary PM impacts. The Air Quality Committee supported the recommendation that all available models be used at this stage at its November 1999 meeting in Washington, DC.

The plan provides an inventory of transboundary episodes, data comparability studies, Canadian/U.S. database infrastructure, source-receptor modeling, extended episode analysis and reporting, and entering data into the database.

In addition, Canadian/U.S. analysis of specific episodes is already under way in eastern North America following two episodes. During February 1998, very high particle nitrate concentrations were observed, followed by increasing particle sulfate concentrations as air masses began to move at the end of the episode. In the July 1995 summer episode, particle sulfate dominated the mass observations.

Transboundary impacts model applications will be made using a combined 1995/1996 Canadian-U.S. emissions inventory. In addition, applications for the regional scale modeling system, Models-3/Community Multi-Scale Air Quality (CMAQ) have been initiated for the continental United States and southern Canada, with a 36-kilometer (km) grid for the 1996 base year. CMAQ will be applied for $PM_{2.5}$ visibility and several PM species. Preliminary results are expected by the end of the year.

There are several different monitoring methods used within the Canadian and U.S. networks. They operate on various sampling schedules, from continuous hourly measurements to 24-hour average measurements taken once every six days. A major challenge of the ambient data analysis work is determining how these various methods can be compared. Another challenge is understanding the spatial patterns and historical trends by merging data from these different methods and networks.

During 2001, another workshop on modeling and data analysis will assess progress and products, and refine joint efforts to complete the transboundary impact assessment.

Particulate Matter Monitoring

CANADA

Canada has monitored for $PM_{2.5}$ and PM_{10} under the NAPS program since 1984. Currently, the highest observed $PM_{2.5}$ concentrations are in eastern Canada's border regions. More than half the PM, especially the finer fraction $PM_{2.5}$, is of secondary origin from atmospheric reactions of precursor gases, including SO_2, NO_x, VOCs, and ammonia (NH_3). This results in PM composition varying with season and location, as illustrated below left for Abbotsford, British Columbia, and St. Andrews, New Brunswick. The most recent national summary of Canadian PM air quality and impacts can be found in the *Particulate Matter, Science Assessment Document*, 1999, at www.hc-sc.gc.ca/ehp/ehd/catlogue/bch_pubs/99ehd220-1.htm.

Variations in the Composition of PM in Two Canadian Cities

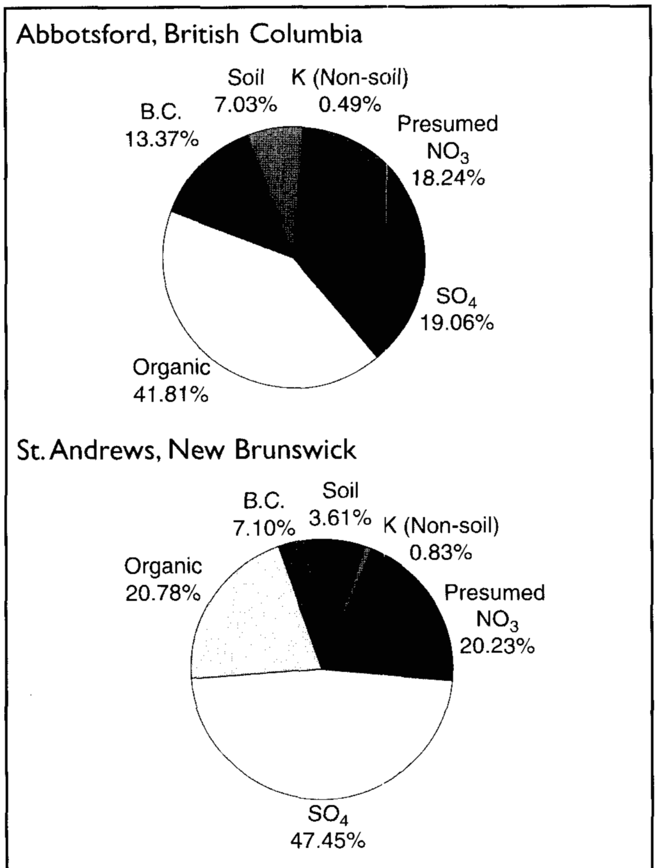


Figure 15

UNITED STATES

In the United States, deployment of new monitoring networks for $PM_{2.5}$ is supplying additional information to both the Aerometric Information Retrieval System (AIRS) and AQI systems. Specific monitoring network data will include:

- Approximately 300 Federal Reference Method (FRM) sites that have complete data for 1999, and about 600 FRM sites with some 1999 data and complete 2000 data. The network will have 1,089 FRM sites installed by December 2000.
- Approximately 200 continuous ambient monitors.
- The initial 15 speciation sites, which had limited data available as of April 2000. The completed speciation network, expected to total 250 to 300 sites with 54 sites operating for trends purposes, will be installed by December 2000.
- Eight supersites with useful data in 2001.
- An expansion of the IMPROVE network, expected to be complete by December 2000. It will include 110 sites nationally.
- CASTNet data.

Particulate Matter Modeling

CANADA

Understanding the potential for long-range transport of particles between Canada and the United States requires insight from both ambient data and predicted ambient concentrations using regional chemical transport models. These models use the current understanding of chemical transformations and meteorological influences on particle behavior, plus the best estimates of primary particle and precursor gas emissions estimates. The governments are working jointly to merge mobile source emission and modeling files. This common emission inventory is critical as a foundation to the joint modeling effort to characterize transboundary impacts.

Canadian $PM_{2.5}$ Monitoring Sites Within 200 Km of U.S. Border

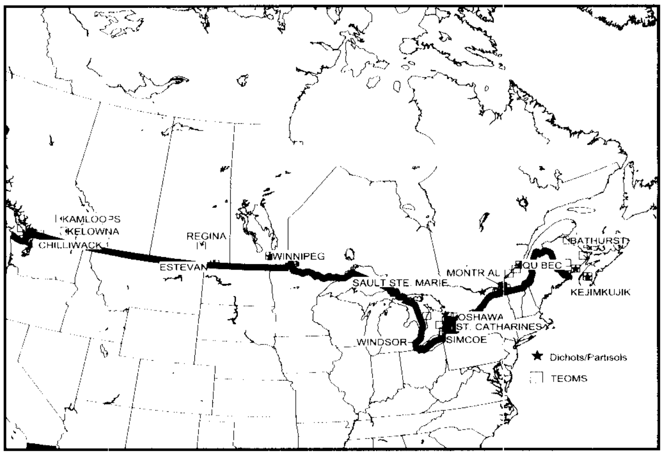


Figure 16

Canadian modeling efforts are directed toward development and evaluation of A Unified Regional Air Quality Modeling System (AURAMS), capable of predicting multi-pollutant responses to changes in gaseous and particle emissions. This model, now in its first stage of development, can predict size-resolved particle mass concentrations (including sulfate, nitrate, ammonium, organic carbon, elemental carbon, crustal material, and water), sulfate and nitrate deposition, and ozone. This model is currently being evaluated on an eastern North America domain, and plans are in place to apply it to western North America.

[redacted]

The United States also is proceeding with development, testing, and application of the Regional Modeling System for Aerosols and Deposition (REMSAD). The application of the REMSAD into a variety of sensitivity analyses and control strategy simulations continues. Current applications are for the continental United States with 36 km grids. Concentration estimates are being made for $PM_{2.5}$, visibility, and several PM species with a complete 1996 base year (both emissions and meteorological conditions). In addition, consistent with recommendations from a scientific peer review, the model is being updated and documented for both emissions and air quality. Model performance comparisons will be conducted with observed data for both the 1996 base year application and the improved model. As discussed previously as part of a joint effort, progress is being made in applying the regional scale CMAQ for the continental United States and southern Canada for PM, visibility, and acid deposition.

Status of $PM_{2.5}$ Monitoring Deployment (United States)

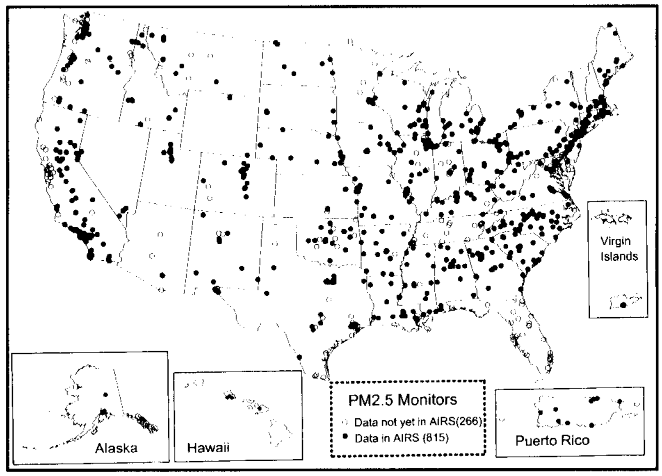


Figure 17

Data Analysis

[redacted]

A completed general trends analysis using IMPROVE data for $PM_{2.5}$ appears in the 1998 *National Ambient Air Quality Trends Report.* Ongoing data analysis activities with both short- and long-term products are underway to spatially and temporally characterize $PM_{2.5}$. These activities include but are not limited to: (1) continual data quality assessment of the monitoring network; (2) investigation of interrelationships between primary and secondary formed pollutants; (3) intercomparison of pollutants and emission patterns; and (4) investigation of uncertainties and limitations in source-receptor analysis. The use of data from various databases and networks is an issue that is continually addressed.

Particulate Matter Mapping

[redacted]

In addition to ozone mapping, EPA is working toward making real-time $PM_{2.5}$ data available through the AIRNOW Web site at www.epa.gov/airnow. Based on feedback at the annual Ozone Mapping Workshop, data are expected to be readily available across the United States in 2001. Several states will make data available this year, but the majority prefer to wait until they are fully operational with real-time ozone data before extending their coverage to $PM_{2.5}$.

Particulate Matter Research

EPA is carrying out a major PM research program focused on: (1) improving the scientific underpinnings for setting ambient air standards; and (2) expanding the scientific and technical tools to implement control strategies needed to attain the standards. To support standard setting, research is conducted to improve understanding of the characteristics of particles to which people are exposed; to identify and clarify mechanisms by which particles cause adverse health effects; to understand factors that place some subpopulations at increased risk; and to characterize the risks to public health. Research to support standards implementation is designed to determine major sources of PM, to develop methods to measure PM constituents, to develop air quality models of PM's atmospheric fate and transport, and to identify the most cost-effective methods to reduce or prevent risks associated with PM exposure.

During the next several years, EPA's PM research program will address the immediate and long-term research priorities recommended by the National Research Council's Committee on Research Priorities for Airborne Particulate Matter. Specific examples of ongoing efforts include:

- Conducting atmospheric sciences research such as speciated ambient monitoring, emissions characterization, atmospheric chemistry and processes, and modeling, under the aegis of NARSTO. (For more information on NARSTO, see Section III, p. 16.)
- Carrying out "exposure panel studies" that follow small groups of individuals by using intensive personal exposure monitoring and activity diaries.
- Using concentrated ambient particle systems to explore animal susceptibility models and to evaluate characteristics of particles affecting health in human clinical, animal toxicological, and in vitro systems.
- Reviewing and summarizing exposure and health effects work for the next Air Quality Criteria Document for PM.
- Conducting risk management research to evaluate options for reducing emissions of both particles and gaseous precursors.

(For more information on EPA's research program, see the international inventory of PM research activities at www.pmra.org.)

Aquatic Effects Research and Monitoring

Cooperative Regional Trends Assessment

In 1999, Canadian and U.S. researchers[12] analyzed whether emissions reductions have led to chemical recovery of surface waters in five North American regions: Maine/Atlantic Canada, Vermont/Quebec, southern/central Ontario, Adirondacks/Catskills, and midwestern North America. The analysis examined regional trends in surface water chemistry between 1980 and 1995. Results generally confirmed those reported in the 1998 Progress Report.

Trends in surface water sulfate concentrations provided the strongest evidence for regional responses to decreasing sulfate deposition. Lake and stream sulfate concentrations decreased in all North American regions, with downward trends stronger in the 1990s than in the 1980s. Regional declines in lake and stream nitrate concentrations were rarer, smaller in magnitude, and likely confounded by climatic effects and effects of insect infestations. Researchers expected to see recovery (either decreasing acidity or increasing alkalinity) in all areas with strong regional sulfate declines. Recovery was observed, however, only in the Vermont/Quebec region in the 1990s. Southern/central Ontario, the Adirondack and Catskill Mountains, and midwestern North America demonstrated either an absence of regional increases in alkalinity or continued acidification. Lack of

[12] Stoddard, J.L., et al. "Regional trends in aquatic recovery from acidification in North America and Europe." Nature, Volume 401, October 7, 1999.

recovery in the Canadian and U.S. regions is primarily attributed to strong regional declines in base cation[13] concentrations. These declines exceeded decreases in sulfate concentrations. Another potential factor is the increasing role of nitrogen in acid-sensitive regions as sulfate levels decline. Evidence points to base cation declines being caused by high rates of acidic deposition, which in the past, have leached enough cations from sensitive soils to severely deplete cation pools.

As described in Section III, the New England Governors and Eastern Canadian Premiers (NEG/ECP) Acid Rain Action Plan also provides a forum for exchange of scientific information related to aquatic effects monitoring. The Action Plan resulted in preparation of two state-of-the-art reviews. One review by the NEG/ECP Water Quality Monitoring Workgroup in 2000, *Is Nitrogen Deposition a Serious Issue?*, addresses the issue of nitrogen. The other is a 2000 report, *Model Estimations of the Effects of SO_2 Emission Reductions on Regional Aquatic Chemistry and Biology in Eastern North America*, issued by Environment Canada's National Water Research Institute. A review of the biological damages caused by acid deposition is planned for 2000/2001. Also, regional lake and river monitoring sites in four New England states and four Canadian provinces will be used to jointly assess temporal trends in water chemistry.

Monitoring lakes near major SO_2 sources at Rouyn-Noranda, Quebec, and Sudbury, Ontario, complements the regional trends analyses. Emissions from the smelter at Rouyn-Noranda have declined by more than 70% since the early 1980s. This reduction, added to those achieved in Ontario and in the United States, explain the 40% to 50% sulfate decrease in surrounding lakes. Like the regional results, however, reduction of lake acidity has been less successful. There was a significant increase in pH (mean 0.5 unit) in clear water lakes south of the smelter between 1991 and 1996, but the pH of colored lakes remained low. Alkalinity remained stable or decreased slightly, while base cations and aluminum decreased significantly. Finally, despite no change in atmospheric deposition or land use, there was a twofold increase in nitrate concentrations in lakes within 50 km of Rouyn-Noranda.[14]

Lakes near the smelters at Sudbury show the strongest evidence of acidification recovery. Of 38 monitored lakes, 35 exhibit increasing alkalinity. The consistency of recovery response in Sudbury lakes is probably due to local emission reductions being very large (about 90% overall) and the fact that a large proportion of the reduction occurred in the 1970s. Hence, Sudbury lakes have had a longer time to adjust to lower acid input than the regional or Rouyn-Noranda lakes. Local smelters' influence on lake water sulfate and acidity extends out approximately 45 km. Beyond this radius, lake chemistry and trends are indistinguishable from those more than 200 km away. Unlike Rouyn-Noranda, there are few nitrate trends in Sudbury area lakes.[15]

Acid deposition has had a major destructive impact in many of Canada's lakes and rivers. Salmon spawning rivers in southern Nova Scotia continue to acidify, and there is no evidence of salmon recovery.[16] Nova Scotia is the most heavily impacted Canadian province in terms of the proportion of fish habitat damaged by acid rain. The Southern Upland is the main area impacted. Naturally reproducing salmon are no longer present in many of the 65 rivers that have their source in the Southern Upland, and they are reduced in all other area rivers. The principal factors responsible are acid toxicity due to acid deposition, and low marine survival. Because of acid deposition, salmon reproduction is no longer possible in several rivers and impeded to varying degrees in most others. Chemistry data from six Southern Upland rivers show a sulfate decline between 1982 and 1996. This decline did not result in a decrease in acidity, however. Instead, pH declined from 1992 to 1996. In addition to calls for further reductions in acid deposition, liming has been used as a management tool to protect remaining salmon stocks.

[13]Positively charged ions, such as magnesium, calcium, potassium, and sodium, that increase the pH of water when released to solution through mineral weathering and ion exchange reactions.

[14]Dupont, J. 1997. Projet Noranda Phase III–Effets des réductions de SO_2 sur la qualité de l'eau des lacs de l'ouest québécois. Ministère de l'Environnement et de lat Faune du Québec, Direction de la qualité des cours d'eau, rapport no. Pa-53/1, Envirodoq no. EN 980066.

[15]Keller, W., et al. 2000. Sulphate and nitrate in Sudbury lakes: Trends and status. Cooperative Freshwater Ecology Unit, Laurentian University, Sudbury, Ontario.

[16]Department of Fisheries and Oceans. 2000. The Effects of Acid Rain on Atlantic Salmon of the Southern Upland of Nova Scotia. DFO Maritimes Regional Habitat Status Report 2000/2E.

In 1999, the Hubbard Brook Research Foundation convened a 10-member scientific work group to assess Patterns and Effects of Acidic Deposition in the Northeastern U.S.[17] The study utilized recent literature and other studies in addition to model calculations to synthesize current scientific knowledge about the extent and effects of acidic deposition in the northeastern United States. The study focused particularly on SO_2. It found that, despite SO_2 control measures under the 1970 Clean Air Act (CAA) and the 1990 CAAA, acidic deposition is still high and adversely affecting lakes and streams. Recovery of surface water acidity has been delayed due to effects of long-term deposition inputs on the leaching of nutrient cations such as calcium from forest soils.

The report shows that decreasing atmospheric deposition of sulfur during the last few decades has coincided with some decrease in the acidity of New England lakes. But little change is evident in lakes and streams of the Adirondack and Catskill regions of New York. Surveys show that 41% of lakes greater than 2.5 acres in size in the Adirondack region and 15% of lakes in New England are either acidic year round or susceptible to acidic conditions for short periods associated with high flow. Surface water acidification affects fish populations by decreasing size, number, and diversity.

The study also includes computer model calculations estimating that acid-sensitive surface waters, like those in New Hampshire's Hubbard Brook Experimental Forest, will not recover significantly under acidic deposition reductions anticipated from the 1990 CAAA. The study's modeling projections indicate that additional emissions reductions are necessary to accelerate the recovery of forested watersheds.

Forest Effects

Exposure of forest ecosystems to air pollutants—and the effects these pollutants and other stressors might have on susceptible forest resources—is a major forest health issue.

Both countries are cooperating to assess impacts of air pollution and acid deposition on forest ecosystems. A forest mapping initiative included in the Acid Rain Action Plan adopted by NEG/ECP builds on recent research in North America. The research shows acid deposition resulted in both acidification and depletion of nutrient cations (e.g., calcium, magnesium) essential for tree growth in relatively poor soils. This forest mapping initiative will assist scientists in assessing risks that acid deposition poses to forest ecosystems in New England and eastern Canadian provinces.

Forest research scientists from the Quebec Ministry of Natural Resources documented losses of calcium, magnesium, and potassium from forest soils at their intensive monitoring site at Forêt Duchesnay near Quebec City. During the study, the watershed lost 2.5% of the available calcium pool per year and 3% of the available magnesium pool. If calcium depletion continues at this rate, the site will be calcium-deficient in 4 to 5 decades. Lake sediment analysis indicates base cations losses since the 1920s. Liming the site during a 4-year period has resulted in strong positive tree growth response.

In addition, CL for forest soil acidification of the Quebec Forest Intensive Monitoring Network—known as RESEF—were calculated using the simple mass-balance (SMB) approach. The CL calculations indicated that 18 of the 31 RESEF plots received atmospheric

[17]Driscoll, C.T., et al. Acidic deposition in the Northeastern U.S.: Sources and inputs, ecosystem effects, and management strategies. Bioscience, in review.

[18]Houle, D., R. Paquin, C. Camiré, R. Ouimet, and L. Duchesne. 1997. Response of the Lake Clair Watershed (Duchesnay, Québec) to changes in precipitation chemistry (1988-1994). Can. J. For. Res. 27.

[19]Moore, J.D., C. Camiré, and R. Ouimet. 2000. Effects of liming on the nutrition, vigor, and growth of sugar maple at the Duchesnay forest station, Québec, Canada. Can. J. For. Res. 30.

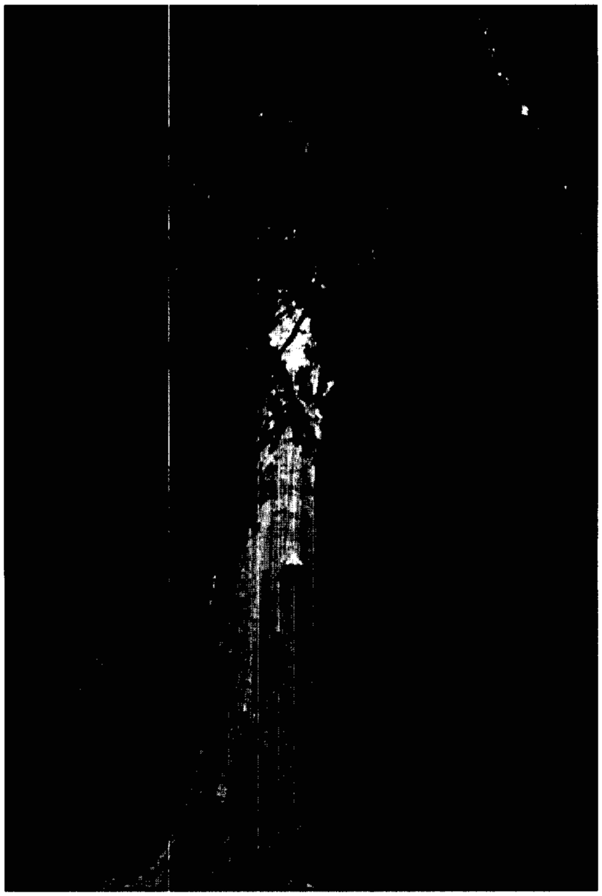
[20]Ouimet, R., L. Duchesne, D. Houle, and P.A. Arp. 2000. Critical loads of atmospheric S and N deposition and current exceedances for northern temperate and boreal forests in Quebec. Water Air Soil Pollut. (accepted).

[21]McLaughlin, D. 1998. A decade of forest tree monitoring in Canada: Evidence of air pollution effects. Environ. Rev. 6.

[22]Arp, P. A., T. Oja, and M. Marsh. 1996. Calculating critical S and N current exceedances for upland forests in southern Ontario, Canada. Can. J. For. Res. 26.

acidic inputs in excess of their CL (55% and 61% of the hardwood and coniferous plots, respectively). The range of CL exceedance varied from 60 to 470 equivalence (eq) per hectare per year for the hardwood stands, and from 10 to 590 eq per hectare per year for the coniferous stands. The stands with CL exceedance were mainly located in western and central Quebec.

Stand growth associated with exceedance class of acidity was determined using RESEF plots and selected permanent forest survey plots that had similar site characteristics and for which longer growth records were available. A significant negative correlation was found between forest growth rates and exceedance of critical soil acidification for both the northern hardwood and boreal conifer sites. Specifically, plots with exceedances had a growth reduction of about 30% from 1972 to 1990 (plots with no exceedance of soil acidification served as controls). While this correlation is not necessarily causal, it is consistent with the notion that increased losses of soil base cations due to growing soil acidification lead to deteriorating forest health. These results correspond to growth-exceedance trend studies reported for Ontario that suggest northern hardwood stand growth has declined by 0.66 to 0.96 cubic meters per hectare per year since the mid-1960s and that forest decline has been greatest on poorly buffered soils. The results also agree with the tree decline versus CL exceedance evaluation for southern Ontario. On the average, forest decline rates were about 30% to 40% higher for forest stands with estimated exceedances of 300 to 500 eq per hectare per year than for forest stands with no exceedance.



In a broader context, from preliminary analyses based on data from Acid Rain National Early Warning System plots (ARNEWS), CL are consistently exceeded in southern and central Ontario and portions of the Maritimes. Preliminary analyses indicate that annual productivity losses of 10% are associated with areas of highest CL exceedance.

In 1998, the Canadian Forest Service (CFS) initiated the Forest Indicators of Global Change Project (FIGCP). Its objectives are to: develop new early-warning indicators of forest conditions; investigate interactions among air pollution, climate change, and forest productivity; and establish an array of permanent research/monitoring plots for detailed studies of nutrient/carbon cycling in eastern Canada. The gradient, or study area, stretches 1,800 km and encompasses the highest levels of acidic deposition in Canada. The area includes ecosystems receiving among the highest incidences of ground-level ozone in Canada. There is a variation of 2° to 7° Celsius of mean annual temperature and a 700 to 1,500 millimeter (mm) variation of mean annual precipitation across the gradient. The temperature and precipitation gradients will yield insight into the climate's role in influencing other stressors on forest ecosystems.

In 1999, the CFS decided to focus on case studies and longer term research and monitoring linked to specific issues and policy direction. The ARNEWS and North American Maple Project (NAMP) plot networks were affected. Plots within these networks, but not supporting current investigations such as the Global Change Gradient, would be archived.

Currently, 26 sites from Turkey Lakes, Ontario, to Fundy National Park, New Brunswick, supporting either adult sugar maple or adult conifers (white pine in the west, red spruce in the east), are selected for FIGCP. Eighteen were a subset of ARNEWS, and four were a subset of NAMP. Three sites were added to fill geographical gaps. The sugar maple series (17 sites) and the conifer series (15 sites) were chosen to be as ecologically analogous as possible given the geographic extent.

Within this gradient, plot monitoring continues, using ARNEWS protocols. During 1999, leaf surface studies were initiated on selected plots; passive ozone monitors were deployed and monitored across the gradient. Several university and provincial government agencies have joined as partners in FIGCP, which will evaluate several candidate plots for inclusion in Nova Scotia and Prince Edward Island from 2000 to 2001.

Preliminary analysis of cumulative ozone levels, measured by passive ozone monitors within this gradient's plots, suggest that modeled levels extrapolated from urban-centered continuous ozone monitors consistently have underestimated actual ozone levels occurring within the gradient. During three separate time periods of accumulated ozone measurements from May to August 1999, the onsite passive ozone monitors recorded higher actual ozone levels when compared with the most current modeled values for the gradient area. Generally, cumulative totals were between 30 and 40 ppb.

The Forest Health Monitoring Program (FHM) is a joint effort among the U.S. Department of Agriculture Forest Service (USFS), the National Association of State Foresters, and universities to address forest health and sustainability. FHM has collected data on forest health since 1991 and had expanded to include 36 states as of 2000. FHM uses ground plots and surveys, aerial sketch mapping, and satellite imagery to evaluate the status and changes of stressors and indicators of forest ecosystem conditions throughout the United States. The program evaluates stressors such as land use and forest fragmentation, air pollution, drought, storms, insects and pathogens, alteration of historic fire cycles, and non-indigenous invasive species.[23]

Current Forest Conditions

The biological condition of U.S. forests was recently evaluated, and three major geographical areas of concern were identified: the North (i.e., the Northeast, Great Lakes States, and mid-Atlantic); the Rocky Mountains (i.e., western Wyoming and northern Idaho); and the Pacific Coast (i.e., eastern Oregon and Washington and parts of California). The factors that raised concerns in these areas were the fragmentation and land use of forests, native and invasive insects and pathogens, altered fire regimes, air pollution, relatively high deterioration of tree crowns, and invasive plant species. In the North, the 1998 status of dieback of tree crowns was at the highest level for hardwood trees in 2% of the area and 16% of the area for softwood trees. There was a greater than 2% per year increase in dieback found in 2% of the area's softwoods and 3% of its hardwoods. Hardwood transparency was at the highest level in 8% of the area; softwood transparency was at the highest level in 19% of the area. In this same general area, annual increases of greater than 2% were found in 19% of the area's hardwoods and 8% of its softwoods. In the South, 1998 crown condition estimates indicated only a very small percentage of forest had relatively high dieback or transparency values.[24] Overall, FHM found mortality ratios greater than 0.6[25] in 22% of forests in the North. No forest areas in the South were affected.

Sulfate and Nitrate Deposition

Since the last Progress Report, FHM evaluated the deposition of sulfate, nitrate, ammonium, total nitrogen, and precipitation pH in all forests in the contiguous 48 states from 1979 from 1995. Wet deposition of these substances were analyzed from 1979 to 1995 for all states from the NADP/NTN and CAPMoN programs. The analysis estimated that relatively high sulfate deposition covered 46.2% of forest area in the North and 20.9% of forest area in the South. Relatively high nitrate deposition was estimated to cover 39.7% of forest area in the North and 0.7% of forest area in the South. Similarly, relatively high annual ammonium deposition was estimated to cover 62.1% of forests in the North, 19.8% of forests in the South, and 0.8% of forests in the Rocky Mountains. Annual total nitrogen deposition was relatively high in 42.1% of forests in the North and 1.5% of forests in the South. The annual deposition of the most acidic precipitation (4.2 to 4.5 pH) covered 61% of the North and 20.4% of the South. Most forested areas in both the North (85%) and South (90.7%) received precipitation with an annual average pH of less than 4.8.

Ground-Based Ozone Forest Effects

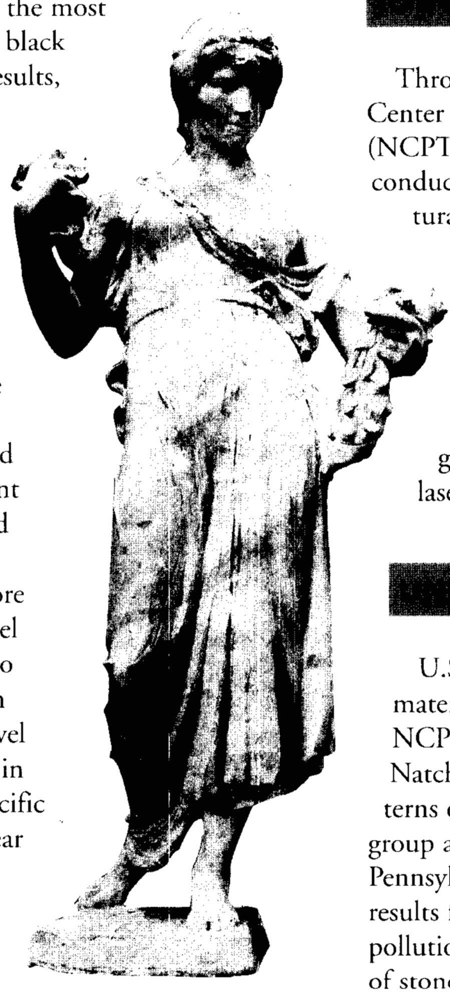
FHM has developed an ozone monitoring plot system throughout much of the Northeast, the Great Lake

[23] Stolte, et al. 2000. FHM National Technical Report 2000 (1991-1998). In preparation. USDA Forest Service, Southern Research Station. General Technical Documents.

[24] Stolte, K.W., et al. 2000. FHM-RPA Summary Report 2000. Forest Health. In review. USDA Forest Service, RPA 2000 Report.

[25] A mortality ratio of 0.6 means that for every 1.0 cubic meter of wood produced in growth, 0.6 cubic meters are lost to mortality.

states, the mid-Atlantic, the South, and some parts of the West. Analysis of ozone air pollution from 1993 to 1996 indicated that much of the eastern and parts of the western United States were exposed to relatively high ozone. The analysis used a range of W126 (index) values grouped into different classes to reflect the suspected sensitivity of tree species to ozone exposures.[26] Level 1 exposures affect only the most sensitive tree species, such as black cherry. According to study results, 54% of the North and 16.6% of the South endured Level 1 exposures. Level 1 exposures also were found in the Rocky Mountain region and the Pacific Coast, but it is unclear whether tree species in drier climates are sensitive to these relatively low levels. Level 2 exposures are believed to affect slightly more tolerant tree species such as green and white ash, tulip poplar, and white pine, as well as the more sensitive Level 1 species. Level 2 exposures were estimated to occur in 44.3% of the North and 83.3% of the South. Level 2 exposures also were found in the Rocky Mountain and Pacific Coast regions, but it is unclear whether the western tree species are sensitive to these exposure levels. Level 3 exposures are believed to affect even more tolerant tree species such as loblolly pine, white and red Oak, American beech, and Virginia pine, as well as Level 1 and 2 species. Level 3 exposures are estimated to occur in only 0.1% of the South, 1.8% of the Rocky Mountains, and 10.5% of the Pacific Coast, mostly in the mountainous areas of southern and central California. Level 4 exposures are believed to affect all eastern tree species susceptible to Levels 1 to 3, as well as western tree species such as ponderosa pine, Jeffrey pine, and black oak. Level 4 exposures were found only in 1.6% of the Pacific Coast region, affecting the mountainous forests of southern California.



Effects on Materials

Canada and the United States continue research on the extent and nature of SO_2 and NO_x deposition effects on buildings and materials.

[illegible]

Through federal research support, the U.S. National Center for the Preservation of Technology and Training (NCPTT) and the Canadian Conservation Institute will conduct studies on using lasers for conservation of cultural materials and on the potential benefits of laser technology in general. This research will rely on use of the newly established NCPTT-sponsored Laser Research Facility at the Los Angeles County Museum of Art in Los Angeles. From projects generated by this collaboration, NCPTT researchers plan to investigate the interaction of air pollutants with laser-cleaned stone surfaces.

[illegible]

U.S. efforts to understand air pollutant effects on materials and cultural resources continue through NCPTT's Materials Research Program (MRP) in Natchitoches, Louisiana. The evolution of soiling patterns on limestone buildings is the focus of a research group at Carnegie Mellon University in Pittsburgh, Pennsylvania. The group's hypothesis is that soiling results from two competing processes: the deposition of pollution to the stone and the dissolution and washing of stone surfaces by rain. Studies also are being conducted on changes in soiling patterns at the Cathedral of Learning Building at the University of Pittsburgh. The studies are based on examination of archival photographs, analysis of soiling on architectural features, measurement of air pollutant concentrations and deposition, and computer modeling of rain impingement.

Another NCPTT-funded project studies interactions between air pollutants and biofilms on historic limestone. Although it is known that air pollutants have serious detrimental effects on limestone buildings and monuments, the mechanisms of deterioration are poorly understood. A Harvard University team is heading a study looking at the role of microorganisms in lime-

[26] Southern Appalachian Man and the Biosphere (SAMB). 1996. The Southern Appalachian Assessment Atmospheric Technical Report. Report 3 of 5. Atlanta: U.S. Department of Agriculture, Forest Service, Southern Region.

stone degradation in the presence of air pollutants. At the July 1999 International Biodeterioration Symposium in Washington, DC, the Harvard team reported that the population of sulfur-utilizing bacteria is three times higher on stones in polluted areas than on stones in clean environments. Similarly, the number of hydrocarbon-degrading microorganisms is approximately twice as high in polluted areas. Using electron microscopy studies, the team demonstrated that pollutants stimulate penetration of microflora into limestone. Currently, the team is examining the production of acid by these microorganisms and their ability to release calcium from the limestone.

Health Effects

The effect of SO_2, NO_x, and PM on human health, particularly the human heart and lungs, is being researched through various efforts and studies.

[redacted]

Investigators from EPA's Pulmonary Toxicology Branch are continuing ongoing work with investigators from Health Canada in Ottawa to study the hematological and cardiopulmonary effects of urban particles in cardiac-compromised rats. Joint efforts are taking place to measure the various biological endpoints examined in this study. The investigators plan to study rats over a wide age range and in various stages of health and disease.

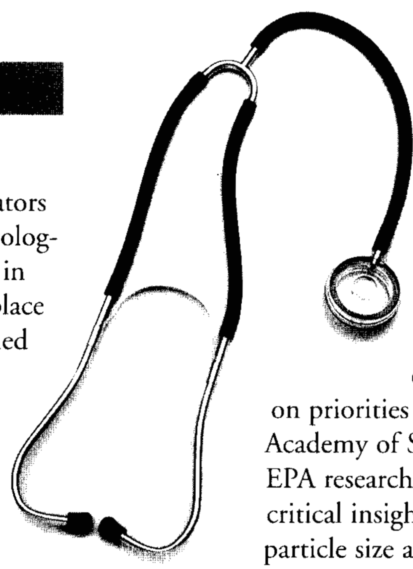
[redacted]

In 1999, Environment Canada and Health Canada published the PM science assessment document (see www.hc-sc.gc.ca/ehp/ehd/catalogue/bch_pubs/99ehd220-1.htm). The science assessment adds to the numerous studies that are providing the scientific basis for action on PM by governments. Although concentrations of PM_{10} have long been associated with adverse health effects, recent studies show that these particles are responsible for premature deaths from lung and heart disease-related causes and that the population is being affected at current concentrations across the country. Scientists now believe that there is no apparent "threshold," or safe level for exposure to PM_{10}. Children, the elderly, and people with respiratory disorders such as asthma are particularly susceptible to health effects caused by PM_{10}.

The effect is even more accute with smaller $PM_{2.5}$ particles. Health effects include breathing and respiratory symptoms, irritation, inflammation and damage to the lungs, and premature death. PM is not limited to urban areas. Exposure to PM_{10} in Canada is demonstrated to be widespread, and it remains a problem in every region of Canada throughout the year.

PM is also an effective delivery mechanism for other toxic air pollutants, which attach themselves to airborne PM. These toxics are then delivered into the lungs where they can be absorbed into the blood and tissue.

[redacted]



The United States has concentrated much of its health effects and risk management work on PM, both exclusively and in combination with other pollutants. As discussed earlier (see p. 26), this program has been coordinated among a number of different groups and has focused on priorities identified by a National Academy of Sciences committee. Recent EPA research on PM toxicity has provided critical insight into how factors such as particle size and chemical nature might cause adverse health effects in humans. EPA also conducted research with the University of North Carolina on the health effects of PM on sensitive groups (elderly persons in Baltimore, Maryland). The research yielded insights into heart and lung functioning changes.

Conclusion

Canada and the United States have not only successfully reduced emissions of SO_2 and NO_x—the major contributors of acid rain—but also surpassed current reduction requirements. Acid rain was the initial focus of cooperative transboundary efforts under the Air Quality Agreement. With significant progress, both governments continue to cooperatively pursue efforts to address acid rain.

During the last few years, the two governments expanded their commitments to cooperatively address transboundary air issues to include ground-level ozone and PM. This was an outgrowth of the April 1997 signing of an agreement by the Canadian and U.S. environmental ministers to develop a Joint Plan of Action for Addressing Transboundary Air Pollution. Since the last Air Quality Committee Progress Report in 1998, the governments have made significant headway. Canada and the United States held bilateral negotiations this year to develop an ozone annex to the Air Quality Agreement, addressing their common concerns about ground-level ozone's transboundary impacts. At the same time, both governments are undertaking new cooperative efforts in PM modeling, monitoring, and data analyses to assess transboundary PM impacts and support development of a joint work plan to address PM.

Following a successful decade of working together to reduce acid deposition, Canada and the United States are pursuing a new era of cooperation on additional transboundary air issues.

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