CONTINENTAL POLLUTANT PATHWAYS

An Agenda for Cooperation to Address Long-Range Transport of Air Pollution in North America

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COMMISSION FOR ENVIRONMENTAL COOPERATION

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PROFILE

In North America, we share vital natural resources, including air, oceans and rivers, mountains and forests. Together, these natural resources are the basis of a rich network of ecosystems, which sustain our livelihoods and well-being. If they are to continue being a source of future life and prosperity, these resources must be protected. This stewardship of the North American environment is a responsibility shared by Canada, Mexico and the United States.

The Commission for Environmental Cooperation (CEC) is an international organization whose members are Canada, Mexico and the United States. The CEC was created under the North American Agreement on Environmental Cooperation (NAAEC) to address regional environmental concerns, help prevent potential trade and environmental con icts and promote the effective enforcement of environmental law. The Agreement complements the environmental provisions established in the North American Free Trade Agreement (NAFTA).

The CEC accomplishes its work through the combined efforts of its three principal components: the Council, the Secretariat and the Joint Public Advisory Committee (JPAC). The Council is the governing body of the CEC and is composed of the highest-level environmental authorities from each of the three countries. The Secretariat implements the annual work program and provides administrative, technical and operational support to the Council. The Joint Public Advisory Committee is composed of fteen citizens, ve from each of the three countries, and advises the Council on any matter within the scope of the Agreement.

MISSION

The CEC facilitates cooperation and public participation to foster conservation, protection and enhancement of the North American environment for the bene t of present and future generations, in the context of increasing economic, trade and social links among Canada, Mexico and the United States.

Chapter

Continental Pollutant Pathways

FOREWORD

This report highlights critical issues concerning the long-range transport of air pollutants in North America with the intent of fostering increased trilateral cooperation at all levels to deal with this pressing problem. Clear data and evidence exist to show that transboundary pollution affects human health, nature, and natural resources. There is ample evidence to conclude that the three nations and their societies can collaborate successfully in responding to continent-wide problems, broadening and deepening existing areas of bilateral cooperation. It is important to take account of this interdependency and begin to act on it together, with due consideration for shared responsibilities and concerns, as well as for differing conditions and possibilities in the three countries.

This study for the Council of the Commission for Environmental Cooperation (CEC), initiated under the authority of Article 13 of the North American Agreement on Environmental Cooperation, reviews the nature, extent, and significance of the pathways by which pollutants travel to, from, and within North America (termed "continental pollutant pathways" in this report). This report speaks to the public concerns over worsening air quality, reviews opportunities for cooperation between the three countries, and suggests ways to further the development of a joint strategy for addressing issues of air pollution in North America, by looking at the problem from a transboundary and regional North American perspective.

In order to conduct this study, the Secretariat coordinated, and was supported by, a number of institutions, organizations, and individuals to whom we are indebted for their contribution. We are very grateful to all of the individuals associated with this project, who brought to it their expertise, innovation, enthusiasm, optimism, and a high degree of commitment. Critical contributions were made by an Expert Advisory Panel on Continental Pollutant Pathways, a group of over 30 scientists from throughout North America which produced a science-based review of sources, pathways and effects of air pollution in North America (hereafter referred to as "the Panel Report"). The Panel was able to reach general, though not complete, consensus on main issues addressed in its report (see Subsection 2.2.2).

The Secretariat also coordinated a Consultative Group on Continental Pollutant Pathways, composed of approximately 50 representatives from various interest groups, which advised the Secretariat and the Expert Advisory Panel on the scope and direction of their efforts. A Policy Group was convened, drawing together 20 North Americans with extensive experience in the development and implementation of policies related to long-range transport of pollutants. Further advice was provided by the Advisory Group of the CEC Air Monitoring and Modeling Project, some 15 experts from government and academia who have been providing ongoing assistance to the CEC in air quality data compatibility efforts for the past years. The project also benefited from two public hearings convened by the Joint Public Advisory Committee of the CEC that, in part, addressed the long-range transport of air pollutants issue.

Acting alone, no one nation of North America will be able to protect adequately its domestic environment or its citizens from pollutants transported along continental pathways. While pollutants are not constrained by political boundaries, programs to reduce them often are, and domestic decisions continue to be made with little reference to their implications for all of North America.

Where the unilateral efforts of one country would be ineffective or weakened without region-wide support, the CEC provides a forum for continental cooperation. Such efforts include the generation and use of information and the promotion of environmental analysis on a pan-North American scale, as well as piloting innovative regional models of effective and result-oriented international cooperation. This Article 13 report attempts to add value to the work underway at the CEC and elsewhere, building on existing initiatives on the long-range transport of pollutants and catalyzing new ones.

Victor Lichtinger
Executive Director
Secretariat of the Commission for Environmental Cooperation

EXECUTIVE SUMMARY

The North American Agreement on Environmental Cooperation (NAAEC), which went into effect along with the North American Free Trade Agreement (NAFTA) on 1 January 1994, was negotiated to establish a framework for continental environmental cooperation, to address concerns regarding the potential impacts of trade liberalization and increased economic integration on the North American environment, and to promote a cooperative environmental agenda among the three countries on issues of regional importance and mutual concern. The long-range transport through the air of several persistent pollutants of widespread concern throughout North America (continental pollutant pathways) was judged to be such an issue, and at the instigation of the Secretariat of the Commission for Environmental Cooperation (CEC), an Expert Advisory Panel was convened to study the problem. This document draws upon the report produced by that Expert Panel.

The study itself was initiated under the authority of Article 13 of the NAAEC, which allows the Secretariat to prepare a report for the Council on any matter within the scope of the CEC's annual work program. This document is being made available to the public with the hope that the recommendations contained in it will foster trilateral cooperation on the issue of continental pollutant pathways in North America. Major conclusions are that:

- Continental pollutants are affecting human health and the environment throughout North America. As the scientific Expert Advisory Panel emphasized: *enough is already known on most fronts for us to say, unequivocally, that significant emission reductions from present levels are needed now.*

- There are populations in all three countries that are more vulnerable to the effects of pollutants. They include children, pregnant women and women of childbearing age, the elderly, people with respiratory problems, and indigenous peoples and others who rely on fish and wildlife as a major part of their diet. Developing embryos and nursing infants are also particularly at risk.

- Major sources of continental pollutants include electric power plants, the transportation sector, the combustion of fossil fuels by some industries, municipal and medical waste incinerators, as well as chemicals used in agriculture. Improved emission-reduction technologies and pollution-prevention techniques and processes are available to reduce emissions of many of these pollutants.

- North American collaborative action could focus on a small number of important common source categories. This would enhance the capacity of the region as a whole to reduce the risks from continental pollutants, since each country shares many of the same types of sources for these pollutants and many emission sources are responsible for more than one pollutant.

- North America will need to work with other regions to address emission sources outside the continent, as well as those from North America affecting other regions. Effective collaboration

on this issue could also strengthen an important international leadership role by demonstrating the potential for multilateral action to address an issue of growing concern for many regions in the world.

- Comprehensive and up-to-date information and understanding are essential for effective and efficient control strategies at the domestic and international levels. The three countries need to coordinate and update emission inventories to make them more comparable and more comprehensive. There is a similar need for collaboration among those involved in ecological research and monitoring of terrestrial and aquatic ecosystems in the three countries, in the development and adoption of indicators of the status and integrity of these systems, and in the sharing of data and information. These approaches, as well as atmospheric monitoring and modeling efforts, are all essential to understanding and addressing the issue of continental pollutant pathways. A greater effort to combine these different activities into a more integrated ecosystemic approach is warranted.

- It is apparent that funds and human resources dedicated to research on and monitoring the continental pollutant pathways issue have declined substantially during recent years. Reversing this trend is essential for understanding the problem of transboundary pollution, taking appropriate action, and evaluating the effectiveness of domestic and international efforts.

- North American ecosystems and weather patterns link three very different countries. Collaborative action will have to take into account the differences in economic and social situations and levels of development in each country, as well as their financial capacities and technological capabilities.

In light of the above, it was concluded that a central issue is the need to establish an effective collaborative mechanism (or mechanisms) with the authority, expertise, and motivation to develop and take the steps that are needed to ensure that the continental pollutant pathways issue becomes, and remains, a significant trinational priority. This will necessitate a long-term commitment and continuing vigilance in order to reduce gradually human and environmental exposure to pollutants released to, formed within, or transported by environmental media.

1.0 INTRODUCTION

Important changes are occurring in the economic, social and environmental relationships among the three North American countries. Competitiveness and market access are closely tied to the availability and use of modern, efficient, clean technologies. At the same time, the increased trade flows that NAFTA both facilitates and promotes add another complex set of environmental challenges, including some that might have transboundary implications. For example, an increased demand for transportation services, such as highways, effects of deregulated energy markets, and increased production of goods under NAFTA could impact air quality and add to the long-range transport of air pollution in North America, the subject of this review.

Because airborne pollutants travel far, and rapidly, a strategy to mitigate this threat to the North American airshed should be established and given due priority under the rubric of trinational cooperation. Although a number of national, binational, and even global instruments exist, the lack of a North American approach to the complex problems of air pollution is striking. In calling for such a strategy to deal with the long-range transport of air pollution, the CEC Secretariat proposes a cooperative approach, building initially on the coordination of existing programs and resources, and a sustained commitment by the Parties to address and solve this collective problem.

To be sure, the program for enhanced trinational cooperation must recognize that the three nations are at different levels of development, with different capacities to act. In particular, Mexico faces the challenge of limited financial and human resources. However, given the commitment to a long-term strategy and the will to act, the three governments can and should be able to move forward expeditiously to implement an appropriate program to reduce air pollution in North America.

Just as the need for a continental approach to air pollution is pressing, so the timing is ripe for the Parties to act together. This document describes the nature, extent and significance of pollution pathways and recommends further steps to implement a regional response. It draws upon the conclusions of the Report provided by the Expert Advisory Panel on Continental Pollutant Pathways, which provides a science-based overview of these regional pathways by which pollutants travel. [Attachment 1 to this report lists the members of this Panel, and the Consultative and Policy Groups and their alternates.] In addition, some 15 case studies on specific pollutants or on other matters considered by the Panel to be important for a comprehensive understanding of the many aspects of this integrated, cross-media phenomenon were included in the second volume of that report. [Attachment 2 lists those case studies.]

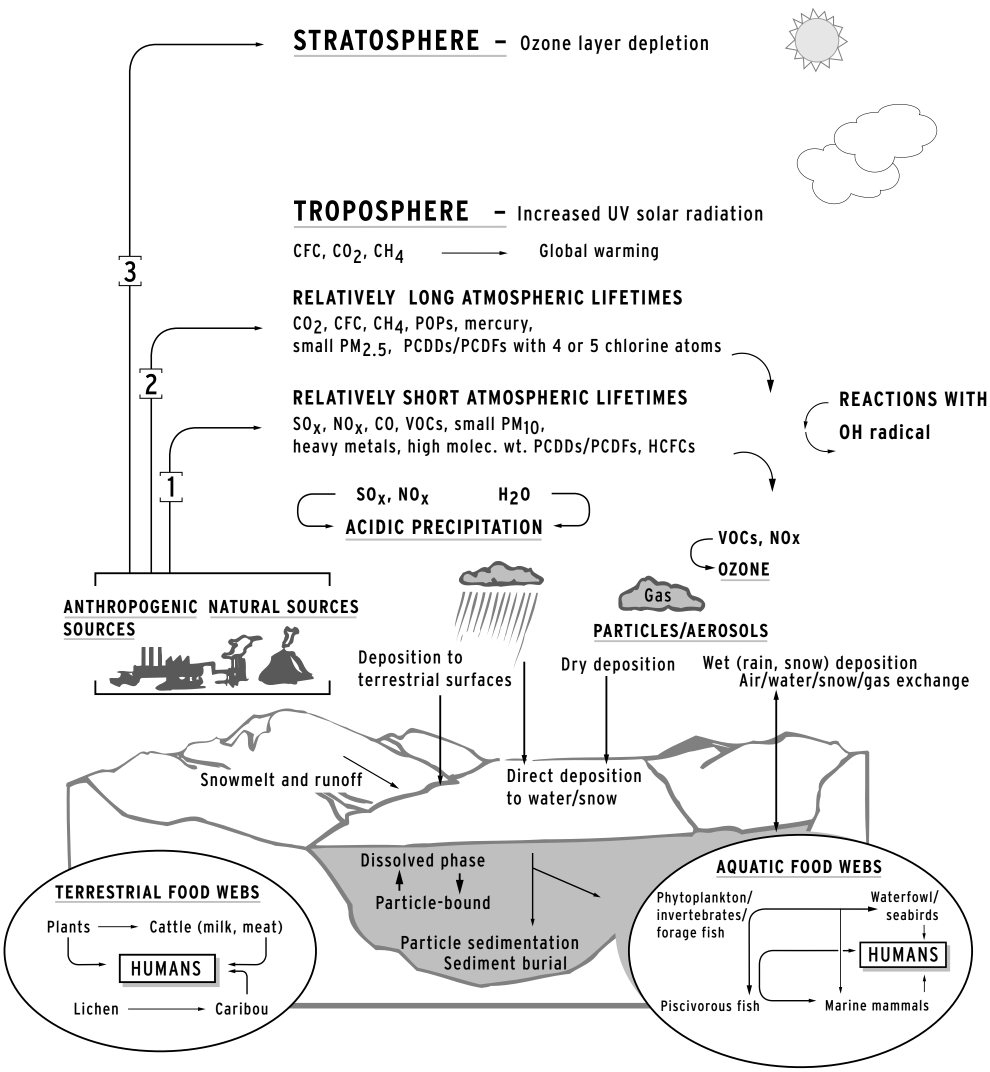
Section 2 provides the rationale for collaborative action on continental pollutants. Subsection 2.1 summarizes the significant human health and environmental impacts of five of the air pollutants addressed in the Panel Report: acid deposition, mercury, ground-level ozone, particulate matter, and persistent organic pollutants (POPs). It emphasizes that these pollutants do not respect national boundaries, limiting the capacity of countries acting unilaterally, and even bilaterally, to safeguard human health and environmental quality within their own borders. Subsection 2.2 further observes that collaborative action focused on a small number of common source categories (i.e., coal-fired electric power facilities, transportation, and municipal and industrial incinerators) could enhance the capacity of the region as a whole to reduce the risks from continental pollutants since (a) each country shares many of the same types of sources of these pollutants, and (b) many of these common source categories are responsible for more than one pollutant. Section 3 reviews various opportunities for collaboration. Finally, Section 4 briefly summarizes the main conclusions of this review and recommends actions to identify priorities and develop plans to reduce anthropogenic releases of pollutants to the atmosphere and other environmental media.

The term *continental pollutant pathways*, as used throughout this document, refers to cross-media phenomena, operating at a variety of spatial and temporal scales, and linking pollutant releases to environmental media, and the subsequent transport and effects of these pollutants on humans and terrestrial and aquatic ecosystems. However, this report is intended to provide an initial focus on pollutants released to, formed within, and transported by the atmosphere, and especially on pollutants or pollutant clusters that are transported long distances across national boundaries—even across continents. It does not consider pollutants whose relatively short atmospheric lifetimes mean that they have only local impacts.

Some continental-scale and global-scale issues that are also part of the continental pollutant pathway phenomenon have not been addressed in this review. Examples include global greenhouse gas pollutants, and pollutants contributing to the depletion of the stratospheric ozone layer and increased ultraviolet radiation. At the same time, the Panel emphasized in its report that these atmospheric changes are also directly related to many of the same emission sources and sectors as those contributing to continental and transboundary airborne pollution issues. The transboundary and continental-scale pollutants shown schematically in **Figure 1** (pathways 1 and 2) and their subsequent routes of exposure to humans and terrestrial and aquatic ecosystems have been the primary focus of attention.

Figure 1

PATHWAYS OF TRANSPORT AND ACCUMULATION OF CONTINENTAL POLLUTANTS



2.0 CONTINENTAL POLLUTANTS REQUIRE COLLABORATIVE ACTION

2.1 CONTINENTAL POLLUTANT PATHWAYS DO NOT RESPECT NATIONAL BOUNDARIES

The pollutants described in this report recognize no political boundaries. Once they have been emitted into the atmosphere, their ultimate destination depends in part on their chemical and physical characteristics, and in part on the prevailing meteorological conditions. Due to their relatively heavy weight, for example, large dust particles remain in the atmosphere for only a matter of minutes to a few hours, and thus typically exert only a local influence. At the other extreme, some PCBs can stay aloft for decades, traveling throughout the global atmosphere. As **Table 1** indicates, most of the pollutants listed in this report remain in the atmosphere for several hours to a few days—long enough to cross into neighboring states, provinces or countries.

Table 1 ATMOSPHERIC RESIDENCE TIMES FOR VARIOUS POLLUTANTS

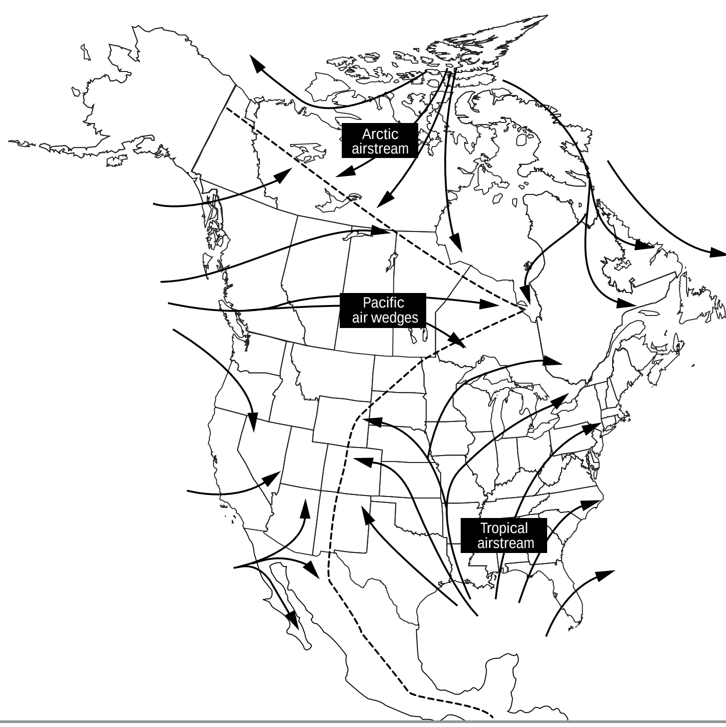
Pollutant	Atmospheric Residence Time in Days*	Notes
Mercury	30+	
Persistant Organic Pollutants (POPs)	1–30+	Vapor pressure- and temperature-dependent; final destination may be much farther away due to the “grasshopper effect” (see below)
Dioxins	3–7	Tetra/Penta-chlorinated
Volatile Organic Compounds (VOCs)	0.1–7+	Species-specific, ranging from minutes (isoprene) to days (butane) or even years (methane)
Ozone	3–5	
Nitrogen oxides	1–5	Species-specific
Sulfur dioxide	1–2	
Large particles	<1	
Fine particles	8–10	< 2.5µm

* In general, residence times vary with many factors, such as temperature, humidity, and cloud cover.
Source: *Panel Report,* Table B-2.

Figure 2 depicts the surface wind patterns that are more or less typical for the month of July in North America. It illustrates how these windflows, or "transportation corridors" can carry atmospheric pollutants in various directions across the continent. Similarly, **Figure 3** shows the calculated back-trajectories for the pesticide toxaphene found in a number of precipitation samples taken in 1989-1990 in Egbert, Ontario.

The resulting interconnectedness of North American pollution problems is extensive. It is estimated, for example, that more than half of the ground-level ozone in Toronto on a hot summer day originates in the United States.[1] Emissions of various pollutants in Los Angeles and San Diego are thought by some experts

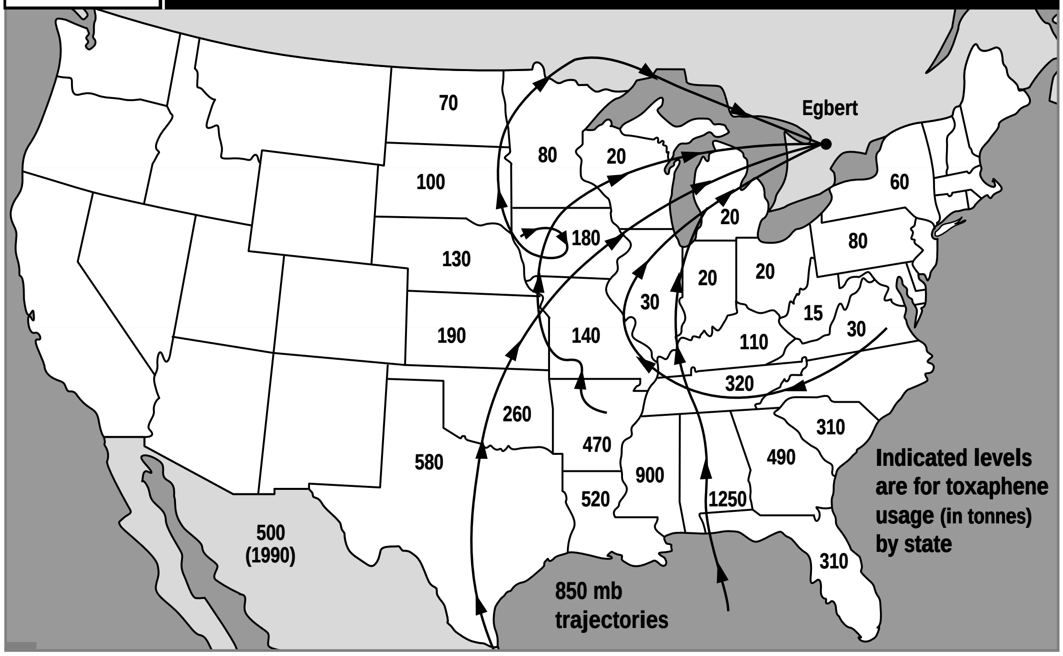
Figure 2 **SURFACE WIND FLOW ACROSS CANADA AND THE UNITED STATES, BASED ON JULY RESULTANT SURFACE WINDS**



Source: From Bryson and Hare 1974, quoted in the *United States-Canada Memorandum of Intent on Transboundary Air Pollution*, MCARLO Interim Model Profile, July 1981.

[1] This was the conclusion of Ontario's Ministry of Environment and Energy and transmitted to the US EPA in the submission, *National Ambient Air Quality Standards—Proposed Decisions on Particulate Matter and Ozone,* of 6 March 1997.

Figure 3 BACK-TRAJECTORIES CALCULATED FOR TOXAPHENE DEPOSITED DURING PRECIPITAION EVENTS AT EGBERT, ONTARIO, CANADA, IN 1989/90

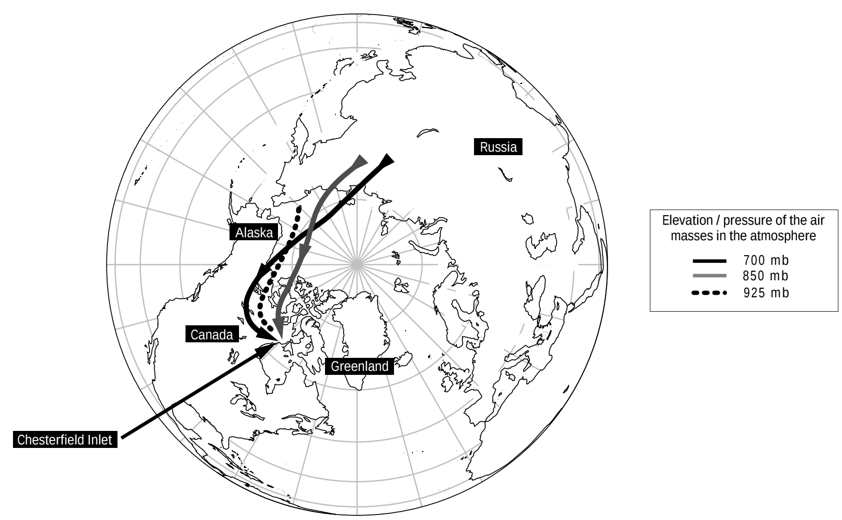


Source for the figure is R.M. Hoff et al. 1993. Measurement of PCCs in air in southern Ontario. *Chemosphere* 27: 2057-2062. Source for toxaphene usage data is E.C. Voldner and W. H. Schroeder 1989. Modelling of atmospheric transport and deposition of toxaphene into the Great Lakes ecosystem. *Atmos. Environ.* 23: 1949-61. Toxaphene usage data are from 1980, unless otherwise specified.

to contribute to the high levels of air pollution in Tijuana. Some semi-volatile chemicals released throughout North America and elsewhere are concentrating in cold regions such as the Arctic and the high mountainous regions in all three countries. Ontario is a major contributor to sulfur loadings in Vermont and New Hampshire. Researchers have discovered significantly elevated concentrations of mercury and persistent organic pollutants in fish, soil, and the breast milk of native women in the Arctic. The atmospheric "region of influence" is very large. A proportion, in some cases a major proportion, of the airborne pollutants reaching any location will have originated hundreds or even thousands of kilometers away.

While the emissions of these pollutants in North America are significant and must be reduced, the three countries cannot solve the problem associated with long-range transport alone. Emissions from sources outside the continent contribute to pollution concerns in North America. Atmospheric deposition of pollutants such as PCBs, DDT and other pollutants have been tracked to sources in Europe and Asia. **Figure 4** traces the airborne pathway taken by the thousands of tons of fine particulate matter (clay and soot particles with adsorbed PCBs, DDT-related compounds, and various herbicides and insecticides) originating in Siberia that were deposited as "brown snow" in the central Canadian Arctic in late April 1988. Although the transport of such pollutants from outside North America to regions such as the Arctic

Figure 4 THE "BROWN SNOW" EVENT IN CHESTERFIELD INLET, 27-28 APRIL 1988: 120-HOUR BACK-TRAJECTORY OF THE AIR MASS CONTAINING FINE PARTICLES AND POPs



Source: H.E. Welch, et al. 1992. Brown snow: A long-range transport event in the Canadian Arctic. *Env. Sci. Tec.* 25: 280-286.

is well documented, more data are needed to define the relationship of North America as a source and receptor of air pollution with other continents and regions.

2.2 CONTINENTAL POLLUTANTS POSE SIGNIFICANT RISKS TO HUMAN HEALTH AND THE ENVIRONMENT

The continental pollutant pathways phenomenon is thus a regional manifestation of a larger global challenge. The focus in this review has been on pathways of air pollutants with atmospheric lifetimes ranging from hours to months and their subsequent terrestrial and aquatic pathways and food webs that result in exposure to humans and the environment. At a global scale, there is clear evidence that the Earth's capacity to assimilate pollutants generated by human activities is being exceeded. The productive capacity of terrestrial and aquatic ecosystems is also at risk, and there are clear signals that pollutants released to, formed within, and transported by the atmosphere are a significant factor in the loss of global biodiversity.

The atmosphere is, in a global sense, the "lungs of the planet," and its health and integrity are essential. While it is obvious that the health and integrity of planetary life-support systems are critical to the long-term health of humans, as well as to their social and economic well-being, they are often taken for granted. It is difficult to mobilize public and political support for threats that seem vague, distant, and without clear and simple solutions. There is, however, a growing recognition of the need to address some of the threats at the international level.

The following review of five pollutants (acid deposition, mercury, ground-level ozone, particulate matter, and POPs), addressed as case studies in the Panel Report, provides a brief summary of their anthropogenic sources, the means by which they are released to, formed within, and transported—often over very long distances—by the atmosphere, and the major exposure pathways that pose the greatest risks to human health and the environment.[2] The Panel Report emphasizes that these pollutants do not represent a complete list of the continental pollutants of concern, and are presented only as examples. The Panel Report also observes, for example, that various emerging issues such as endocrine disrupters and the airborne transport of biological pests and pathogens should also be monitored and evaluated for the potential need for cooperative action in the future.

2.2.1 ACID DEPOSITION

Acid deposition can occur in two ways. "Wet deposition" occurs when emissions of sulfur oxides (SO_X), primarily sulfur dioxide (SO_2), and nitrogen oxides (NO_X) are transformed into acids in the atmosphere and then fall to earth as fog, rain, hail or snow. "Dry deposition" occurs when these acid aerosols are brought to earth by gravity or other non-precipitative means. Despite intensive abatement efforts in recent years, sulfur compounds of anthropogenic (human-generated) origin make up about two-thirds of acid deposition in eastern North America, with nitrogen compounds contributing the remaining one-third. Approximately 60 percent of Canada's SO_2 emissions result from oil and gas processing and the smelting of sulfur-rich ores, and about 22 percent from the burning of sulfur containing coals or heavy oil, particularly in electric power plants.[3] The situation is somewhat different in the United States, where power plants account for about two-thirds of SO_2 emissions, with most of the remaining emissions coming from the combustion of fossil fuels in industrial and manufacturing processes. Estimates for Mexico are that about one-half come from the increasing reliance on the electric power generation sector. The bulk of NO_X emissions in all three countries similarly comes from fossil fuel combustion in motor vehicles and power plants, or the manufacturing of nitric acid or nitrated materials.

The human health impacts of acid aerosols are well documented. They can cause serious cardiorespiratory damage. Prolonged exposure can lead to chronic bronchitis. Acid deposition can also mobilize heavy metals such as copper, cadmium, zinc, aluminum, lead, and mercury from soil and bedrock. These metals can

[2] Unless otherwise noted, the descriptions in this section are based on the Panel Report and the case studies it contains.

[3] International Joint Commission 1996. *Canada—United States Air Quality Agreement: Progress Report 1996.* Ottawa.

subsequently reach humans through plants, animals or drinking water. Aluminum has been linked to Alzheimer's disease, and high concentrations of various other metals in the body can have toxic effects.

The environmental impacts of acid deposition are legion and costly. It has been implicated, for example, in the acceleration of metal corrosion; the erosion of limestone, marble and chalk (which are used as building stone), and concrete; and in the decline and loss of fish populations in thousands of lakes and streams in eastern North America. While acid deposition may not directly kill trees, it can harm forests by causing leaf damage, limiting the availability of nutrients in the soil, and releasing toxic substances such as heavy metals (e.g., aluminum) in the soil. In Canada alone, it is estimated that acidic deposition causes yearly damage of approximately C $1 billion to forestry, tourism, and agricultural industries.[4]

Although acid deposition has traditionally been seen as a transboundary issue facing the northeastern United States and southeastern Canada, it is pervasive across the continent. Whereas dry deposition typically occurs close to the source of the SO_2 or NO_X emissions, wet deposition can occur thousands of kilometers away. Acid deposition has been detected in Mexico City and is prevalent throughout Mexico's east coast, where it is damaging such national treasures as the Mayan monuments, which are made of acid-sensitive limestone. Acidic deposition in the Arctic has been traced to sources thousands of kilometers away in North America, Europe and Asia.

Acid deposition illustrates the problem of addressing pollutants from a local perspective only. Early efforts to minimize the local effects of fossil fuel combustion at electric utilities and smelters led to the construction of high smokestacks, designed to allow the emissions to spread out as the prevailing winds scattered them far from the communities at the base of the stacks. While the higher stacks partially alleviated local problems, they have exacerbated those in distant sites such as the Arctic and the east coast of Mexico, where there are few local emission sources of acidic substances.

2.2.2 MERCURY

Mercury is a natural element found in air, water, land, and biota. However, anthropogenic sources have increased substantially since the beginning of the industrial era and may now be responsible for one-half or more of total emissions to the atmosphere each year.[5] The main anthropogenic sources include coal-fired electric power plants, waste incinerators, chlor-alkali facilities using the mercury cell process, landfills, primary copper and lead smelters, and cement manufacturers. In addition, a significant proportion of the

[4] Environment Canada 1996. *State of Canada's Environment,* 1996. Ottawa (SOER 1996).

[5] The case study in the Panel Report cites a published estimate of 70 percent.

mercury emitted to the atmosphere from oceans, terrestrial, and vegetative sources is actually due to the re-emission of previous anthropogenic releases of mercury to environmental media.[6]

As the Panel Report observes, these and other anthropogenic emissions have probably increased the global atmospheric burden of mercury by two- to five-fold. German researchers estimate that concentrations in the air over the Atlantic Ocean in the northern hemisphere, far from any industrial source, have increased by 1.5 percent per year between 1977 and 1990.[7] A major proportion of the mercury present in the atmosphere is elemental mercury, which is extremely volatile and, in its gaseous form, has an estimated atmospheric residence time ranging from three months to two years.

The mercury case study included in the Panel Report indicates that the industrial areas of the United States and Canada are the main sources of airborne mercury in North America. A significant proportion of these emissions circulate far beyond their sources, resulting in elevated levels throughout North America, particularly in the northeastern United States, eastern Canada, and the Arctic. For example, a recent Environment Canada study indicates that major atmospheric pathways of mercury into Canada are from the Atlantic Coast of the United States northward and from Eurasia over the Arctic. The Environment Canada study found that mercury levels in the blood of loons in the Canadian Maritimes are more than twice as high as in the Great Lakes or the northwestern United States. As well, the International Air Quality Advisory Board of the IJC stated that if shifts in electrical power production result in increased generation by the coal-fired utilities in US midwestern states, there should be concern about an increase in emissions of mercury, which would be transferred and deposited into downwind areas, including the Great Lakes Basin.[8] In another study, researchers have found that high concentrations of mercury precipitation in the Lake Champlain Basin in Vermont are traceable to air masses arriving from the northwest in Canada and from the southwest, originating in the US Midwest.[9] In the Arctic, elevated levels of mercury appear to be attributable in part to distant sources, including those in Europe and Russia.

Elevated levels of mercury pose significant risks both to the natural environment and to human health. Organic mercury compounds can inhibit photosynthesis and growth in phytoplankton, and have caused death and reproductive failure in birds.[10] Aquatic ecosystems are particularly susceptible to high mercury concentrations. Methylmercury can bioaccumulate through the food chain in aquatic systems to reach levels in predatory fish that are thousands of times greater than those found in the water. Humans and animals

[6] EPA 1996. *Mercury Study Report to Congress.* Office of Air Quality Planning and Standards and Office of Research and Development.

[7] As reported in the *Globe and Mail*, 8 April 1997.

[8] International Air Quality Advisory Board statement on the recent Federal Energy Regulatory Commission Ruling concerning open access by public utilities, 18 April 1996.

[9] EPA 1994. *Deposition of Air Pollutants to the Great Waters: First Report to Congress.* Office of Air Quality Planning and Standards.

[10] *SOER* 1996.

then become exposed to mercury by eating fish. This problem is so prevalent that five Canadian provinces and over 35 US states have issued health advisories to reduce the consumption of certain freshwater fish that are known to contain excessive levels of mercury.

Exposure to inorganic mercury can cause liver and kidney damage. Mercury can also cause reproductive problems, such as infertility and delayed pregnancy. Methylmercury is a potent neurotoxin, causing loss of sensation, tunnel vision, lack of coordination, and impairment of speech, hearing and gait, as well as tremors and hallucinations. Because methylmercury is fetotoxic, affecting embryonic development and causing fetal malformations, pregnant women, the developing fetus, nursing infants, and young children are most at risk from exposure to excessive levels of mercury.[11] The neurobehavioral effects of mercury are particularly important where a high percentage of the population is in the developmental stage, as in Mexico, where 40 percent of the population is of reproductive age (15 to 44 years of age). However, even in the United States, data contained in a draft US Environmental Protection Agency (EPA) report on mercury allow the calculation of the number of US women of childbearing age who have been exposed to sufficient levels of the substance to affect the brain development of their babies as possibly numbering as many as 85,000.[12]

2.2.3 OZONE

Ground-level ozone, the primary component of smog, is an important air pollution problem shared by all three countries.[13] Canada and the United States have high levels of ozone in most major cities, particularly in the east, and photochemical smog is a primary air pollution problem in Mexico City. Ozone is produced as a result of the reactions of nitrogen oxides (NO_X) and volatile organic compounds (VOCs) in the presence of sunlight. In all three countries, fossil fuel combustion by electric utilities and transport vehicles is the major source of NO_X. The transportation sector is also a major source of VOCs. Other sources of VOCs include incinerators, gasoline fuel vapors, paints and solvents, and various industrial processes.

Ozone can cause significant human health problems, particularly for young children, the elderly, and people who are active outside during the summer months. Its effects include significant impairment of lung functioning—with symptoms such as coughing, shortness of breath, pain on deep inspiration, throat dryness,

[11] Chiho Watanabe and Hiroshi Satoh 1995. Evolution of our understanding of methylmercury as a health threat. Department of Environmental Health Sciences, Tohoku University School of Medicine, Sendai, Japan. Prepared as a background paper for the Workshop on Risk Assessment Methodology for Neurobehavioral Toxicity convened by the Scientific Group on Methodologies for the Safety Evaluation of Chemicals (SGOMSEC), held 12-17 June 1994 in Rochester, New York.

[12] Based upon figures provided in EPA 1996. *Draft Mercury Study Report to Congress.* Office of Air Quality Planning and Standards and Office of Research and Development.

[13] Ground-level ozone should not be confused with the ozone layer, which is located in the stratosphere at higher altitude.

wheezing, chest tightness—and inhibition or interference with the immune system. American and Canadian research has repeatedly documented a strong correlation between episodic high ozone levels and rates of hospitalization and worker absenteeism.[14] One Ontario study concluded, for example, that "five percent of daily hospital admissions due to respiratory problems in the months of May to August were associated with ozone."[15] And based on studies by Health Canada and others, Ontario's Ministry of Environment and Energy estimates that smog causes about 1,800 premature deaths per year in Ontario alone.[16]

Ozone also causes significant harm, even death, to plants and forests. It can induce cracking in rubber and plastic compounds that are stretched or under pressure.[17] The tendency of ozone to cause textile dyes to fade has forced the textile industry to develop ozone-resistant dyes and chemicals. These tend to be more expensive and have poor dyeing properties.

Although ozone and smog have long been understood to have serious health and environmental effects, they have often been viewed as local issues. Recently, however, aided by the work of such groups as the Ozone Transport Assessment Group (OTAG) and the Ozone Transport Commission (OTC), research in North America has confirmed that both ozone and its precursors, NO_X and VOCs, can travel relatively long distances in the atmosphere and be transported from region to region. A recent US study concluded that the typical transport range of ozone is 240 to 800 kilometers, depending on meteorological conditions.[18] However, its precursors can remain aloft even longer and travel much farther.

Some of the major ozone transportation corridors of concern in North America include:[19]

- the East Coast from Washington, D.C., to Maine and the southern Canadian maritime provinces;
- mid-continent transport, including the Lake Michigan, Lake Erie, and Lake Ontario air basins, the industrial areas of the midwestern United States, and the corridor stretching through southern Ontario and along the St. Lawrence River from Windsor, Ontario, to Quebec City;
- the Gulf Coast region, including much of the Texas and Louisiana coast and adjacent inland areas; and
- intra- and interbasin transport in southern and central California.

[14] See for example, R. Burnett et al. 1997. Association between ozone and hospitalization for respiratory diseases in 16 Canadian cities, *Environmental Research* 72: 24–31.

[15] R. Burnett et al. 1994. Effects of low ambient levels of ozone and sulfates on the frequency of respiratory admissions to Ontario hospitals, *Environmental Research* 65: 172–194.

[16] The figure is reported in two news releases of the Ontario Ministry of Environment and Energy: "Minister announces new measure to reduce smog particles," 21 May 1997, and "Sterling says proposed U.S. smog standards not tough enough," 14 March 1997. <http://www.ene.gov.on.ca/envision/news>

[17] The first effect of elevated ozone levels noticed in Los Angeles was the cracking of rubber. Indeed, in the 1950s rubber cracking was used to monitor ozone concentrations in the atmosphere.

[18] Northeast States for Coordinated Air Use Management 1997. *The Long-Range Transport of Ozone and Its Precursors in the Eastern United States.*

[19] There are other significant ozone areas of concern, including Atlanta and Mexico City. There are no obvious air transport corridors located in these areas, however.

Given that its levels are additive, ozone or its precursors arriving from elsewhere can create dangerous conditions even where local emissions are only moderate. Research thus suggests, for example, that some of the ozone created in the Ohio Valley results from emissions of NO_X and VOCs from the midwestern United States, and that this Ohio Valley ozone in turn flows into Canada, where it raises ozone levels in southern Ontario.

2.2.4 PARTICULATE MATTER

"Particulate matter" (PM) is a broad category of air pollutants that includes a range of small solids or liquids that vary in size and chemical composition. Some particles are acidic "acid aerosols." There are particles composed of relatively benign materials and others that include toxic substances, such as heavy metals, polycyclic aromatic hydrocarbons, as well as numerous other organic compounds. Particulate matter can be caused by natural sources, such as sea salt, dust, smoke, and volcanic ash. Major anthropogenic sources include industrial activities (such as mining and quarrying), incineration, roads, agriculture, construction, and various grinding and pulverizing activities. Fuel combustion in vehicles and power plants is the most significant source of the smaller particles—those judged as potentially the most hazardous.

The continental pathways by which particulate matter is disseminated are not well understood. Generalizations are difficult due to the vast array of emission sources and the complex chemistry involved. Small particles are produced throughout the daylight hours, as well as at night under some conditions. They typically reside in the atmosphere for hours or days before aggregating or condensing to form larger particles. The largest of these particles can settle rapidly. Smaller particles, though, can remain aloft for days or even weeks, traveling thousands of kilometers. Some fine particles containing mercury, dioxin and POPs can also be re-injected into the atmosphere by a variety of mechanisms, moving considerable distances from their original sources.

Until recently, most of the concern about particulates has focused on visibility, corrosion, and the erosion of stone and cement buildings. Scientific evidence increasingly demonstrates, however, that human health risks may be far more serious than previously believed. Known as PM_{10} because they measure 10 micrometers or less in diameter, inhalable particles have been implicated in chronic lung disease since 1979. A 1994 study by researchers at Harvard University estimated that 60,000 people die each year in the United States from the effects of fine particulate air pollution.[20] More recent studies suggest that certain types of particulate matter are also associated with pulmonary and heart diseases. In January 1995, a groundbreaking British study suggested that deaths due to particulate matter are caused primarily by particles measuring 2.5 micrometers or less.[21] Subsequent research supports the association between concentrations of fine par-

[20] D.W. Dockery and C.A. Pope III 1994. Acute respiratory effects of particulate air pollution, *Annual Review of Public Health* 15: 107–132.

[21] A. Seaton et al. 1995. Particulate air pollution and acute health effects, *Lancet* 345 (January 21): 176-178. Although the mechanism by which such particles cause mortality is not yet well understood, the *Lancet* article and subsequent research demonstrates that such particles, if insoluble, can lodge for months or even years in the alveoli of the lungs where gas exchange into the bloodstream takes place. If soluble, the particles can pass into the bloodstream within minutes.

ticulate matter and cardiorespiratory illnesses,[22] premature death due to respiratory disease,[23] reduced pulmonary function levels,[24] and bronchitis.[25] Studies suggest that among the elderly, particulate matter causes increased death and hospital admissions rates due to respiratory and cardiovascular problems, while children and asthmatics may be particularly susceptible to reduced lung functioning.

2.2.5 PERSISTENT ORGANIC POLLUTANTS

Persistent organic pollutants (POPs) degrade very slowly in the environment and are characterized by low water and high fat solubility, causing them to accumulate to high levels as they move up the food chain. Many POPs are pesticides (e.g., mirex, toxaphene, DDT, chlordane) or industrial chemicals like PCBs and hexachlorobenzene. Others (e.g., dioxins and furans) are unwanted byproducts of industrial processes and the incineration of municipal and medical wastes.

Many POPs have the potential to be transported regionally, continentally, and even hemispherically. The dioxin case study included in the Panel Report estimates that 15 to 25 percent of the dioxin deposited in Lake Michigan comes from sources as far away as southern Texas. A large proportion (estimates range upwards of 90 percent) of POPs applied as agricultural pesticides are retained in the atmosphere or are re-volatilized to it.[26] An EPA report to Congress on the deposition of air pollutants to major US bodies of water estimates that atmospheric deposition currently contributes “approximately 77 to 89 percent” of the total yearly input of PCBs to Lake Superior.[27] Noting that the use of lindane in North America is extremely restricted, but that it is increasing in concentration in major water bodies, the EPA suggests that the pesticide may travel across the Pacific to North America from Asian countries that still employ it.[28] Many POPs eventually concentrate in water, soil, and wildlife in the cooler, northern latitudes because of atmospheric circulation patterns, their tendency to revolatilize many times (the “grasshopper effect,” see box below), and global distillation (their re-volatilization and rates of degradation are reduced at cold temperatures, resulting in higher concentrations of POPs in cooler, northern ecosystems).

[22] R. Burnett et al. 1995. Associations between ambient particulate sulfate and admissions to Ontario hospitals for cardiac and respiratory diseases, *American J. of Epidemiology* 142(1): 15-22.

[23] Ozkaynak et al. 1995. *Proceedings of the International Society for Environmental Epidemiology* (August). Nordwijkerhout, The Netherlands.

[24] Raizenne et al. 1996. Health effects of acid aerosols on North American children: pulmonary function, *Environmental Health Perspectives* 104(5).

[25] Dockery et al. 1996. Acid aerosols and respiratory symptoms in children, *Environmental Health Perspectives* 104(5).

[26] World Resources Institute 1996. *Pesticides and the Immune System: The Public Health Risks.*

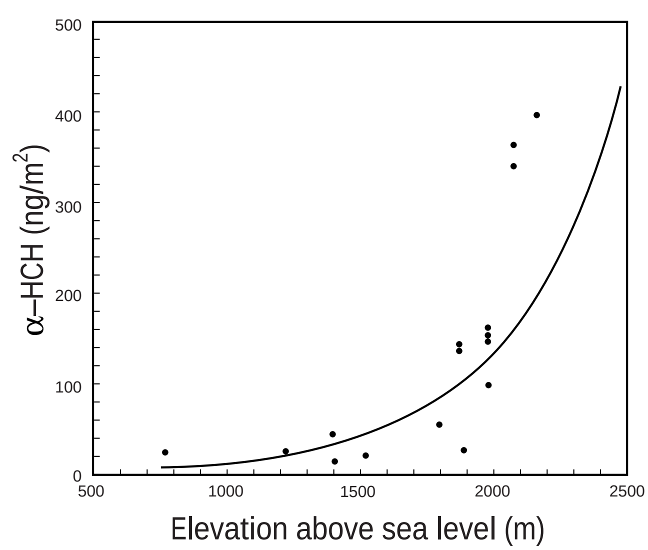
[27] EPA 1994. *Deposition of Air Pollutants to the Great Waters: First Report to Congress.* Office of Air Quality Planning and Standards, p. 49.

[28] EPA 1994. pp. 62-63.

Some of the POPs found in the Arctic also accumulate at high elevations due to cold temperatures that cause reduced rates of degradation, reduced volatility, and subsequently reduced chance of re-volatilization. Samples collected in 1996 in Alberta and British Columbia, Canada, showed very high accumulation rates of several POPs relative to those at lower elevations. Currently, researchers are testing other sites to determine the extent to which this phenomenon is occurring in other high-elevation regions throughout the continent. **Figure 5** shows this exponential rise in deposited α–HCH (α–hexachlorocyclohexane, an isomer of the pesticide lindane) with elevation.

Because they generally dissolve more easily in fat than water, POPs tend to accumulate in the fatty tissue of living organisms. In most cases, the dominant route of human exposure is through eating fish and other wildlife. Some POPs, such as dioxin, bioaccumulate through terrestrial food webs and concentrate in milk and other dairy products. As a result of this tendency to bioaccumulate, POPs are a particular problem to indigenous people in the North, who rely on fatty foods such as polar bear, seal and fish. Pregnant women there are often found to have high levels of POPs in their placentas, potentially affecting the development of their unborn children.

Figure 5 ACCUMULATION OF α–HEXACHLOROCYCLOHEXANE IN 1994-1995 SNOW PACK SAMPLES FROM TRANSECTS IN ALBERTA AND BRITISH COLUMBIA, CANADA



Source: J. Blais and D.W. Schindler, personal communication.

Recent research suggests that exposure to POPs may pose a significant risk to a much larger proportion of the general population than previously thought. Some POPs are now known to act as endocrine disrupters, mimicking the body's hormones, turning on and off important developmental processes at critical times. Some scientists believe that fetal exposure to endocrine disrupters or estrogenic chemicals (including some organochlorines such as DDT, some PCBs, dioxins, and furans) may be responsible for declining sperm counts and the rising incidence of abnormalities in the human male reproductive tracts. There is also growing evidence that some POPs are able, on their own or in combination, to disrupt enzyme function and impair reproductive capacity in animals and humans. Women and children are generally considered at special risk because of the transfer of these contaminants through the placenta and breast milk. **Table 2** provides a brief summary of the health effects of some of these pollutants.

Table 2 **POTENTIAL EFFECTS OF SELECTED PERSISTENT TOXIC POLLUTANTS[a,b]**

Potential Effects on Human Health[c]

Pollutant[d]	Cancer[e]	Reproductive Restrictions[f]	Neurological/ Behavioral	Immuno-logical	Endocrine	Other Noncancer[g]
Cadmium and compounds	Probable[h]	•	•	•		Respiratory and kidney toxicity
Chlordane	Probable[h]	•[f]	•[f]	•	•	Liver toxicity[h]
DDT/DDE	Probable[h]	•[h]	•[f]	•		Liver toxicity[h]
Dieldrin	Probable[h]	•[h]	•[f]	•	•	Liver toxicity[h]
Hexachloro-benzene	Probable[h]	•	•[h]	•	•	Liver toxicity[h]
α-HCH[i]	Probable[h]					Kidney and liver toxicity
Lindane (ϒ-HCH)	Probable[j]	•	•	•		Kidney and liver toxicity[h]
Lead and compounds	Probable[h]	•[k]	•[k]	•	•	Kidney toxicity[k]
Mercury and coumpounds		•	•	•	•	Kidney toxicity
PCBs	Probable[h]	•	•	•	•	Liver toxicity
Polycyclic organic matter	Probable[h]	•		•		Blood cell toxicity
2,3,7,8-TCDF	Not classifiable[h]	•		•	•	Liver toxicity
2,3,7,8-TCDD	Probable[j]	•[l]	•[l]	•[l]	•[l]	Integument toxicity[l]
Toxaphene	Probable[h]	•[f]	•[f]	•	•	Cardiovascular effects; liver toxicity[f]

Source: EPA 1994. *Deposition of Air Pollutants to the Great Waters. First Report to Congress*. Office of Air Quality Planning and Standards.

[a]These data are based on a compilation of results from both human and animal studies. Potential for effects will depend on the level and duration of exposure and the sensitivity of the exposed organism.

[b]Where footnoted, data for this table are taken both from EPA sources and the applicable Agency for Toxic Substances Disease Registry (ATSDR) Toxicological Profile. Otherwise, all data are taken from the applicable ATSDR Toxicological Profile alone.

[c]For this table, a chemical was considered to induce an effect if human or laboratory mammal data indicating a positive result were available. Blanks mean that no data indicating a positive result were found in the references cited (not necessarily that the chemical does not cause the effect).

[d]Nitrogen compounds are not included in this table because they are considered a pollutant of concern only for eutrophication.

[e]A chemical is classified as a "probable human carcinogen" when there is limited or no evidence of human carcinogenicity from epidemiological studies but sufficient evidence of carcinogenicity in animals (corresponds to EPA weight-of-evidence category B). A chemical is classified as "not classifiable as to human carcinogenicity" when there is inadequate human and animal evidence of carcinogenicity or when no data are available (corresponds to EPA weight-of-evidence category D).

[f]Data from the applicable EPA Health Effects Assessment (HEA) document.

[g]This is only a sample of other noncancer effects that may occur as a result of chronic exposure to the pollutant. Additional adverse human health effects may be associated with each chemical.

[h]Data from EPA's Integrated Risk Information System.

[i]Toxicity data are available primarily for ϒ-HCH and technical-HCH (a mixture of several HCH isomers), with limited data available for α-HCH.

[j]Data from EPA's Health Effects Assessment Summary Tables (HEAST). HEAST classifies these chemicals as probable human carcinogens; however, these carcinogenic evaluations are currently under review by EPA.

[k]Data from EPA's Reportable Quantity (RQ) Document for lead.

[l]Data from M.A. Gallo et al., ed. 1991. *Biological Basis for Risk Assessment of Dioxins and Related Compounds.* Cold Spring Harbor Laboratory Press.

2.2.6 THE IMPORTANCE OF ACCOUNTING FOR MULTI-MEDIA PATHWAYS AND SYNERGISTIC EFFECTS

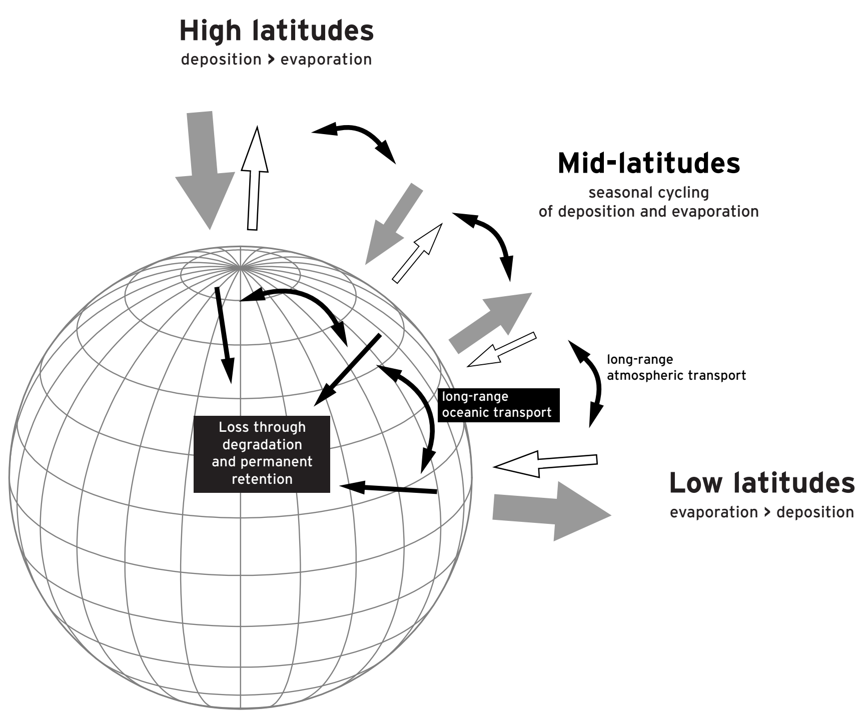
In order to understand fully how pollutants are transported through the atmosphere and the nature of the risks they pose, however, it is necessary to study how they interact with water and soil as well. As **Figure 1** (above) illustrates, terrestrial and aquatic ecosystems also play important roles in the transport of many pollutants, acting both as "sinks" (recipients of atmospheric deposition) and as sources (reservoirs for their re-emission through processes such as evaporation and erosion). Once deposited on land or water, many airborne pollutants can also bioaccumulate through food webs, reaching humans at highly concentrated—and harmful—levels. And because these pollutants cycle continuously among the air, land, and water, humans are typically exposed to them through more than one medium at a time. The cumulative multi-media risk to human and ecological health can therefore far surpass the risk associated with a single medium such as air.

It is also important to account for the potential synergistic effects of multiple chemicals acting together. Small amounts of some chemicals having low toxicity alone may produce, upon interaction with other chemicals in the environment, new chemical combinations that are highly toxic.

The Grasshopper Effect

The "grasshopper effect" occurs when pollutants such as some semi-volatile POPs re-volatilize into the atmosphere after being deposited on land or water. When the airborne chemical reaches its condensation temperature, it is scavenged out of the atmosphere and deposited on land or water. **Figure 6** depicts this effect and shows that, at high latitudes, deposition tends to prevail over evaporation; at low latitudes, it is the contrary. Because of the low solubility of PCBs, unless they degrade or are buried, they are typically re-released, transported further, and re-deposited elsewhere—usually in cooler regions, such as in the Arctic. Originally a PCB sink, Lake Ontario has been acting as a net source of PCBs for more than a decade now. PCBs have been degassing out of the lake at a rate that more than offsets inputs and, as a result, PCBs in the lake sediments are reintroduced into the water column to balance the concentration gradient.

Figure 6 THE "GRASSHOPPER EFFECT": PATHWAYS AND PROCESSES INVOLVED IN THE LONG-RANGE TRANSPORT OF SEMI-VOLATILE PERSISTENT ORGANIC POLLUTANTS (POPs)



2.3 CONTINENTAL POLLUTANTS HAVE COMMON SOURCES

Collective action is required to reduce the significant risks posed by transboundary pollutants. Another reason for collaboration, though, is that many of these pollutants are generated primarily by a relatively few common source categories (i.e., electric utilities and the transportation and agricultural sectors) in all three countries, as illustrated in **Figures 7–9,** which summarize the main Canadian, Mexican, and US sources of various pollutants. These figures show that:

- ***Industrial sources*** (such as primary base metal smelters) produce significant emissions of SO_2, NO_X, and mercury;

- ***Mobile sources burning fossil fuels*** (cars, trucks, buses, and construction and agricultural vehicles) are responsible for approximately one-third of the NO_X and VOC emissions in North America, for a significant proportion of the fine particle emissions, and for some POPs;

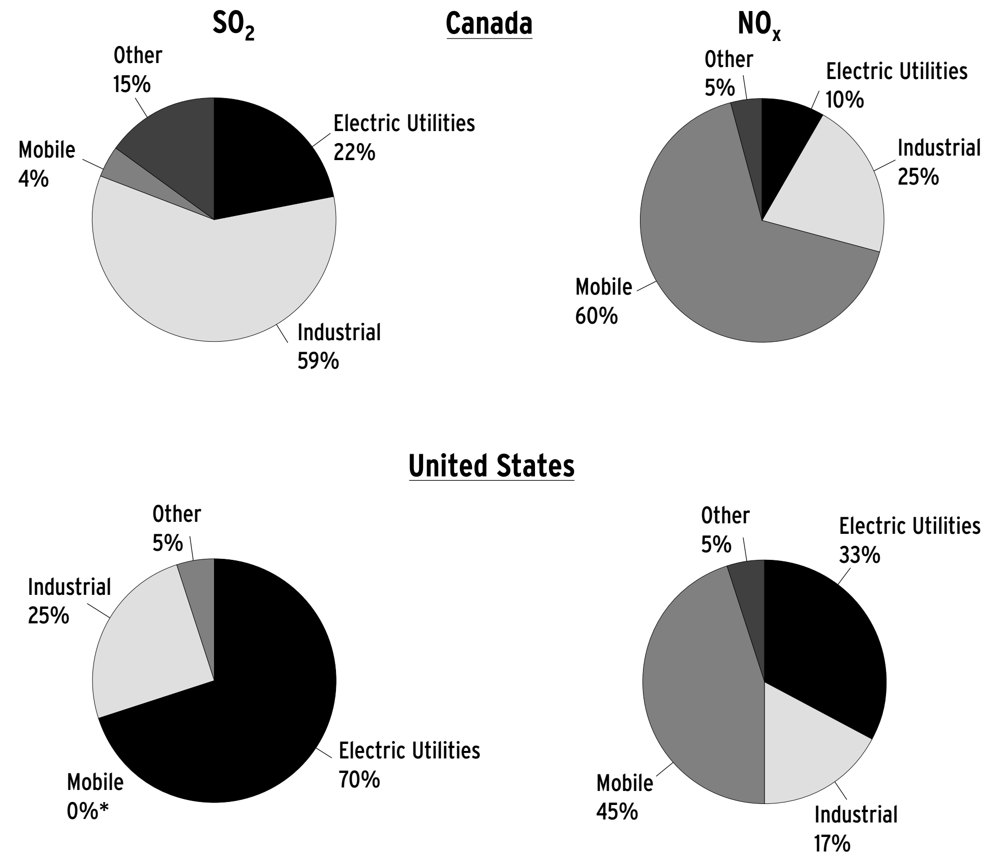
- ***Medical, hazardous, and municipal waste incinerators*** are significant sources of particulate matter, mercury and dioxins; and

- Some ***pesticides***, like DDT, toxaphene, aldrin, heptachlor, and endosulfan, that for the most part are banned or restricted in North America, are still used in substantial quantities in Latin America and Asia. Canadian and US farmers, though, continue to utilize a limited number (e.g., lindane).

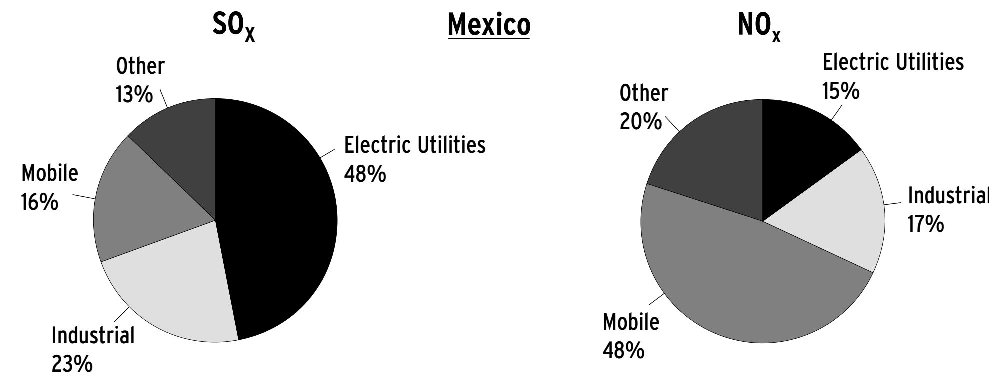
The capacity of the region as a whole to reduce the human health and environmental impacts of these activities would therefore be enhanced significantly by focusing collaboratively on these few key sources. The active sharing of best practices—both with respect to policy and technological methods for reducing emissions, and concerning techniques for monitoring and evaluating their impacts—would aid this process.

Figure 7

ESTIMATES OF SO_2 AND NO_X AIR EMISSIONS FOR CANADA, THE UNITED STATES, AND MEXICO, (CANADA/US ESTIMATES FROM 1994; MEXICO FROM 1995)

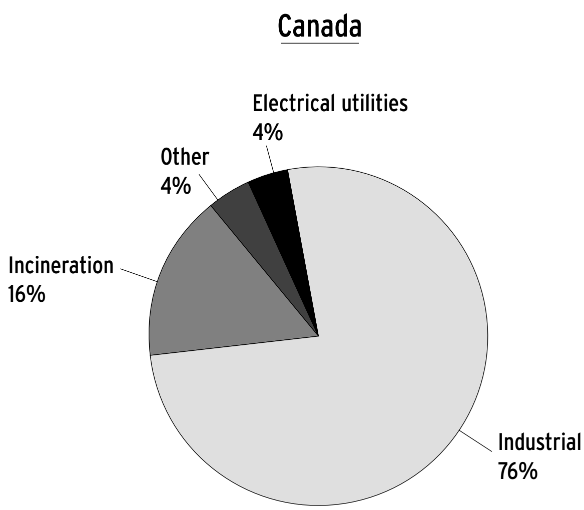


Source: IJC 1996. *Canada-United States Air Quality Agreement Progress Report.*
*Note: According to EPA 1995, estimates of SO_2 emissions from mobile sources may amount to as much as 3% of the total.

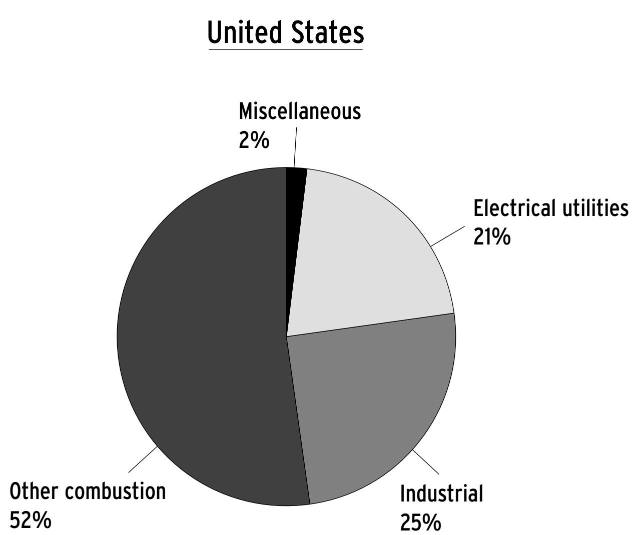


Source: J. Quintarilla and M. Bauer. *Protections of Energy Demand and Related Emissions.* PUE-UQAM. 1995 data.

Figure 8 ESTIMATES OF CANADIAN AND US AIR EMISSIONS OF MERCURY FROM VARIOUS SOURCES



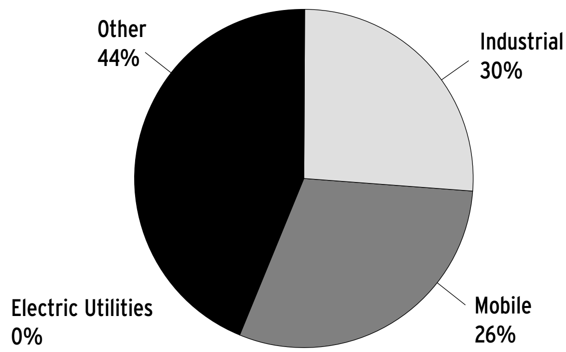
Source: *Canadian Emissions Inventory of Air Contaminants*–1995, Pollution Data Branch, Environment Canada, in preparation.
Note: Data for emissions are for 1990 and are available from Pollution Data Branch.



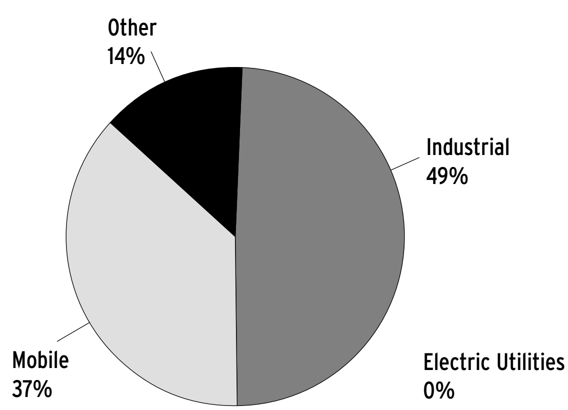
Source: *EPA Study Report to Congress, Science Advisor Board Review Draft*, June 1996.
Notes: 1990 anthropogenic mercury emissions in the US, excluding mobile sources, refineries, by-product coke production, and manufacturers of mercury and mercury compounds. Overall mercury data for Mexico are not available.

Figure 9 ESTIMATES OF AIR EMISSIONS OF VOCs FOR CANADA AND THE UNITED STATES

Canada



United States



Source: IJC 1996. *Canada–United States Air Quality Agreement Progress Report.*
*Note: VOC emission data for Mexico are not available.

2.4 EXISTING BILATERAL AND GLOBAL INITIATIVES LACK A CONTINENTAL PERSPECTIVE

Canada, Mexico and the United States are currently engaged in various international efforts to control the transboundary transport of air pollution. These include:

- ***The 1983 La Paz Agreement*** between Mexico and the United States includes an annex and implementation programs which set forth the basis for comprehensive emission inventories, air quality monitoring and modeling, and emission reduction and control strategies for the border area.

- ***The Great Lakes Water Quality Agreement*** (GLWQA) commits Canada and the United States to *"restore and maintain the chemical, physical and biological integrity of the waters of the Great Lakes Basin Ecosystem."* Annex 15 of the GLWQA on Airborne Toxic Substances states that Canada and the United States *"shall conduct research, surveillance and monitoring, and implement pollution control measures for the purpose of reducing atmospheric deposition of toxic substances, particularly persistent toxic substances, to the Great Lakes Basin ecosystem."*[29]

- ***The Canada–United States Strategy for the Virtual Elimination of Persistent Toxic Substances in the Great Lakes Basin*** calls for phasing out or banning toxic chemicals that pose an unmanageable threat or unreasonable risk to human and ecosystem health in the Basin. It sets quantifiable reduction targets and time frames for specified persistent toxic substances in the Great Lakes.

- ***The Canada–United States Air Quality Agreement of 13 March 1991*** focuses on acid deposition but also, more generally, directs the Parties to control transboundary air pollution between the two countries;[30]

- ***The 1997 Canada–United States Program to Develop a Joint Plan of Action for Addressing Transboundary Air Pollution*** sets out an agreement between the two countries to extend domestic air pollution programs to address transboundary air pollution. The plan to be developed is expected to provide the basis for joint action addressing the transport of ozone and particulate matter across the Canada–United States border.

[29] Under the GLWQA, the International Joint Commission (IJC) monitors and assesses progress toward achieving general and specific GLWQA objectives. The IJC has catalyzed new programs and more stringent goals (including "virtual elimination" of persistent substances such as mercury) to help reduce contamination of the Great Lakes System. The Agreement and the IJC have pioneered the "ecosystem approach," which recognizes that water quality depends on the interplay of air, land, water and living organisms, including humans, within the system. This philosophy has helped restore the health of the Great Lakes and could be a model for further action on continental pollution.

[30] The Air Quality Committee established under this Agreement has focused its efforts primarily on meeting existing commitments, but has recently started to address issues involving ground-level ozone and air toxics.

- ***The United Nations' Economic Commission for Europe*** (UNECE), ***Convention on Long-Range Transboundary Air Pollution***, an umbrella agreement (1997) to which Canada and the United States—but not Mexico—are party, provides a mechanism for the development of individual protocols addressing specific families of pollutants. Five protocols have so far been concluded, two on the control of sulfur emissions, one on nitrogen oxides, one on volatile organic compounds, and one on international sharing for monitoring and modeling. In addition, three further protocols are in preparation: on heavy metals, persistent organic pollutants (POPs), and a second protocol on nitrogen.

- ***The United Nations Environment Programme*** (UNEP) and other related global initiatives are also addressing various dimensions of pollutants. In May 1995, the Governing Council of UNEP identified 12 specific POPs and invited the Intergovernmental Forum on Chemical Safety (IFCS) to develop recommendations concerning an "appropriate international legal mechanism on POPs." Subsequent work under this initiative, including a 1995 Intergovernmental Conference on the Protection of the Marine Environment from Land-Based Activities, has led to a decision to develop an international, legally binding instrument on POPs.

- ***The Arctic Council,*** made up of Canada, the United States, Denmark, Norway, Sweden, Finland, Iceland, and Russia under the Arctic Environmental Protection Strategy, commits its member governments to support the actions on POPs under UNEP and UNECE described above, as well as to undertake comprehensive monitoring of environmental conditions in the Arctic.

- ***Other state and provincial cooperative programs***, in addition to the above initiatives at the federal level, are being undertaken in all three countries. For example, British Columbia and Washington State have developed an air quality program that includes information sharing, initiatives to develop compatible data, and processes to provide for interjurisdictional consultation on air emission permits for sources with potentially significant cross-border air quality impacts. In another example, the Paso del Norte Air Quality Task Force, a binational initiative between the cities of Juarez and El Paso, is developing cooperative transboundary strategies to improve air quality in that air basin.

The existence of these initiatives demonstrates that governments in North America have recognized the problem of transboundary pollution and the need for greater cooperation to address it. These initiatives are generally bilateral or global in scope, however. There is not at present a program to address the North American dimensions of long-range transport of air pollution. The IJC has recognized the need for this and, in its *Eighth Biennial Report on Great Lakes Water Quality* (pp. 19-20), concluded that:

"This evidence leads us to conclude that part of our focus must be on atmospheric emissions…. Also, our traditional concept of the geographic area that impacts the Great Lakes basin must be expanded. The scale should at least encompass most of North America, and for some purposes, the globe."

3.0 IMPORTANT REASONS AND OPPORTUNITIES FOR COLLABORATIVE ACTION ON CONTINENTAL POLLUTANTS

3.1 A TIME FOR ACTION

A key conclusion of the Expert Advisory Panel was that while acknowledging that continuing scientific uncertainty remains with respect to some issues, *"enough is already known on most fronts for us to say unequivocally that significant emission reductions from present levels are needed now."* Responding to this imperative will require domestic action on the part of each country and increased collaboration at the bilateral and trinational level. Some of the key realities that are likely to drive binational and trinational cooperation and action are discussed below.

3.2 TRANSBOUNDARY AND INTERNATIONAL ASPECTS

Pollutants that have been transported long distances through the atmosphere or other environmental media are frequently beyond the control capacity of any one country. While some pollutants can be effectively addressed by bilateral efforts, there are others that, because of the distance they travel, require trilateral attention. Furthermore, the impact of a country's emissions on its neighbors cannot always be known *a priori*. Atmospheric chemistry associated with these pollutants is very complex, as are the pathways through which they move, and it is very difficult to predict the ultimate environmental and human health impacts of any given emission. Therefore, the three countries need to work together, sharing information and control strategies, as they strive to address this mutual problem.

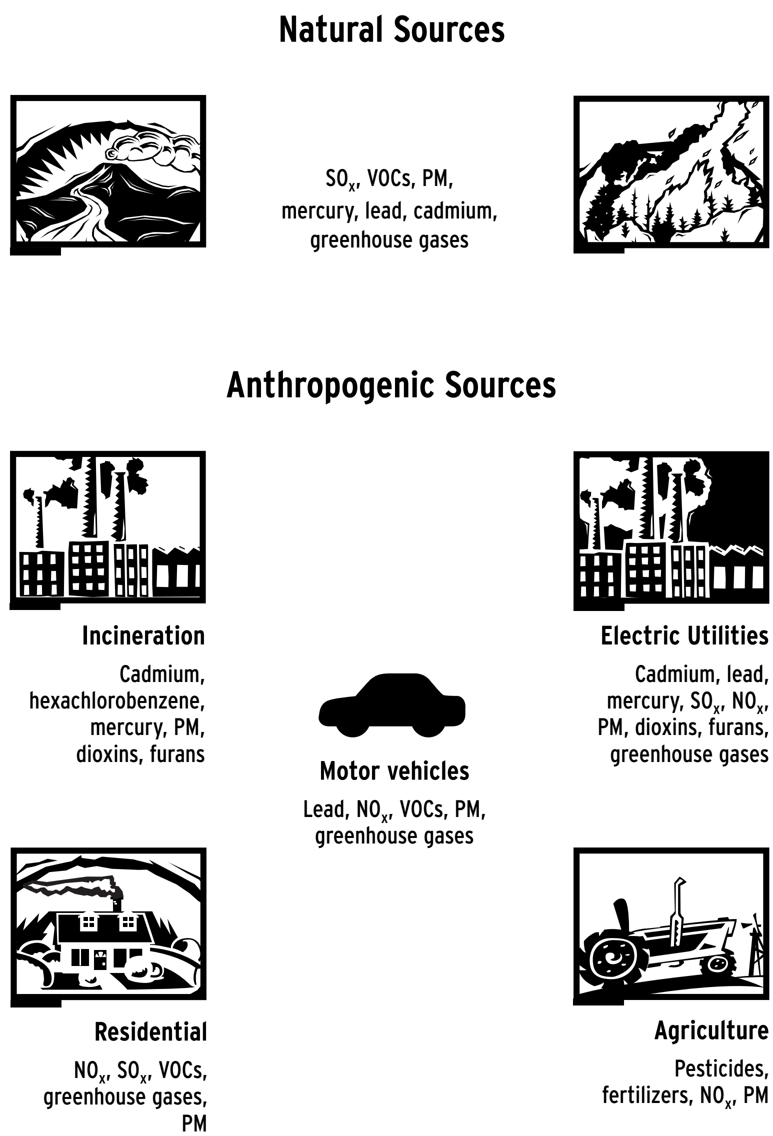
3.3 COMMON SOURCES OF POLLUTANTS

In many cases, collaborative action focused on a limited number of sources will be the most efficient way to reduce the emissions of pollutants of concern on a North American regional basis. Even where the pollutants of concern associated with a particular point source are not known to cross borders, similar sources are emitting similar pollutants, and many locations are grappling with similar problems. The sharing of best practices can reduce the collective costs of addressing such pervasive problems, and help maximize each country's capacity to address both domestic and regional aspects of the continental pollutants issue.

Major source categories that are common to the three countries include electric power plants, mobile sources, incinerators, and organic pesticides used in agriculture and for vector control (see **Figure 10**). Power plants, mobile sources, and incinerators each emit NO_X, SO_2, mercury, particulate matter, and various POPs. Many of the pollutants from these sources can have multiple effects. For example, the same nitrogen oxides that create ozone can also be transformed into acid aerosols that contribute to acid deposition and excessive loading of nutrients to lakes and estuaries.

With respect to electric power plants, a source responsible for significant proportions of many of the pollutants of concern (**Figures 7–9**), the three countries could compare pollutant emissions from their older

Figure 10 COMMON SOURCES OF POLLUTANTS



Sources: Modified from EPA 1994. *Deposition of Air Pollutants to the Great Waters: First Report to Congress.* Office of Air Quality Planning and Standards.

plants with those from newer ones and assess the potential impacts of electricity deregulation on the generation of these emissions. Because they usually employ less effective control technologies, many old power plants emit significantly more of these pollutants than do modern plants. Some analysts have warned that the pending deregulation in various parts of Canada and the United States, if not explicitly addressed, could lead to greater use of older coal-fired power plants and thus considerably increase pollutant emissions.[31]

Another very important source category is mobile sources. The three countries could decide to increase their requirements and incentives for the auto industry in order to encourage it to produce more energy efficient, cleaner vehicles for private use and transport. Experience in North America has shown that emissions and fuel economy standards for motor vehicles have made major contributions both to improved air quality and to the development of more efficient technology. More stringent standards, such as those currently under consideration in the United States, could result in further advances. And with the increasing integration of the North American vehicle industry under NAFTA, closer collaboration between the three countries could significantly reduce a number of continent-wide pollution problems.

An important benefit of reducing the emissions of continental pollutants from the utility and transportation sectors is that it would also contribute to meeting national (the United States and Canada) and international goals for reducing greenhouse gas emissions since it is the combustion of fossil fuels by cars, trucks and power plants that produces a major proportion of the anthropogenic emissions of carbon dioxide and other greenhouse gases.

3.4 SHARED ECOSYSTEMS, ECOREGIONS AND MIGRATORY SPECIES

In many instances, a mutual desire to protect and conserve shared ecosystems and shared wild flora and fauna can provide a powerful rationale for cooperative action. Many landscape features, such as rivers, lakes and shared ecoregions that are transected by or form national boundaries, are of special value to all three countries. In other instances, it can be a desire to protect shared migratory species from the effects of pollutants that prompts cooperation. Migratory species, including the monarch butterfly and many species of birds and mammals, fall in this category.

[31] In its draft report on restructuring the electric utility industry in Vermont, the Vermont Public Service Board states that many of the older thermal power plants, which were exempted from the 1970 *Clean Air Act*, are still in operation and, in a deregulated power generation market, will enjoy a competitive advantage over plants that currently must comply with modern emission standards. According to the report, the older plants are a major source of acid deposition and high mercury levels in the Northeast's rivers, streams and lakes. See Vermont Public Service Board 1996. Docket No. 5854 (16 October). *Investigation into the Restructuring of the Electric Utility Industry in Vermont, Draft Report and Order,* pp. 97-98. Similarly, in a report on the environmental effects of restructuring in Ontario, prepared for the Advisory Committee on Competition in Ontario's Electricity System, expert independent analysts concluded that, absent any new restrictions, deregulation would extend the lives of coal-fired power plants and result in their operation at higher capacity levels. See ARA Consulting Group 1996. *Electricity Competition in Ontario: Environmental Issues,* pp. 2-17.

3.5 IMPROVING THE QUALITY AND AVAILABILITY OF ENVIRONMENTAL INFORMATION

3.5.1 GENERAL CONSIDERATIONS

Cooperative research and monitoring programs can be important steps towards developing a shared understanding of air pollution problems, as well as providing the basis on which to develop coordinated action. There is clearly a need to catalyze important *international*, *interagency* and *interdisciplinary* cooperation in measuring, monitoring and assessing anthropogenic releases of pollutants to the atmosphere (and to other environmental media), their transport and transformation, their wet or dry deposition to terrestrial and aquatic ecosystems, and their pathways within these ecosystems. Addressing issues such as these will require collective as well as domestic investments in improved science and modeling capacities, harmonized emissions inventories, and the generation and use of quality information from coordinated monitoring programs.

In practice, data collected on emissions, atmospheric transport and deposition, and on receptor ecosystems are collected for different reasons and by scientists with different disciplinary backgrounds. There is an opportunity and a need for a more integrated approach, combining information on emission inventories and emission monitoring with atmospheric monitoring and modeling and, in turn, with the effects-oriented monitoring that predominates in ecological monitoring programs. Another major need is for the three countries to continue promoting the development of data and information systems that will facilitate the exchange of pertinent environmental data and information amongst the three countries.

3.5.2 POLLUTANT RELEASE AND TRANSFER REGISTERS

The development of cost-effective measures for pollution prevention requires knowledge of the relative contribution of different sources to a given problem. Ideally, emission inventories should include estimates of the quantities of pollutants from all significant source categories, including mobile sources (such as cars, trucks, off road vehicles, ships and trains), stationary sources (such as utilities and large manufacturers), area sources (groups of small sources such as dry cleaners and gasoline stations), and natural sources (such as volcanoes). Canada and the United States each maintains various emissions inventories, although the types of pollutants they cover, their level of detail, the methods for compiling the information, and the frequency of updating differ, Nevertheless, there are opportunities to make them more comprehensive and comparable.

Pollutant release and transfer registers (PRTRs) report on an annual basis on the releases and transfers of certain pollutants from facilities, and are intended for regular and active public dissemination. In the United States, the PRTR system is known as the Toxics Release Inventory (TRI); in Canada it is the National Pollutant Release Inventory (NPRI). Mexico is in the process of developing its PRTR system, which will be the *Registro de Emisiones y Transferencia de Contaminantes* (RETC).

The US and Canadian PRTRs have similarities and many differences, including the coverage of somewhat different populations of industries and sets of chemicals. All three countries recognize the need to expand the coverage of their PRTRs. For example, the US Environmental Protection Agency has a current initiative to expand the chemical list and broaden the industrial coverage. The Mexican PRTR is planned to begin data collection in 1997, although its industrial and chemical coverage has not yet been made final.

Although it is unrealistic to expect the development of fully integrated emissions inventories in the short term, the three countries could work together to facilitate the sharing of information on emission sources and their relative importance. Over the long term, the goal should be compatible emissions and release inventories from each country that can be combined to provide the public with current, accurate data.

This work could build on existing initiatives within the CEC to promote the harmonization of emissions data, including Resolution 96-05, in which the three countries agreed to "promote regional cooperation...for the development of air quality monitoring, modeling and assessment programs in North America through the promotion, collection and exchange of appropriate data...." Through the Air Monitoring and Modeling Project, the CEC is working with the Western Governors' Association to evaluate the applicability of the US emission inventory database system to Canada and Mexico, and if it seems promising, to initiate system design in order to facilitate data interchange.

3.5.3 RESEARCH AND MONITORING OPPORTUNITIES

An important consideration is the need for increased trinational collaboration in the ecological monitoring of status, trends, conditions and emerging issues within North American ecosystems, with emphasis on the extent to which ambient air quality and pollutant loadings are affecting these ecosystems and human health. Specific opportunities for cooperation include:

- sharing existing and emerging knowledge on: a) techniques for monitoring emission rates and ambient loadings; b) methods to assess ecological and human health impacts; and c) technologies and processes to prevent and reduce pollution from common North American sources, including power generation, transportation, and agriculture;
- joint planning of cooperative research and monitoring initiatives, including regional surveys to address spatial trends and variability, long-term monitoring to address temporal trends and variability, and targeted research to address key unresolved issues;
- agreement on reference or index sites, including some at high elevation sites, for integrated ecological monitoring;
- agreement on sampling protocols and key parameters to be assessed;
- agreement on procedures for data quality assurance and control;

- modeling to guide research and monitoring efforts;

- evaluation and assessment of science-based environmental information to assist governments, industry and the public in making more informed, more responsible decisions concerning the continental pollutant pathways issue;

- collaborating on the development of analytical methods for measuring pollutant concentrations and fluxes within and between environmental media; and

- collaborating on the development of models linking releases to the atmosphere, to atmospheric transport or deposition, and to ecological impacts on terrestrial and aquatic ecosystems. These models should be intended to enhance understanding of the nature and significance of the long-range transport of pollutants and predict pollutant loadings to target ecosystems in response to emission reductions.

In August 1996, the CEC resolved to promote regional cooperation for the development of air quality monitoring, modeling and assessment programs. An important point emphasized by the Panel Report is that improving our understanding of the nature of the continental pollution problem will require that such cooperation extend beyond harmonized methodologies and shared data. In particular, the Panel Report suggests that the following issues should be addressed:

- There is too little monitoring of atmospheric transport trends and conditions. Current monitoring tends to focus on ground level as opposed to atmospheric air quality. This is largely because most monitoring networks have been established to determine local ambient concentrations. Consequently, most are located in and around cities and at, or close to, ground level. This has two implications. First, the focus on ground-level conditions provides an incomplete understanding of continental-scale mechanisms because much of the long-range transport occurs higher in the atmosphere. Second, it underestimates the influence of transported air pollution since many pollutants, such as ozone, can be destroyed at ground level.

- Current monitoring efforts do not adequately link air quality with other (water, soil and biota) parameters. While there have been major reviews of ecological monitoring programs in both Canada and the United States, there is much to be gained by encouraging international cooperation in the planning and operation of national programs so that they are more compatible, and hence better suited to addressing transboundary and international aspects of environmental pollutants. A case study in the Panel Report highlights the need for cooperation in the establishment of reference sites for the integrated ecological monitoring of ambient concentrations, depositions and fluxes, effects and fates of continental pollutants.

- An effective North American program dealing with these pollutants will require the ability to monitor their extent of transport, deposition, and ecosystem and health effects. Efforts to develop this capacity could build upon the monitoring networks already in place.[32]

- There are opportunities to build upon existing scientific collaborations. The North American Research Strategy for Tropospheric Ozone, for example, is a public/private partnership whose membership spans government, the utilities, industry, and academia throughout Mexico, the United States, and Canada. Its primary mission is to coordinate and enhance policy-relevant scientific research and assessment of tropospheric ozone behavior, with the central goal of determining workable, efficient, and effective strategies for local and regional ozone management.

- Funds and human resources dedicated to research on and monitoring the continental pollutant pathways have declined substantially during recent years. This trend will need to be reversed in order to enable the three countries to assess accurately the problem of long-range pollutant transport and evaluate the effectiveness of domestic and international programs.

3.6 BUILDING NATIONAL CAPACITY

There is a clear opportunity for the three countries to work together in the sharing of information, expertise and best practices for reducing emissions of pollutants to the atmosphere and other environmental media. An important aspect could be specific capacity development programs oriented to continental pollution. As a minimum, the three countries should ensure that existing and new capacity development programs, wherever possible, contribute to addressing these issues. The three countries could also commit to work with international financial institutions to design and implement programs to enhance Mexico's capacity to address continental pollutants. In any event, it will be important to support ongoing efforts such as the pilot project of the Western Governors' Association to provide training and build technical capacity by assisting in the development of an emissions inventory for Mexico (Subsection 3.5.2).

3.7 BUILDING ON BINATIONAL ACHIEVEMENTS

As outlined in Subsection 2.4 and in the Panel Report, the success and experience that Canada, Mexico and the United States have gained working together at the bilateral level provide a firm basis for environmental cooperation at the trinational level. Clearly, many of the more pressing air pollution challenges are in boundary areas and call for binational cooperation and binational action. There are, however, also many instances where pollutants are transported by the atmosphere and other media over distances that extend well beyond boundary areas. In these cases there is a clear need for a similarly broad scale of cooperation—cooperation that will complement and strengthen binational initiatives. Trinational cooperation provides this and also invites consideration of the underlying social, economic and political realities that are part of the problem and potentially part of the solution.

[32] The Panel Report describes major monitoring systems in Canada, Mexico, and the United States with particular relevance to the continental pollutant pathways issue.

3.8 INTERNATIONAL LEADERSHIP

Canada, Mexico and the United States are well positioned to play a collective leadership role on long-term and large-scale environmental issues. All three countries have been, and are, active participants in international negotiations on current and pending international environmental conventions and other agreements. The NAAEC and the increasing cooperation on environmental issues amongst the three countries could be a basis for greater cooperation in international fora, especially to ensure that collective concerns of the North American region are reflected in these settings. There are instances—such as the long-range transport of pollutants—when a collective North American perspective could serve as an important example of how three quite different countries are working together on a matter of growing concern to many regions in the world.

3.9 SETTING THE STAGE FOR COLLABORATIVE ACTION: DOMESTIC PROGRAMS

While collaborative action must take account of the three countries' different circumstances, capacities and rights to determine appropriate domestic environmental management strategies, there is a range of opportunities for collaborative action to reduce emissions of these pollutants.

As a minimum, the countries could work towards the development of shared objectives and mutually agreed-upon country-specific emission reduction targets for selected source categories (such as the transportation and electric power generation sectors). These emission reduction targets should be based on similar overarching objectives, but will need to be differentiated to reflect different economic and environmental circumstances. This is an increasingly common approach for multilateral environmental agreements and initiatives. It is the approach taken, for example, by the UN Framework Convention on Climate Change.

North American collaboration must have the underpinning of effective domestic action. Domestically, a number of important changes appear to be warranted. First, the Panel Report emphasizes the need for a more integrated approach to the regulation of air pollution. As Subsection 2.2.6, above, emphasizes, such an approach should be multi-media-based and ecosystemic in orientation, to reflect the integrated nature of pollution problems. Policy makers may therefore need to re-evaluate the efficacy of those existing regulations that are based on the risks of exposure to a chemical through a single pathway.

Second, domestic policy should also be focused primarily on pollution prevention as the primary means for reducing pollution. Compared to approaches focused on management and cleanup, pollution prevention can more efficiently address the risks associated with widely disseminated pollutants by avoiding or minimizing their creation and release. Expanding programs to reduce solid waste, increase energy efficiency, and further the use of renewable energy sources and low emission vehicles could also have significant air pollution benefits throughout the three countries.

Finally, each nation may have to seek new sources of revenue, both to continue implementation of effective monitoring and pollution prevention and control efforts and to support cooperative programs. At present, each country is actually reducing public expenditures in several areas related to environmental protection. Many existing monitoring sites in the United States and Canada are being dismantled as a result of current funding cuts. These ominous trends do not bode well in terms of the long-term capacity to reduce the exposure of humans and the environment to persistent pollutants released to the atmosphere and other environmental media.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

- Many persistent pollutants, once released to the atmosphere or other environmental media, are transported long distances within North America as well as to and from it. The distance a pollutant is transported depends on many factors, including its physical and chemical characteristics, the location and elevation of the emitting sources, and wind and weather patterns. Continental pollutant pathways, as emphasized in the Panel Report, are not simply an air pollution issue. While initial focus of attention has been on anthropogenic pollutants released to, formed within, and transported by the atmosphere, it is clear that this is very much a cross-media issue involving multiple routes of exposure to humans and other living organisms.

- Continental pollutants are affecting human health and the environment throughout North America. As the scientific Expert Advisory Panel emphasized: "*enough is already known on most fronts for us to say, unequivocally, that significant emission reductions from present levels are needed now.*"

- Pollutants released to, formed within, and transported by the atmosphere pose a significant risk to human health and to the ecological integrity of sensitive terrestrial and aquatic ecosystems.

- There are populations in all three countries that are more vulnerable to the effects of pollutants. They include children, pregnant women and women of childbearing age, the elderly, people with respiratory problems, and indigenous peoples and others that rely on fish and wildlife as a major part of their diet. Developing embryos and nursing infants are also particularly at risk.

- Major sources of continental pollutants include electric power plants, the transportation sector, industrial combustion of fossil fuels, municipal and medical waste incinerators, and chemical use in agriculture. Improved emission reduction technologies and pollution prevention techniques and processes are available to reduce emissions of many of these pollutants.

- Domestic and bilateral efforts are not sufficient on their own. This is a continent-wide problem, whose effective and efficient resolution requires trilateral collaboration to:

1. reduce anthropogenic emissions of pollutants, focusing initially on major common source categories such as transportation, electricity generating utilities using fossil fuels, and agricultural chemicals;

2. increase our understanding of continental pollutants and pathways; and

3. enhance each country's capacity to manage continental pollutants.

- North American collaborative action could focus on a small number of important common source categories. This could enhance the capacity of the region as a whole to reduce the risks from continental pollutants, since each country shares many of the same types of sources of these pollutants and many emission sources are responsible for more than one pollutant.

- North American ecosystems and weather patterns link three very different countries. Collaborative action will have to take into account the differences in economic and social situations and levels of development in each country, as well as their financial capacities and technological capabilities.

- North America will need to work with other regions to address emissions sources from outside the continent, as well as those from North America affecting other regions. Effective collaboration in addressing this issue could also strengthen an important international leadership role by demonstrating the potential for multilateral action to address an issue of growing concern for many regions in the world.

- Comprehensive and up-to-date information and understanding are essential for effective and efficient control strategies at domestic and international levels. The three countries need to coordinate and update emission inventories to make them more comparable and more comprehensive. There is a similar need for collaboration among those involved in ecological research and monitoring of terrestrial and aquatic ecosystems in the three countries, in the development and adoption of indicators of the status and integrity of these systems, and in the sharing of data and information. These approaches, as well as atmospheric monitoring and modeling efforts, are all essential to understanding and addressing the issue of continental pollutant pathways. A greater effort to combine these different lines of effort into a more integrated ecosystemic approach is warranted.

It is apparent that funds and human resources dedicated to researching and monitoring the continental pollutant pathways issue have declined substantially during recent years. Reversing this trend is essential for understanding the problem of transboundary pollution, taking appropriate action to deal with it, and evaluating the effectiveness of domestic and international efforts.

4.2 RECOMMENDED NEXT STEPS

4.2.1 THE CONTEXT

A central issue is the need to establish an effective collaborative mechanism with the authority, expertise and motivation to develop and take the steps that are needed to ensure that the continental pollutant pathways issue becomes, and remains, a significant trinational priority. This will necessitate a long-term commitment and continuing vigilance in order to reduce gradually human and environmental exposure to pollutants released to, formed within, or transported by environmental media.

The precise details as to what would constitute an effective collaborative mechanism for addressing the many dimensions of the continental pollutant pathways challenge would, it is assumed, evolve during the course of trinational discussions and negotiations. There are, however, some elements that seem both obvious and essential. These include a joint recognition of the seriousness of the issue and agreement to make a concerted collaborative effort to address this international, cross-media challenge that is so intimately linked to human activities and to the health of humans and the environment. It is assumed that some form of framework agreement would be necessary and that the framework would reflect an ecosystem orientation.

A shared vision and sense of direction as expressed through generally-held goals and objectives for the protection of human health and the environment are important, as is a recognition of the need to allow for compatible but differentiated targets, timetables, and approaches by each of the countries. Agreement on ambient air quality objectives, acceptable pollutant loading rates to sensitive terrestrial and aquatic ecosystems, and parameters to be used as indicators of ecosystem health would in turn provide a basis for measuring progress and assist in identifying and assessing emerging issues.

The need for adequate environmental information is clear. This will mean a continuing commitment to work together—in an international, interdisciplinary manner—in the planning and conduct of monitoring, modeling, and research programs. It is particularly important that the data collected be comparable, of known quality, and adequate for intended purposes, and that provisions be made to ensure that information on the status and trends of environmental indicators, including regular reports on progress—or lack thereof—be made available to the public.

An agreed-upon strategy can encourage the establishment of common objectives, the development and use of differentiated targets and timetables and the development and implementation of cooperative programs.[33]

[33] The Sound Management of Chemicals Project of the CEC is a good example of an initiative that addresses specific chemicals of concern by establishing targets and implementation measures.

It would explicitly adopt a holistic perspective based on the concept of the interconnected components of the North American ecosystem. It would need to have the ability to evolve and adapt in response to new information on long-recognized problems and emerging problems so as to restore and maintain the ecological integrity of North America.

Understanding and addressing "continental pollutant pathways" calls for an integrated "ecosystem approach" such as that developed under the Canada–United States Great Lakes Water Quality Agreement of 1978, amended and extended in 1987. Such an approach is seen as being very important to the establishment of collaboration appropriate to the scale and complexity of the challenge of continental pollutants, and is at the same time conducive to more informed and more responsible decisions and actions by all stakeholders. The Panel Report makes this point very explicitly: *"continental pollutant pathways is a cross-media issue and an integrated approach is required if it is to be understood and addressed effectively."*

It must be made very clear, however, that an ecosystem approach is not an excuse for inaction, but on the contrary, can provide a powerful rationale for making timely, informed, and responsible decisions *based on available data and information.* It is also important to understand, as has been applied in the Great Lakes Basin Ecosystem, that humans and human activities are an integral part of the system. Recognition of the linkages between human activities, human health, social and economic well being, and the integrity of the rest of the system have served to build and sustain public and political support and guide public policy. Point source-by-point source, media-by-media, and especially substance-by-substance approaches to the reduction of anthropogenic releases of pollutants to the environment can be useful and important, but they need to be nested within a comprehensive overall strategy that reflects an ecosystem approach. Given the scope of the problem posed by continental pollutants, it will be necessary to build on existing collaborative initiatives, mechanisms and institutions, and establish priorities to focus collaborative action.

4.2.2 SPECIFIC RECOMMENDATIONS

The Secretariat of the CEC recommends to the Council that it:

1. actively promote collaboration amongst the Parties to NAAEC, when working in international and multilateral fora, to ensure that collective regional interests are adequately reflected. NAAEC provides a framework for cooperation that can, in the Secretariat's view, be used by the Parties to help them play a major global leadership role in addressing critical long-term and large-scale threats to regional environmental security.

2. recommend that the Parties ensure that the funds and human resources allocated to continental pollutant pathways research, monitoring, and modeling and assessment in their national and cooperative programs are adequate to meet current and future needs. The Secretariat recommends that recent alarming trends of reduced expenditures on research and monitoring be reversed.

3. foster and increase cooperation to promote capacity building and best practices in all matters pertinent to the continental pollutant pathways issue and identify new opportunities for implementing "win-win" and "no regrets" programs and projects to reduce emissions of targeted pollutants.

4. take into account the differences in the three North American nations and, where new and additional resources are required by Mexico, encourage the Parties to work jointly with international institutions in seeking additional funding to support the implementation of measures pertinent to technological innovation and to the understanding and management of atmospheric pollutants and those of other environmental media. This must include researching, monitoring, and modeling the sources, transport, fate, and effects of pollutants on human health and terrestrial and aquatic ecosystems.

5. assume a lead responsibility for promoting and coordinating trinational action to reduce the exposure of humans and the environment to pollutants released to, formed within, and transported by the atmosphere and other environmental media.

6. establish a high-level working group composed of experts responsible for regulating anthropogenic releases of pollutants to the atmosphere, for managing atmospheric monitoring and modeling programs, and for the ecological monitoring of the deposition and effects of airborne pollutants on humans and terrestrial and aquatic ecosystems. This working group should report to the Council, initially within a two-year time-frame, with advice and recommendations on matters such as the following:

(a) priorities for action with respect to specific pollutants, clusters of pollutants, or specific source categories that are major emitters of pollutants to the atmosphere;

(b) science-based ambient air quality objectives for the protection of human health and the environment;

(c) scientifically determined maximum target loadings of certain pollutants to selected terrestrial and aquatic ecosystems;

(d) science-based regional emission reduction targets that are estimated to be generally consistent with recommended ambient air quality objectives and target loadings;

(e) measures to enhance trinational coordination amongst research, monitoring, and modeling programs in the three countries;

(f) monitoring sites to be designated as reference or index sites for the long-term integrated ecological monitoring of status, trends, and ecological conditions, including measurement, monitoring, and assessment of ambient air quality, the atmospheric deposition of selected pollutants, and the fluxes, fate, and effects of these pollutants on reference ecosystems. The group should also include suggestions as to the selection of indicative parameters and sampling protocols to ensure appropriate levels of quality control and quality assurance of the data generated at these sites; and

(g) a draft agreement presenting an action-oriented framework, consistent with an ecosystem approach, to guide and facilitate trinational cooperation in addressing matters pertinent to the understanding and management of the continental pollutant pathways issue, including recommendations as to appropriate mechanisms to lead and coordinate framework implementation.

7. consider the effects of future policies and programs that are expected to have significant impact on the continental pollutant problem, including, for example, the pending restructuring of electricity markets, and the development of North American mobile source emission and pesticide-related standards.

8. consider, as part of the 1998 annual work program of the CEC, relevant studies of emission source categories in specific sectors to better understand and identify opportunities for minimizing the magnitude and impact of transboundary pollution, and to facilitate the increased exchange of information on these matters.

9. establish, in the interests of accountability and informed decision making, a public advisory body to support, review, and inform the decisions made throughout this process, and report on an annual basis on progress towards the development and implementation of the framework agreement referred to in 6(g) above.

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***** Dr. Robert Garrett and Dr. Patricia Rasmussen, scientists involved in the Expert Advisory Panel, have registered their concerns that the report does not adequately reflect the complexity associated with source apportionment where aerosols have both natural and anthropogenic origins.

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CASE STUDIES PREPARED BY THE EXPERT ADVISORY PANEL ON CONTINENTAL POLLUTANT PATHWAYS FOR THE CEC SECRETARIAT

G. Case Studies on Chemicals

G1: Mercury

W. Pilgrim, M. Lucotte, S. Montgomery, C. Santos-Burgoa, M.I. Ibarrola Uriarte, F. Abascal-Garrido, M. Round, D. Porcella

G2: Persistent Organic Pollutants: General Characteristics and Continental Pathways in North America

T. Bidleman, D. Muir, F. Wania

G3: Dioxin

M. Cohen, B. Commoner, A. Espitia Cabrera, D. Muir, C. Santos-Burgoa

G4: Ozone and Particulate Matter in the Atmosphere

G. M. Mejía, J. McTaggart-Cowan, B. Hicks, C. Santos-Burgoa

G5: Effects of Acid Rain

T. Brydges, H. Bravo, R. Sosa

H. Case Studies on Source-Receptor Relationships

H1: Source-Receptor Relationships

J. Young, S. R. Radonjic, D. V. Michelangeli, F. Guzmán, C. Santos-Burgoa

H2: Impact of Air Pollution on Forest Ecosystems

D. Cantin, P. Hall, K. Percy

H3: Persistent Organic Contaminants in the Canadian Arctic: Implications for Indigenous Peoples

D. Muir

H4: Water Perspective

M. Mazari-Hiriart

I. Case Studies on Cooperation

I1: The International Joint Commission and its Role in Transboundary Air Quality Issues

A. Hamilton

I2: Solving Air Problems in Paso del Norte

P. M. Emerson, C. L. Shaver, C. A. Rincón et al.

I3: Monitoring Air Toxics: The Integrated Atmospheric Deposition Network of the Great Lakes

A. Bandemehr, R. Hoff

I4: Ecological Monitoring in North America

T. Brydges, C. Santos-Burgoa, G. Veith

I5: International Cooperation: The Arctic Environmental Protection Strategy and the Arctic Council

D. Stone

J. Case Study on Opportunities

J1: Pollution Prevention through Technology Innovation and Increased Regional Competitiveness

C. Santos-Burgoa, M. I. Ibarrola, M. Cohen, J. MacDonagh-Dumler, J. McTaggart-Cowan

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