Summary of Critical Air Quality Issues in the Transboundary Region

Report from the
International Air Quality Advisory Board

to the
International Joint Commission

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Cover Illustration Credit:
Geographic Distribution of Contributions to
Atmospheric Deposition of Mercury to Lake Superior,
2001-2003 Priorities Report to the International Joint Commission
(Dr. Mark Cohen, NOAA-ARL)

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FIGURES

1.0

MANY 'DIRTY DOZEN' PERSISTENT TOXICS DIMINISHING IN THE GREAT LAKES. NEW POLLUTANTS TAKING THEIR PLACE. THOSE WHICH REMAIN ARE PRIMARILY FROM REGIONAL AND GLOBAL ATMOSPHERIC TRANSPORT.

1.1 Story

A number of toxic substances are capable of intercontinental atmospheric transport; their ability to ultimately increase contamination of terrestrial and aquatic ecosystems continues to be of great concern. Among these substances are some of those identified as Critical Pollutants by the Water Quality Board of the International Joint Commission in 1985, including mercury, toxaphene, hexachlorobenzene, and PCBs.

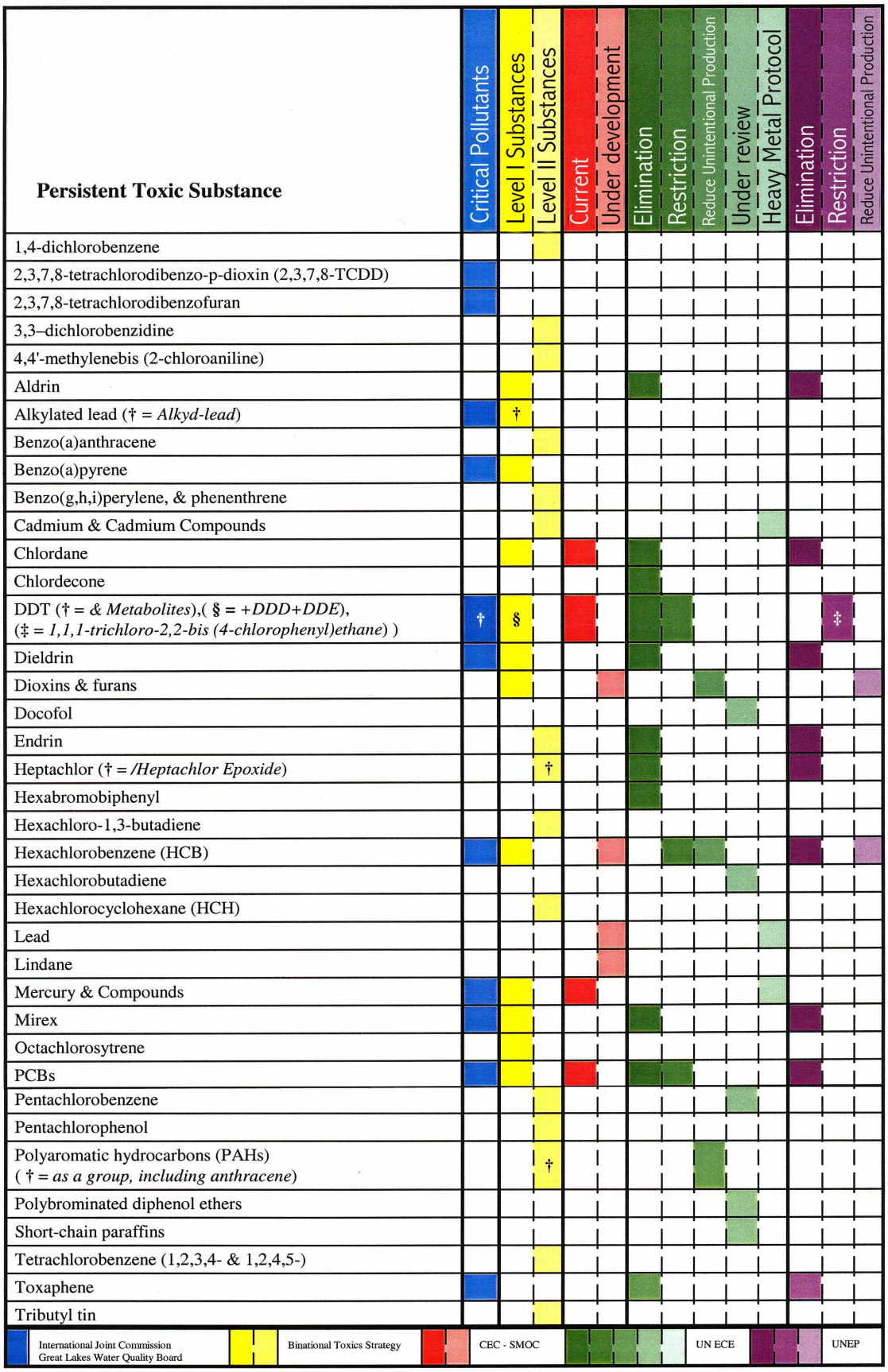
These pollutants were designated because of their chronic toxic effects, long lifetimes in the environment and their bioaccumulation in ecosystems which continues to cause a variety of deleterious effects, particularly in humans. At certain levels, current Great Lakes pollutants are associated with adverse health effects including damage to liver, kidney, nervous system, endocrine system, reproductive organs and immunological systems. Exposure to some of these contaminants has also been linked to breast cancer, learning disabilities, autism, and infertility.

Evidence of the accumulation of persistent toxic substances (PTSs) in various ecosystems, such as the Great Lakes and the Arctic, as a result of the long-range transport of these substances, has mounted. Atmospheric deposition has been identified as the principal pathway for new inputs to these regions of several of these contaminants.

Since 1985, the Great Lakes Water Quality Board, the US-Canada Binational Toxics Strategy (BTS), the United Nations Economic Commission for Europe (UNECE) Protocol on Persistent Organic Pollutants (POPs), the Stockholm Convention (UNEP), and the Commission for Environmental Cooperation (CEC) Sound Management of Chemicals (SMOC) initiative have all focused attention on the chemicals summarized in Table 1.

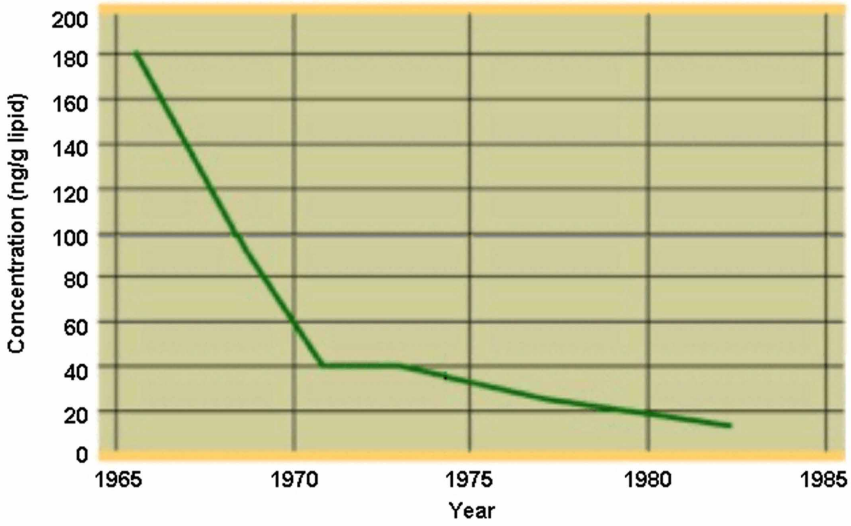
Substantial progress has been made in management of the 'dirty dozen' PTSs, identified by the Water Quality Board in 1985. Active use and production of many persistent, bioaccumulating toxic substances has been banned or sharply curtailed over the past twenty years. However, even in the case of banned substances, soil and sediments in water bodies remain contaminated, leading to significant re-emissions and continued damage to ecosystems.

Table 1 Various Organizational Frameworks and Program Status: Persistent Toxic Substances



The levels of many of these persistent toxic substances have been decreasing, not only in the environment but also in human tissue samples. For example, the pesticide dieldrin was banned from almost all uses in the early 1970's. Figure 1 shows the corresponding drop in dieldrin in human breast milk. This is evidence that the efforts to reduce environmental levels of PTSs can result in relatively rapid and noticeable reductions in human exposure levels.

Figure 1 Dieldrin in Breast Milk, Canada



Source: Natural Resource Defense Council
http://www.nrdc.org/breastmilk/chem3.asp

In the Great Lakes region, the deposition of HCH, DDE, PCBs and total metals is showing a steady decreasing trend. Furthermore, contaminant levels in fish decreased in the 1970s and 80s, and levels of PCBs and DDT in top predators have declined significantly (Ref. 1). Indeed, at this time, the lakes may prove to be of more significance as a source of several of these contaminants to other regions.

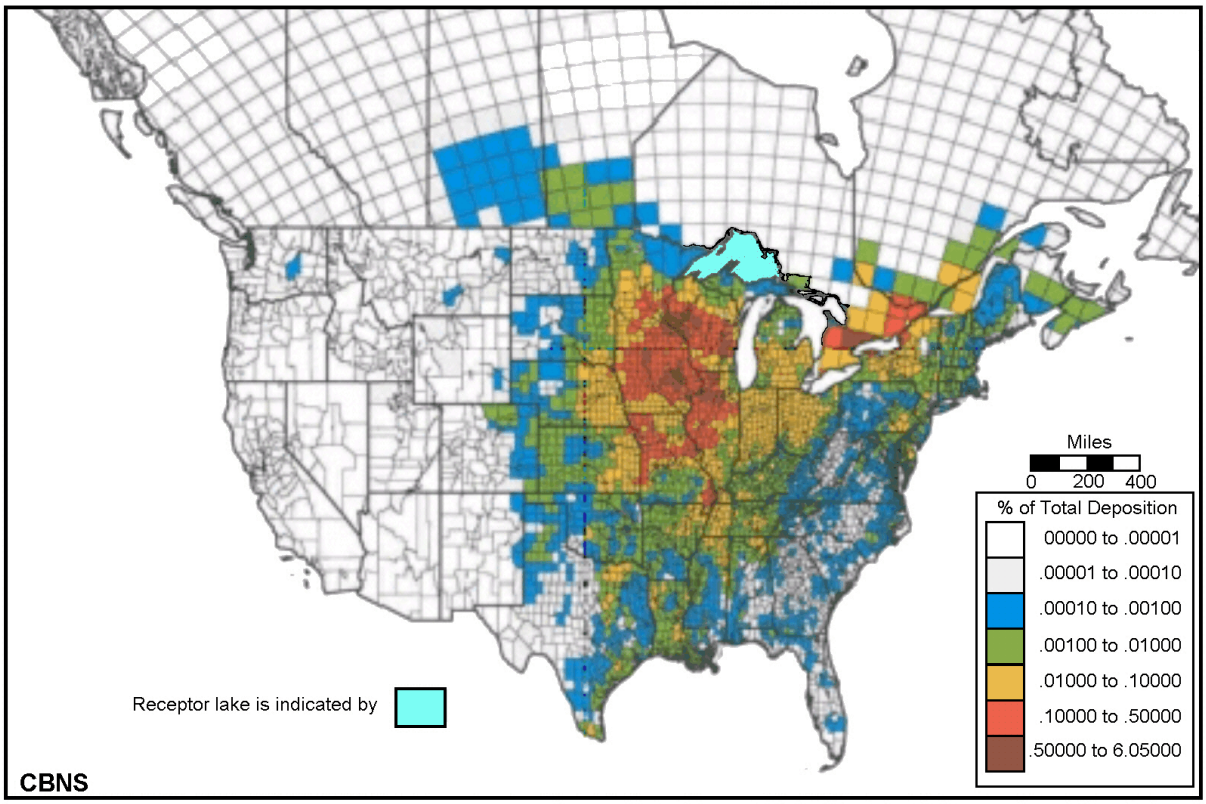
Unfortunately, this story is not uniformly positive. Unlike many PTSs, mercury levels have increased in the past 20 years in fish-eating birds and mammals (see section on mercury). It is important to note that although pathways into and out of the Great Lakes basin are relatively well understood, this is not the case in areas such as the west coast, the mountain ecosystem, and the central agricultural region of the United States and Canada.

Further, the transport of particulate matter from Mongolian dust storms under various meteorological conditions to North America has been confirmed, suggesting that persistent toxic substances from southern urban and industrial centres might also follow the same route to this continent.

In addition, current-use pesticides such as atrazine (Figure 2 shows the geographic distribution of sources contributing to the deposition of atrazine to Lake Superior) have been

Figure 2 Geographic Distribution of Source Contributions to Atrazine Deposition

(% of Atrazine Deposited on Lake Superior from Each Source)



demonstrated to be ubiquitous and more persistent in many regions than indicated by their initial assessment. These 'second generation' contaminants are appearing in many foods, and their management is of concern. Finally, as the transport and deposition of POPs (Persistent Organic Pollutants, a subgroup of these contaminants) to the Arctic, and the subsequent contamination of the food chain there are documented further, concern regarding impacts on the human population has been heightened.

For those PTSs for which significant progress toward remediation has yet to be made, the knowledge base for future management has developed rapidly on all scales from local to global. Recent research, however, has suggested that urban centers are a substantial source of toxic emissions, including mercury, PCBs and dioxins and the magnitude of these sources remains largely unquantified. Special attention should be paid to quantifying the transport of such contaminants from urban cores to adjacent agricultural crop districts and other non-urban areas. However, evidence is mounting that other similar pollutants could pose significant threats. Further, a new class of hazardous persistent compounds, including PBDE's and phthlates, is emerging. Some of these are "estrogenic" compounds which have the capability to disrupt human and animal reproductive systems.

1.2 What Does It Mean?

While existing international agreements for further control should be supported, knowledge of the levels and trends of these pollutants in the environment and ecosystems should be enhanced, and remediation efforts intensified, there is also an evident need to move beyond the substances currently addressed by various agreements toward emerging contaminants such as those noted above. The elements of a regional and global assessment program, including binational and multilateral monitoring, modeling and emission inventory initiatives, and further research on effects on humans and the environment must be put in place if the significance of these contaminants is to be fully understood and effective prevention and remediation programs developed.

1.3 Recommendations

1. A scientific assessment of the current state of and gaps in our understanding for PTSs is required. Areas of particular importance are:

    a. Mercury, where levels in fish eating birds and mammals in some locales continue to increase as does the number of fish advisories.
    b. The role of urban centers as major sources of PTSs. Special attention should be paid to the impact of urban emissions on crops in adjacent agricultural lands.
    c. The ubiquitous nature of current-use pesticides and unlisted Persistent Organic Pollutants which are now appearing in foods and sources of drinking water.

2. This assessment should evaluate emerging research on substances thought to be reproductive or endocrine disrupters and recommend specific future activities to assess the extent of this threat.

3. The Commission should continue to reinforce its advocacy of the development and implementation of multilateral programs to reduce emissions of these substances regionally and, where appropriate, globally.

4. As a review of the Great Lakes Water Quality Agreement is under consideration, the Commissioners should encourage the Parties toward inclusion of substances of emerging concern as well as delineation of a process for their continued assessment.

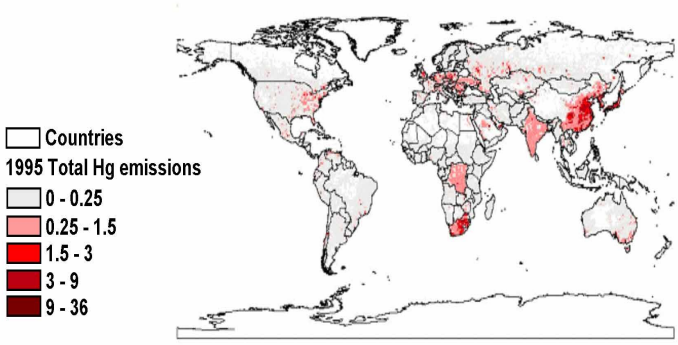
2.0

GLOBAL MERCURY EMISSIONS UNCHANGED: REDUCTIONS IN NORTH AMERICA OFFSET BY INCREASES IN ASIAN CONTRIBUTION.

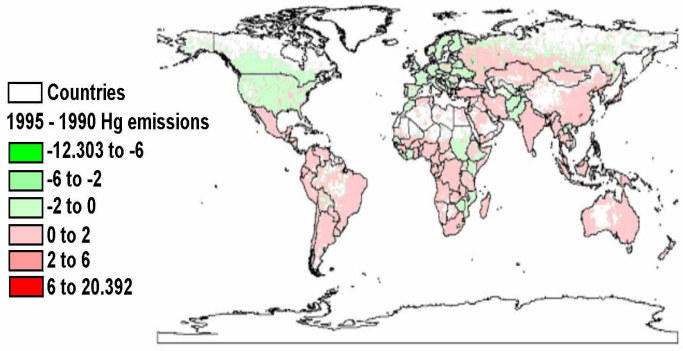
2.1 Story

Total annual anthropogenic mercury emission trends estimated from global emission inventories indicate no significant change in total emissions between the years 1990 and 1995. However, a shift is apparent in the nature of the dominant sources, and their respective geographic locations. The 1995 anthropogenic mercury sources attributed to Asian emissions were estimated at 56.1 percent of the total global anthropogenic emissions, a 25 percent increase over emissions from this continent in 1990. The increase was due largely to additional coal combustion in China and has been offset by reductions in other parts of the globe.

Figure 3 Global Mercury Emissions



Anthropogenic emissions of total mercury in 1995 (tonnes)



Comparison of anthropogenic emissions of total mercury in 1995 and 1990 (legend shows difference in emissions, in tonnes, per grid cell between 1990 and 1995, green shades indicating reductions, red shades indicating increases).

Mapping 1995 global anthropogenic emissions of mercury
(Jozef M. Pacyna, Elisabeth G. Pacyna, Frits Steenhuisen, and Simon Wilson)

Mercury is capable of intercontinental atmospheric transport and can, through deposition, increase contamination of aquatic ecosystems.

At current levels, mercury in the Great Lakes and the Arctic pose the greatest health risk to individuals whose diet is composed largely of local fish and game, those who have higher than typical fish consumption habits, or sensitive subpopulations such as young children and pregnant women. In some of these locales, mercury levels have increased in the past 20 years in fish-eating birds and mammals. The number of North American water bodies subject to fish consumption advisories due to mercury contamination has also increased.

In seeking a global remedy, European nations, United States and Canada initially approached the United Nations Economic Commission for Europe (UNECE) where a convention on the Long-Range Transport of Air Pollution (LRTAP), meant to address acid rain precursors, already existed. Subsequently the UNECE established a protocol in June1998 on heavy metals which included mercury. Ratification of that protocol is now complete and it entered into force as of December 29, 2003.

Many of the UNECE members also promoted the development of a global agreement under the auspices of the United Nations Environment Programme (UNEP) to contend with the growing global problem of persistent organics. This global agreement is acknowledged as the UN Stockholm Convention on Persistent Organic Pollutants (a subset of the PTS). Mercury was not added to the Stockholm Convention although its organic form, methyl mercury, was considered.

In North America, a tri-lateral approach facilitated by the North American Commission for Environmental Cooperation has developed and is implementing a North American Regional Action Plan focused on mercury. In addition, the US/Canada Binational Strategy under the Great Lakes Water Quality Agreement set targets for mercury reduction from both countries. Several legislative initiatives meant to reduce mercury emissions from the electric utility sector are under consideration in the US and Canada but the promulgation and implementation of such legislation are uncertain at this point.

2.2 Recommendations

1. Governments from both countries should continue to support mercury reduction efforts. In addition, the existing mercury measurement programs in North America should be refocused to demonstrate the effectiveness of mercury control programs in reducing mercury in the atmosphere, fish, wildlife and humans.

2. The contribution of urban centers as a fugitive source of mercury emissions should be quantified.

3. The governments should continue to vigorously pursue a global agreement on the reduction of mercury from all of the major source regions.

3.0

MEETING TIGHTENED US AND CANADIAN AMBIENT AIR QUALITY HEALTH BASED STANDARDS FOR OZONE AND PARTICULATE MATTER (PM) WILL CHALLENGE GOVERNMENTS AND THE PUBLIC.

3.1 Story

Since the last IAQAB Special Report, analyses of the scientific bases for the ozone and particulate matter (PM) health standards have been completed and new standards were promulgated in each country. In each case both the form and numerical value of the standards were made more stringent to reflect new scientific information on the immediate (acute) and long term negative health effects experienced by the general population, and most dramatically by sensitive subgroups or exposure to these pollutants.

The previous standards for ozone and PM were not adequately protective of public health, and there were incidences of morbidity and/or mortality experienced by sensitive members of the general population caused by levels of exposure that were once considered safe. While the new standards are more stringent, most recent research indicates that adverse health impacts will persist at concentration levels equal to or below those in the new standards.

The new US ozone standard of 80 ppb is based on an 8-hour running average. (The previous standard was 120 ppb over one hour). There is also a new statistical basis for determining noncompliance. The Canada Wide Standard is to be lowered from the current 82 ppb level for one hour to 65 ppb averaged over eight hours, to be attained by the year 2010. Achievement will be predicated on the 4^{th} highest daily maximum 8-hour mean concentration averaged over three years being below the standard value.

For particulate matter, the focus was redirected from PM_{10} to $PM_{2.5}$ or the finer fraction, to respond more fully to concerns of excess morbidity and mortality among sensitive or susceptible members of the general public from this contaminant. In Canada the new daily (24 hour) $PM_{2.5}$ standards will be 30 $\mu g/m^3$ to be achieved by 2010. In the United States the $PM_{2.5}$ standard will be an annual average of 15 $\mu g/m^3$, and a daily (24 hour) average of 65 $\mu g/m^3$. These latter US standards are based on averaging data from three years and are to be achieved within the next few years, following submission and approval of State Implementation Plans (SIPs). Both federal governments and the states and provinces are currently developing strategies to achieve these revised standards.

Recognizing that the transboundary flow of air pollution has a significant effect on attainment and maintenance of air quality standards in the adjacent country, in 2003, the governments of the United States and Canada announced two airshed pilot projects to further explore the human health effects of air pollution. In response to serious concerns about air quality expressed by Canadians and Americans, particularly those living in the Great Lakes basin and Georgia Basin-Puget Sound border regions, both projects are to explore possible joint strategies and management measures to maintain or improve air quality in these regions. Health studies, the appreciation of atmospheric science tools and science assessments, and targeted public outreach form some of the elements under consideration between the two federal governments as these projects evolve.

3.2 What does it mean?

These new, more stringent standards will require the development and implementation of new control strategies in both countries. In the United States implementation of these new strategies must demonstrate achievement of benchmarks indicating that affected populations are successfully being protected from continued exposure.

For ozone, the focus will be on reduction of the levels of nitrogen oxides as well as specific classes of hydrocarbons (VOCs) in the atmosphere, to lower the total burden of ozone in the atmosphere, and not just a reduction in the peak level observed during any particular day.

Recent modeled estimates of the contribution of global ozone background concentrations are in the vicinity of 15 ppb, with an Asian contribution of approximately 4-7 ppb. While these estimates should be considered preliminary, and global concentrations associated with particular elevated ozone events are lower, given the tightening of standards in both countries this external contribution takes on more significance. New opportunities to reduce the anthropogenic inputs contributing to the increasing global background for ozone should be identified and pursued.

For particulate matter, new strategies must be developed and employed to define and reduce the primary particle emissions of $PM_{2.5}$ from specific sources, and reduce the emissions of precursors, including acidic species such as SOx and NOx, which result in the formation of secondary $PM_{2.5}$. Because of the complexity of the $PM_{2.5}$ mass it is not possible to specifically identify those components associated with the most toxic effects. In future years, research may identify the specific compounds or components of concern, but at this time control strategies should be designed to reduce the entire ambient $PM_{2.5}$ mass.

In the Board's view, in areas affected by transboundary air pollution, air quality management would benefit from a procedure to understand and communicate the distinctions between the standards of each country and the further development and refinement of communication tools including forecasting capabilities that provide citizens of both countries with equitable protection of human health and the environment. This will be discussed in further detail later in the report.

Also, in addition to the steps already in place, including the further regulation of gasoline and diesel powered vehicles, successful attainment of these standards will require alterations in individual behaviour patterns and practices. Particularly important in urban settings, these changes should include the development of alternate transit and flexible workplace strategies to reduce traffic burden. Reductions in emissions from off road vehicles and small gasoline engines such as those used in personal watercraft, lawnmowers, chainsaws, etc., and reductions from open burning and wood-burning fireplaces should continue to be pursued.

FURTHER REDUCTIONS IN EMISSIONS FROM BOATS, SHIPS, PLANES, CONSTRUCTION EQUIPMENT AND SMALL GASOLINE ENGINES NEEDED

While both federal governments tighten emissions standards for cars and trucks fueled by gasoline and diesel fuel, other sectors such as off-road and non-road applications remain largely uncontrolled. Cleaner diesel fuel entering the market in 2006, and new diesel engine emission standards in 2007 should reduce $PM_{2.5}$ and hazardous air pollutants emissions substantially. However, even with these improvements, emissions from off-road diesel applications will remain significant largely due to the increased number of vehicles and increased usage.

Due to both the volume of emissions and their discharge in the upper atmosphere, aircraft also contribute significantly to air pollution, as do airport operations. Ships contribute approximately seven percent to the global emissions of NOx while adding to the $PM_{2.5}$ burden as well. The effects of this are most apparent in areas near major harbors and confined channels. Further multilateral action will be required to attain widespread reductions from these latter sources. A recent commitment under the Canada-U.S. Border Air Quality Strategy by the governments to address emissions from marine vessels on the west coast of North America is encouraging.

Also, the relative importance of emissions from ski-doos, sea-doos, outboard motors and lawn maintenance equipment, chainsaws, small generators and other personal use devices has increased substantially. The introduction of 4-stroke technology to many of these applications has the potential to reduce the negative impacts substantially.

With the number and types of engines and their applications increasing, the implementation of technological advancements in every sector must outpace growth, or substantive emission reductions will not be realized. Further, inadequate attention to maintenance procedures contribute to the growth of emissions from these devices on a global basis.

3.3 Recommendations

1. The Board encourages the Commission to maintain a dialog with the Parties and support the implementation of effective control strategies to reduce the levels of ozone and PM transported between the United States and Canada.

2. The Board encourages the Commission to request a review including the application of benchmarks (for example, monitoring hospital admissions) that can identify success in reducing the exposure to ozone and PM among sensitive or susceptible members of the general population as part of the demonstration of progress in achieving each standard.

3. The Parties should continue to further define the global ozone background and strategies necessary to address it.

4. The Board is encouraged by the announcement of the pilot airshed management strategies and recommends the International Joint Commission continually review their evolution over the next two years. As governments move forward with the development of these pilot projects, the Board emphasizes that they must be developed in a coordinated manner with the involvement of local communities and stakeholders if they are to be effective in attaining and maintaining air quality standards.

5. Governments must address emissions from all internal combustion engines and aircraft and their associated airport operations if ozone and $PM_{2.5}$ are to be fully met. Given the continued global growth in all vehicular sectors and the proliferation of the internal combustion engine, proper maintenance must be pursued in a comprehensive manner through inspection programs or other means.

6. All levels of government should focus on the delivery of local programs, including public education emphasizing informed choice, to reduce or eliminate use of personal device sources, particularly small gasoline engine use in recreational, yard maintenance and other applications.

4.0

NITROGEN COMPOUNDS REMAIN PIVOTAL.

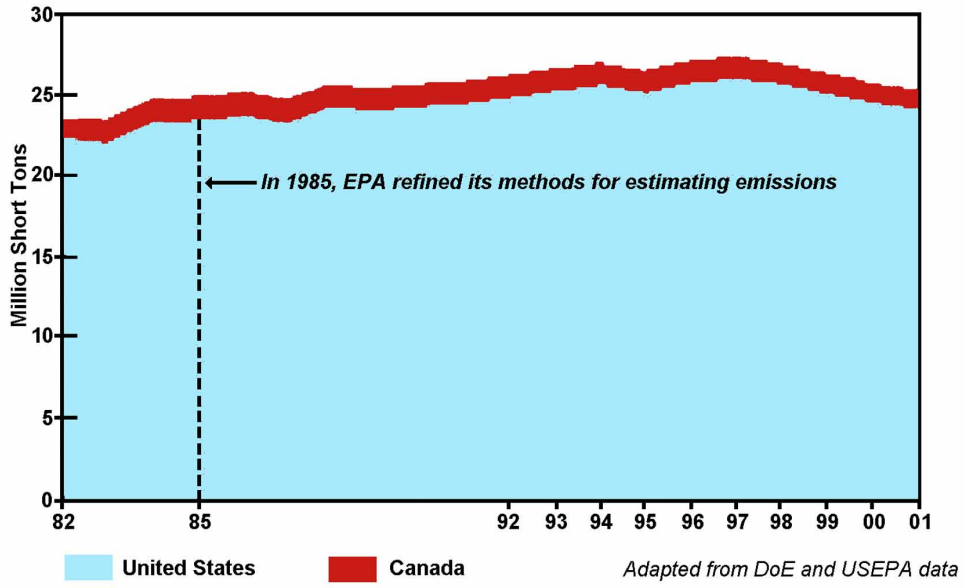
4.1 Story

Nitrogen and nitrogen compounds are essential to all living organisms. Nitrogen can serve as a nutrient, enhancing growth and productivity, or as a toxin, causing ecological damage (Ref. 2). In cases where nitrogen acts as a toxin, in addition to the role of NOx in ozone formation, plant populations and forest growth can be affected with the removal of nutrients from soil, inhibiting the natural growth and persistence of forest cover. Other nitrogen compounds can also have a negative effect on the environmental and human health. Emissions of other nitrogen species, in particular ammonia, appear to have increased; ammonia will be further considered in the latter portion of this segment of the report.

NOx Emissions

As the Board emphasized in its first Special Report, while there have been reductions in emissions of NOx in certain sectors, total nitrogen oxide emissions in both countries have essentially remained unchanged over the past two decades. NOx emission reduction

Figure 4 U.S./Canada Combined NOx Emissions, 1982-2001



efforts have been countered by economic growth; activities such as motor vehicle operation and the burning of fossil fuels now account for more than 90 percent of United States nitrogen oxide emissions. Further regulation of gasoline and diesel powered vehicles in and around 2007 should affect some reduction in these emissions in North America, if fuel economy and the total annual vehicle miles traveled remain stable.

NOx and Fine Particulate and Ozone Formation

Various forms of nitrogen, including nitrogen oxide and ammonia, when in the atmosphere, react with water vapour and other available compounds to form fine particulate. These very small particles enter the human respiratory system and, even at concentrations below current air quality standards, can have deleterious effects on the health of sensitive individuals.

NOx also reacts in the presence of sunlight with Volatile Organic Compounds (VOCs) to form ozone, a pollutant which can compromise the human respiratory system for some individuals even at levels below the current standards. While there has been much consideration of which of the two precursors is the crucial or limiting factor in ozone formation in various locales, reduction in NOx emissions is a critical part of any strategy to reduce ozone formation.

Acid Rain: Lake and Stream Recovery

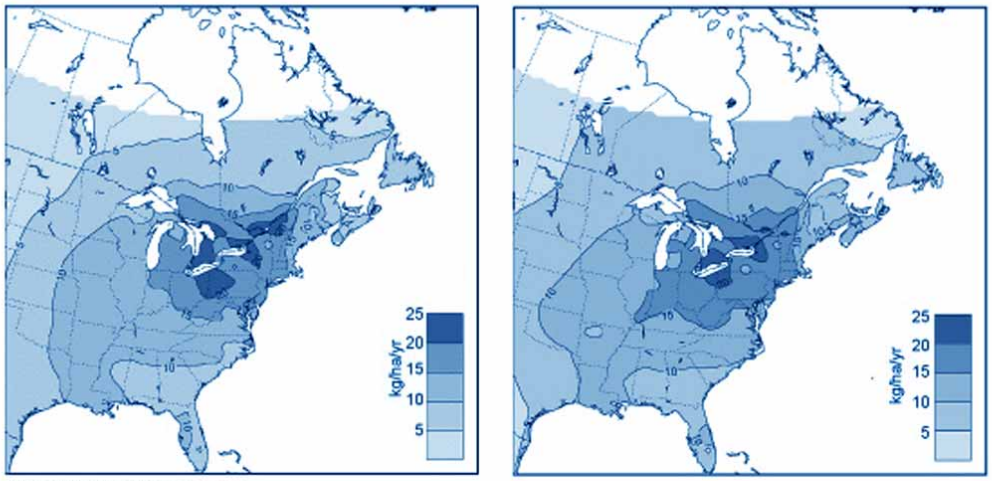
Acidic pollutants can be transported through the atmosphere in both wet and dry forms and subsequently deposited to the earth's surface at locations which may be some distance from the original source. One of the impacts of the resulting acidification of lakes and streams is a decline in the sport fish population.

The acidity of rain is determined by the concentration of hydrogen ions, and this concentration depends on two things: the presence of acid-forming substances such as sulphates and nitrates, and the availability of acid-neutralizing substances such as calcium and magnesium salts. Non acidified rain has a pH value in the vicinity of 5.1. By comparison, vinegar has a value on the ph logarithmic scale of three.

The readily evident transboundary effects of acid precipitation impelled jurisdictions in both the US and Canada to reduce acidic sulfur compound emissions and subsequent transport and deposition of sulfur dioxide and other sulfate species, resulting in significant decreases of sulfate in wet and total deposition and in surface waters. Wet sulfate deposition to lakes and streams declined approximately 40 percent in the 1990's in regions of the United States (Ref. 3)

The Acid Rain Program, created under the U.S. Clean Air Act and Amendments (CAAA) of 1990, targets both SO_2 and NOx emissions. Sulphur dioxide reductions to date are within 80 percent of the CAAA goal of lowering annual sulfur dioxide emissions by 50 percent below 1980 levels by the year 2010.

Figure 5 Nitrate Deposition in 1990-1994 and 1996-2000



1990-1994 Wet Nitrate Deposition

1990-2000 Wet Nitrate Deposition

(Canada-U.S. Air Quality Agreement Progress Report, 2002)

As is evident in the illustration (Figure 5) from the 2002 Progress Report under the Canada US Air Quality Agreement, the lack of significant reduction in nitrate emissions is evident in the relative stability of wet nitrate deposition in the last decade; with the exception of lowered inputs in some particular areas of intense deposition.

United States

Slight declines in nitrate deposition were demonstrated to some extent in the northeast, where many sensitive ecosystems are located. On the contrary, the upper midwest experienced somewhat elevated nitrate concentrations and areas in the western United States were subject to observed nitrate deposition increases of 20 to 50 percent, although deposition there remains relatively low. Continued atmospheric nitrogen loading to these watersheds may influence the acid-base status in these locales and more waterbodies may lose their capacity to absorb any inputs without significant damage. Areas with the highest nitrogen emissions do not necessarily experience the greatest deposition effects, which can occur far from the original source. The only region with a pronounced decreasing trend in nitrate deposition was the southern United States.

Canada

Rain in significant portions of eastern Canada remains acidic, largely because calcium and magnesium salts have also decreased more or less in tandem with the reduction in acidic emissions principally sulphur dioxide. While the reasons behind the decrease in concentrations of acid-neutralizing salts are not yet fully understood, the result has been a smaller-than-anticipated reduction in acidity.

For example, the pH of rain in Ontario's Muskoka-Haliburton area ranges between 3.9 and 4.4 - about 40 times more acidic than normal.

Some acidified lakes are recovering, but many more are not. Of 202 Canadian lakes studied since the early 1980s, 33 percent have reduced levels of acidity while 56 percent have shown no change and 11 percent have actually become more acidic. The greatest improvements have been seen in the Sudbury area, where lakes had been very badly damaged. Here, fish populations have rebounded and fish-eating birds, such as loons, have increased in parallel with very significant reductions in sulphur dioxide emissions from regional sources at INCO and Falconbridge. However, no substantial wildlife recovery has been seen beyond the Sudbury area. The least improvement has been seen in Atlantic Canada, even though lakes in this region were never as highly acidified as those in some part of Ontario and Quebec.

Forestry Impacts

Acidic atmospheric deposition can also impact terrestrial environments through increased nutrient depletion. Forested areas are susceptible to increased levels of sulfuric and nitric acid deposition and some eventually become regions of sensitivity. Current or projected acidic deposition exceeds the level that would sustain forest ecosystem health and productivity.

Continued deposition of nitric acids, along with sulphuric acids, accelerates the loss of critical nutrients such as calcium, magnesium and potassium, all essential minerals, from forest soils. A significant implication of such deposition is slow forest growth, increasing the time between timber harvests, and the ultimate decline in forests (Ref. 4). The species mix of particular forests may be skewed in favour of plant species able to cope with or thrive in increased nitrogen concentrations.

Preliminary modeling shows that annual forest growth in eastern Canada is estimated to decrease by 10 percent when critical acid loads are exceeded. The economic contribution of the forestry sector in eastern Canada is estimated at over $26 billion a year.

As one response to these threats, the Eastern Canadian Premiers and New England Governors have developed a coordinated forest mapping initiative, called The Forest Mapping Project. Analysis of these maps is ultimately meant to allow determination of sustainable levels of acid deposition for forest soils in the New England states and Atlantic provinces.

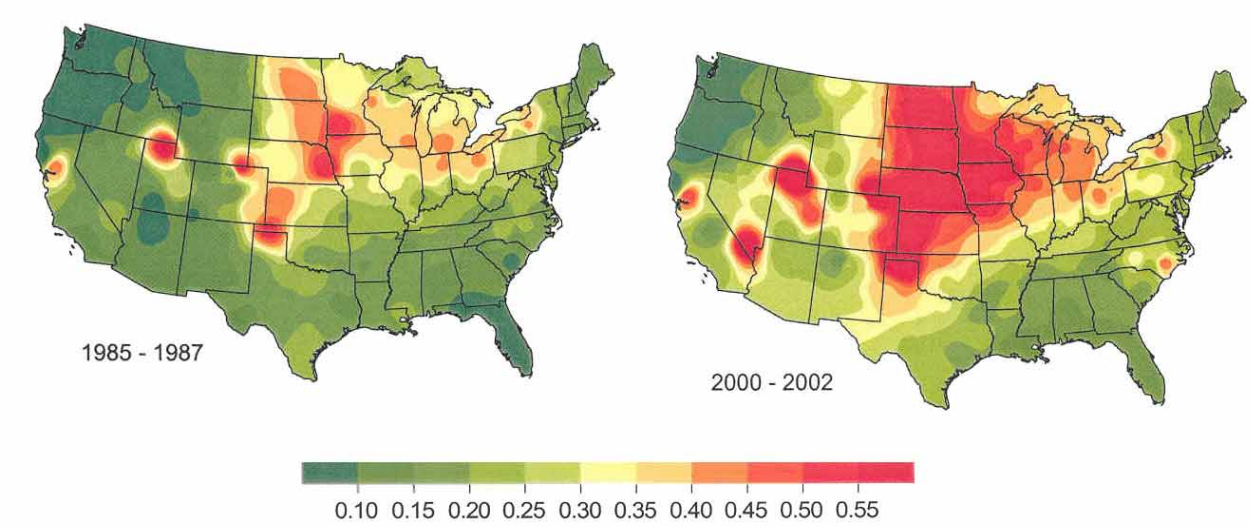
Maps of sustainable deposition and actual exceedances have been prepared for Vermont and Newfoundland. Maps for all New England states and eastern provinces are anticipated in subsequent years. The second phase will include an assessment of forest sensitivity for the whole region.

Ammonia (NH_4)

Emissions of ammonia, particularly from these large scale operations, support the atmospheric formation of ammonium sulfate and ammonium nitrate, contaminants that contributes to levels of $PM_{2.5}$, a threat to human health, and a cause of visibility impairment. ***In many locations, ammonia is the limiting factor for secondary particle production and unchecked ammonia emissions will likely offset decreases in other PM precursor emissions.***

In addition, ammonia is a preferred source of nitrogen to plants and is quickly metabolized by many organisms, often contributing to algal blooms and other degradations of estuaries and other sensitive ecosystems, reducing productivity of coastal waters. The extent of ammonia deposition in the United States has increased significantly since 1985, as shown in Figure 6.

Figure 6 Average Ammonium Ion Concentration as NH_4^+ (mg/L)



Source: National Atmospheric Deposition Program, 2002 Annual Survey

Large Scale Animal Husbandry Operations:

Livestock and poultry operations are undergoing consolidation; in the US, there are currently 1.3 million livestock and poultry operations, a 23 percent reduction from 1974. About 238,000 of these are animal feeding operations, which annually produce more than 500 million tons of manure. The USDA estimates that, in 1997, operations in 165 US counties resulted in 1.5 billion tons of nitrogen outputs from manure in excess of absorption capacity of adjacent lands.

This source sector often is referred to as confined animal farm operations (CAFOs). While these operations have emerged as among the chief methods of meat production in North America, their environmental impact is also significant.

In consideration of the above, further quantification of the contribution of emissions from CAFOs to air pollution is necessary, along with a management strategy and technology options to abate these emissions.

4.2 What Does It Mean?

The impact of acid deposition and the amelioration of its effects are among the longest standing environmental issues considered singly and jointly by federal, state and provincial governments by, among many others, the Canada US Air Quality Accord. Reduction in emissions for sulphur dioxide has been the subject of international agreements and substantial progress has been made and will continue to be made in both countries. Some of this limited progress is evident in reduced acidification of particular water bodies in both countries.

Reduction in the emissions of nitrogen oxide species has proved less tractable; the burning of fossil fuels in both large utilities and mobile sources (cars and trucks) is the source of a great majority of these emissions and they have not decreased substantially over the last decade.

In addition to the negative impact of acidification on fisheries in smaller water bodies and the health of forests, nitrogen oxides are also essential to the formation of ozone and fine particulate matter, both of which have an immediate and direct negative impact on human health.

Ammonia (NH_4) is another nitrogen species emerging as a contributor to fine particulate formation and the excessive nutrification of water bodies, resulting in algal blooms and other undesirable outcomes in affected locales. Large animal husbandry operations (cattle feedlots and intensive hog farming) contribute substantially to this burden and their impact needs further examination.

The Board continues to see the delineation of the effects of nitrogen species, and continued efforts toward a reduction in their emission, as pivotal to improvement in several aspects of air quality.

4.3 Recommendations

1. Further coordinated approaches, such as those undertaken by the New England Governors and the Eastern Canadian Premiers in addressing the impacts of acidic deposition in both aquatic and terrestrial ecosystems, should be encouraged.

2. In order to reduce the impacts of acid species on the ecosystem and the production of excessive levels of ozone, further reductions in the emissions of nitrogen oxides from stationary and mobile sources must be pursued.

3. The need for further controls on production of other nitrogen species, such as ammonia, must be further investigated.

4. The US and Canadian governments should extend their investigation of the environmental impacts of intensive animal husbandry operations to include a consideration of the effects of emissions of gaseous ammonia compounds from these operations on air quality and appropriate remedial actions.

5.0

CAN DETERIORATION OF AIR QUALITY IN NON URBAN, RELATIVELY CLEAN, DESIGNATED AREAS BE PREVENTED?

5.1 Story

Prevention of significant deterioration of visibility has been the topic of discussion in a number of the more recent reports under the Canada US Air Quality Agreement. The two countries have distinctly different approaches to such prevention, largely as a result of differences in the structure and distribution of environmental authority in each country.

The visibility protection commitments (Annex 1, part 4) contained in the Canada US Air Quality Agreement of 1991 are a reflection of the interest of both parties in the protection and improvement of air quality in national, international and state or provincial parks and designated wilderness areas in their respective countries.

Briefly, in that Agreement, the US extended the provisions of Part C, Title I of the Clean Air Act which call for both non-deterioration and eventual elimination of visibility impairment from anthropogenic sources in specific US National Parks and Wilderness Areas, several of which lie along the US Canada boundary, to further include consideration of sources that could cause significant transboundary air pollution. Canada's commitment was to develop and implement, by January 1, 1995, means affording comparable levels of prevention of significant deterioration and protection of visibility with respect to sources affecting transboundary air quality.

At the time of the Agreement, these commitments were considered balanced, as neither country had any formal regulatory requirements specific to visibility protection.

However, in July 1999 the US EPA issued the Regional Haze rule, requiring states and tribes to work together via regional transport associations to remediate any existing impairment of visibility resulting from manmade air pollution in 156 Class I areas, including national parks and wilderness areas, and to prevent any future impairments.

Particles causing visibility impairment include ammonium sulfate, ammonium nitrate, secondary organic aerosols, carbon and soil. A number of regional air strategies will be needed to improve and preserve visibility in clean air areas, including further control of combustion sources, windblown dust and emissions from biological burning.

The US Rule defines visibility impairment as "reconstructed light extinction" as measured by specific sampling and analytical methods and requires no deterioration on the cleanest 20 percent of sampling days (often days with transboundary flows from Canada), as well as steady progress toward a long-term (year 2064) national visibility goal of eliminating all anthropogenic haze inputs on the haziest 20 percent of sampling days. By 2008, Regional Planning Organizations (RPOs) are to develop interim strategies to make progress toward these goals.

There are five RPOs in the US, four of which abut the Canadian border - WRAP (Western), CENRAP (Central), MRPO (Midwest), and MANE-VU (Northeast). In 2001, these RPOs collected monitoring and emission inventory data and assessed regional modeling tools as part of their requirement to complete regional air management implementation plans by 2008. Modeling using some Canadian emissions data would be necessary in the development of several of these strategies.

The success of air management strategies is to be demonstrated by the ongoing nationwide monitoring of visibility-reducing particles via the currently operational 110-station Interagency Monitoring of Protected Visual Environments (IMPROVE) network, representative of all Class I areas where monitoring proved practical.

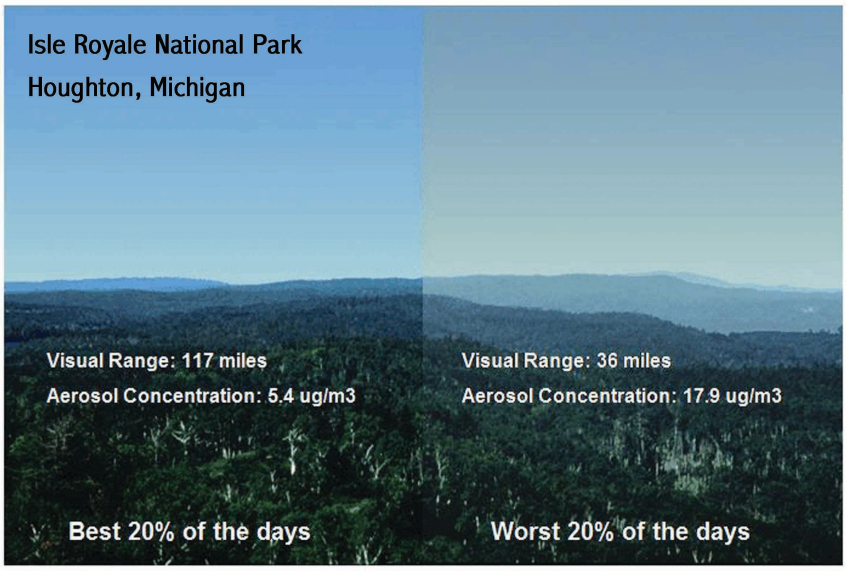
Canada has maintained that it is addressing its commitment through the implementation of Canada-wide Standards for PM and Ozone and the Canada-Wide Acid Rain Strategy Post-2000. The standards for PM and ozone, to be achieved by 2010, include principles such as pollution prevention, continuous improvement (CI), and keeping clean areas clean (KCAC) meant to prevent the deterioration of air quality and address pollutants that are linked to visibility impairment.

CI would be applied in areas with ambient pollution levels better than required standards but still above the levels associated with observable health effects. The KCAC principle recognizes an interest in preserving relatively clean areas. Jurisdictions are encouraged to take remedial and preventive actions to reduce emissions from anthropogenic sources to the extent practicable using a cooperative national guidance document on CI/KCAC currently under development.

5.2 What does it mean?

Recent consideration of the commitments to Prevention of Significant Deterioration in the Air Quality Agreement has focused on visibility. The promulgation of the Regional Haze Rule in the US and the monitoring and regional planning that accompany it have resulted in differences in the level of specificity with which the dialogue is conducted on this issue between the Parties. In the US, the ability of Regional Planning Organizations to develop regional clean air strategies to meet specific visibility targets will be tested; the Canadian approach to visibility protection is less specific to parks and wilderness areas and does not explicitly create or employ regional planning groups.

Figure 7 Regional Haze



Source: WinHaze Model using IMPROVE Monitoring Network data

Given the contribution of fine particulate to haze, there may be an opportunity to more closely align fine particulate ($PM_{2.5}$) regulations in the two countries. Current US Primary $PM_{2.5}$ standards do not address visibility; the annual average requirement of 15 $\mu g/m^3$ is over far too long a time scale to address what is a short term and frequently transitory phenomenon, while the 24-hour standard of 65 $\mu g/m^3$ represents extremely hazy conditions. However, the value associated with the Canada-Wide 24-hour standard of 30 $\mu g/m^3$ (although primarily meant to protect human health) would be roughly equivalent to a visibility of 16 km (10 miles), and its implementation should also provide some measure of visibility protection.

5.3 Recommendations

1. The Commission should champion keeping clean areas clean in the border region. As a first step, the Commission should convene an expert workshop in one of the transboundary areas currently within a US Regional Planning Organization (RPO) to review prevention of significant deterioration and related visibility programs in both the US and Canada in detail and obtain advice on effective ways and means to preserve and enhance such programs under both national approaches.

2. The Commission should encourage the United States to consider the desirability of a secondary 24 hour fine particulate ($PM_{2.5}$) standard similar to the Canada Wide Standard of 30 g/m^3 as additionally protective of human health and supportive of improved visibility.

3. As a step toward integration of programs meant to directly or indirectly preserve or enhance visibility, the Commission should encourage the formal inclusion of Canadian federal and provincial agency personnel in those US RPOs whose mandate extends along some portion of the boundary.

6.0

THE AVAILABILITY OF NEW PUBLIC INFORMATION TOOLS INCLUDING AIR QUALITY INDICES AND/OR HEALTH BASED ADVISORIES, IS STIMULATING GREATER PUBLIC INTEREST AND CONCERN REGARDING AIR QUALITY.

6.1 Story

State, provincial and federal governments continue to develop public communication tools which broadcast the status of local air quality in real or near-real time. Some of these tools include the Canada and United States Air Quality Indices, US National Ozone forecasting and mapping, the Smog Alert program in Ontario, Air Quality Forecasting in Canada and the United States, and Ozone Action Days and similar activities in several states. In addition to their use in print, radio and television media, the extension of such tools by jurisdictions to the internet is facilitating near real-time public access to critical air quality information, and associated health risk information. The increased availability and reliability of air quality information of this kind is of particular interest to those people that are more sensitive to the effects of air pollution. A cooperative initiative between NOAA and EPA to further develop an air quality prediction capacity in the US is also currently underway.

Because of several factors, among them the fact that calculation of a particular value of the air quality index (AQI) historically has been based on one dominant pollutant rather than the cumulative contributions of all the smog-related air pollutants tracked under a given index, negative effects on human health have been observed in circumstances when the AQI value has been characterized as 'good' or 'adequate' ***and indeed, such effects are evident even when all tracked pollutants are within attainment***. As a result, modifications to this communication tool are currently under consideration to allow a more accurate representation of air quality levels at a given time with health risk.

Some jurisdictions have begun to incorporate measurement of fine particulate matter (PM) into the AQI. The ability to measure fine PM in real time is relatively new and technologies to do so are continuing to evolve and improve. At the moment, the monitoring network for real-time fine PM in some areas where an AQI exists is significantly less dense than that for many of the other pollutants traditionally factored in the index, making inclusion of such $PM_{2.5}$ measurements to the AQI challenging. However, this is gradually improving as measurement capabilities are enhanced in response to the need to demonstrate the success of emission reductions to address smog pollutants and precursors. Such enhanced networks

would also support the development of more accurate air quality forecasting and related health advisories.

The International Center for Air Quality and Health, based in Fredericton, New Brunswick is developing comparable health messages for application under its related transboundary ozone and PM mapping projects.

6.2 What Does It Mean?

Public communications tools, particularly in weather forecasting, have included the development of several national and regional programs in the United States and Canada to predict or quantify air quality and advise on its impact. Air Quality Indices are determined on an at or near real time basis in several locales along the boundary; unfortunately, the bases for the individual index are often different, resulting in indices that are not completely comparable. In addition, the categories established under these indices (good, poor, unacceptable) are not totally indicative of impacts on the health of the population, particularly its most sensitive members i.e. air quality classed as "good" may not be so for some individuals.

Additional pollutants, such as fine particulate ($PM_{2.5}$) are being added into the Index calculation, and altering the nature of that calculation. It is evident that, in attention to sharpening their own determinations, jurisdictions adjacent to the boundary must strive to improve the coherence and consistence of air quality indices and advisories across their particular transboundary region.

6.3 Recommendations

1. The Commission should encourage governments to continue to collaborate on air quality information products on the internet and elsewhere, with the objective of providing clear, comparable, coherent, and effective health messages across common airsheds, while reconciling differences associated with current distinct health-based air quality indices and acknowledging differences in national standards.

2. The governments should also be encouraged to continue development of public information tools and services such as air quality forecasts and real time air quality reporting that provide the public with the information they need to make appropriate choices about protecting their health and their environment.

7.0

HOW WELL ARE AIR QUALITY MANAGEMENT PROGRAMS PERFORMING? INVENTORIES, MONITORING AND ANALYSES ALL NEED RENEWAL TO PROVIDE VERIFICATION AND GUIDANCE.

7.1 Story

Monitoring programs are the basic tools required to maintain vigilance for known chemicals of concern and serve an alerting function for emerging environmental concerns. Responsibility for developing and maintaining these programs is shared among federal, state/provincial/territorial and local governments and, very occasionally, industry.

Emissions inventory programs are typically meant to estimate emissions of pollutants of concern from specific sectors (stationary and mobile) to the atmosphere. In the United States, most state regulatory efforts are tied to federal emissions programs, with the onus for data collection at the state level, and the assembly, maintenance and dissemination of the resulting national inventory the responsibility of the federal government. The type and number of regulated emission sources, level of production or other activity, quantity of pollutants emitted, and other supporting information are necessary data for sources in the inventory.

Emissions inventory information is a primary input to the modeling of the transport and deposition of pollutants. Current and accurate emissions inventories of all important emitter types including stationary sources (power plants, incinerators, industrial operations), areal sources (drycleaning, backyard burning, etc.), and mobile sources, are crucial to a successful monitoring effort. The sharing of responsibility for monitoring, inventory management and data analysis, among agencies, with each portion of the program responding to different needs and drivers, makes achieving a high quality inventory input most difficult.

Concentration and deposition monitoring programs fall into two main categories: *regulatory* monitoring, meant to demonstrate compliance with standards protective of human health, and *research* monitoring, used to study the transport, fate, and trends of various pollutants of immediate or emerging concern. Both types require continual scrutiny to maintain peak usefulness. Typically, federally mandated air quality programs require widespread monitoring - in some cases, at thousands of locations nationwide. It appears that routine monitoring programs for substances that are currently relatively well controlled, for example lead or sulfur dioxide, could now be diminished and resources moved to support emerging regulatory programs (e.g. support for new fine particulate and ozone air quality standards) and several agencies are currently attempting to do so.

Research monitoring, particularly for hazardous and persistent air toxins, is a distinctly different challenge. Concentrations of pollutants of concern tend to be at levels typically well below those associated with regulatory monitoring, when appropriate regulations exist. In addition, the universe of contaminants is much larger, and the release of new compounds into the environment continues to expand this number.

To be of best use as an aid to the computer modeling and other elements of the environmental policy and management community, measurements must be made continuously over very long periods of time (often decades) and at a sufficient number of locations across the continent to allow reasonable estimates of concentration and deposition trends. Simply put, strong research monitoring programs require stable funding, carefully selected and well-established analytical laboratories, and sufficient resources to analyze, archive, disseminate, interpret and verify the resulting data.

Recognizing that it is impossible to monitor all chemicals at all desired locations, computer models are frequently applied to fill the gaps. However, such models are only as good as the data used to drive them and the understanding scientists have of the underlying physics and chemistry. Comprehensive fate and transport models used to determine sources of pollutants of concern affecting receptors of interest such as the Great Lakes, require high quality emissions inventories, a thorough understanding of atmospheric chemistry occurring during transport from source to receptor, and sufficient monitoring data near receptor locations to evaluate model results.

7.2 What does it mean?

The United States and Canada have many programs to control pollution emissions resulting from a broad range of human activity. Implementation of these programs has been expensive, often costing tens of billions of dollars over the course of several decades. In comparison, regulatory and scientific monitoring and modeling programs are relatively inexpensive. However, the Board recognizes that ***it is imperative that those programs that continue to be useful be maintained, those that have outlived their usefulness be redirected, and new programs to address emerging issues, such as multi-jurisdictional comparison objectives, be instituted.***

To do this effectively, while maintaining the program continuity necessary to allow evaluation of progress and the design of new control programs, a more collaborative and coordinated approach to managing and integrating emissions inventory development, monitoring, and analysis (modeling) is needed. As there is further recognition of the extent to which many persistent toxic substances (mercury) and criteria pollutants (ozone) are subject to global transport, this collaborative approach must cross national and continental boundaries. Without such an approach, as governments struggle to respond to emerging issues, duplication of efforts, erosion of baseline monitoring and failure to address significant knowledge gaps will continue.

7.3 Recommendations

1. The Commission should encourage the governments, as an activity under the Air Quality Accord, to assess monitoring programs, particularly those adjacent to the boundary, and identify those most productive in the monitoring of transboundary air quality and supporting related science. The Board will track progress toward such a review as an effort to identify the core monitoring networks in the boundary region.

2. While recognizing that most monitoring programs have already been subjected to extensive examination and review, the Board believes that new ways of managing existing resources must be developed to allow reapportionment of existing funds. In some cases, new sources of funds may also be required.

3. As an outcome of the review recommended about, and other such considerations, support for programs that have outlived their usefulness should be redirected to address emerging pollutants of concern.

4. In cases where new programs must be continuous to be of greatest value, the availability of funds on a multi-year basis must be ensured at initiation to prevent critical lapses or gaps in the monitoring report subsequently derived from such programs.

5. Initiatives to secure support from industry and other major pollutant sources for monitoring efforts adjacent to their facilities, including appropriate quality control and public accessibility to the data, should be considered.

ACRONYMS

ANC	acid neutralizing capacity
CAAA	Clean Air Act and Amendments
CAFOs	confined animal farm operations
CEC	Commission for environmental Cooperation
CI	continuous improvement
EPA	Environmental Protection Agency
GLWQA	Great Lakes Water Quality Agreement
HAPs	hazardous air pollutants
HCH	hexachlorocyclohexane
IAQAB	International Air Quality Advisory Board
IJC	International Joint Commission
IMPROVE	Interagency Monitoring of Protected Visual Environments
KCAC	keeping clean areas clean
LRTAP	Long-Range Transport of Air Pollution
NOAA	National Oceanic and Atmospheric Administration
PAHs	polyaromatic hydrocarbons
PBDE	polybrominated diphenol ethers
PCBs	polychlorinated biphenyls
PM	Particulate Matter
POPs	persistent organic pollutants
PTSs	persistent toxic substances
RPOs	Regional Planning Organizations
SIPs	State Implementation Plans
SMOC	Sound Management of Chemicals
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environmental Program
US	United States
VOCs	Volatile Organic Compounds

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