Towards Cleaner Air

Scientific Assessment Report 2016: North America

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North America has benefited greatly from the U.S. and Canadian participation in the Convention. Its strong science and modelling have shown impacts on North America's environment, particularly in vulnerable northern areas. In addition to their commitments under the Conventions, Canada and the United States cooperate on long-range transport of air pollutants under the 1991 Canada–U.S. Air Quality Agreement[1] (AQA) and the Great Lakes Binational Toxics Strategy[2].

Particulate matter

Health Impacts

Since the late 1990s, a significant research investment has been made in understanding the human health impacts associated with exposures to ambient particulate matter (PM). As a result, evidence has continued to accumulate that fine particulate matter ($PM_{2.5}$) and its precursors have significant effects on the health of humans and ecosystems.

The extensive body of studies providing evidence on the effects of fine particles on health has grown. Epidemiological studies have produced evidence of effects associated with both long- and short-term $PM_{2.5}$ exposures at the population level. These studies provide evidence of consistent increases in premature mortality and morbidity related to ambient $PM_{2.5}$ concentrations, with the strongest evidence being reported for cardiovascular related effects. Furthermore, the ubiquity of $PM_{2.5}$ implies that exposure to ambient $PM_{2.5}$ concentrations can have a substantial public health impact, even with recent reductions.

Currently available scientific information supports the notion that the effects of $PM_{2.5}$ are generally proportional to its concentration. Health effects may occur over the full range of concentrations observed in epidemiological studies of long- and short-term $PM_{2.5}$ exposures, since no population-level thresholds, below which it can be concluded with confidence that $PM_{2.5}$-related effects do not occur, can be discerned from the available scientific evidence (United States - Canada Transboundary Particulate Matter Science Assessment 2013, August 2014). This relationship is of considerable significance for risk management because of its prediction of health benefits associated with air quality improvements focusing on $PM_{2.5}$.

Scientists at the United States Environmental Protection Agency (U.S. EPA) have also evaluated the evidence for health effects associated with exposures to various $PM_{2.5}$ components. Many different components of $PM_{2.5}$, as well as groups of components associated with specific $PM_{2.5}$ sources, have been linked with adverse health effects (2009 PM Integrated Science Assessment). In the 2012 review of the $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS), the EPA concluded that the available evidence is not sufficient to differentiate those components or sources that are most closely related to adverse health outcomes, and that $PM_{2.5}$ remains the most appropriate indicator of health effects associated with fine particle exposures[3].

The 2012 Canadian Smog Science Assessment: Highlights and Key Messages also concluded that all Canadians are at some risk from the effects of ongoing exposure to air pollution, particularly PM, and noted a heightened level of sensitivity for those with cardiovascular and respiratory disease. This is important due to the prevalence of such diseases in the Canadian population, where cardiovascular causes account for 30% of mortality and respiratory disease for 10%. Asthma, which is exacerbated by both PM and ozone, has been diagnosed in at least 8% of the Canadian population over the age of 12.

[1] http://www.epa.gov/airmarkets/us-canada-air-quality-agreement
[2] http://www.epa.gov/greatlakes
[3] 78FR3123 (January 15, 2013) – National Ambient Air Quality Standards for Particulate Matter; Final Rule

Diabetes, a common and increasing disease currently affecting one in ten Canadians, is also adversely affected by smog[4].

In response to these issues, both countries recently lowered ambient air quality standards to protect human and ecosystem health from the harmful impacts of $PM_{2.5}$. In December 2012, the U.S. EPA strengthened the annual health National Ambient Air Quality Standard (NAAQ) for $PM_{2.5}$ at 12 micrograms per cubic meter ($\mu g/m^3$) and retained the existing standard for 24-hour $PM_{2.5}$ at 35 $\mu g/m^3$. In May 2013, Canada established new more stringent Canadian Ambient Air Quality Standards (CAAQS) for annual $PM_{2.5}$ of 10 $\mu g/m^3$ in 2015 and 8.8 $\mu g/m^3$ in 2020. A 24-hour $PM_{2.5}$ standard of 28 $\mu g/m^3$ in 2015 and 27 $\mu g/m^3$ in 2020 was also established. The 2020 standards for $PM_{2.5}$ will be reviewed in 2017.

Trends in ambient $PM_{2.5}$ levels and related emissions

In both countries, ambient concentrations of $PM_{2.5}$ have diminished significantly. More specifically, between 2000 and 2012 the national U.S. average annual and 24-hour concentrations of $PM_{2.5}$ decreased by 33% and 37%, respectively. In Canada, the national averages of the annual and the 24-hour concentrations of $PM_{2.5}$ decreased by 4% and 6.5%, respectively over this same period. However, between 2003 and 2012, the percentage of Canadians living in communities where ambient concentrations of $PM_{2.5}$ exceeded the 2015 CAAQS for $PM_{2.5}$ dropped from approximately 40% to 11%. In 2012, ambient concentrations reported at most monitoring sites in the United States along the Canadian border met the U.S. annual and 24-hour National Ambient Air Quality Standards for $PM_{2.5}$ set in 2012.

National emission inventories in Canada and the United States show that emissions of the $PM_{2.5}$ precursors SO_2, NO_x and VOCs declined between 1990 and 2014 (see Figures CN1 and US1). However, total direct emissions of anthropogenic $PM_{2.5}$ remained fairly stable in the United States during this period, as have emissions of NH_3 in both countries. In Canada, anthropogenic emissions of $PM_{2.5}$ decreased by 57% between 1990 and 2014, with a steady decline in emissions from all sectors.[5] Drivers for SO_2, NO_x and VOC emissions reductions are provided in sections “Acid deposition” and “Ozone and ozone precursors and their impacts on health and ecosystems”, below.

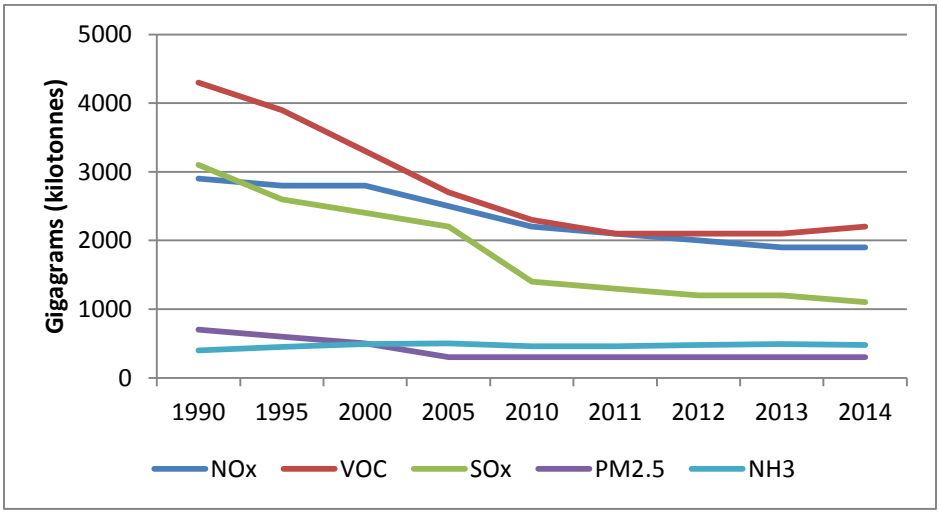


Figure CN1: Trends in Canadian emissions of $PM_{2.5}$ and its precursors from 1990 to 2014 (Environment and Climate Change Canada, Air Pollutant Emission Inventory Report: 1990-2014)

[4] Government of Canada (2012). Canadian Smog Science Assessment - Highlights and Key Messages. https://www.ec.gc.ca/Publications/AD024B6B-A18B-408D-ACA2-59B1B4E04863%5CCanadianSmogScienceAssessmentHighlightsAndKeyMessages.pdf

[5] Canada (2016). Air Pollutant Emission Inventory Report 1990-2014 (excluding emissions from open sources).

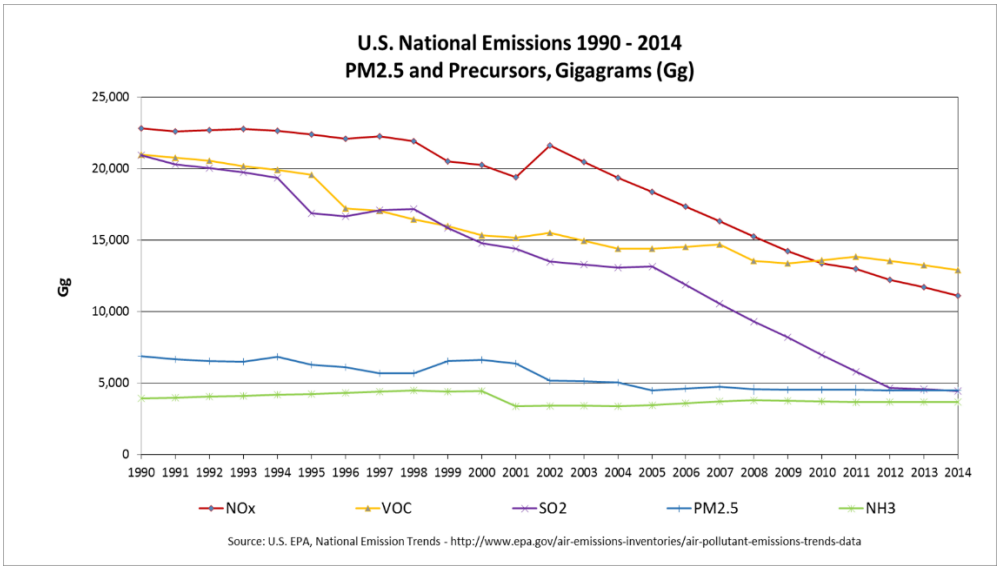


Figure US1: Trends in U.S. emissions of Primary $PM_{2.5}$ and its Precursors from 1990 to 2014

In addition, although significantly reduced in most border areas, $PM_{2.5}$ continues to contribute to visibility impairment in the United States and Canada, particularly in highly populated regions of southern Ontario and Quebec in Canada and the Midwest and Montana in the United States.

Black carbon as a component of $PM_{2.5}$

Black carbon is a component of $PM_{2.5}$ resulting from the incomplete combustion of fossil fuels, biofuels and biomass. In 2013, approximately 45,000 tonnes (45 kilotonnes) of black carbon were emitted in Canada. The transportation sector is by far the most important source of black carbon emissions in Canada, representing 65% (29 kilotonnes) of national emissions, largely from on- and off-road vehicles and engines, which accounted for 20% and 35% of national emissions, respectively. Residential wood burning represented the second largest source, at 26% (12 kilotonnes). The remaining 9% came from upstream oil and gas industries (8%) and other industrial sources (1%) (see figure CN2).

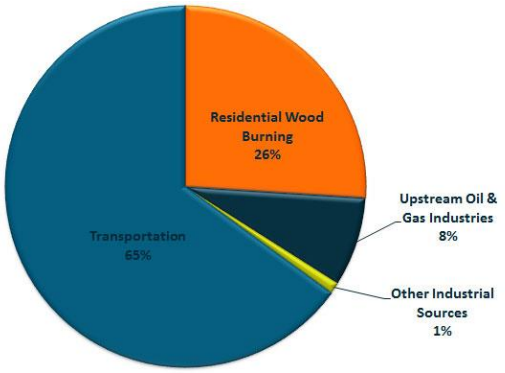


Figure CN2. Overview of Major Contributing Sources to National Black Carbon Emissions (2013) (Source: Environment and Climate Change Canada, 2015)

Canada is taking domestic action to address air pollution through a range of measures and regulations that also reduce emissions of black carbon across major-emitting sectors and throughout the country. Federally, these include a suite of transportation sector air pollutant regulations for new on- and off-road vehicles and engines as well as selected federal infrastructure and transportation programs. A number of provinces and territories have implemented measures that are reducing black carbon, such as motor vehicle inspections and diesel retrofit programs, regulations on sale of wood burning appliances and

wood-stove change-out programs, and measures to reduce flaring from oil and gas operations.

In the United States, black carbon emissions account for 11% of fine particle emissions. In 2011, transport and biomass burning were the largest sources of black carbon in the United States as illustrated in Figure US2.

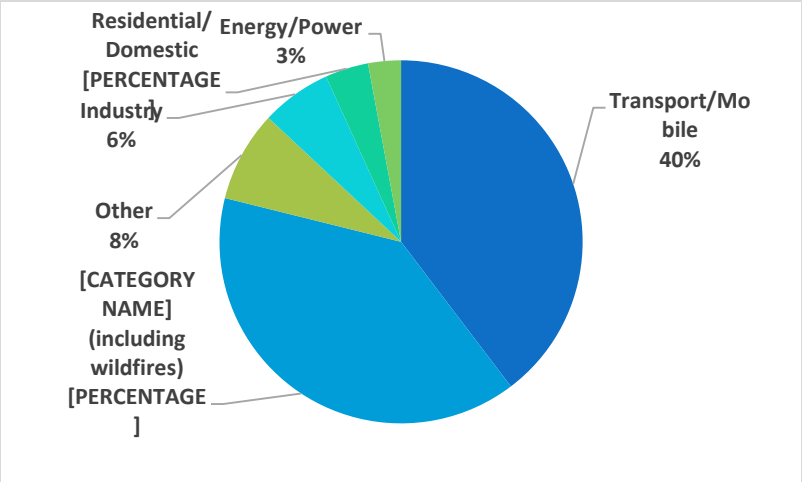


Figure US2: U.S. Black Carbon Emissions, 2011 (Source: U.S. EPA 2011 National Emissions Inventory Modeling Platform (2011v6.1))

The U.S. EPA does not regulate black carbon emissions directly, but achieves emission reductions through programs and regulations addressing $PM_{2.5}$ emissions. In the U.S. black carbon emissions have been declining and additional reductions are expected, largely through controls on mobile diesel engines. Furthermore, the U.S. EPA has promulgated new source performance standards for residential wood heaters to make new heaters significantly cleaner and improve air quality in communities where people burn wood for heat.

The U.S. EPA also encourages states to assess climate change and air pollution together and account for the potential effects of climate change in their multi-pollutant planning efforts.[6] For example, reductions in black carbon, particularly north of the 40th parallel, can help to mitigate warming in the Arctic specifically by reducing deposition on snow and ice while also leading to potentially significant health benefits.

Projections in $PM_{2.5}$ and related emissions

Projections of $PM_{2.5}$ emissions and emissions of $PM_{2.5}$ precursors based on known policies established in Canada and the United States are shown in Figures CN3 and US3. In the United States $PM_{2.5}$ emissions forecasts show an 8% decrease by 2030 from 5 million to 4.6 million tons per year, with reductions coming from the fuel combustion and on-road vehicles, and nonroad mobile sources. Emissions of SO_2, NO_x, and VOCs are forecasted to decrease substantially during this time period. SO_2 emissions have already decreased from 10.2 million tons in 2008 to 6.8 million tons in 2011, and SO_2 is expected to decrease to 3.6 million tons by 2030. Nitrogen oxides emissions have decreased from 16.7 million tons in 2008 to 12.8 million in 2011, and NO_x is expected to further decrease to 8.8 million tons by 2030. Similarly, VOC emissions have decreased from 14.9 million tons in 2008 to 13.5 million tons in 2011 and could decrease further in 2030 to 11.3 million tons. These decreases primarily stem from decreases in mobile sources, and the forecasts do not yet completely reflect complete estimates in any year from the oil and gas sector. Finally, emissions of NH_3 are expected to increase 2% from 4.16 million tons to 4.28 million tons in 2030, due to forecasted increases in emissions from animal waste.

[6] 80FR15448 (March 23, 2015) - Fine Particulate Matter National Ambient Air Quality Standards: State Implementation Plan Requirements; Proposed Rule

In Canada, emissions projections are based on policies that were known in 2010. Emissions of $PM_{2.5}$ under 2010 policies are forecast to increase by 8% between 2010 and 2035. This does not reflect the impact of several transportation sector regulations now in place, including Tier 3 vehicle and fuel standards for on-road vehicles, and Tier 4 standards for off-road compression-ignition engines. SO_2 and NO_x are projected to decline by 29% and 18%, respectively, during this same period. In the case of SO_2, forecast reductions are driven by closures in the non-ferrous smelting and refining sector and reductions in coal-fired electricity generation. These reductions are predicted to be partially offset by projected increases from the upstream oil and gas sectors and oil sands activities in Alberta. Projected decreases in NO_x emissions from transportation sector measures and reduced coal-fired electricity generation are also expected to be offset somewhat by anticipated increases in the oil and gas sector emissions. For the most part, VOC emissions are predicted to decrease by 12% between 2010 and 2035 largely due to reductions in the transportation and upstream oil and gas sectors, offset by increases in residential wood combustion and solvents. By contrast, Canadian NH_3 emissions are projected to increase by 28%.

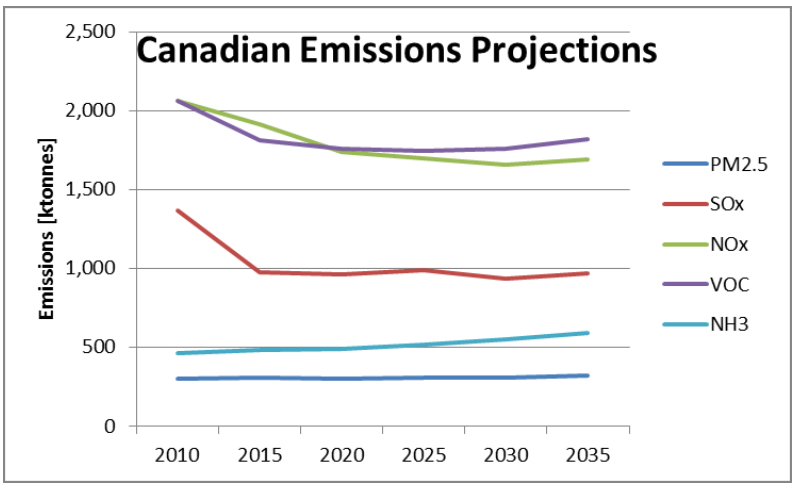


Figure CN3: Projected emissions of major pollutants in Canada from 2010 to 2035 excluding open and natural sources. (Source: United States - Canada Transboundary Particulate Matter Science Assessment 2013, August 2014)

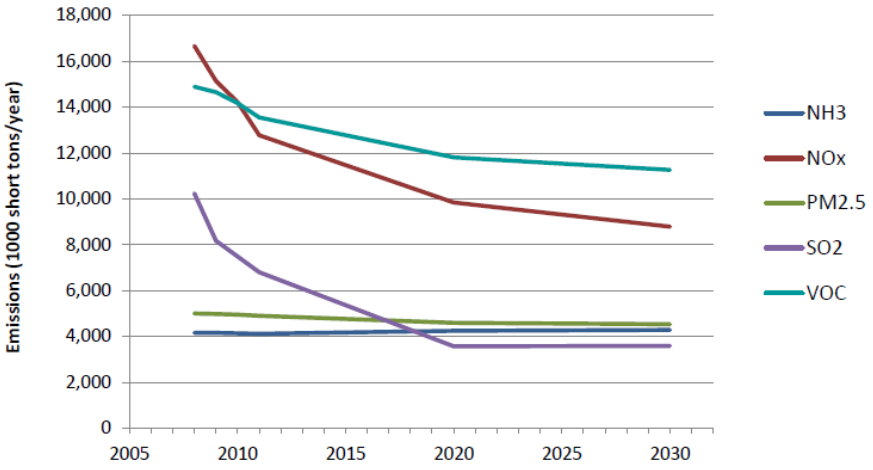


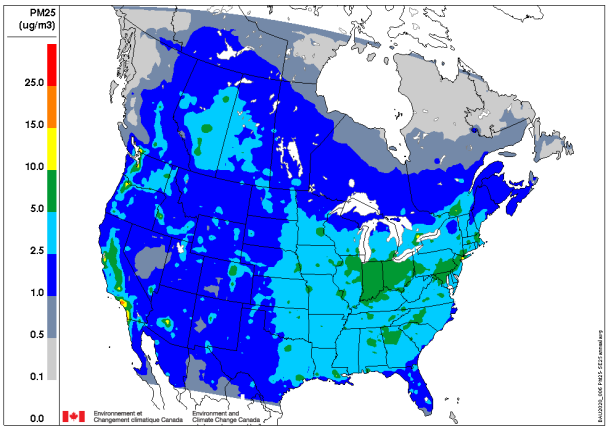
Figure US3: U.S. Emissions Projections, 2008 to 2030 (Source: United States - Canada Transboundary Particulate Matter Science Assessment 2013, August 2014)

Modelling analyses of the impact of future emission projections show reductions in ambient $PM_{2.5}$ concentrations between 2006 and 2030 in the United States and 2035 in Canada. Significant declines in

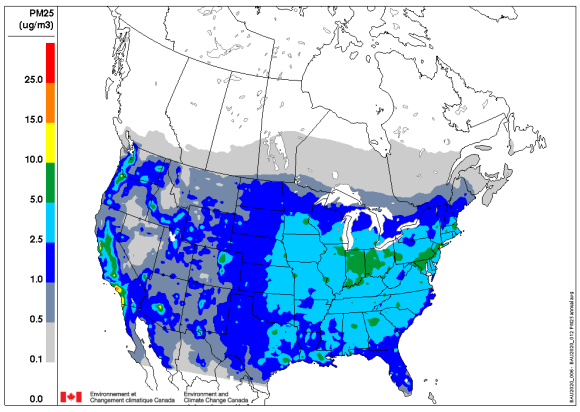
ambient $PM_{2.5}$ concentrations are expected to occur in most Canada-U.S. border region cities, with percentage reductions ranging up to 35% in major U.S. cities near the border and up to 25% in their Canadian counterparts. There is ongoing evidence that $PM_{2.5}$ is transported across the U.S.–Canada border. However, for most cities in both countries, the dominant sources of $PM_{2.5}$ in 2020 will continue to be domestic emissions; overall, transboundary influence is projected to be less in 2020 than 2006. For instance, the influence of U.S. emissions on $PM_{2.5}$ concentrations in Canadian cities near the border is projected to decrease by approximately 2–10%, with the largest reductions occurring in eastern Ontario and southwestern Quebec. The exceptions are Abbotsford, B.C., where there is a small projected increase in U.S. influence, and in North Dakota, Montana, Alberta and Saskatchewan where rapid growth in extraction from the Bakken formation is leading to greater emissions and more transboundary transport in both directions. However, there is uncertainty about how changes in climate and in energy production and use will ultimately impact $PM_{2.5}$ concentrations and transboundary flow of $PM_{2.5}$ along the U.S.-Canada border.

The influence of Canadian emissions on select U.S. cities near the border is also projected to decrease—but by less, in the range of 1–3%, with the exceptions of Seattle, WA, Buffalo, NY, and Rochester, NY, where the Canadian influence is projected to increase slightly. In the United States, no areas in the border region are predicted to exceed the current annual or 24-hour $PM_{2.5}$ standards in 2020, including areas with projected increases in Canadian influence. See Figure USCN1 for the changes in $PM_{2.5}$ projected for 2020. This figure provides useful insight into potential future levels and the continued impact of transboundary movement on each country.

(a) 2020 Annual Average $PM_{2.5}$



(b) 2020 USA Influence on Average $PM_{2.5}$



(c) 2020 Canada Influence on Average $PM_{2.5}$

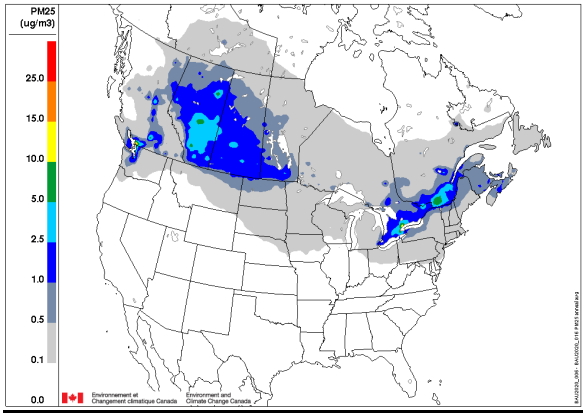


Figure USCN1: Predictions of ambient $PM_{2.5}$ concentrations in North America using the AURAMS model (Source: United States - Canada Transboundary Particulate Matter Science Assessment 2013, August 2014)

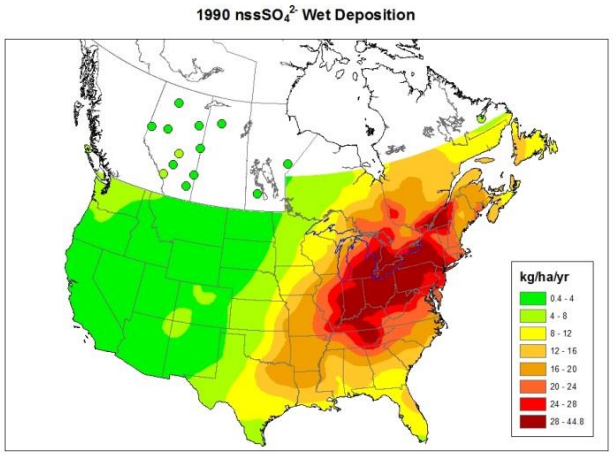
Acid deposition

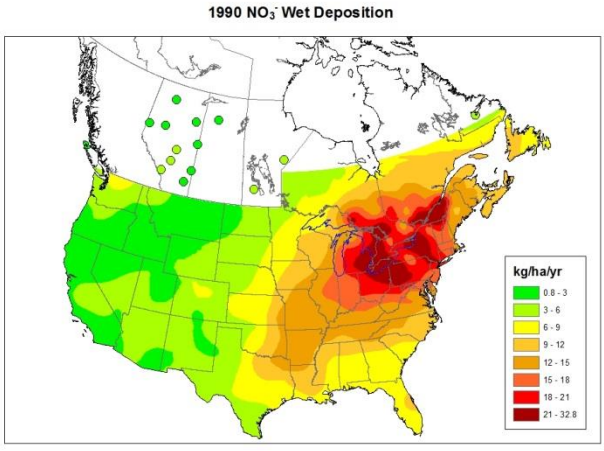
Acid deposition is primarily the result of emissions of SO_2 and NO_x that are transformed into dry or moist secondary pollutants such as sulfuric acid, ammonium nitrate and nitric acid as they are transported in the atmosphere over great distances. These airborne pollutants are deposited on the Earth's surface by three processes: (1) wet deposition (rain and snow); (2) dry deposition (particles and gases); and (3) by cloud or fog water deposition. Wet deposition is comparatively easy to measure using precipitation monitors, and the concentration of sulfphate and nitrate in precipitation is regularly used to assess the changing atmosphere as it responds to decreasing or increasing sulphur and nitrogen emissions.

Figure USCN2 shows the United States–Canada spatial patterns of wet sulphate (sea salt–corrected) deposition for 1990, 2000 and 2012. Deposition contours are not shown in western and northern Canada, because Canadian experts judged that the locations of the contour lines were unacceptably uncertain due to the paucity of measurement sites in all of the western provinces and northern territories. To compensate for the lack of contours, wet deposition values in western Canada are shown as colored circles at the locations of the federal/ provincial/ territorial measurement sites.

Wet sulphate deposition is consistently highest in eastern North America around the lower Great Lakes, with a gradient following a southwest to northeast axis running from the confluence of the Mississippi and Ohio rivers through the lower Great Lakes. The patterns for 1990, 2000 and 2012 illustrate that wet sulphate deposition in both the eastern United States and eastern Canada have decreased in response to decreasing SO_2 emissions. The wet sulphate deposition reductions are considered to be directly related to decreases in SO_2 emissions in both the United States and Canada.

The patterns of wet nitrate deposition show a similar southwest-to-northeast axis, but the area of highest nitrate deposition is slightly north of the region with the highest sulphate deposition. Major reductions in wet nitrate deposition occurred in the period between 1990 and 2012, when large NO_x emission reductions occurred in the United States and, to a lesser degree, Canada.





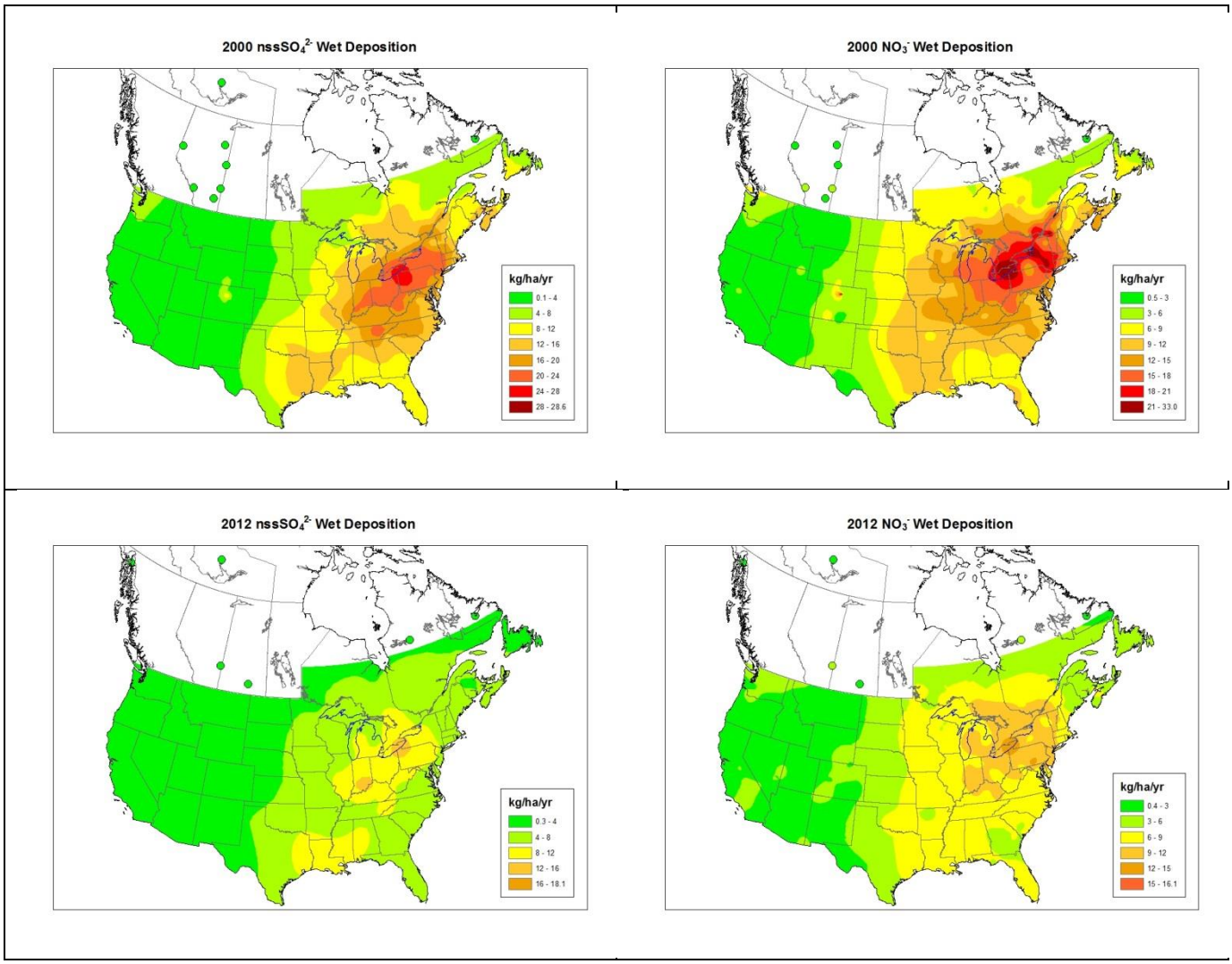


Figure USCN2: 1990-2012 Annual wet sulphate and wet nitrate deposition (Source: National Atmospheric Chemistry Database (NAtChem) Database (www.ec.gc.ca/natchem) and the National Atmospheric Deposition Program (nadp.isws.illinois.edu), 2016)

The impact of anthropogenic sulphur and nitrogen emissions on terrestrial and aquatic ecosystems is widely assessed using a critical load approach. Acidic deposition and fine PM are closely linked; both are strongly affected by the emissions of gaseous SO_2 and NO_x and their secondary products and these atmospheric pollutants have been linked to ecosystem damage in Canada (United States - Canada Transboundary Particulate Matter Science Assessment 2013, August 2014). Critical loads for lakes and upland forest soils are exceeded in various areas across Canada (see next section).

The significant reductions in SO_2 and NO_x emissions achieved in both the U.S. and Canada have resulted in reductions in ecosystem acidification and improvements in air quality. Reductions in the United States, particularly SO_2 emissions, are largely due to efforts to control power sector emissions. For example, the Acid Rain Program (ARP), established under Title IV of the 1990 Clean Air Act (CAA) Amendments, requires major emission reductions of SO_2 and NO_x, the primary precursors of acid rain, from the power sector[7]. In addition, the Clean Air Interstate Rule (CAIR)[8] requires emission reductions in NO_x and SO_2.

[7] http://www.epa.gov/airmarkets/acid-rain-program
[8] http://archive.epa.gov/airmarkets/programs/cair/web/html/index.html

The EPA's Emissions Tracking Highlights site contains the most up-to-date emission and control data for sources subject to the ARP and CAIR: www.epa.gov/airmarkets/ quarterlytracking.html. In addition to the electric power generation sector, emission reductions from other sources not affected by the ARP or CAIR, including industrial and commercial boilers and the metals and refining industries, and the use of cleaner fuels in residential and commercial boilers, have contributed to an overall reduction in annual SO_2 emissions. In the U.S., national SO_2 emissions from all sources have fallen from nearly 24 million short tons (21.8 million metric tons) in 1990 to just over 5 million short tons (4.7 million metric tons) in 2012 (see www.epa.gov/ttn/chief/trends). Reductions in nitrogen deposition recorded since the early 1990s have been less pronounced than those for sulfur. Although the ARP and CAIR NO_x programs have contributed to significant NO_x reductions, emissions from other sources (such as motor vehicles and agriculture) contribute to changes in air concentrations and deposition of nitrogen in many areas. Also in the U.S., national NO_x emissions from all sources have fallen from about 25 million short tons (22.7 million metric tons) in 1990 to 13.5 million short tons (12.3 million metric tons) in 2012 (see www.epa.gov/ttn/chief/trends).

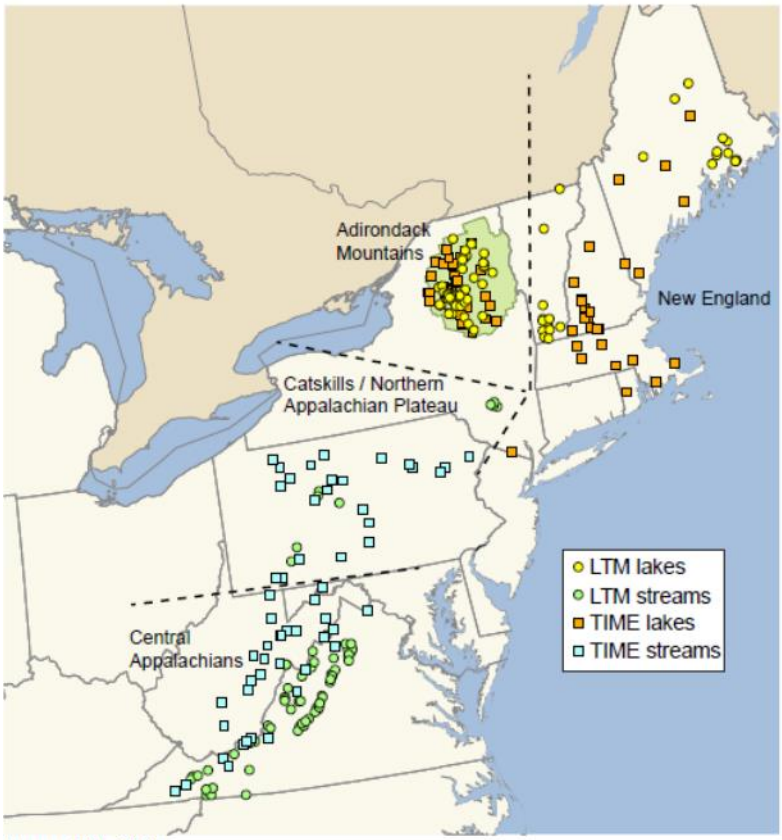
Canada has significantly reduced SO_2 emissions through various actions, including the requirements to reduce sulphur content in fuels, the implementation of the Canada-Wide Acid Rain Strategy for Post-2000. At the sector level, large reductions in SO_2 emissions are attributable to technological and process changes and facility closures in the non-ferrous mining and smelting industries, the phase-out of coal-fired electricity generation in Ontario, and better emission control technologies in the upstream oil and gas sector. In 2012 Canada's total SO_2 emissions were 1.2 million metric tons (1.3 million short tons), a 61-percent reduction from Canada's total SO_2 emissions in 1990 (54.2% reduction between 2000 and 2014). NOx emissions also dropped from 2.9 million metric tons (3.2 million short tons) in 1990 to 2 million metric tons (2.2 million short tons) in 2012, a 31% reduction (32% between 2000 and 2014). Lower NO_x emissions are attributable to more stringent emissions regulations for the transportation and electric power generation sectors.[9]

Additional measures to reduce SO_2 and NO_x emissions from certain industrial sectors are being undertaken as part of Canada's Air Quality Management System (see section on Transboundary and multi-sectoral approach needed" for more information).

Acidification of Lakes and Streams

Acid rain, resulting from SO_2 and NO_x emissions, is one of many large-scale anthropogenic effects that negatively affect the health of aquatic ecosystem (lakes and streams) in the United States and Canada. Reductions in emissions of these pollutants have resulted in improvement in acid-sensitive lakes and streams and enabled recovery from acidification. Surface water chemistry provides the strongest and most direct indications of the potential effects of acidic deposition on the overall health of aquatic ecosystems. In collaboration with other federal and state agencies and universities, EPA administers two monitoring programs that provide information on the impacts of acidic deposition on otherwise pristine lakes and streams: the Temporally Integrated Monitoring of Ecosystems (TIME) and the Long-term Monitoring (LTM) programs. These programs are designed to track changes in surface water chemistry in the four regions sensitive to acid rain shown in Figure US4: New England, the Adirondack Mountains, the Northern Appalachian Plateau, and the central Appalachians (the Valley and Ridge and Blue Ridge Provinces).

[9] Canada (2016). Air Pollutant Emission Inventory Report 1990-2014.



Source: EPA, 2013

Figure US4: Long-Term Monitoring Program Sites

Four chemical indicators of aquatic ecosystem response to emission changes are presented: trends in sulphate and nitrate anions, acid neutralizing capacity (ANC), and sum of base cations. Figure US5 and Table US1 show regional trends in indicators of acidified surface waters from 1990 (before implementation of the U.S. Acid Rain Program) to 2013 in lakes and streams monitored by the LTM program. Over this time frame, significant improving trends in sulphate concentrations are found at nearly all LTM monitoring sites in New England, the Adirondacks, and the Catskill mountains/Northern Appalachian Plateau. However, in the Central Appalachians only 21 percent of monitored streams have a decreasing sulphate trend, while 20 percent of monitored streams had increasing sulphate concentrations. This is due to the highly weathered soils of the Central Appalachians which are able to store deposited sulphate such that the decrease in acidic deposition has not yet resulted in lower sulphate concentrations in most streams. As long-term sulphate deposition exhausts the soil's ability to store more sulphate, a decreasing proportion of the deposited sulphate is retained in the soil and an increasing proportion is exported to surface waters. Thus sulphate concentrations in some streams in this region are not changing or are still increasing despite reduced SO_2 emissions and sulphate deposition.

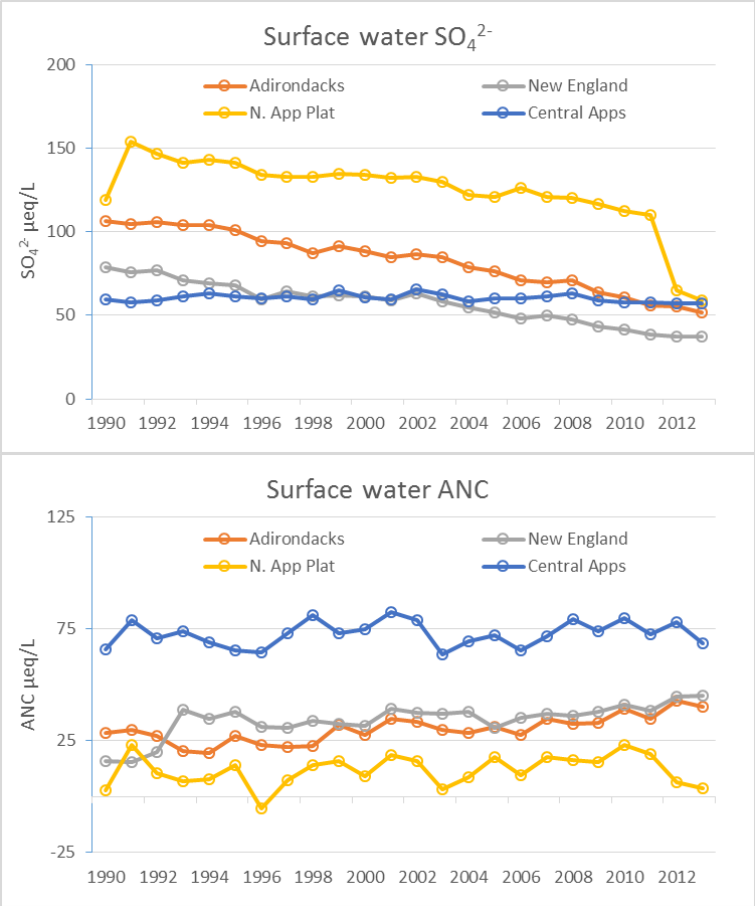


Figure US5: Trends in surface water chemistry at Long-term Monitoring (LTM) locations from 1990-2013. Shown are the mean concentration of sulphate (SO_4^{2-}) and ANC at 151 lakes and streams in four sensitive regions. (Source: U.S. EPA, 2016)

Region	Water Bodies Covered	Percentage of Sites with Improving Sulphate Trend	Percentage of Sites with Improving Nitrate Trend	Percentage of Sites with Improving ANC Trend	Percentage of Sites with Improving Base Cations Trend
Adirondack Mountains	50 Lakes in New York	100%	56%	86%	88%
New England	26 Lakes in Maine and Vermont	100%	25%	58%	86%
Northern Appalachian Plateau	9 streams in New York and Pennsylvania	80%	40%	58%	74%
central Appalachians	66 streams in Virginia	21%	59%	12%	14%

Table US1: Regional Trends in Sulphate, Nitrate, ANC, and Base Cations at Long-term Monitoring Sites, 1990–2013 (Source: U.S. EPA, 2016)

Notes:

- Trends are statistically at the 95 percent confidence interval ($p < 0.05$)
- Base cations are calculated as the sum of calcium (Ca), magnesium (Mg), potassium (K), and Sodium (Na) ions.
- Trends are determined by multivariate Mann-Kendall tests.
- Data for Pennsylvania streams in N. Appalachian Plateau is only through 2011.

Nitrate concentration trends are variable across the LTM site network, with improving trends measured at approximately half of the monitored sites. This improvement in nitrate trend may only be partially explained by decreasing deposition. Ecosystem factors, such as vegetation disturbances, increased uptake by vegetation, and soil retention are also known to affect surface water nitrate concentrations. Improving ANC trends are likely the result of reductions in sulphate deposition. Recovery in ANC, however, often lags behind declining surface water sulphate and nitrate concentrations. Dynamics in surface water chemistry are complicated and highly dependent on local factors such as watershed size, geology and hydrology, which can influence the availability of base cations, thereby inhibiting ANC recovery. From 1990 to 2013, ANC concentration increased markedly at LTM monitoring sites in the Adirondacks (86 percent), in the Catskills/ northern Appalachian Plateau (58 percent), and in New England (58 percent). In contrast, only 12 percent of LTM streams in the Central Appalachians had improving ANC trends, likely due to decreasing base cation levels and the still increasing sulphate concentrations at some sites.

A critical load provides a quantitative estimate of whether deposition levels resulting from reduction in SO_2 and NO_x emissions and acid deposition are protective of aquatic ecosystems[10]. This approach provides a useful lens through which to help understand the potential aquatic ecological benefits that have resulted from emission reduction programs such as the U.S. Acid Rain Program and the Clean Air Interstate Rule (CAIR).

Figure US6 shows mapped critical load exceedances for aquatic ecosystems from 1990 to 2013 (most current deposition data).[11] For this analysis, the critical load represents the annual total deposition load of sulphur and nitrogen to which a waterbody could be subjected and still support a moderately healthy ecosystem (i.e., having an ANC greater than 50 µeq/L).[12,13,14] The area exceeded or at risk for aquatic acidification diminished from 40 percent in 1990 to 20 percent in 2013 for acid sensitive areas with data in the eastern United States. This analysis suggests that emission reductions achieved since 1990 have contributed to broad aquatic ecosystems improvements and increased aquatic ecosystem protection across the eastern United States. This result is consistent with the water quality monitoring findings (see above). Based on this critical load analysis, current acidic deposition loadings (with respect to 2013) still fall short for recovery of many modeled lakes and streams, particularly in the southern half of the eastern United States, which indicates additional emission reductions would be necessary for acid-sensitive ecosystems in the eastern United States to fully recover and be protected from acid deposition.

[10] Nilsson J. and Grennfelt P. (editors). 1988. Critical loads for sulphur and nitrogen. UNECE/Nordic Council workshop report, Skokloster (SW). March 1988. Nordic Council of Ministers: Copenhagen (DK).
[11] Schwede, Donna B., and Gary G. Lear. 2014. A novel hybrid approach for estimating total deposition in the United States. Atmospheric Environment 92 (2014) 207e220.
[12] Blett, T.F., J.A.Lynch, L.H. Pardo, C. Huber, R Haeuber, R. Pouyat. 2014. FOCUS: A pilot study for national-scale critical loads development in the Unites States. Environmental Science and Policy. 38:225-236.
[13] Scheffe, R. D J. A. Lynch, A. Reff, J. T. Kelly, B. Hubbell, T. L. Greaver, J. T. Smith. 2014. The Aquatic Acidification Index: A New Regulatory Metric Linking Atmospheric and Biogeochemical Models to Assess Potential Aquatic Ecosystem Recovery. Water Air Soil Pollution 225:1838.
[14] McDonnell, Todd C., Timothy J. Sullivan, Paul F. Hessburg, Keith M. Reynolds, Nicholas A. Povak, Bernard J. Cosby, William Jackson, and R. Brion Salter. 2014. Steady-state sulfur critical loads and exceedances for protection of aquatic ecosystems in the U.S. southern Appalachian Mountains. Journal of Environmental Management, Volume 146, 15 December 2014, Pages 407–419.

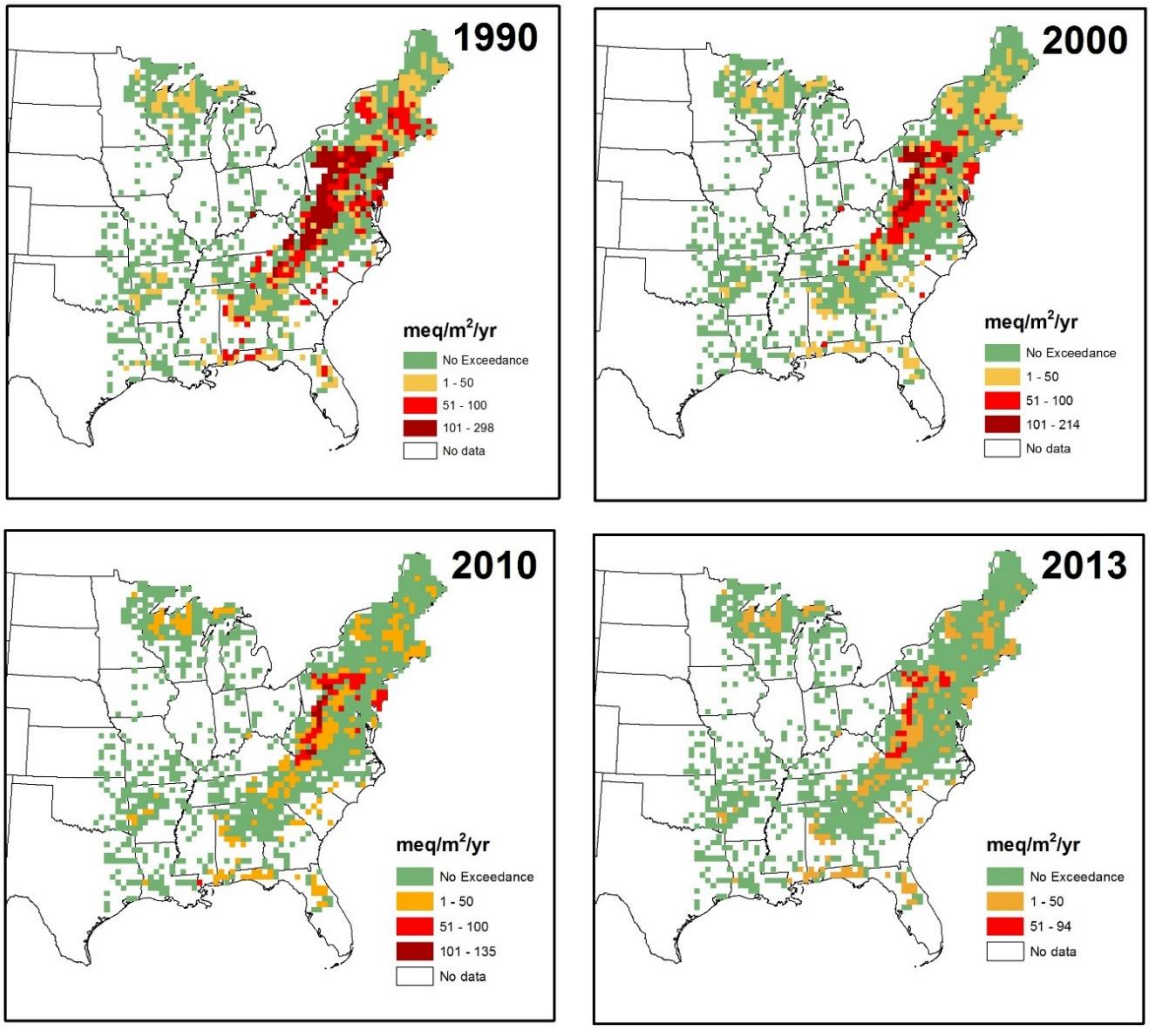


Figure US6: Lake and Stream Exceedances of Estimated Critical Loads for Total Nitrogen and Sulphur Deposition for 1990 to 2013. (Source: U.S. EPA 2016)

Notes:

- Averaged exceedance for 36 km grid
- Exceedances base on total N and S deposition (wet and dry) from TDEP[10]
- Critical load data provided by National Critical Load Database (NCLD)[11]
- Calculated using the simple mass-balance model[12,13]

In Canada, critical loads of acidity are estimated for many lakes and upland forest soils across Canada. If actual sulfur and nitrogen deposition does not exceed the critical load within a given area, at least 95% of all lakes and soil ecosystems in the area are protected from the adverse effects of acid deposition.

Canada has created a new national critical load map for acidity that combines current information for lakes and soils (see Figure CN4) Critical load values depend on a chemical threshold that defines the onset of harmful ecosystem effects. In total, critical loads were estimated for 4,572 lakes and 7,867 soil areas across Canada, which represents an area of approximately 5.8 million km^2 covering 2,874 grid squares in the map. This methodology focuses on ensuring that the most sensitive elements of an ecosystem are protected. If actual acid deposition does not exceed the identified threshold (5th percentile critical load value), at least 95% of all lakes and soil ecosystems within the grid are protected from the adverse effects of acid deposition.

There are obvious “hot spots” of sensitive ecosystems, represented by very low critical loads (red and orange squares in Figure CN4). These are located in southern Quebec, northwestern Saskatchewan and extreme northeastern Alberta, and the coastal mountain range of southwestern British Columbia (including some parts of Vancouver Island). There are also isolated occurrences of very low critical loads in southern Nova Scotia, Newfoundland, northern Ontario, northwestern Manitoba, east central Alberta, and northwestern British Columbia. The commonality among all these areas with low critical load values is the occurrence of lakes with very low base caption and ANC concentrations.

Overall, approximately 0.44 million km^2 or 7.6 percent of the Canadian terrain covered by the analysis shown in Figure CN4 is extremely sensitive to acidic deposition, i.e., falling within the two lowest critical load classes. An additional 2.1 million km^2 or 35 percent of the total falls within the next two critical load classes. [15]

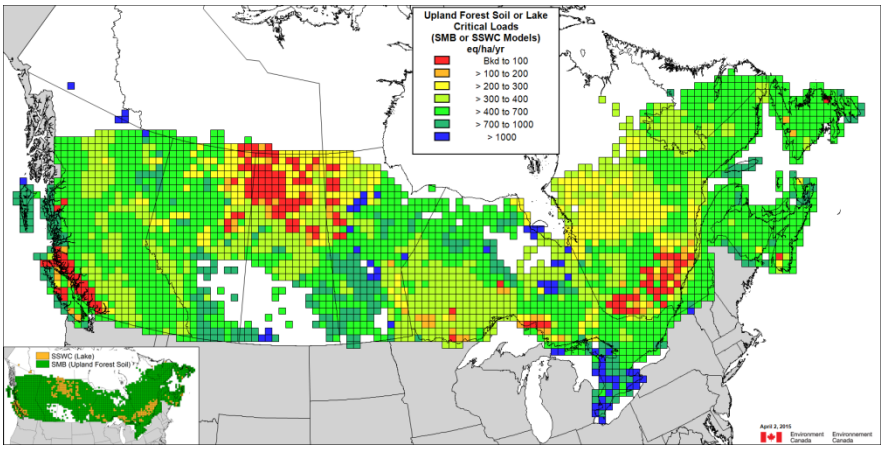


Figure CN4: Critical Loads of Acidity for Lakes or Upland Forest Soils across Canada. Areas that cannot be classified by either the lake or forest soil models are white. (Source: Environment and Climate Change Canada, 2016)

Ozone and ozone precursors and their impacts on health and ecosystems

Ozone has long been recognized as an important health and ecosystem-related air quality concern in the United States and Canada. Exposure to ground-level ozone is associated with a wide variety of adverse health effects, ranging from decreased lung function and increased respiratory system symptoms to serious indicators of respiratory morbidity. Children and individuals with lung disease are considered at-risk populations. Ozone exposure also leads to detrimental environmental effects: repeated exposure to ozone during the growing season damages sensitive vegetation; and cumulative ozone exposure can lead to reduced tree growth, visibly injured leaves, and increase susceptibility to disease, damage from insects and harsh weather. See “Key Challenges and Opportunities” section for further discussion on the health impacts of ozone.

Both United States and Canada recently set stricter ambient air quality standards for ozone. On Oct. 1, 2015, the U.S. EPA strengthened the National Ambient Air Quality Standards (NAAQS) for ground-level ozone from 75 parts per billion (ppb) to 70 ppb, based on extensive scientific evidence that includes

[15] Henriksen, A. and Posch, M. 2001. Steady-state models for calculating critical loads of acidity for surface waters. Water Air Soil Poll.: Focus 1, 375-398.
Sverdrup, H., de Vries, W.. 1994. Calculating critical loads for acidity with the simple mass balance method. Water Air Soil Poll. 72, 143-162.

thousand of studies on ozone's effects on public health and welfare. EPA also strengthened the standard to improve protection for trees, plants and ecosystems based on new studies that add to evidence showing that exposure to ozone reduces growth and has other harmful effects on plants and trees. These types of effects have the potential to harm ecosystems and the benefits they provide. The EPA's final rule and risk assessment includes our latest scientific findings and conclusions about health and ecosystem impacts of ozone.[16]

Similarly, in May 2013, Canada established new more stringent Canadian Ambient Air Quality Standards for ozone of 63 ppb in 2015 and 62 ppb in 2020. These standards were established as objectives under the Canadian Environmental Protection Act 1999 and replace the previous Canada-wide Standard for Ozone. The 2020 standard for ozone will be reviewed in 2016. New air quality standards for SO_2 and nitrogen dioxide (NO_2) are currently under development.

The United States and Canada have also committed to addressing transboundary ozone under the AQA, by reducing emissions of NO_x and VOCs, the precursors to ozone. The commitments apply to a defined region in both countries known as the Pollutant Emission Management Area (PEMA), which includes central and southern Ontario, southern Quebec, 18 states and D.C., and which is where emission reductions are most critical for reducing transboundary ozone (see "Need for transboundary and multi-sectoral approaches continues" section for further details).

Canadian efforts to reduce NOx include a cap on NO_x emissions from large fossil fuel–fired power plants in the Ontario and Quebec portions of the PEMA, as well as additional provincial measures in Ontario and Quebec that help to address ozone. Canada has also implemented a series of regulations with new stringent NO_x and VOC emissions standards for vehicles, including cars, vans, light-duty trucks, off road vehicles, small and diesel engines, as well as fuels. Increasingly stringent emissions standards for off-road vehicles and engines were the most significant driver of reductions in VOC emissions in Canada. In addition, regulations are in place to reduce VOC emissions from dry-cleaning, solvent-degreasing and to set VOC concentration limits in certain consumer products. Federal, provincial and territorial governments are working together to implement the Air Quality Management System (see section on "Need for transboundary and multi-sectoral approaches continues" for more information) to further address ozone.

U.S. efforts to reduce NO_x emissions under the Agreement have focused on the implementation of NO_x transport emission reduction program, known as NO_x SIP Call, from 2003 to 2008. Starting in 2009, the NO_x annual and ozone season programs under CAIR took effect. The United States has also continued to implement: (1) existing U.S. vehicle, non-road engine and fuel quality rules; (2) existing rules for the control of emissions from stationary sources of hazardous air pollutants and of VOCs from consumer and commercial products, architectural coatings and automobile repair coatings; and, (3) 36 existing New Source Performance Standards to achieve VOC and NO_x reductions.

Canada-US collaboration to date has led to significant reductions. Between 2000 and 2012, Canada's total NO_x emissions in the PEMA region decreased by 45 percent, while in the United States total NO_x emissions in the region declined by 47 percent. Emissions are projected to continue to decline through to 2025 (see Figures CN5 and US7 below).

Gains are also being made on ambient ozone levels. In Canada, average ozone levels[17] decreased by 15% between 1998 and 2012. Between 2003 and 2012, the percentage of Canadians living in communities where ambient concentrations of ground-level ozone exceeded established air quality standards dropped from approximately 50% to 28%. In the United States, nationally, average ozone levels declined in the 1980's, leveled off in the 1990's, and showed a notable decline after 2002. From 1990 to 2014 national average ozone levels decreased 23%.

[16] http://www3.epa.gov/ttn/naaqs/standards/ozone/s_o3_index.html

[17] Average ozone levels are based on the annual fourth-highest daily maximum 8-hour ozone concentrations.

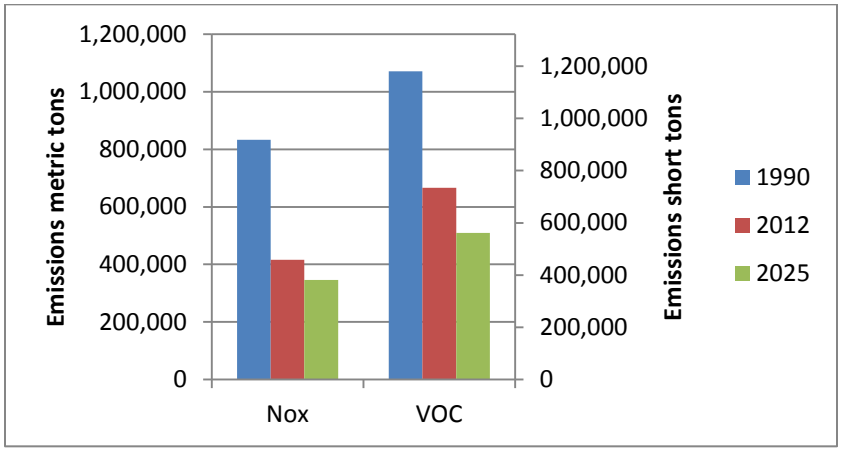


Figure CN5: Emissions of NOx, VOC, methane and CO in Canada and emissions in the PEMA region (Source: Environment and Climate Change Canada, 2014)

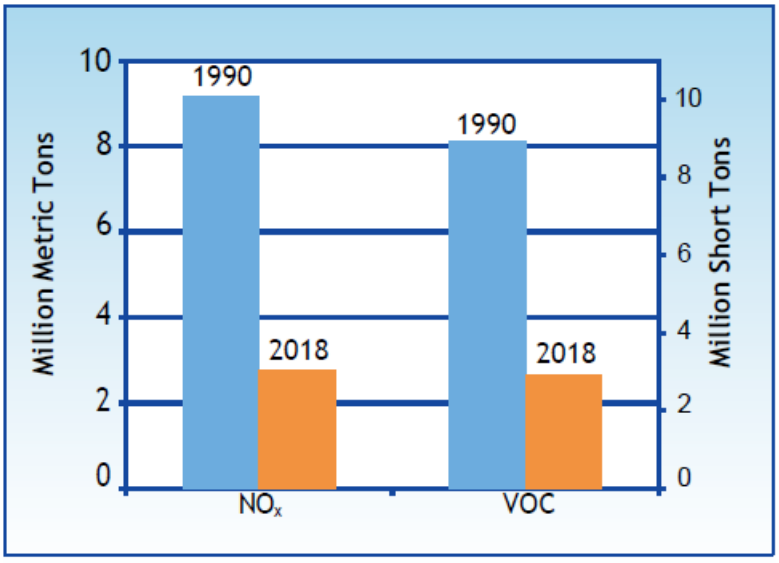


Figure US7: U.S. NO_x and VOC PEMA Emissions and Projections

POPs and Heavy Metals

The U.S. Clean Air Act (CAA) addresses hazardous air pollutants (HAP - also known as toxic air pollutants or air toxics). The U.S. EPA is required to control 187[18] HAP including mercury, lead, cadmium and some persistent organic pollutants. From 1990 to 2011, emissions of air toxics in the U.S. declined by over 60 percent as a result of implementing stationary and mobile source regulations[19]. More specifically, lead ambient air concentrations in the U.S. have been reduced from 1990 to 2014 by 97 percent[20]. Mercury air emissions in the U.S. have been reduced from 246 tons per year (tpy) in 1990 to 56 tpy in 2011. In December 2011, the U.S. EPA signed a rule to reduce emissions of toxic air pollutants from

[18] http://www3.epa.gov/airtoxics/188polls.html
[19] http://www3.epa.gov/airtrends/aqtrends.html#comparison
[20] http://www3.epa.gov/airtrends/lead.html

power plants. Specifically, these mercury and air toxics standards (MATS) for power plants will reduce emissions from new and existing coal and oil-fired electric utility steam generating units (EGUs) larger than 25 megawatts.

Key challenges and opportunities

The science of air quality – sources, emissions, atmospheric trends, fate and transport, and health and environmental impacts – continues to evolve. Emerging areas of science relevant to the management and reduction of air pollution in the United States and Canada include the need for improved understanding of:

- The combined health effects from exposure to multiple pollutants, including ozone, $PM_{2.5}$ and toxics, and how these combined effects could affect air quality standards and management strategies;
- The bidirectional linkages between air quality and climate, including the impacts of climate change on ozone and $PM_{2.5}$ concentrations and of the effects of ozone, $PM_{2.5}$ and its components on climate change;
- The effects of changes in the mix of energy generation and end-use technologies on the pollutant concentrations, including ozone and$PM_{2.5}$, and the impacts of growing domestic fossil fuel extraction activities, such as the oil sands, and unconventional oil and gas development, such as the use of hydraulic fracturing (fracking);
- Changes in the relative importance of natural sources and intercontinental transport that could affect the management of ambient ozone and $PM_{2.5}$ concentrations in Canada and the United States; and
- The relationship between air quality concentrations and pollutant deposition for multiple pollutants, including NO_x, SO_x and toxic metals, and how these relate to water quality and ecological effects.

Air pollution reductions have economic benefits

The impacts of air pollution on the Canadian economy include direct economic impacts as well as indirect economic impacts stemming from the human health and environmental effects of air pollution. Reductions in illness and mortality have direct social benefits and improve the productivity of Canadian industry while decreasing health care costs. For example, a 2008 analysis of the Canadian Medical Association estimated that as many as 21,000 Canadians premature deaths per year were associated with air pollution, along with hundreds of thousands of asthma and respiratory symptom days and millions of minor illnesses and restricted-activity days, It calculated the value of human health damages from air pollution at exceeding $8 billion annually, due to premature death, worker absenteeism, higher health care costs and other factors. In many cases the public health benefits may exceed the costs of control. Air pollution reductions have the potential to directly increase the productivity of the forestry, agriculture, fishing, and tourism industries by decreasing environmental damages suffered by these industries.

Although the costs of reducing air pollution can be high at times, most recent cost-benefit studies such as Cost-Benefit Analysis: Replacing Ontario's Coal-Fired Electricity Generation (2005) demonstrate that, at current pollution levels, the potential benefits to Canadians of air pollution reductions are much greater than the costs of those reductions.

Efforts to reduce air pollution may also lead to innovative new industries and economic spin-offs related to green technology in Canada. A number of tools are being used, including regulations and partnerships, to encourage activities that support both the environment and the economy. For instance, new technologies, cleaner fuels, science and research, electricity production and conservation, alternative transportation, and new forms of infrastructure can stimulate economic growth in a way that also helps the environment.

In the United States, effective implementation of clean air laws and regulations, as well as application of efficient control technologies, has resulted in significant improvements in U.S. air quality. The decrease in

annual emissions of major pollutants is one indicator of the effectiveness of U.S. programs. The graph in Figure US8 shows that between 1970 and 2014, gross domestic product increased 238 percent, vehicle miles traveled increased 172 percent, energy consumption increased 45 percent, and U.S. population grew by 56 percent. During the same time period, total emissions of the six principal air pollutants (carbon monoxide, lead, nitrogen oxide, volatile organic compounds, particulate matter (PM_{10} and $PM_{2.5}$), and sulfur dioxide) dropped by 69 percent. The graph also shows that between 1970 and 2013, CO_2 emissions increased by 27 percent. Despite great progress in air quality improvements, there were 57.3 million people living in counties in the U.S. with air quality concentrations above the levels of the U.S. national ambient air quality standards in 2014. In the United States, scientists at the EPA estimate that exposure to recent air pollution contributed to 1 of every 20 deaths in the U.S. and have found that reducing exposures to fine particulate matter and ozone nationwide by 33% would avoid about 43,000 premature deaths, tens of thousands of non-fatal heart attacks and respiratory and cardiovascular hospitalizations and hundreds of thousands of acute respiratory symptoms. The economic value of premature deaths, heart attacks, hospital admissions, emergency department visits, and missed school work exceeds $1 trillion every year.[21]

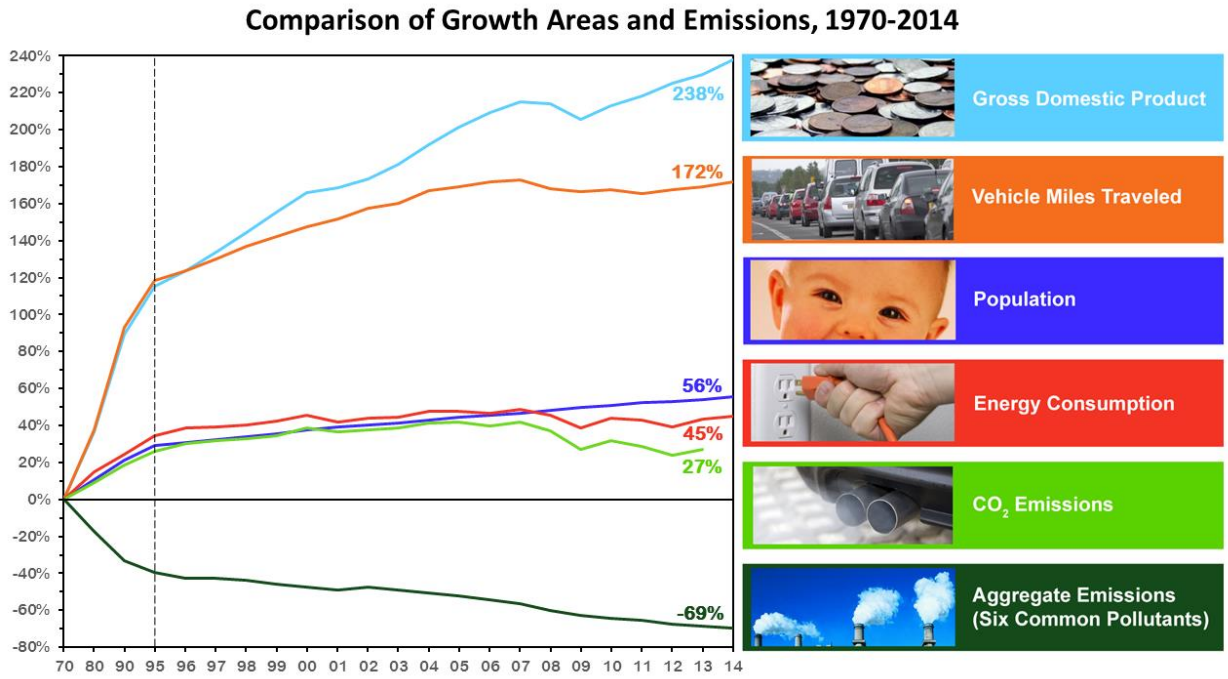


Figure US8: Comparison of Growth Areas and Emissions, 1970-2014 (Source: http://www3.epa.gov/airtrends/index.html)

Need for transboundary and multi-sectoral approaches continues

In 1991, Canada and the United States established the AQA to address transboundary air pollution. The Agreement initially focused on reducing levels of acidic deposition in each country, and in 2000 was amended to also address ground-level ozone. Under the Agreement, the United States and Canada have agreed to work together to:

- harmonize national vehicle, engine and fuels standards for emissions of smog-forming pollutants;

[21] Fann N, Lamson A, Wesson K, Risley D, Anenberg SC, Hubbell BJ. Estimating the National Public Health Burden Associated with Exposure to Ambient $PM_{2.5}$ and Ozone. Risk Analysis; 2011.

- optimize vehicle and engine emission-testing activities, taking advantage of unique testing capabilities, and sharing emission test data where appropriate to facilitate regulatory administration activities in both countries;
- share information and discuss strategies and approaches on greenhouse gases (GHG) emission standards for motor vehicles; and
- on sharing information on the mix of different air emissions being emitted from upstream and downstream oil and gas operations, including hazardous/toxic air pollutants, air quality pollutants, and emissions that contribute to climate change.

As a result of bilateral collaboration, large reductions in SO_2 and NO_x emissions in regions covered by the Agreement have been achieved to date, along with associated reductions in ecosystem acidification and improvements in air quality (see section "Ozone and ozone precursors and their impacts on health and ecosystems").

Under the Agreement, Canada and the US also participate in scientific and technical cooperation and research and provide updates on new actions in each country that will help further reduce levels of acid rain, ozone and particulate matter (PM). In recent years, both countries undertook joint scientific and technical analyses to assess the transboundary transport of PM and precursor emissions, due to significant concerns for both countries regarding the potential risks to public health and ecosystems. The two countries will continue to monitor and evaluate $PM_{2.5}$, particularly in border areas, and will continue to develop and implement emission reduction programs to reduce $PM_{2.5}$ concentrations. These efforts signify the ongoing importance both countries place on cooperation and innovation in addressing transboundary air pollution issues. The Agreement provides a formal and flexible method for addressing transboundary air pollution and continues to provide a framework under which the two countries can cooperate on ongoing and future air quality issues.

Recent research has demonstrated that air pollutants do not always independently affect health. Exposures to mixtures of pollutants, e.g. ozone and $PM_{2.5}$, can lead to greater than additive effects on respiratory and cardiovascular health. In addition, exposure to one air pollutant can sensitize individuals to subsequent exposures to another air pollutant, leading to greater health impacts from sequential exposures than to individual exposures to either pollutant. Recent studies have also shown that exposures to high temperatures can increase the impact of exposures to ozone. Related studies suggest that future increases in extreme temperatures will thus result in both higher ozone concentrations and a greater health impact associated with exposures to high ozone. Continued cooperative efforts are necessary to address the ongoing health and environmental effects associated with air pollutants.

Air pollution at a wider scale

North America continues to receive transport of particles and gases from other continents (see Figure CN6 a&b below). The transport of particles and gases from Asia, Europe and Africa across the Pacific Ocean increases the background concentrations of pollutants over North America. Conversely, North America contributes to global pollution levels through the prevailing atmospheric circulation that carries particles and gases away from the continent and over the Atlantic Ocean. Although some fraction of the pollution exported by North America across the Atlantic can circle the Northern Hemisphere and return to North America, this fraction is small in comparison to more direct sources, such as the trans-Pacific transport from Asia (2012 Smog Science Assessment).

The fast growing economy in Asia has both increased the levels of pollution that reach North America and increased the difficulty with which their impact can be accurately quantified in a timely manner. In addition, pollutants such as sulphur and nitrogen compounds, persistent organic pollutants, lead and mercury from Eurasia can be transported to the North American Arctic through the trans-Arctic pathways in winter and early spring. This has increased the ambient levels of these compounds in the Arctic to levels comparable to polluted regions in North America.

Domestic reductions have the greatest impact on avoided death however there is still a noticeable positive contribution being made as a result of reductions from outside the region due to reduced long-

range transport inputs. For example, while 93–97% of avoided deaths from reducing emissions in four major industrial regions (North America, Europe, East Asia, and South Asia) occur within the source region, 3–7% occur outside the source region. For North America, the percentages are 96 and 4% respectively. For ozone, the conclusions were the same for the four industrial regions where there was a decrease in the number of days per month when daily maximum ozone concentrations did not exceed limits when emissions were decreased from the source region.

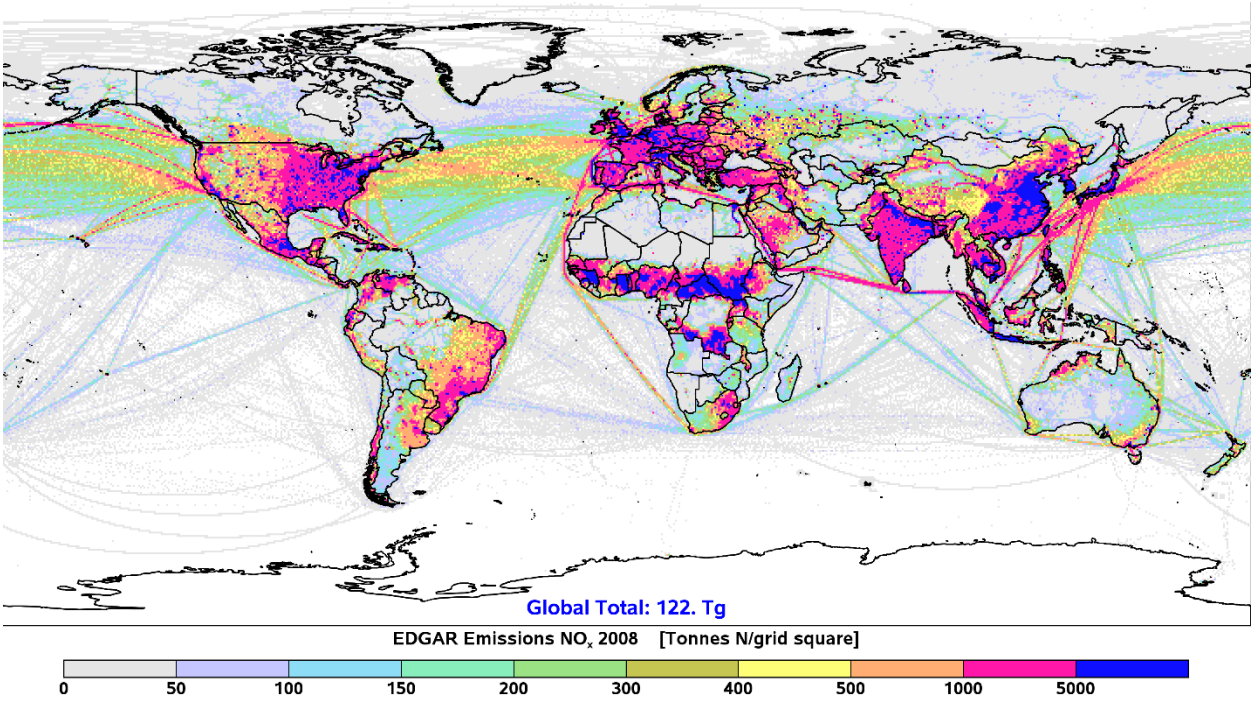


Figure CN6a: EDGAR global emission maps for NO_x for 2008 shows the global distribution of emissions and how Canadian and US emissions fit in the global context. (Source: EDGAR, European Commission, Joint Research Centre, Ispra, Italy. http://edgar.jrc.ec.europa.eu/index.php.*)*

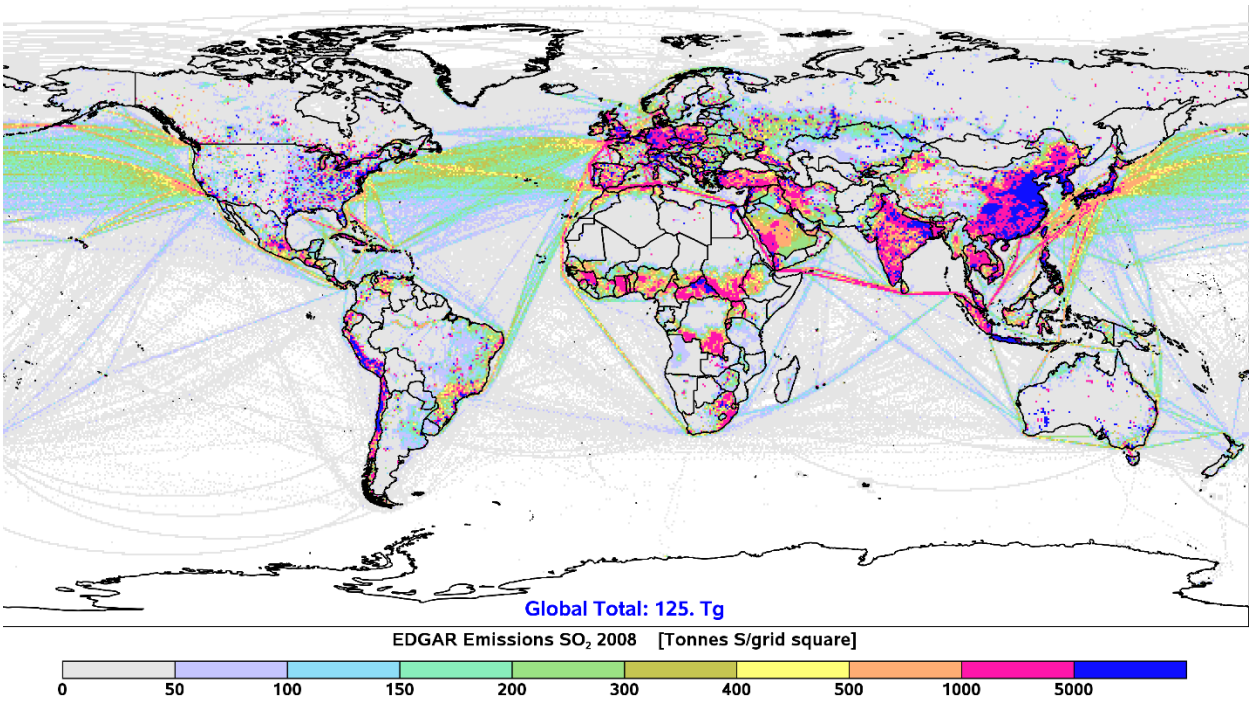


Figure CN6b: EDGAR global emission maps for SO_2 for 2008 shows the global distribution of emissions and how Canadian and U.S. emissions fit in the global context. (Source: EDGAR, European Commission, Joint Research Centre, Ispra, Italy. http://edgar.jrc.ec.europa.eu/index.php)

Air quality and climate change: two sides of the same coin

Ongoing research is improving the understanding of the bidirectional linkages between air quality and climate, which will allow air quality managers to understand both how climate change will impact future air quality, and how air quality management programs fit in to overall strategies to mitigate the causes of climate change. Climate change is expected to have important negative impacts on the air pollution, including increasing ozone PM levels and emissions of ozone precursors, and PM from natural sources such as wildfires. Many air quality management actions that directly reduce emissions of some short-lived climate pollutants (SLCPs), such as black carbon, have the co-benefit of reducing emissions of long-lived greenhouse gases, and vice versa. For example, recent actions such as the U.S. EPA's Clean Power Plan and Canada's greenhouse gas regulations for coal-fired electricity generation are resulting in reductions in both climate pollutants and traditional air pollutants. Another example of this linkage is the use of wood or biomass in place of fossil fuels for heating, which reduces greenhouse gas emissions, but increases emissions of $PM_{2.5}$ and black carbon.

SLCPs include black carbon, methane, ground-level (tropospheric) ozone and some hydrofluorocarbons (HFCs), defined by their relatively short atmospheric lifespans compared to longer-lived GHGs such as carbon dioxide (CO_2), and their warming impact on climate. Reducing emissions of SLCPs can help slow the rate of near-term climate warming as a complement to reducing CO_2 and other GHGs while, in the cases of black carbon and ozone, also realizing significant benefits for human health, agricultural productivity and ecosystems. Addressing black carbon is particularly important at northern latitudes as its deposition on snow and ice produces additional warming effects by darkening the surface, and accelerating melting. SLCPs provide an important link between efforts to address air pollution and climate change. Canada and the Unites States are collaborating on SLCPs bilaterally, and with other international partners under several multilateral fora outside of the Convention or Gothenburg Protocol, including the Arctic Council and the Climate and Clean Air Coalition (CCAC). Current efforts to develop analytical tools that integrate climate pollutants and traditional air pollutants will improve the ability to identify optimal strategies to reduce climate pollutants and air pollution simultaneously.

Institutional arrangements

In Canada, the Canadian Environmental Protection Act, 1999 (CEPA) provides the federal government with the authority to set national ambient air quality objectives and regulate the release from industrial sectors and other sources of air pollutants listed under the Act, emissions performance of a wide range of on-road and off-road vehicles and engines, and the content of specific pollutants in fuels.

Protecting the environment is a shared jurisdiction between the federal and provincial/territorial governments, and governments have been working together for more than three decades to manage air pollutants and improve air quality using regulatory and non-regulatory measures to reduce the emissions from various sources. Many provinces/territories have taken action to address air pollution issues through their own regulatory frameworks and permitting processes.

Currently, federal, provincial and territorial Environment Ministers are working collaboratively to implement the Air Quality Management System (AQMS). The AQMS includes four key elements: more stringent Canadian Ambient Air Quality Standards (CAAQS); base-level industrial emission requirements (BLIERs) that target the reduction of harmful air pollutant emissions from key industrial sectors and equipment groups; management of air quality using local air zones and regional airsheds; and a collaborative effort to reduce emissions from mobile sources.

CAAQS for $PM_{2.5}$ and ground-level ozone established in 2013 and those under development for SO_2 and NO_x are designed to drive improvement of air quality, and provide the basis for provincial and territorial governments to determine what level of air quality management action is needed. Proposed Multi-Sector Air Pollutant Regulations published for public comment in June 2014 would implement BLIERs to limit emissions from the cement manufacturing sector, non-utility boilers and heaters, and stationary spark-ignition gaseous-fuel-fired engines.

The air zone/airshed management of air quality is a framework used by federal, provincial and territorial governments to manage air quality locally (within a jurisdiction) and regionally (may include several jurisdictions) to ensure that air quality does not exceed the CAAQS. The system includes air quality management levels and threshold values that will guide provinces and territories to undertake increasingly more stringent action within specific air zones to ensure that proactive measures are taken to protect and prevent deterioration of air quality. The federal government coordinates six regional airsheds that will facilitate reporting on regional air quality and coordinate actions to address regional air pollution issues, including the transboundary flow of pollutants from the United-States and across inter-provincial and inter-regional boundaries. In addition, an intergovernmental working group facilitates collaboration related to mobile sources and reducing emissions from the transportation sector.

In the United States, the Clean Air Act (CAA) provides the principal framework for national, state, tribal and local efforts to protect air quality. The U.S. Congress designed the CAA to protect public health and welfare from different types of air pollution caused by a diverse array of pollution sources. Congress established the law's basic structure in the CAA Amendments of 1970, and made major revisions in 1977 and 1990. The U.S. EPA works in partnership with state and local agencies to manage air quality. To protect public health and welfare nationwide, the law requires the U.S. EPA to establish national ambient air quality standards (NAAQS) based on the latest science, and requires states to adopt enforceable plans to achieve the standards. State plans also must control emissions that drift across state lines and harm air quality in downwind states. The law is designed to minimize pollution increases from growing numbers of motor vehicles, and from new or expanded stationary sources (i.e., power plants, industrial plants, and other facilities). The law calls for new stationary sources to be built with best technology, and generally allows less stringent standards for existing stationary sources. States and tribes are responsible for many activities related to implementing national policies and programs. The U.S. EPA provides guidance and technical assistance to assist state planning, issues national emissions standards for new stationary sources, and reviews state plans to ensure that they comply with the CAA. Preconstruction permits are required for major new and modified stationary sources and operating permits are also required for new and existing sources. In most areas, state or local air agencies serve as the CAA permitting authority.