Acid Rain

SOLEC Indicator #9000

Purpose

To assess the pH levels in precipitation and critical loadings of sulphate to the Great Lakes basin, and to infer the efficacy of policies to reduce sulphur and nitrogen acidic compounds released to the atmosphere.

Ecosystem Objective

The 1991 Canada/U.S. Air Quality Agreement pledges the two nations to reduce the emissions of acidifying compounds by approximately 40% relative to 1980 levels. The 1998 Canada-Wide Strategy for Post 2000 intends to further reduce emissions to the point where deposition containing these compounds does not adversely impact aquatic and terrestrial biotic systems.

State of the Ecosystem

Acid rain, more properly called "acidic deposition", is caused when two common air pollutants (sulphur dioxide—SO_2 and nitrogen oxide—NO_x) are released to the atmosphere, react and mix with high altitude water droplets and return to the earth as acidic rain, snow, fog or dust. These pollutants can be carried over long distances by prevailing winds, creating acidic precipitation far from the original source of the problem. Environmental damage typically occurs where local soils and/or bedrock do not effectively neutralize the acid.

Lakes and rivers have been acidified by acid rain causing the disappearance of many species of fish, invertebrates and plants. Not all lakes exposed to acid rain become acidified however. Lakes located in terrain that is rich in calcium carbonate (e.g. on limestone bedrock) are able to neutralize acidic deposition. Much of the acidic precipitation in North America falls in areas around and including the Great Lakes basin. Northern Lakes Huron, Superior and Michigan, their tributaries and associated small inland lakes are located on the geological feature known as the Canadian Shield. The Shield is primarily composed of granitic bedrock and soils that cannot easily neutralize acid, thereby resulting in acidification of many of the small lakes (many of which are in norther Ontario). The five Great Lakes are so large that acid precipitation has little effect on them directly. Impacts are mainly felt on vegetation and on inland lakes.

Sulphur dioxide emissions come from a variety of sources. Most common releases of SO2 in Canada are a byproduct of industrial processes, notably metal smelting. In the United States, electrical utilities constitute the largest emissions source (Figure 1). The primary source of NO_x emissions in both countries is the combustion of fuels in motor vehicles.

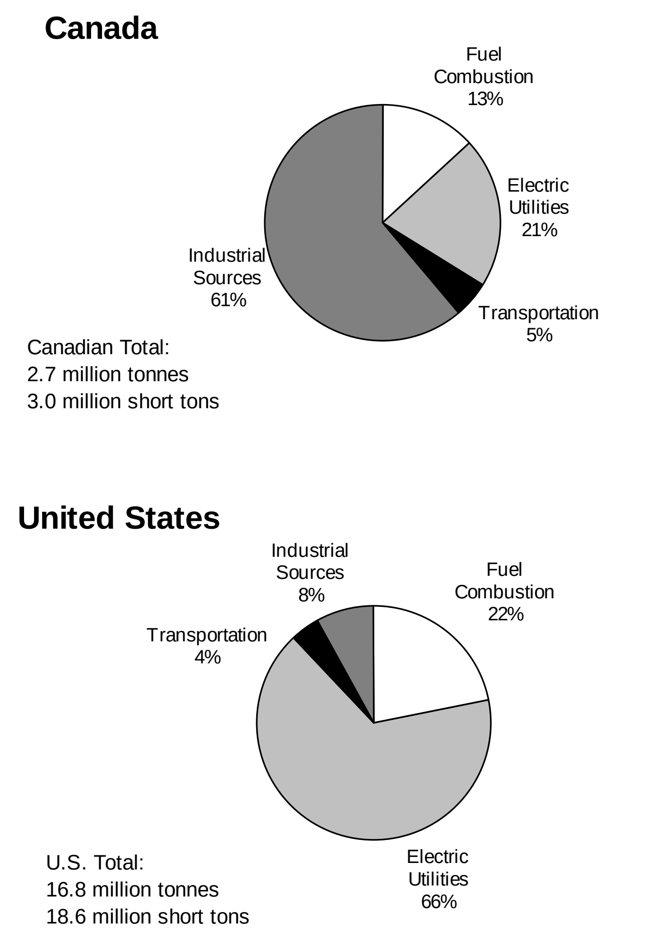

Figure 1. Sources of Sulphur Dioxide Emissions in Canada and the U.S. (1995)

Future Pressures

Figure 2 illustrates the trends in SO_2 emission levels in Canada and the United States measured from 1980 to 1995 and predicted from 1995 to 2010. U.S. levels are expected to decrease by approximately one-third by 2000 and by up to 40% by 2010. Canadian levels dropped 54% from 1980 to 1994 and thereafter are expected to remain at approximately current levels. Despite these

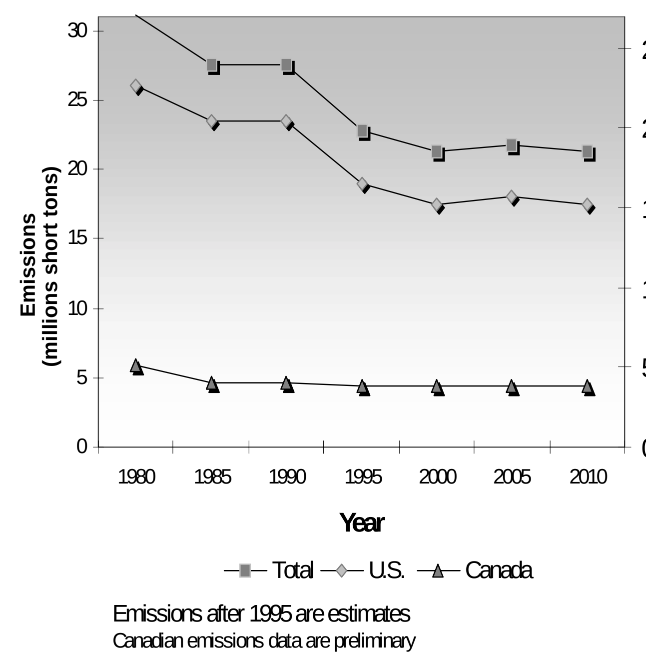

Figure 2. Past and Predicted Sulphur Dioxide Emissions in Canada, the U.S. and Combined.

efforts, rain is still too acidic throughout most of the Great Lakes region.

Figure 3 compares wet sulphate deposition over eastern North America between two five-year periods, 1980-84 and 1991-95 in kilograms sulphate per hectare per year. In response to the decline in SO_2 emissions, deposition decreased between the two periods. If SO_2 emissions remain relatively constant after the year 2000, as predicted (Figure 2), it is unlikely that sulphate deposition will change in the coming decade. The predicted sulphate deposition exceedances of critical loads for 2010 in Canada are seen in Figure 4.

Pressures will continue to grow as the population within and outside the basin increases, causing increased demands on electrical utility companies, resources and an increased number of motor vehicles. Considering this, reducing nitrogen deposition is becoming more and more important, as its contribution to acidification may soon outweigh the benefits gained from reductions in sulphur dioxide emissions.

Future Activities

The effects of acid rain can be seen far from the source and so the governments of Canada and the United States are working together to reduce acid emissions. The 1991 Canada/United States Air Quality Agreement addresses transboundary pollution. To date, this agreement has focussed on acidifying pollutants and significant steps have been made in the reduction of SO_2 emissions. However, further progress in the reduction of acidifying substances is required.

The 1998 *Canada-Wide Acid Rain Strategy for Post-2000* provides a framework for further actions, such as establishing new sulphur dioxide emission reduction targets in Ontario, Quebec and other provinces.

Further Work Necessary

While North American SO_2 emissions and sulphate deposition levels in the Great Lakes basin have declined over the past 10 to 15 years, many acidified lakes do not show recovery (increase in water pH or alkalinity). Empirical evidence suggests that there are a number of factors acting to delay or limit the recovery response, e.g. increasing importance of nitrogen-based acidification, soil

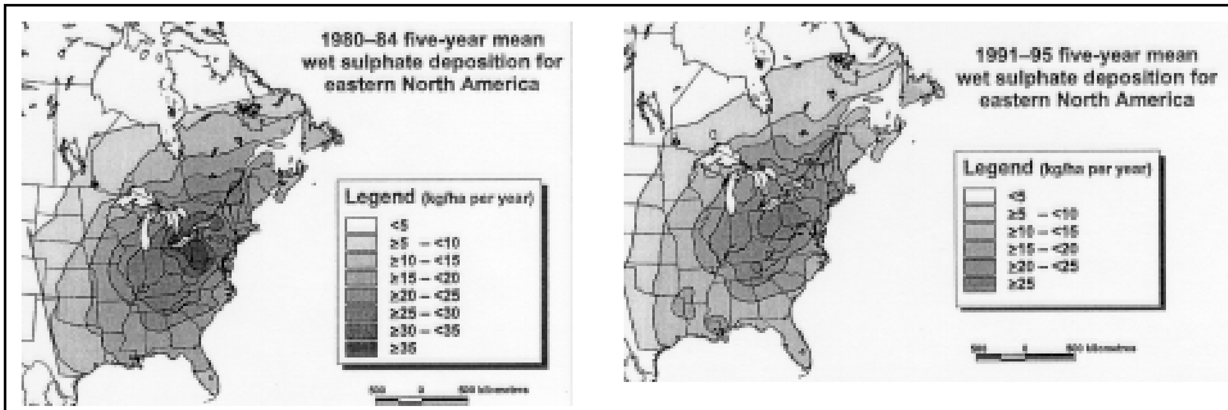

Figure 3. Comparison of Mean Wet Sulphate Deposition in Eastern North America from 1980-84 and 1991-95.

depletion of base cations, mobilization of stored sulphur, climatic influences, etc. Further work is needed to quantify the additional reduction in deposition needed to overcome these limitations and to accurately predict the recovery rate.

Acknowledgments
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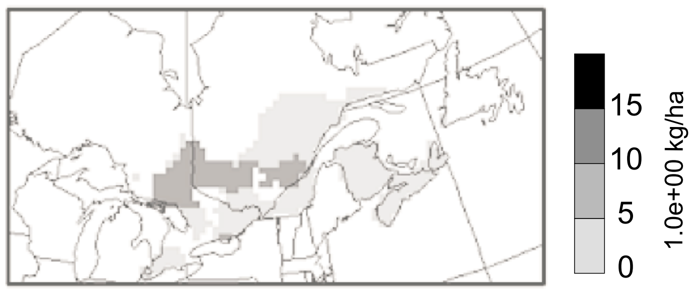

Figure 4. Predicted 2010 Sulphate Deposition Exceedances of Critical Loads