EFFECTS OF ACID RAIN ON ATLANTIC CANADA'S INLAND WATERS

The Acid Rain Problem

World attention was drawn to the problem of the long range transport of air pollutants and their effect on the environment in the 1960's when Sweden and Norway first documented the "acid-rain phenomenon". This has subsequently been recognized as a major environmental issue in Canada and the United States.

Acid rain is caused by the release of oxides of sulphur and nitrogen during the burning of fossil fuels at coal-fired thermal generating stations and smelters and by automobiles. These oxides in turn combine with water vapour in the atmosphere to form sulphuric and nitric acids. The acids are then typically transported over long distances before being deposited as rain, snow or dry particles.

The acidic nature of precipitation is commonly measured using the pH scale (Figure 1) with values below 5.6 considered to be indicative of acid rain. The pH scale is logarithmic; that is, a decrease of one pH unit, for example from pH 5 to pH 4, represents a ten-fold increase in acidity.

In places downwind of industrial emission sources, such as eastern Ontario, southern Scandinavia, and parts of Germany, precipitation pH values at or below 4.0 have been observed. In some of these areas, acid

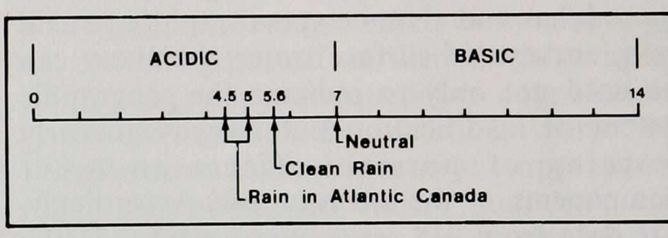

Figure 1: *The pH Scale.*

rain has been linked to changes in surface water chemistry, the loss of commercial fisheries, forest diebacks, the accelerated aging of building materials and possible adverse human health effects due to increased toxic metal concentrations in acidified drinking water supplies and distribution systems.

The Atlantic provinces lie downwind of major pollution sources and are receiving acid precipitation originating from central Ontario and the midwestern United States (Figure 2) and to a lesser extent from local sources. The most acidic precipitation in Atlantic Canada is observed in western New Brunswick and

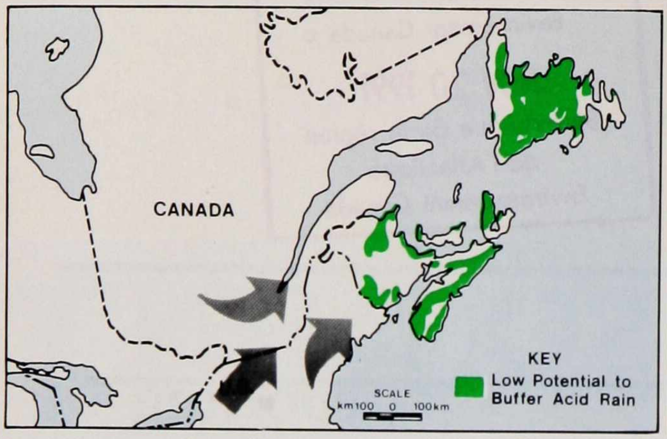

Figure 2: *Major Emission Sources Impacting Atlantic Canada.*

southwestern Nova Scotia (pH approximately 4.5) and the level of acidity diminishes eastward with the least acidic rain being observed in Newfoundland (pH approximately 5.0). The higher levels of acid rain have resulted in significant changes in the chemistry of surface waters and have been linked to losses of Atlantic salmon in Nova Scotian rivers.

Lakes and rivers are an important part of the social and economic fabric of Atlantic Canada. They are valued for their fishing, recreation, transportation, and power generation and as supplies of drinking water. Since these lakes and rivers respond rapidly to acid rain, surveys of surface water chemistry can be used not only to indicate the geographic extent of acidification but also as an early warning of possible effects on other components of the environment. Accordingly, pH data from 918 representative lakes in the Atlantic Region were investigated to document the extent of the effects of acid rain. However, due to the lack of data, Labrador was excluded from this analysis.

The Acidification Process

Many of the lake and river waters in Atlantic Canada are commonly brown in colour due to organic acids which are produced naturally from the decay of vegetation in bogs and peatlands. These brown waters thereby receive acids both from natural sources, as well as from man-made sources via acid rain. It has only recently been recognized that these naturally acidic waters are also being influenced by acid rain.

Lakes and rivers vary in their ability to handle acidic inputs, whether natural or man-made. It is ultimately the bedrock and soil composition of their drainage basins that determines whether the surface waters will become acidic or not. Major portions of Atlantic Canada such as southwestern Nova Scotia and Newfoundland have granite bedrocks and very thin soil layers which provide little ability to counteract or "buffer" the incoming acid rain. In other areas such as the Saint John River Valley, the Annapolis Valley and Prince Edward Island the limestone-sandstone geology and soils provide high buffering capability.

The acidification process can be best understood as an environmental teeter-totter, with the acid inputs from all sources on one side and the geological and soil buffering potential on the other side (Figure 3). When the "weight" of the acid input is much less than the weight of the buffering potential, the pH value will be high and there will be no negative effects on the biological community. This is termed the "Unacidified Phase". As the weight on the acid side increases, that arm of the teeter-totter moves downward and the lakes exhibit a decline in pH values and increased stress on sensitive aquatic species such as salmon and trout. This is called the "Sensitive Phase". At the point where there is equal weight on both sides, lakes will have no buffering potential, pH values of 5.3-5.7, and are considered to be acidic. It is during this stage that sensitive amphibians and fish species may fail to reproduce, resulting in reduced populations. As the "weight" of the acid side continues to increase, that arm continues its descent and the result is major reductions in pH values and drastic losses of many species of plants and animals. This is termed the "Acidic Phase". A recent biological survey by W. D. Watt (see Additional Reading) indicated that acid rain has resulted in a 9 percent loss of Atlantic salmon biological reproduction capacity for the Maritimes as a whole and up to a 50 percent loss for poorly buffered portions of Nova Scotia.

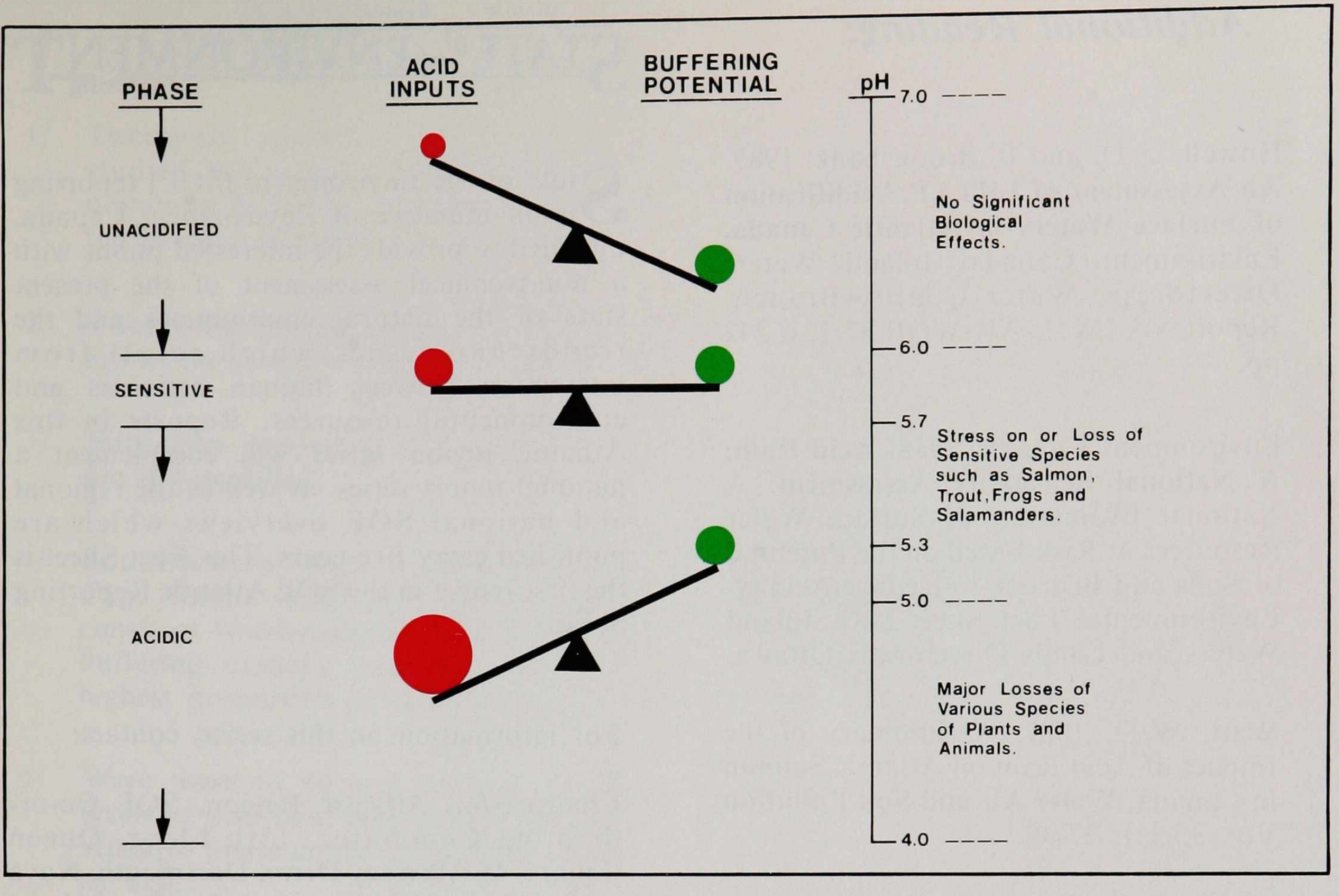

Figure 3: *The Acid Rain Teeter-Totter.*

The Extent of the Problem

Figure 4, which is based on pH and uses water colour as an indicator, provides an overview of the extent of acidification in Atlantic Canada and indicates whether the

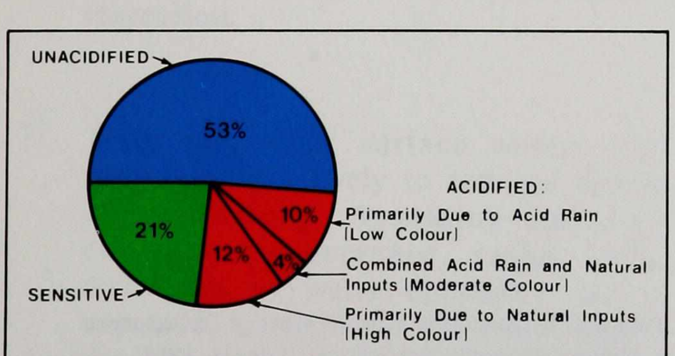

Figure 4: *Proportion of Acidified Lakes in Sample.*

observed acidification is due to acid rain, natural organic acids or a combination of both sources. The illustration shows that 26 percent of the 918 representative lakes studied are considered to be acidified; 10 percent are due primarily to acid rain, 4 percent are due to combined acid rain and natural organic acids and the remaining 12 percent are due primarily to natural organic acidity. This percentage of acid rain acidified lakes is similar to that observed in the Adirondack Mountains of New York and in Maine but it is significantly lower than that reported for Norway. A further 21 percent of the lakes are currently in the "Sensitive Phase". As is shown in Figure 5, the acidified and sensitive lakes are concentrated in southwestern Nova Scotia, Cape Breton Island and the south and west coasts of Newfoundland. The remaining 53 percent of the lakes are in the "Unacidified Phase" and their locations are consistent with the high buffering capacity zones of New Brunswick, Prince Edward Island and Central Newfoundland.

However, this information does not tell the whole story because it does not indicate how the pattern of acid rain effects has been changing with time. Figure 6 represents the results of a statistical analysis of historical pH data from several rivers in Nova Scotia and

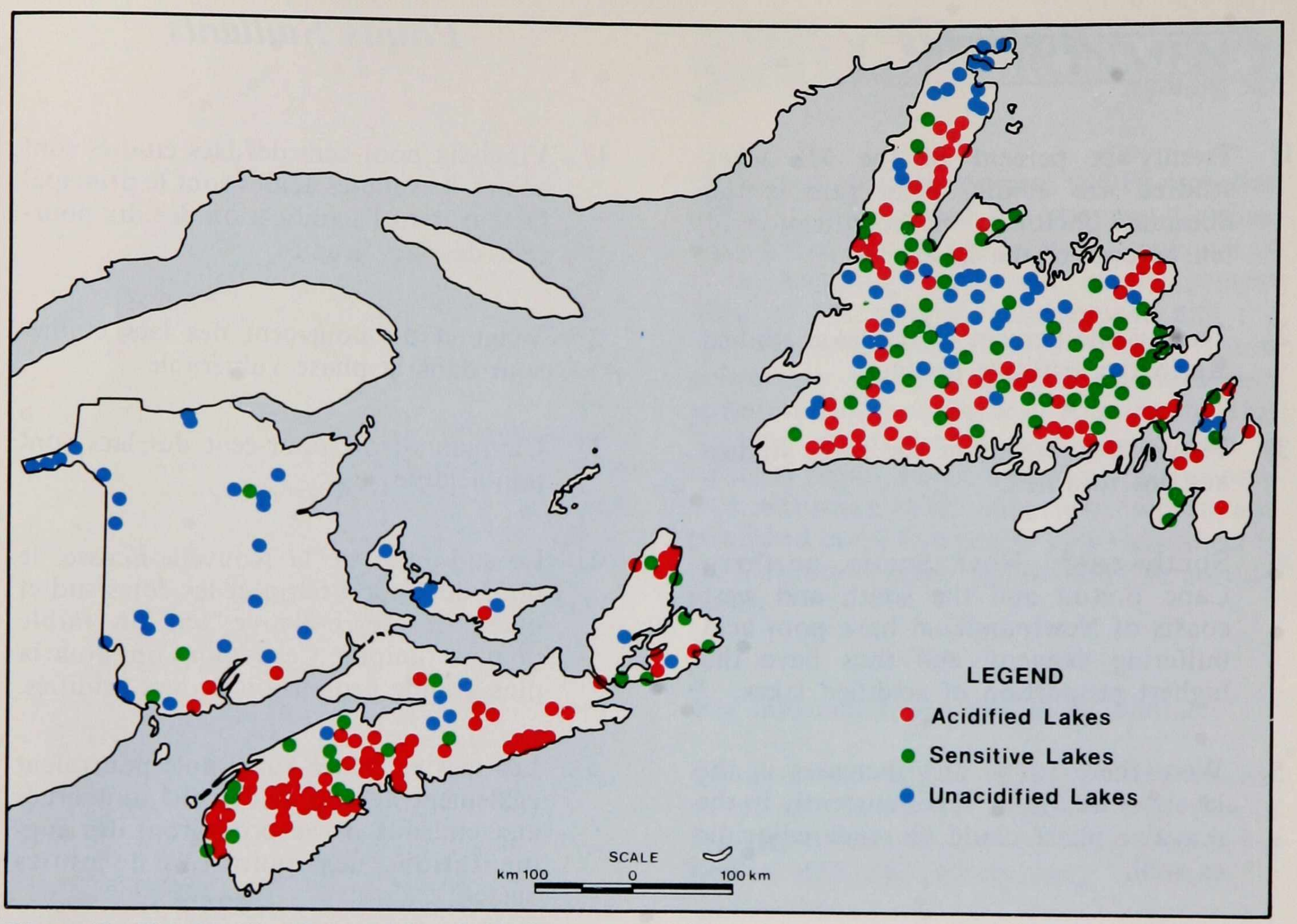

Figure 5: *The Extent of Acidification in Atlantic Canada.*

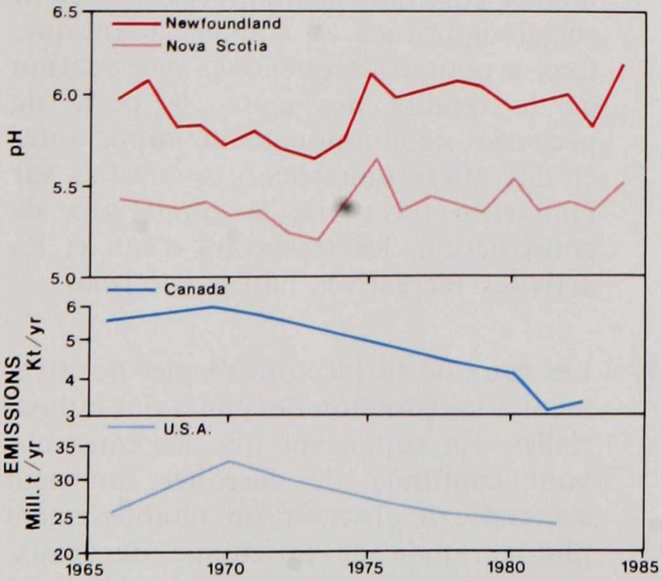

Figure 6: *Industrial Emissions and Nova Scotia, Newfoundland pH Patterns from 1965 to 1985.*

Newfoundland. The study indicates that pH values were at their lowest or worst during the early 1970's. Since industrial emissions in North America peaked during this period and natural organic acidity was constant, these low pH values can be attributed to acid rain. Following the reduced emissions later in the 1970's, the pH levels have increased or improved. The reduced emissions were initially due to economic recession and more recently due to the government emission control agreements. However, even with the recent decrease in emissions and thus reduced acid rain, many of the lakes and rivers in Atlantic Canada are still in the "sensitive" or "acidified" categories.

Assuming that emission reductions will continue, we can expect to see further improvements particularly in the lakes that are presently in the sensitive phase. Although the recovery of sensitive lakes can occur rapidly, major improvements in the chemistry of the acidic lakes will take much longer and will only occur if there are significant (at least 50%) reductions in emissions. The response of plant and animal species to reductions of acid rain is expected to be much slower.

Highlights

1/ Twenty-six percent of the 918 lakes studied are acidic. Acid rain is the dominant factor in the acidification of ten percent of the lakes.

2/ Twenty-one percent of the lakes studied are in the sensitive phase.

3/ Fifty-three percent of the lakes studied are not acidified.

4/ Southwestern Nova Scotia, northern Cape Breton and the south and west coasts of Newfoundland have poor acid buffering capacity and thus have the highest proportion of acidified lakes.

5/ Were there to be any increases in the levels of acid rain, lakes currently in the sensitive phase could be rendered acidic as well.

6/ At present, acid rain is having a significant environmental, economic and social impact in Atlantic Canada. This has resulted in a degradation of fresh water quality, the loss of economically important fisheries and as yet unquantified effects on forestry, buildings and materials, water supplies and water-based recreation.

7/ Lake and river surface waters have responded positively to reduced industrial emissions. Assuming emissions continue to decrease, rather rapid recoveries in water chemistry can be expected, particularly for those sites in the sensitive phase. The recovery of acidic lakes will take much longer and will require major decreases in industrial emissions.

Points Saillants

1/ Vingt-six pour-cent des lacs étudiés sont acides. Les pluies acides sont le principal facteur dans l'acidification des dix pour-cent des lacs étudiés.

2/ Vingt et un pour-cent des lacs étudiés sont dans la phase vulnérable.

3/ Cinquante-trois pour-cent des lacs sont non-acidifiés.

4/ Le sud-ouest de la Nouvelle-Ecosse, le nord du Cape-Breton et les côtes sud et ouest de Terre-Neuve ont un faible pouvoir tampon. Ces régions ont donc la plus grande proportion de lacs acidifiés.

5/ Les lacs en phase vulnérable pourraient également devenir acides s'ils sont situés aux endroits où se produiront des augmentations des quantitiés de pluies acides.

6/ Présentement, les pluies acides ont un impact environnemental, économique et social significatif au Canada atlantique. Ceci a pour conséquence la dégradation de la qualité des eaux, la perte de pêcheries économiquement importantes et des effets non encore quantifiés sur l'industrie forestière, les matériaux de construction, les réservoirs d'eau et les activités récréatives basées sur l'eau.

7/ Les eaux de surface ont réagies positivement à la réduction des émissions industrielles. En supposant que les émissions vont continuer de décroître, on peut s'attendre à observer un rétablissement plutôt rapide de la chimie des eaux, particulièrement aux sites qui se trouvent dans la phase vulnérable. Le rétablissement des lacs acides prendra beaucoup plus de temps et demandera des diminutions importantes des émissions industrielles.

Additional Reading:

1/ Howell, G.D. and P. Brooksbank. 1987. **An Assessment of LRTAP Acidification of Surface Waters in Atlantic Canada.** Environment Canada. Inland Waters Directorate. Water Quality Branch. Report No. IW/L-AR-WQB-87-121. 292 pp.

2/ Environment Canada. 1988. **Acid Rain: A National Sensitivity Assessment.** A National Evaluation of Surface Water Resources at Risk Based on the Potential of Soils and Bedrock to Reduce Acidity. Environmental Fact Sheet 88-1. Inland Waters and Lands Directorate, Ottawa.

3/ Watt, W.D. 1987. A Summary of the Impact of Acid Rain on Atlantic Salmon in Canada. **Water Air and Soil Pollution** Vol. 35 (1): 27-35.

For Additional Information on The Impacts of Acid Rain on Water Quality, Contact:

Water Quality Branch
Inland Waters Directorate
Conservation and Protection
Environment Canada
P.O. Box 861
Moncton, New Brunswick
E1C 8N6
(506) 857-6606

Atlantic Region STATE of the ENVIRONMENT reporting

State of the Environment (SOE) reporting is an initiative of Environment Canada, intended to provide the interested public with a non-technical assessment of the present state of the natural environment and the trends and issues which result from interaction between human activities and environmental resources. Reports in this Atlantic region series will complement a national report series, as well as the regional and national SOE overviews which are published every five years. This Fact Sheet is the first report in the SOE Atlantic Reporting Series.

For information on this series, contact:

Chairperson, Atlantic Region, SOE Co-ordinating Committee, 15th Floor, Queen Square, 45 Alderney Drive, Dartmouth, Nova Scotia, B2Y 2N6; Phone (902) 426-6141.

Published by Authority of the Minister of Environment

Catalogue No. EN1-8/1-1988E
ISBN 0-662-165-14-4

Canada