In fact, until the late 1970's there were few concerted scientific studies that could be used to help explain these apparent ecological anomalies, explains Dr. Ron Pierce, an atmospheric chemist with NRC's Environmental Secretariat. "Then, we began one of the first Canadian attempts to compile and evaluate the scientific information. Under the auspices of NRC's Associate Committee on Scientific Criteria for Environmental Quality, a panel headed by Dr. Harvey looked into the interrelations between acid rain and the observed effects on the aquatic environment."

The report, *Acidification in the Canadian Aquatic Environment: Scientific Criteria for Assessing the Effects of Acidic Deposition on Aquatic Ecosystems*, was published in 1981. Says Ron Pierce: "A major conclusion was that acidic deposition posed a serious threat to aquatic ecosystems in Canada. However, given the information available at the time, we realized that the geographic extent and severity of the threat could not be accurately determined. The panel's state-of-the-art review stimulated a major research effort here to identify and quantify the relationships among sources of emissions, atmospheric transport, deposition, and effects of this rain on aquatic and terrestrial biota, materials, and people."

Acid precipitation (along with the organic acids of decomposing humus) is a more powerful weathering agent than normal rain, which is a dilute carbonic acid. It may be neutralized by carbonate rocks or soils; it may undergo ion-exchange in the lattices of minerals, thereby releasing ions such as calcium, aluminum, and manganese; or, it may pass through the soil unreacted and depress the pH in streams. The solubility of metals such as aluminum, manganese, and iron is pH dependent; thus, their levels become elevated in acid lakes, and precipitate out of solution in alkaline waters.

Acidification, through a variety of chemical processes, may kill nearly all life forms in a lake, except for certain algae and sphagnum moss, which thrive on the lake bottom. "Perhaps the most bizarre effect," says Dr. Harvey, "is the formation of the so-called 'felt-mat' on the lake bottom." This mat, a mixture of algae, leaf detritus, and moss, can reach half a metre in thickness, and in some Swedish lakes, it lifts and literally burps out a gas mixture.

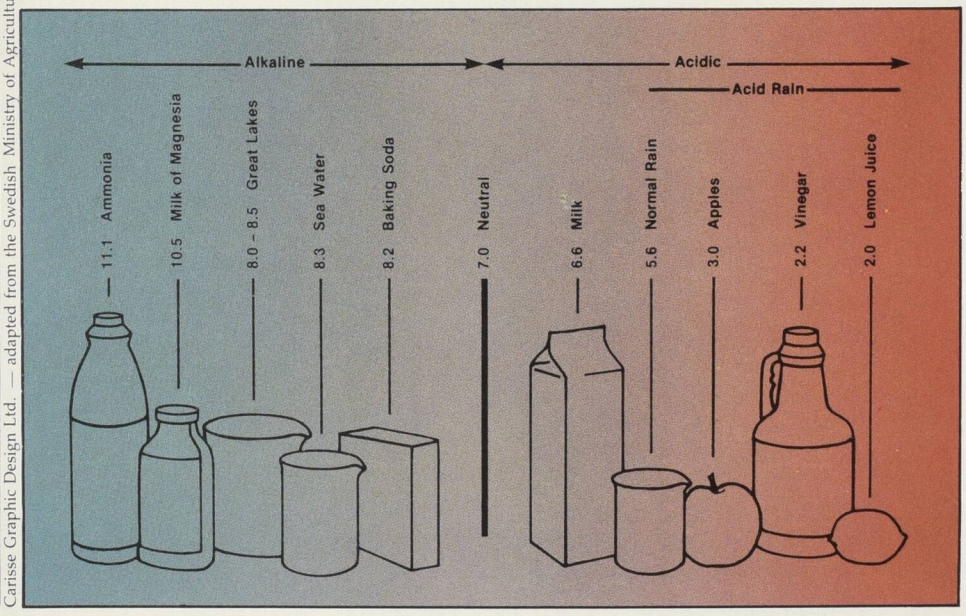
The effects of acid rain are not uniform over time, but occur in pulses, such as the spring runoff, which in addition to depressing the pH can release high concentrations of aluminum and other toxic metals into streams and lakes. Fish die coincident with high levels of aluminum in their gills and much reduced concentrations of chloride and sodium in their blood and muscle. Healthy fish put into such waters in Ontario were observed to die very soon after entry. "A question yet to be answered," says Harvey, "is the extent of the toxic-aluminum phenomenon in North American streams and lakes." In addition to other metals, manganese also increases in concentration as lakes acidify. While it is not considered very toxic, evidence is mounting that it is associated with spinal deformities in fish.

Besides these toxicity studies, aquatic scientists in Canada are looking into the problem in other ways. Since watersheds are considered the best collectors of atmospheric deposition, and therefore prime sources of information on acid precipitation, some of these have been calibrated and are now being intensively measured. Work is also underway at a number of sites, particularly at the Ontario Ministry of the Environment's Dorset station, in which water quality is changed under controlled conditions to obtain better definition of biological effects.

There is now no question that fish populations are suffering acid rain's ill effects in Canada. These aquatic changes were the initial warning of the problem and remain our primary evidence of injury to the biosphere.

"It is apparent," states Harvey, that the current level of acid loading in eastern North America (25 to 45 kg/ha/year of sulfate) is similar to the loading which so profoundly altered the environment in Norway and Sweden, killing many life forms in thousands of lakes.

"The question for North Americans: Is this our fate?"



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What is "acidity"? Scientists use a "pH" scale running from 0 to 14 to indicate the level of acidity or hydrogen ion concentration; 0 is the most acid part of the scale and 14 the least (or most alkaline). Each whole number on the scale represents a tenfold change in the hydrogen ion concentration. A value of 7 is neutral, but normal rainwater is not "neutral"; it is slightly acidic with a pH of 5.6, due to dissolved carbon dioxide from the atmosphere.