# ACID RAIN



## time is running out

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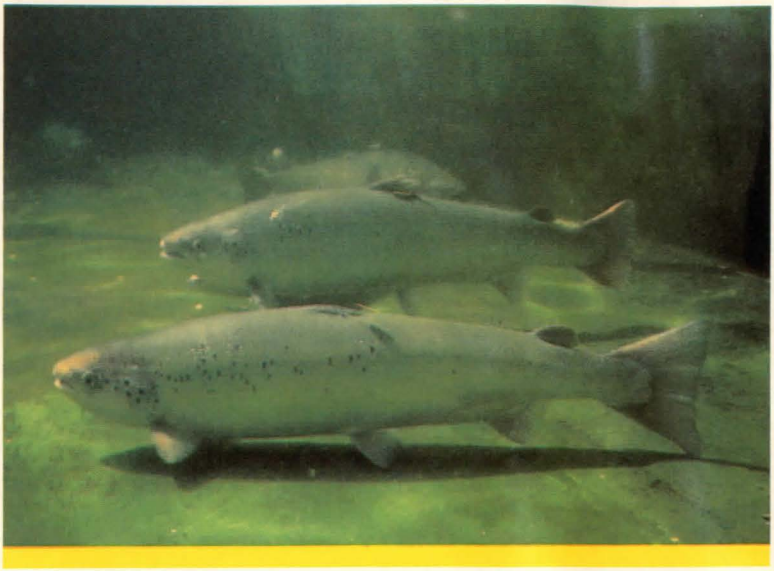


If you're an angler, you should be aware that south of the southern tip of James Bay, running east from the Ontario/Manitoba border, 148,000 lakes and some rivers in eastern Canada now have pH less than 6, a level at which the fisheries resources are adversely affected leading to a total loss of fish if the trend is not reversed.

If you're a sports fisherman you should be aware of the loss of valuable Atlantic salmon runs in Nova Scotia.

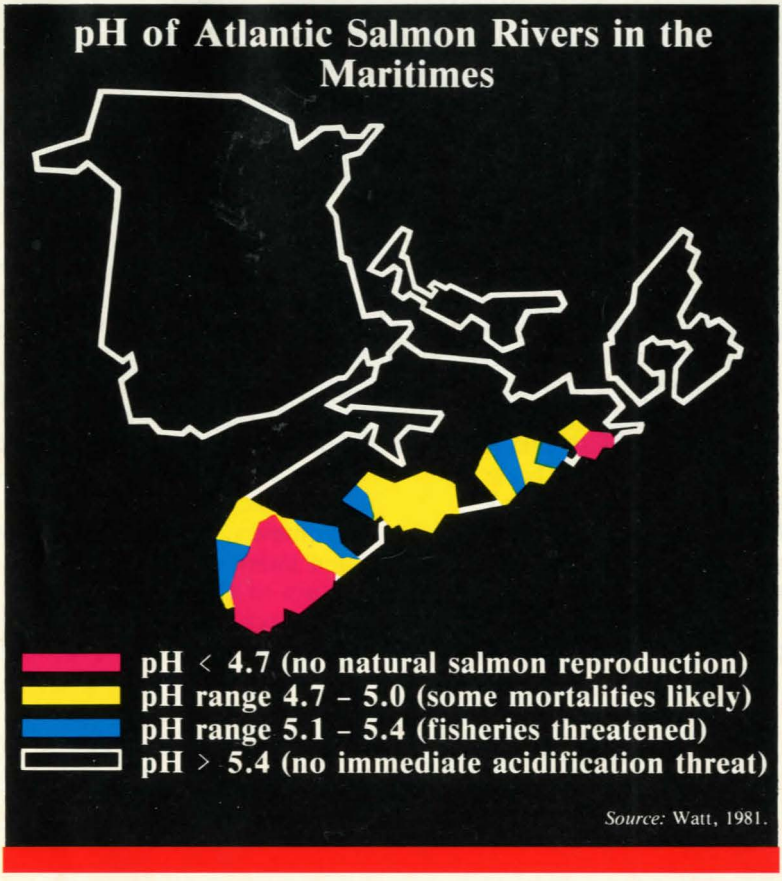
If you're a cottage owner in a popular sportfishing area, you face possible severe losses in the quality of your values as fish disappear.

If you're involved with some part of the sportfishing industry, marinas, tackle stores, tourist lodges, guiding or other services you should know that hundreds of these businesses could collapse if acid rain continues.

These dangers are not theoretical. Although many adverse consequences of acid rain are only now being discovered, effects on fish are thoroughly documented. The problem of acid rain was first documented in North America in 1969 by Dr. Richard Beamish, the current Director of the Department of Fisheries and Oceans Research Laboratory in Nanaimo, British Columbia. This early research found that, lake trout, small mouth bass, pickerel and other fish had disappeared from many small lakes near Sudbury, Ontario because of acid rain. Since then, intensified research has been going forward across Canada and the United States.

These facts have been conclusively proven:

- Over a period of years acid rain can destroy fish populations, not in every lake and river on which it falls, but in those which, because of local geology and other characteristics, are sensitive to acid rain.
- South of the southern tip of James Bay in eastern Canada approximately 14,000 lakes are acidic (pH 4.7) and 148,000 are at a pH level where aquatic resources are adversely affected.



## Where It Comes From

**A**cidic precipitation is the deposition of strong acids from the atmosphere in the form of rain, snow, fog or as dry particles. The acid in the rain is the result of man-made pollution caused primarily by the discharge of oxides of sulfur and nitrogen (i.e. $SO_2$ and $NO_2$) into the atmosphere with the burning of coal and oil by electric utilities, in the operation of plants which smelt nickel and other metal ores, and by transportation (cars, trucks, trains, buses, and airplanes). In the atmosphere these gases combine with water vapour to form sulfuric acid (similar to the substance in car batteries) and nitric acid. These pollutants are carried hundreds and even thousands of kilometers, crossing state, provincial and international boundaries, and return to earth.

In fact, the United States National Commission on Air Quality in a 1981

report described acid rain as both an interstate and international problem. Scientists estimate that almost 51 million tons of man-made sulfuric and nitric acid were released into the atmosphere in 1980 in North America, with 45 million tons originating in the United States and nearly 6 million tons in Canada. The United States discharged 24 million tons of sulfuric acid that year, much of it from the tall smokestacks of electrical power generating plants in the northeastern states and the upper Ohio Valley. In Canada, the main sulfuric acid sources are non-ferrous smelters and power generation. On both sides of the border electric utilities make up the biggest single source of nitric acid, with transportation the second (some 66 percent of the total), while industrial, commercial and residential fuel combustion together contribute most of the rest.

# Deadly to Fish

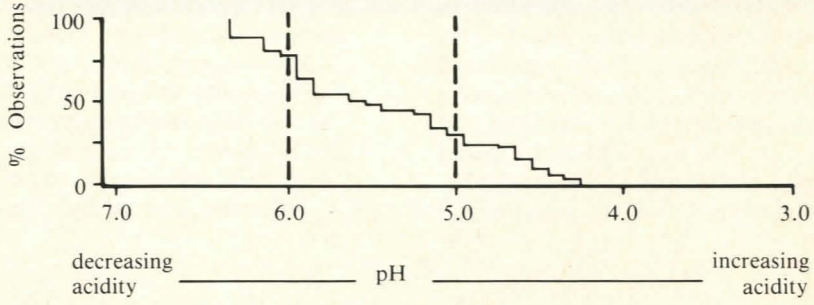
Biologists studying the effects of acid rain on fish have found that different species are affected in different ways and at different levels of acidification. These levels are measured in terms of pH values — the lower the pH value, the more acid there is in the water.

On the pH scale of 1 to 14, a reading of 1 indicates that a solution is very acidic (battery acid), a pH of 5.6 is "pure" rain, values less than 4.7 are considered to be severely affected by pollution, while a pH of 13 indicates a very alkaline solution (lye). Acid rain has a pH of 5.5 or less.

The scale, however, is deceptive to the layman. It is logarithmic, which means that pH 4 is 10 times more acidic than pH 5 and 100 times more acidic than pH 6. For most fish, trouble begins at pH 6 and only a few hardy species survive at pH 4.7 and below. As acidification gets worse it affects fish in the following ways:

- By attacking early life stages acidification can arrest growth and possibly cause death. This can occur before acid levels reach a point dangerous to adult fish. In less severe cases, although the whole fish stock may not disappear, entire age groups may be lost.
- By interfering with food chains. Scientists have shown the process can start at the very bottom of the food chain with the destruction of the tiny life forms on which minnows and other small freshwater

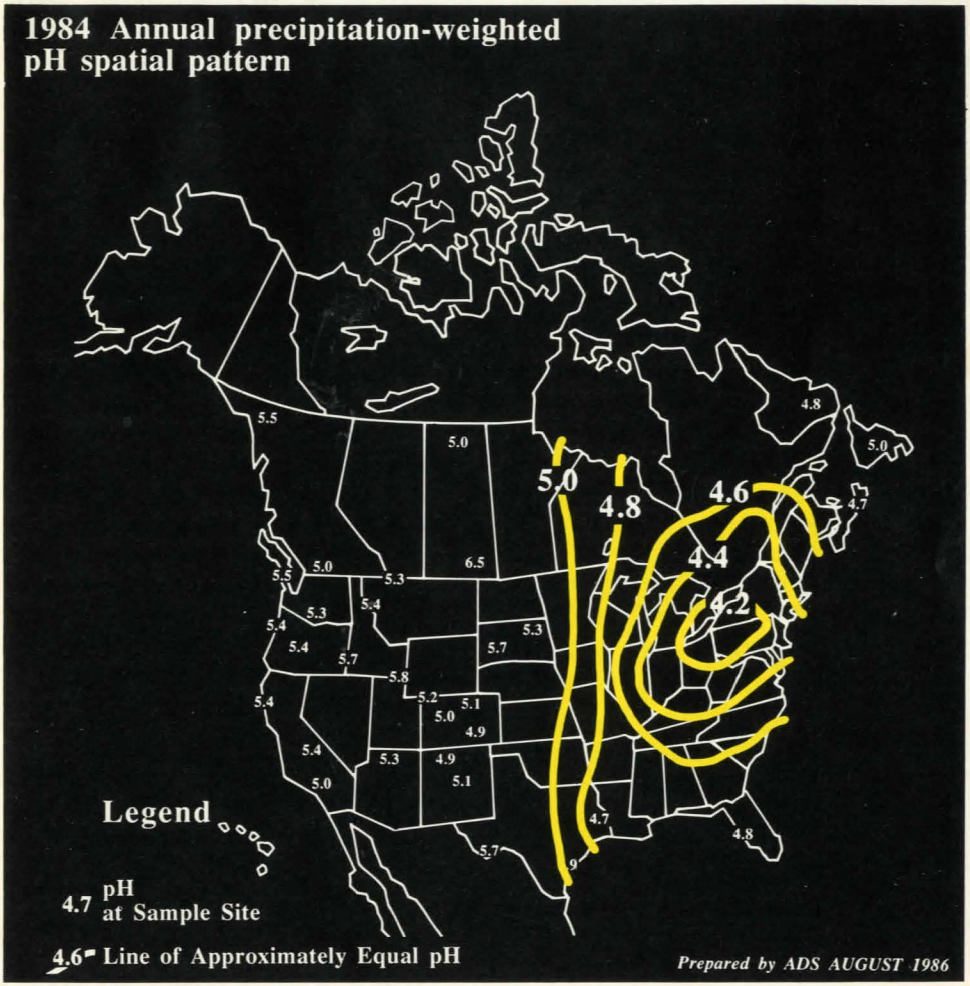
*The lower fish was reared at lower pH (otherwise the conditions were the same). It is smaller, with more yolk remaining and less jaw development.*




Survival of fish species with increasing acidity

food organisms feed before they themselves are eaten by larger fish. Fish can starve as a result or they may be forced into feeding on different possibly less nutritious species, if they are available.

- Metal poisoning. Investigators studying rivers and lakes subjected to acid rain have found fish kills in waters where pH levels still seem to be safe. Research has shown why: the lowered pH dissolves aluminum and other metals allowing them to mix into the water. Even in small concentrations these metals can harm and even kill fish. Aluminum is now thought to act primarily by interfering with ion regulation within the body of the fish, the same as pH.
- Below pH 6 some species — and below 4.7 nearly all species — can be directly injured or killed by acidification. Researchers have found that acid in the water alters body chemistry, impairs oxygen circulation, attacks gills and interferes with heart action.



## High Risk Areas

Of an estimated 700,000 lakes in Eastern Canada (east of the Manitoba border and south of the southern tip of James Bay) more than half are considered sensitive. One-hundred and forty-eight thousand have a pH less than 6, a level considered to have adverse biological effects.

Whether acid rain is an immediate threat to fish depends primarily on the geological characteristics of the area. Lakes and rivers set in land rich in limestone and other natural acid-neutralizers will never be in danger. In areas lacking these natural defences, acidification is progressive. Over a period of time, acid rain can cause the natural buffers in water bodies to be used up. The rapidity with which this happens increases with the acid content of the rain. The result is a decline in the pH levels of receiving waters.

Lakes and rivers can also have their pH lowered abruptly for short periods — for example when acid-laden snow melts and runs into the water, or when large volumes of water run into lakes and streams after heavy rains. The most vulnerable lakes and rivers are those which:

- are located in terrain which lacks natural buffers against acidification.
- have small watersheds (i.e. the area of land surrounding the water is small — for instance high elevation lakes).
- are located in areas receiving highly acidic precipitation.

## Acid Targets

The acidification of water bodies from acid rain is a progressive problem. In some parts of North America the problem is far advanced; in some it is in its early stages; in others it is a dangerous possibility.

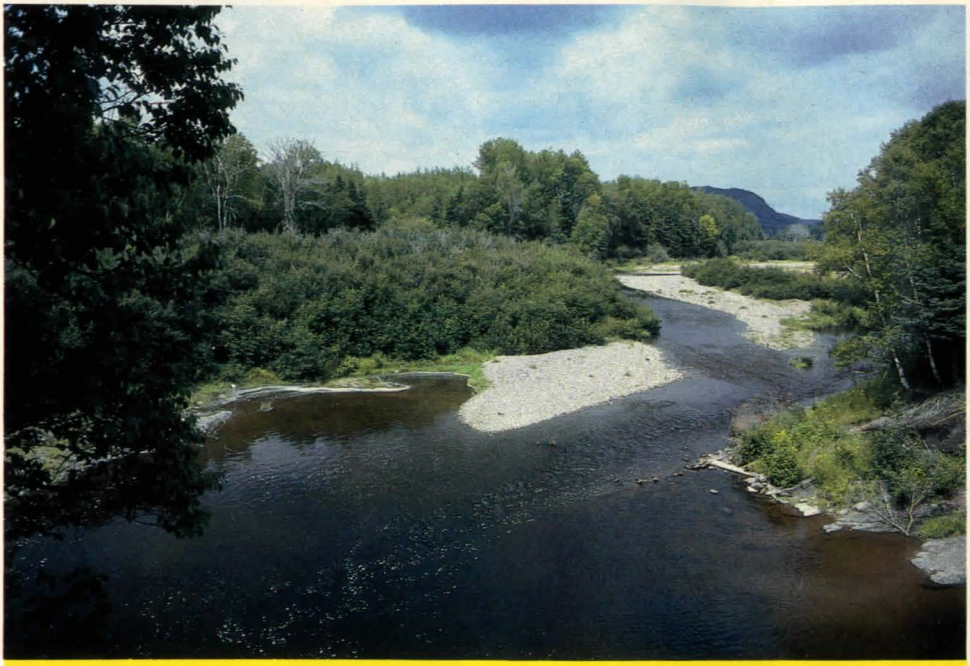
Today's major problem areas include:

**Nova Scotia** In Nova Scotia 73.7 percent (4853) lakes have a pH lower than 6 and 47.3 percent (3115) are acidified. In the northern part of the province, lakes and rivers are well-buffered and scientists believe that in this area there is no immediate danger. In the poorly-buffered southern and western parts of the province the situation is different. Here, Canada's Department of Fisheries and Oceans scientists have documented the loss of Atlantic salmon runs as a result of acid rain in a number of rivers. Recently the casualty list looked like this:

- Thirteen rivers at pH 5.3 to 5.1. This, biologists say, is the cross-over point from safety to danger for Atlantic salmon.
- Eighteen rivers cross the danger line with pH readings from 5.0 to 4.7. From hatchery tests, researchers know that at the least-acid end of this range, three out of ten salmon fry do not survive. At the other end, whole stocks are on the brink of extinction.
- Thirteen rivers with readings of pH 4.7 and below, believed to be now completely empty of salmon. Fisheries officials say this group includes some rivers for which sportfishing catch records go back as far as a century. Some of these rivers were

## Regions of North America Containing Lakes and Rivers Sensitive To Acidification

*Source:* Modified from the Canada/United States Memorandum of Intent on Transboundary Air Pollution on Impact Assessment. Final Report January 1983.



important salmon producers before the first declines began in the 1950s. By 1980, scientists could find no sign of salmon reproduction in any of this group.

Overall estimates of 49 percent of salmon productions in the southern upland zone rivers has been lost due to acidification. For all of Nova Scotia 33.3 percent of salmon production has been lost. In acidified lakes, yellow perch has replaced brook trout.

**Ontario** East from the Ontario/Manitoba border, south of the southern tip of James Bay 22.9 percent (28918) lakes are estimated to have a pH less than 6 and 1.6 percent (2020) are acidified. Within provincial boundaries, DFO scientists estimate that 36,000 Ontario lakes are sensitive to acid rain. The lakes lie in poorly-buffered terrain and are receiving high levels of acid deposition. They are concentrated in a band running east and southeast from Algoma to Algonquin, Muskoka and Haliburton. These sensitive lakes include 30-50 percent of the province's important smallmouth bass, lake trout and brook trout fisheries resources.

**Quebec** East of the Ontario/Québec border south of the southern tip of James Bay, 16.3 percent (72006) lakes are estimated to have a pH less than 6 and 1.4 percent (6185) are acidified. Physiochemical surveys of lakes in the Precambrian Shield have shown that lakes in the northeast are more sensitive to acid rain deposition than lakes in the south-

west. Sulfate deposition is greatest in the southwest part of the Province. Populations of brook trout have disappeared from several lakes in the Charlevoix region and the varieties of fish species in lakes in the Outaouais, Maurice and Abitibi-Baie-James have been reduced. Surveys of salmon rivers on the North Shore of Quebec have shown extreme sensitivity to acidification; slight increases in sulfate deposition could result in substantial rises in acidity levels. During the spring snow melt the acid released caused pH levels to drop below 6 in 21 rivers out of 33, including 11 where the pH was less than 5.5.

**Newfoundland and Labrador** South of the Quebec/Labrador border 29.9 percent (41475) lakes are estimated to have a pH less than 6 and 1.8 percent (2497) are acidified. Specific studies of more than 350 lakes have indicated that over 95 percent can be considered extremely sensitive to the effects of acidic deposition. No widespread damage is apparent at present, but losses in buffering capacity is evident in many lakes. The region's waters are naturally acidic, due to inputs from bogs and peat lands, and this contributes to their susceptibility. Chemical surveys of major Atlantic salmon rivers in Newfoundland have indicated similar results. A major concern for some rivers is seasonal or "episodic" decline in pH (i.e. spring snow melt) to levels that are potentially lethal to juvenile salmon. Surveys have confirmed these episodic pH depressions. However, the effect this may have on the resident salmon populations has not yet been documented. The combined results of these studies suggest that Newfoundland could be on the threshold of a potential acidification problem. Serious effects could become apparent if acidic deposition were to continue at present levels or increase. Labrador is also an extremely sensitive region, but is geographically remote and north of most air movements from heavily industrialized areas in Eastern North America, suggesting no indication of serious concern for the foreseeable future.

**New Brunswick** 35.3 percent (1269) of the lakes in New Brunswick are estimated to have a pH of less than 6 and 15.4 percent (554) are acidic. The Lepreau and Musquash drainage systems are known to be sensitive to acid deposition. The extent of the acid rain problem is still being documented, but large areas containing important sportfishing areas in the province are known to be sensitive.

Much of the continental United States (see map) is sensitive to acid rain.

**New York State** In the popular Adirondack Mountains sportfishing area, the average pH of rainfall has been running at 4.1. In 1976, Cornell University Researcher Carl Scholfield measured both pH levels and fish populations in 217 Adirondack lakes 600 metres above sea level. Half had a pH below 5.0 and contained no fish. Later investigations by state researchers included lakes lower than 600 metres above sea level, and in these, pH values ranged from 7 to 4.8. Sampling fish populations in three lakes at the most acid end of this range, the researchers could net only one fish — a brook trout. A recent state inventory has found that nearly 11,000 acres of Adirondack waters have reached "a critical state of acidification". State officials estimate that 22,000 pounds of sportfishing catch is being lost annually as a result of acid rain.

Similarly, northern areas of **Minnesota, Wisconsin and Michigan** all have soils naturally low in buffering materials, making their lakes sen-

sitive to acid rain. EPA estimates that some 2,600 Wisconsin lakes have pH levels at or below 6, with little or no buffering remaining. Half of the Boundary Waters Canoe Area lakes are also susceptible to acidification due to low buffering.

Tests of snowfall in upper Michigan made in the winter of 1977-78 produced average pH values of 3.5. Scientists believe the acid is being generated in a belt of industrial centres reaching from the Toronto-Buffalo area to Chicago.

In **Pennsylvania**, EPA scientists checking records going back eight years found falling pH levels in one of three of a sample group of streams. Other studies show the average pH of rain and snow to be less than 4.3. Many former trout streams have been emptied not only of the acid-sensitive rainbow trout species, but of the more resistant brook trout. In a 1980 report, EPA scientists say "circumstantial evidence shows damage to Pennsylvania streams may be the result of acid precipitation".

Further south, majestic Great Smoky Mountains National Park straddles the state line separating **Tennessee** and **North Carolina**. Old-timers can remember good brook trout fishing along some 425 miles of park streams. Today brook trout are found along only 125 miles.

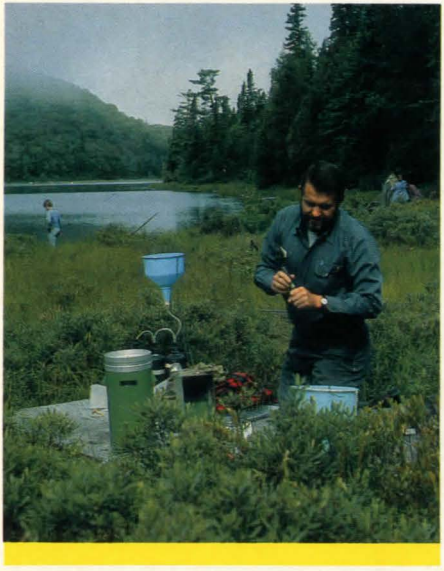
National Park Service officials have found that the pH levels of rain and snow in the park are usually 4.5 and have noted a fall in the pH levels of streams since 1973. A report by NPS officials says "the impact of acid rain may threaten the existence of brook trout in the park".

In **California, Oregon** and **Washington**, as in Canada's Pacific Coast region, the picture on acid rain is just beginning to emerge. University of California scientists, monitoring rainfall in the San Francisco Bay area and other locations as far east as Lake Tahoe, found pH values below 5.6 at all sites. One sample, taken in a storm at San José, measured 3.7. Other tests in the Sierra Nevada showed pH values from 7.6 to 5.8 in the foothills, and lower values at greater altitudes.

## It's Costing Us

In the competition for tourist dollars, sportfishing is a major attraction for many regions of Canada and the United States. In Canada, federal government surveys show that sportfishing contributed $6.1 billion to the Canadian economy in 1985. Anglers spent $4.7 billion in pursuit of their pastime. In Nova Scotia alone, more than $34 million was spent by anglers, of which $5 million was spent fishing for Atlantic salmon.

Sportfishing is an important source of income in many parts of the United States. In 1985, the Sport Fishing Institute in the United States estimated that sport fishermen spent $25 billion in retail expenditures in pursuit of their recreational pastime.



## Fighting Acid Rain

How do we fight acid rain? Measures fall into two main categories: holding actions which can only buy time for key fish stocks, and action to end acid rain itself. The options include:

**Mitigation** In the same way that bicarbonate of soda neutralizes stomach acid, large amounts of slaked lime or other neutralizers can cancel out acid inputs into lakes and rivers. Liming has been used in Sweden with limited success and researchers are testing the process in Canada and the United States. Too costly to apply to all stricken areas, particularly in the wilderness. Liming cannot, in any case, bring back dead lakes. It may prevent rivers from becoming acid, allowing us time to save selected fish stocks until pollution controls can put a cap on acid rain sources. Its side effects on the environment are not yet known and at best it is an interim measure.

**Stopping it where it starts** This is the only answer and it is a feasible one. Coal and oil burning does **not** have to result in the generation of acid rain. In the short term, with the right emission controls installed, each source would put less acid into the air. The control systems for doing this are expensive but not prohibitive. The systems have already been developed and need only be put to use.

## Understanding the Danger

We urgently need to fill gaps in our knowledge about the less direct effects of acid rain. Says Dr. David Schindler of Canada's Department of Fisheries and Oceans' Freshwater Institute: "A recently prepared national inventory has permitted scientists to assess the extent of sensitive waters in Canada. The next step in the process, which is currently underway, is to set up a monitoring network that will allow us to determine how the chemistry and biota of systems of varying sensitivity respond to changes in acid deposition. We also need studies on how acids react with other airborne pollutants such as cadmium, zinc and mercury. These could combine to produce more serious impacts than the acid itself".

## The Bottom Line

In May, 1986, the United States and Canada appointed the Acid Rain Envoy's to review joint problems that both countries are facing in relation to acid rain. The Envoy's report (January 1986) acknowledged the seriousness of the problems, particularily the transboundary difficulties. The prestigious United States National Academy of Sciences noted that acid rain "is causing widespread damage to aquatic ecosystems" to such an extent that "several important species of fish and invertebrates have been eliminated over substantial parts of their natural ranges". They conclude that "the control of emissions of sulfur and nitrogen oxides from fossil fuels is necessary to halt the acidification of sensitive aquatic ecosystems", and that "the picture is disturbing enough to merit prompt tightening of restrictions on atmospheric emissions . . ." "In the long run, only the decreased reliance on fossil fuels, or improved control of a wide spectrum of pollutants can reduce the risk that our descendants will suffer food shortages, impaired health, and a damaged environment.

## Yes — Something Can Be Done

Acid rain is a North American problem and can only be resolved if we work together to ensure cooperation between federal, state and provincial governments. Action by one government alone is not sufficient. We must find the political will to control the emissions of sulphur and nitrogen oxides at their source — the only effective way to resolve the problem. We have the technological capability to control these pollutants. It will be expensive but the consequences for the environments are incalculable compared to the cost of control.

Canada is committed to reducing emissions by 50 percent by 1994, Ontario, as part of this program is planning a 45 percent reduction in sulfur oxides over 1986 levels by 1994. Québec, Newfoundland, and P.E.I., have also agreed to reductions in emissions.

# Additional Reading

**Fisheries Related:**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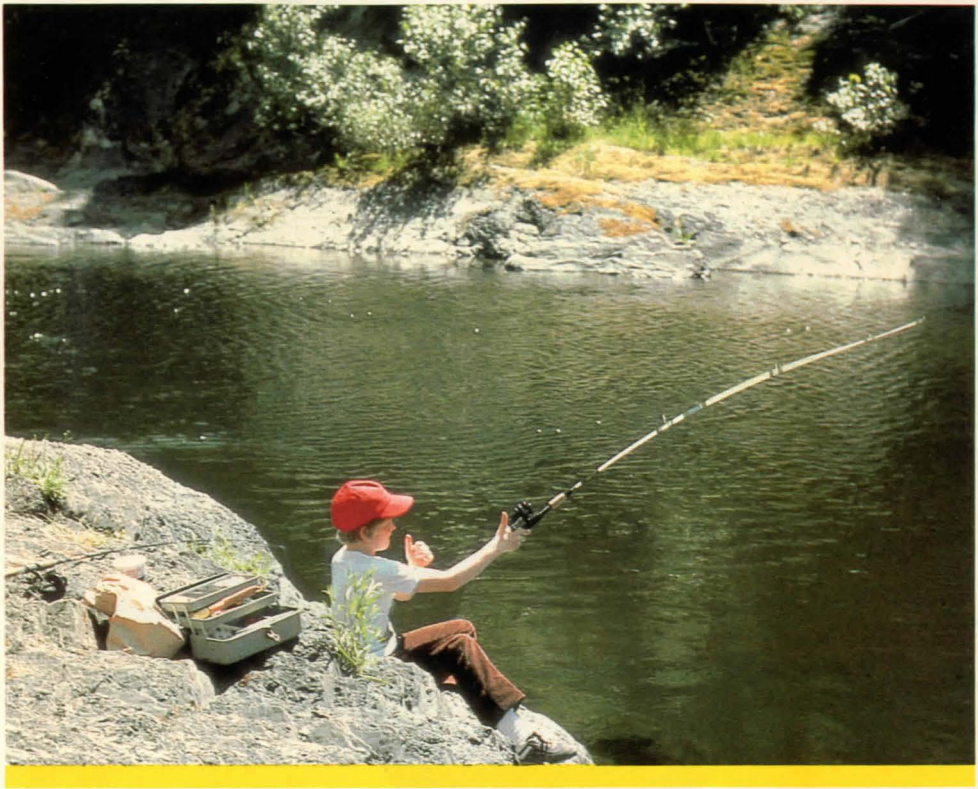


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