

# LONG RANGE TRANSPORT OF AIRBORNE POLLUTANTS

SCF093

## Acid Rain and Wildlife

*During the past few years, researchers have been studying the impacts of acid rain on wildlife. Early findings of Canadian Wildlife Service research indicate that acid rain is damaging, both directly and indirectly, to wildlife. Numerous studies in Scandinavia and North America have also clearly demonstrated the damaging effects of acid rain upon fish. Because a number of review papers deal with these findings, the impacts on fish will not be discussed here.*

### THE ACID ENVIRONMENT

As the waters in rivers and lakes become more acidic, the ability of aquatic organisms to hatch and mature is impaired. Frogs, salamanders, and many species of fish and aquatic insects are important food for many other animals in ecosystems. When the abundance of these life forms is reduced, fewer predators can survive.

Increased levels of acidity, in precipitation and groundwater, dissolve greater amounts of metals, such as aluminum, mercury, cadmium, and lead. These metals can accumulate in the bodies of aquatic animals living in acidified lakes and streams.

Animals which feed upon fish or insects from acidic habitats ingest elevated levels of metals. In the process, metals are concentrated in animals at the top of the food chain — for example, in fish-eating birds and mammals.

### AMPHIBIANS — THE FIRST IN LINE

Peak acid conditions during spring run-off coincide with the most vulnerable stages in the amphibian life cycle — the early embryonic and larval stages. Many species of frogs, toads, and salamanders breed in pools formed

by a mixture of meltwater and spring rains. Since water from melting snow contains the acid accumulation from the entire winter season, these pools may be highly acidic.

Some species, such as the American toad, can be found in acidic habitats. Others, such as the leopard and pickerel frogs, are less tolerant and hence are seldom found in such habitats.

### Laboratory Experiments

Studies using amphibian eggs, collected in the field and incubated under a variety of acidic conditions in the lab, resulted in drastic reductions in hatching success at the higher levels of acidity (pH 5 and below) (Figure 1).

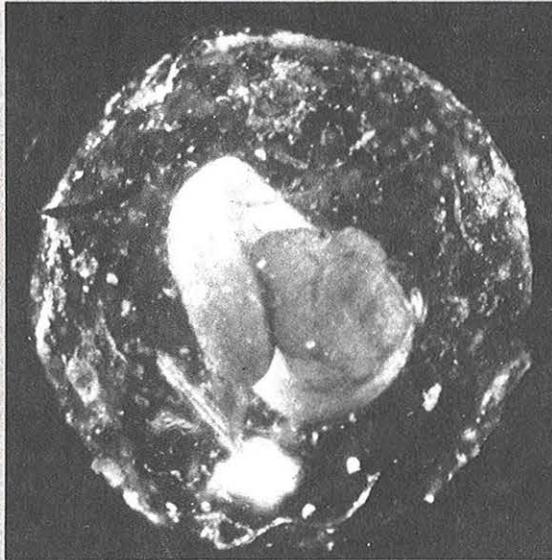
Adding dissolved aluminum to already acidic conditions further decreased amphibian hatching success. To some extent, calcium can ameliorate these toxic effects, while lower temperatures can intensify them.

### Field Experiments

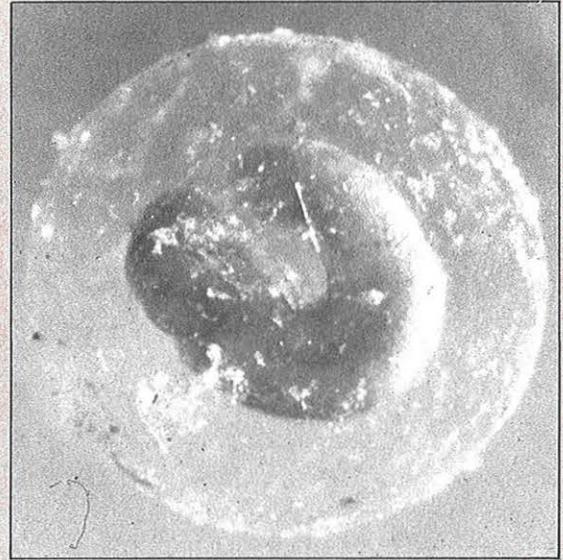
The laboratory findings were confirmed by recent field experiments conducted by the Ontario Ministry of the Environment, where acid levels in a stream were artificially raised. Eggs of two amphibian species — the wood frog and the spotted salamander — suffered immediate damage from a four-day increase in acidity. In fact, wood frog eggs began to die after only one day of exposure to pH 4.3, demonstrating the inability of amphibians to adapt quickly to pH depression.

This research also confirmed the laboratory finding that aluminum, in combination with increasing acidity, is highly toxic to amphibian eggs, even at very low concentrations.





a)



b)

Spring peeper embryo which developed in (a) pH 4 tapwater — the embryo is tightly coiled; (b) pH 7 tapwater, showing normal coiling

**FIGURE 1. HATCHING OF AMPHIBIAN EGGS AT DIFFERENT PH LEVELS**

During the stream acidification experiment, researchers found that toxic effects from acid exposure could be both immediate and delayed. Decreased hatching success was observed in spotted salamander eggs three weeks after the short-term pH depression.

### **TERRESTRIAL WILDLIFE — THE NEXT IN LINE**

The indirect effects of acid rain — reduction of food resources and mobilization of toxic metals — will have effects upon terrestrial wildlife. Failed reproduction, due to the loss of food and accumulation of heavy metals, is a potential hazard faced by animal life in acid-stressed areas.

A key determinant of the numbers of animals living in a region is the availability of food. The reduction of food resources by acid rain will have far-reaching effects on the region's wildlife.

The decline of fish and aquatic invertebrates, such as molluscs and crustaceans (widely reported in acidified waters in Scandinavia and North America), eliminates potential food resources for many wildlife species, including waterfowl and aquatic mammals. Aquatic habitats associated with headwater lakes, ponds, or streams appear to be most vulnerable.

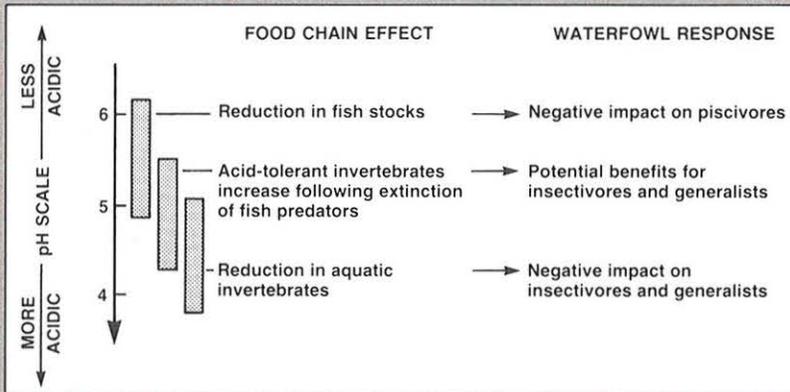


FIGURE 2. POTENTIAL IMPACT OF DECLINING PH ON WATERFOWL DURING THE BREEDING SEASON

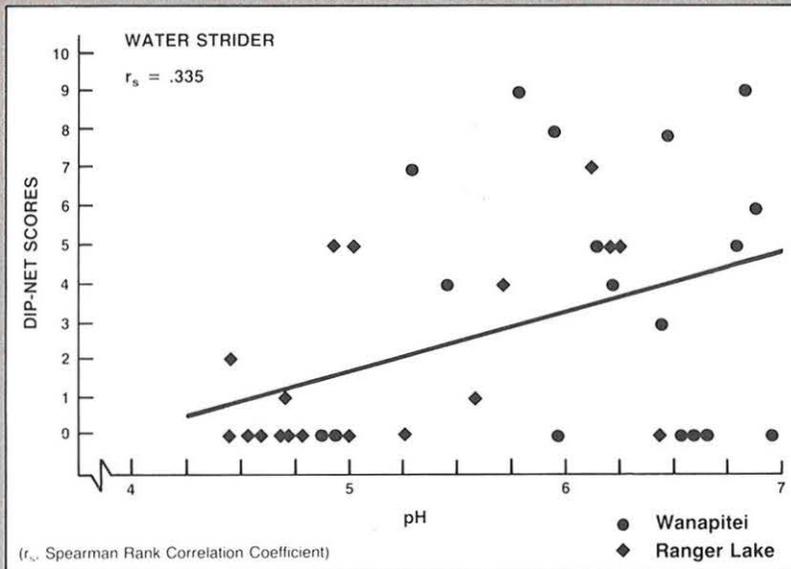


FIGURE 3. RELATIONSHIP BETWEEN PH AND RELATIVE ABUNDANCE OF AN AQUATIC INSECT — WATER STRIDER (RHEUMATOBATES RILEYI) — IN DIP-NET SAMPLES

## The Food Web

Studies conducted by the Canadian Wildlife Service in Ontario indicate that the effects of acid rain on fish reduce the ability of lakes to support breeding by some species of birds, such as loons and mergansers. Nesting may fail as a direct result of the disappearance of fish and acid-sensitive invertebrates, or as a result of altered predator-prey relationships.

The disappearance of fish from acid lakes changes the abundance of numerous organisms in aquatic communities. Fish as predators are replaced by acid-resistant insects, such as waterboatmen, water beetles, and phantom midge larvae.

Such changes in the structure of the food web have important implications for wildlife (Figure 2). Ducks, such as the common goldeneye, which feed on aquatic insects may do well in the short-term, following the disappearance of fish which compete for common insect prey. However, even populations of insects believed to be acid-tolerant decline as acidity increases and pH drops below 5 (Figure 3). As aquatic insects become less abundant, less food is available to numerous insectivorous birds, including ducks.

## Comparison of Acid-stressed and Unaffected Ecosystems

Waterfowl population and food chain studies conducted in heavily acid-stressed lakes of the Lake Wanapitei area and in relatively unaffected but sensitive lakes of the Ranger Lake vicinity suggest that acid rain alters the biological community structure in the affected habitats.

In the Lake Wanapitei area, increased acidity has reduced the ability of the habitat to support healthy and diverse fish communities. Fishless lakes and lakes with only simple communities of acid-tolerant fish, such as yellow perch, are much more common in the acidic Wanapitei area than the Ranger Lake area (Figure 4).

Spring waterfowl surveys indicate that although breeding densities of most waterfowl in the Lake Wanapitei area were comparable to the Ranger Lake area, fewer broods were observed. Omnivorous waterfowl, such as ring-necked ducks and black ducks/mallards, were less successful than their counterparts in the non-acid lakes, suggesting that reproductive failure is occurring following nest initiation. This failure is believed to be linked to the availability of prey during the critical period when newly hatched young require an abundant source of aquatic insects near the nest (Figure 5).

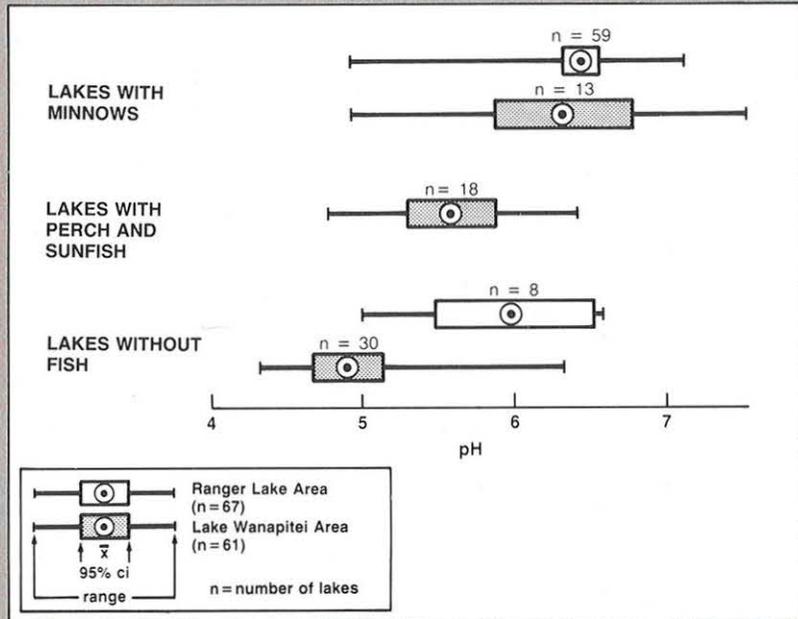


FIGURE 4. FISH COMMUNITY COMPOSITION IN TWO AREAS ACCORDING TO LAKE PH

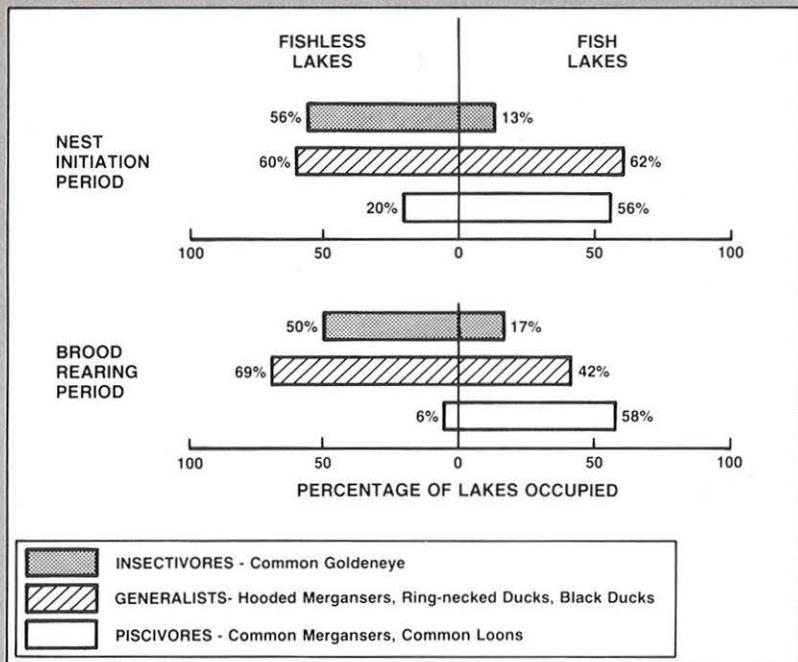


FIGURE 5. DISTRIBUTION OF BREEDING WATERFOWL BETWEEN LAKES WITH AND WITHOUT FISH

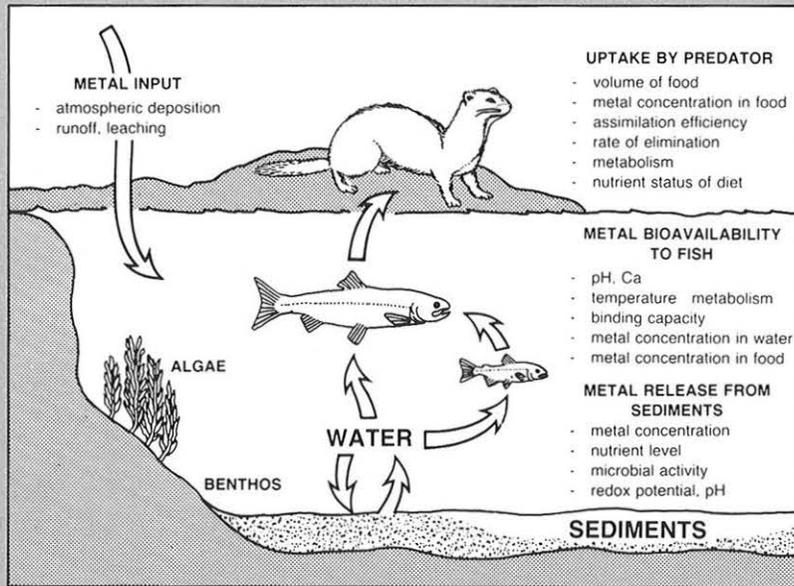


FIGURE 6. FACTORS AFFECTING UPTAKE AND CYCLING OF METALS

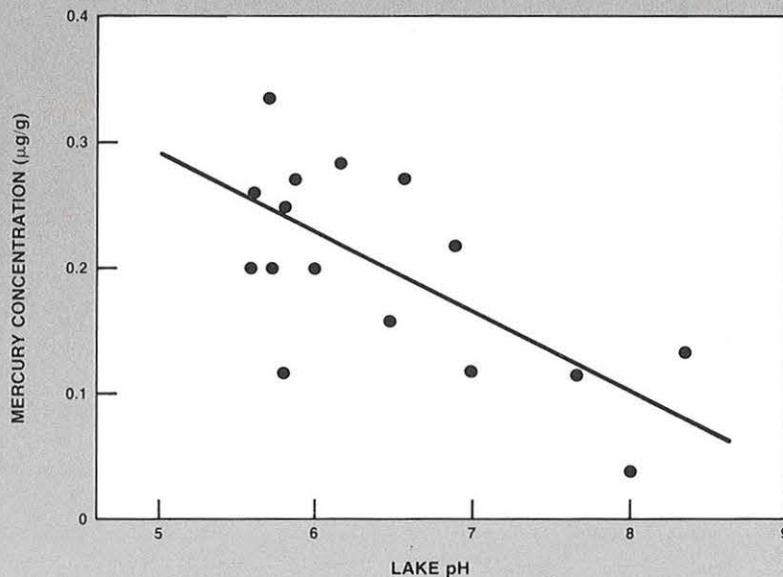


FIGURE 7. RELATIONSHIP BETWEEN MERCURY CONCENTRATION IN MUSCLE TISSUE OF PUMPKINSEED SUNFISH AND PH OF LAKES

## Heavy Metal Contamination of Wildlife

The potential for contamination of wildlife by heavy metals mobilized by acid rain may be high. A direct correlation between acidity in lakes and increased mercury levels in fish has been demonstrated. Some poisonous metals (e.g. mercury, cadmium, and lead) can be concentrated through the food chain, presenting a hazard to wildlife such as fish-eating predators.

Loons, herons, otter, and mink are especially susceptible to the build-up of mercury from fish in their diets (Figure 6). Experiments with mink have shown that relatively low dietary levels of methyl mercury can produce both chronic and acute toxic effects. Lethal mercury poisoning can occur at levels as low as 1.8 µg/g. Mercury concentrations in fish from a sample of Ontario lakes occasionally exceeded lethal levels for mink, measuring almost 2 µg/g (Figure 7).

Birds which eat aquatic insects may also be at risk from the accumulation of toxic metals in their diet. Like fish, insects may accumulate metals from water and their prey, and these levels increase under acidic conditions. Since emergent insects provide the primary food source for many birds, such as swallows and flycatchers and their developing young, metal intake through contaminated prey may be high enough to cause reproductive damage or mortality of the young. This problem is now under study.

## FOR MORE INFORMATION

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