Environmental Science In Action

Loki, D. 2000. Acid Precipitation in the Adirondack Mountains. Biosphere 2000 Project

The Adirondack region of upstate New York, once renowned for its unspoiled wilderness areas and hundreds of lakes teeming with fish, has achieved notice of a more dubious nature. It is one of the first regions in the United States to suffer significant and widespread damage from acid deposition, which includes acidic rainfall, snow, mist, and dry forms of precipitation.

Key Terms
Adirondack State Park; Acid Rain; Clean Air Act

Describing the Resource

Physical Characteristics

The Adirondack Mountains stretch from the Mohawk River valley in the south to the St. Lawrence River in the north and from Lake Champlain in the east to the Black River in the west (Figure 1). Although near the heavily populated eastern seaboard, the Adirondacks encompass twelve wilderness areas so remote that they can be reached only by canoe or foot and a northwest stretch of 50,000 acres (20,235 hectares) that has never been touched by loggers. The region has remained wild because 6 million acres (over 2 million hectares) of the mountains are in the **Adirondack State Park.** The largest park in the lower

48 states, it contains more land than the state of Massachusetts. The park was enlarged in 1993, when the International Paper Company gave 20,000 acres (8,094 hectares) to the Conservation Fund and the State of New York.

FIGURE 1: The Adirondack region of upstate New York is one of the regions most affected by acid precipitation worldwide.

The Adirondack region is vulnerable to the effects of acid precipitation because of its location, altitude, and geologic formation. The northeastern United States is subject to an unusually large amount of acid-forming emissions. About 90 percent of the sulfur, nitrogen, and other acid precursors found in the northeast results from human activities.

Approximately 75 percent of the acid deposition in the Adirondacks originates in Pennsylvania and the Midwest, particularly Ohio, Indiana, and Illinois. Prevailing air currents transport sulfur dioxide from these areas hundreds of miles eastward. When air masses reach the Adirondack Mountains, the first high-altitude area in the eastward path, they ascend and cool, often resulting in rain or snow. Thus, air currents regularly drop the bulk of their acid load on the Adirondacks as they move to the east. Because the higher peaks receive more acid deposition, lakes and vegetation in the more remote, high-altitude regions of the Adirondacks were the first to show adverse effects.

The Adirondacks are also sensitive to acid deposition because of their geologic structure. As an extension of the **Canadian shield**, a large sheet of Precambrian granite, they lack the thick soil cover that could neutralize at least some of the acids from the precipitation. Consequently, much of the acid that is deposited can reach vegetation and lakes.

Biological Characteristics

The forests of Adirondack State Park contain large numbers of northern hardwoods, hemlock, and white pine. Conifers, especially spruce and balsam, flourish at higher elevations. The area's 2,200 ponds and lakes are home to many types of sporting fish, including trout and salmon, as well as other aquatic life. Deer, black bears, small game animals, and coyotes range through the forests, and a healthy beaver community has reestablished itself since it was almost trapped into extinction in the mid-1800s. However, all these populations have become potential victims of acid deposition.

How Acid Deposition Affects Soil and Vegetation

As acid rainfall filters through soil, it affects it in ways that then affect vegetation. By bonding with calcium, magnesium, potassium and other soil nutrients essential to plant growth, acids make these minerals unavailable to vegetation. In the Adirondacks, where soil contains small amounts of these nutrients, this process severely retards the growth of trees and other plants. Acid precipitation can also leach metals from soil and bedrock, thus freeing them and making them available for absorption by plants. Metals such as aluminum and manganese can kill plant roots or damage their ability to absorb nutrients.

Acid deposition attacks trees and plants from above as well as from below. Sulfur dioxide entering trees through stomata on leaves and needles can erode cuticle wax and leave the trees susceptible to insect infestation and loss of moisture. The acid also affects buds and bark and can remove nutrients directly from needles and leaves. Trees and plants not killed outright may be so weakened that they are more likely to succumb to natural stresses such as insects, disease, and harsh weather. Studies show that forests at high altitudes in the Adirondacks are growing at slower rates and losing leaves and needles. Red spruce, especially at risk, have experienced a substantial decrease in growth rate in the past 25 years.

How Acid Deposition Affects Water and Aquatic Life

Most lakes receive water from direct rainfall and from runoff that filters through the surrounding soil. As acid runoff leaches metals from the thin soil, it washes them into streams and lakes where they can damage aquatic life.

Aluminum is especially deadly for fish because it damages their gills, ruining their ability to absorb oxygen from the water. Other metals, such as mercury, accumulate in fish tissues and can be harmful for humans or other animals that eat the fish.

Although runoff picks up toxic metals as it filters through soil, the filtering process can also help to buffer the acids before they reach the lake. Soil rich in minerals such as calcium tends to neutralize acid because the minerals bond with the sulfate or nitrate component of the acid. A 1977 study showed that three lakes in the Adirondacks that received the same amounts of acid deposition varied widely in pH. The lake that retained a neutral pH was surrounded by soil eight times thicker than the soil around the highly acidic lake. Scientists concluded that the thicker soil gave the acid more opportunity to bond with minerals. However, many plants and animals need these same minerals as nutrients, and if the minerals are being tied up by molecules from acid rain, the plants and animals can be deprived. For example, studies of fish in acidified lakes show they lack calcium, a deficiency that sometimes can result in such weak bone structure that their muscles pull their skeletons out of shape.

The acid that remains in groundwater and the acid that falls directly into surface water harms aquatic life forms in ways that are still being explored. One study showed that comparatively low levels of acid (pHs between 5.0 and 5.5) seemed to prevent fish from smelling odors that help them migrate and find mates. Thus, even low levels of acid could virtually end reproduction in entire populations of fishes.

If acid deposition continues to assault a lake, eventually everything in it is destroyed. Almost no forms of aquatic life can live in high concentrations of acid, and those few that can survive may die because of lack of food. Although estimates vary from study to study, acid deposition has rendered approximately 200 lakes in the Adirondack region incapable of supporting fish populations. A study comparing acid levels in 274 lakes in 1989 to measurements taken in a rare study conducted 50 years earlier showed that 80 percent of the lakes had acidified in that time period.

How Acid Deposition Affects the Human Population

The heavy acid deposition in the Adiron-dacks may pose a danger to the 120,000 people who live in the region year-round as well as the 90,000 summer residents. Crops, fish, and meat may be contaminated with toxic metals or lacking in nutritional value. High concentrations of sulfur dioxide in the air can cause sore throats, coughing, and lung irritation and tissue damage. The Adirondack region experienced a mysterious outbreak of cases of gastroenteritis in the mid-1980s. Investigators later traced the outbreak to a normally rare form of bacteria. This bacterium was especially resistant to acid, and temporarily flourished when acid deposition killed off competing life forms.

All water sources in the Adirondacks are in danger of acidification as well, and consuming water with high acid levels is known to increase the chance of cardiovascular disease. An even more immediate problem with acidified water is created when it runs through lead pipes; as sulfuric acid corrodes the pipes, the water can become contaminated with high concentrations of lead.

Social Characteristics

Most of the Adirondack forests had been burned or cut down at least once by 1885. At this time people became concerned about the impact of increasing numbers of tourists, settlers, loggers, and others on the mountains. The New York State surveyor at that time, Verplanck Golvin, had developed a special interest in the area, which he had explored extensively. His interest and public concern led to the creation of the Adirondack Forest Preserve in 1885 and the Adirondack Park in 1892. Two years later, a constitutional amendment declared that forest preserve land would be protected as wild forest forever. The park is an atypical mix of public and private land; much of the two-thirds of the park that is held in private hands is highly developed. The mix has profited the region’s economy, which is heavily dependent on the tourism and timber industries.

Looking Back

Acid deposition may have begun to affect the Adirondacks as early as the beginning of the twentieth century. For instance, Lake Awosting had a pH as low as 4.5 in 1930 and was devoid of fish life as early as 1915; scientists theorize that increased activity in railroads, tanneries, iron forges, and other industries in the area during the late 1800s could have been responsible for acidifying the lake and killing the fish populations.

Damage to lakes and trees in the Adirondacks could easily have occurred long before anyone noticed, since the first damage occurs at the highest, most inaccessible altitudes. Acids also tend to kill smaller, weaker fish first, so fishermen who look only for the bigger fish would not notice any change until the whole population had been affected. However, by the 1970s people were concerned about obvious changes, and scientists began to study why and how these changes were taking place.

By the time the **Clean Air Act** came up for congressional reauthorization in 1977, scientists believed that acid precipitation in the Adirondacks would not end until midwestern electric plants curtailed acid-forming emissions. However, opponents of emissions controls argued that such restrictions would unfairly target industry in their states and wreak havoc on state economies. States that produce high-sulfur coal, such as Ohio, were afraid that plants would opt for burning low-sulfur coals rather than installing expensive scrubbers, thus eliminating jobs in their coal industries. Opponents of emissions regulations stalled decisive action by insisting on more research. They claimed that no one knew if expensive measures to control emissions really would reduce acid precipitation. By this time studies and attempts at reducing emissions in other countries, such as Great Britain, had shown a definite correlation between limiting pollution and reducing acid deposition. Throughout the 1980s most U.S. experts felt that, while more investigation might reveal ways to mitigate the damage of acid rain, waiting to reduce emissions could only lead to increased and possibly irreversible damage in hard-hit areas.

Finally, in 1990, Congress reauthorized the Clean Air Act. The act stipulates that sulfur dioxide production must be reduced to 10 million tons (9.1 million metric tons) per year, half of current output, by the year 2000. Utility plants affected by this bill (in Pennsylvania, West Virginia, Georgia, Ohio, Illinois, Indiana, Kentucky, Tennessee, and Missouri) must either install scrubbers or switch to low-sulfur coal. The legislation also mandated that nitrogen oxide production be reduced by 33 percent (to 4 million tons or 3.6 million metric tons per year) beginning in 1992.

Looking Ahead

Although the only way to prevent acid precipitation is to eliminate acid-forming emissions, scientists are looking for ways to make the effects of acid deposition less harmful to life in threatened areas. Some researchers are concentrating on stocking lakes with fish that are especially good at surviving in acidic waters; geneticists are trying to breed strains of acid-resistant fish. However, some environmentalists point out that even if the fish can tolerate acidity, they must also be able to survive high metal concentrations. In addition, they may die from lack of food if the rest of the aquatic population has disappeared. Other environmentalists point out that finding acid-resistant fish would simply give the polluter states and power plants an excuse not to clean up emissions.

A more widely accepted area of experimentation is liming lakes that have high acid levels on the assumption that the highly alkaline lime will neutralize the acid. The New York State Department of Environmental Conservation and some private organizations have been conducting studies on liming lakes in the Adirondacks since 1959. They have found that liming usually restores a normal pH and so can be used in conjunction with restocking programs to restore lakes that have become acidified. Skeptics point out that acid deposition damages the entire watershed, not just the lakes. They emphasize that liming can neither repair watershed damage nor bring back the rest of the biotic life which has been lost. Moreover, liming is expensive. Estimates predict that it would cost $10 to $20 billion to lime several hundred lakes in the Adirondacks over five years; restocking and monitoring efforts would cost even more. Of course, if acid deposition continues, a limed lake soon loses its normal pH; some lakes have re-acidified in as few as six months after they were limed.

While scientific research may discover new ways to alleviate some of the effects of acid precipitation, real progress in this area depends on our willingness to take the hard steps needed to reduce emissions of sulfur oxides and nitrous oxides. As a nation and a global community, we must weigh the long-term benefits to be gained from such reductions versus the possible short-term economic hardships that may result.

For class discussion

(Be prepared to comment on the questions and statements found below)

Learning Objectives
After reading this material, you should be able to:
1. Describe why the Adirondack region is particularly vulnerable to the effects of acid precipitation.
2. Explain the role of the Clean Air Act in reducing acid precipitation.
3. Be able to list the various problems associated with acid precipitation in the Adirondack region.

Thought Questions

Develop a complete answer for each of the following.

1. What are some experimental methods of combating the effects of acid precipitation? Can these methods make real, long-term progress in the Adirondacks? Explain.
2. Describe how acid precipitation filtering through the soil affects vegetation.
3. How can the type of soil surrounding a lake affect the pH level of the water?