

Scientists Measure Acid Rain Problem At Great Smokies NP

By Jim Wood

Acid rain is its name. Environmental degradation is its game. It begins with the nation's automobile factories, coal- and oil-fired steam plants, steel mills, refineries and smelters, which spew myriad chemical gases into air already contaminated by cars and trucks. These pollutants combine chemically with water vapor to form caustic sulfuric and nitric acids and may be transported great distances by winds. Eventually they fall back to earth in the form of acid rain and snow.

Acid rain knows no political boundaries. It falls on the trout lakes of Ontario, the fir and oak forests of New England and the Adirondack mountains of New York. It spreads southward through the Appalachians of Pennsylvania, the Virginias, and Kentucky and reaches the Great Smoky Mountains of Tennessee and North Carolina.

High up on Clingman's Dome in Great Smoky Mountains NP, data on acid precipitation are being gathered, using special instruments made for the purpose. NPS scientists fear that the Great Smokies soon may experience ecological damage similar to that already encountered in the Adirondacks and elsewhere.

A 1975 survey showed more than half of the Adirondacks' high elevation lakes were devoid of all fish life, due to acid rain. In Ontario, 148 lakes have now been pronounced "dead." Canadian scientists say that if acid rain continues unabated, another 48,000 lakes in Ontario will die within 20 years.

The effects of acid rain are not restricted to lakes and fish. In the cities, marble statues and stone and metal buildings corrode. House paints and auto finishes deteriorate. Acid rain effects on highways and bridges are the subject of federal government studies. Some scientists suspect that already acid rain may be causing declines in farm crops and timber harvests. Dr. Tom Crocker of the University of Wyoming estimates damages to materials (such as stone and auto paint), forest and aquatic ecosystems, crops, water supplies and other health-related systems at \$5 billion for 1978 in the eastern U.S. alone.

The acidity of any solution is measured with what is known as the pH scale, numbered from 0 to 14. A pH of seven is neutral, neither acidic nor alkaline. Distilled water is an example of a neutral substance; anything under seven is acidic, anything over seven is alkaline. The pH scale is logarithmic—that is, each change of one pH unit represents a 10-fold change in acidity. Thus, a drop from pH 6 to pH 3 is a thousandfold increase.

Pure rainwater has a theoretical pH of 5.6 because some acidity occurs naturally due to dust and carbon dioxide in the atmosphere. However, during the past 20 years, the average acidity of rain and snow along the eastern U.S. has dropped from pH 5.6 to between 4 and 4.5. This change represents a value 40 to 50 times more acidic, and some recent individual storms have dumped rain at pH levels even lower. Kane, PA, for example, recorded a shower at pH 2.3, a level far more acidic than vinegar.

Exactly what causes acid rain? The complex chemical process starts with oxides of sulfur and nitrogen emitted by the burning of fossil fuels. These gases stay aloft long enough to interact with water and create sulfuric and nitric acids. The sulfur oxides emanate mostly from power plants, while the nitric oxides come from both power plants and internal combustion engines of cars and trucks. The Environmental Protection Agen-



Ray Mathews checks out weather instrumentation on Convertible Data Collection Platform (CDCP) mounted at Elkmont, a low elevation sampling site in GRSM. The CDCP is powered by lead-acid batteries augmented with a recharging system provided by a solar panel.

cy (EPA) estimates the country's total man-made sulfur dioxide emissions at 26 million metric tons per year. For nitric oxides, the yearly metric tonnage is 23 million. These very fine acidic particles can stay in the atmosphere for an indefinite period and can travel thousands of miles. When they finally fall, they can cause extreme changes in local environments, especially aquatic environments.

When the pH of a lake or stream drops below five, the acidity can kill young fish and prevent reproduction in older fish. In the Adirondack lakes, not only have fish died, but the increased acidity has killed countless salamanders, frogs, plankton, and bacteria—all components of the aquatic ecosystem.

High acidity also increases the solubility of toxic heavy metals, such as aluminum, mercury and lead. In lakes that have not yet gone dead, such metals contaminate the fish and can make them unsafe to eat. If these lakes happen to serve as public drinking water supplies, human health may be endangered in hidden ways. Water from New York's Hinchley Reservoir has acidified to such an extent that when the water passes through household plumbing systems, lead from soldered joints dissolves into the water at concentrations higher than maximum recommended health levels.

A recent two-year study in southern California showed a mean pH of 3.9 for rain in Pasadena. Acid precipitation readings between pH 4 and 5 now are being recorded in Portland, OR, Spokane, WA, Tucson, AZ, and the state of Colorado. Across the Atlantic, Swedish scientist Svante Oden has reported 20,000 acidified lakes in Sweden, with at least a third of these dead. Norway's lakes are similarly affected. Oden traced their acid rain sources to the heavily industrialized areas of Great Britain, Germany and France.

Small high elevation lakes like those in Ontario, the Adirondacks, the High Sierras, the Rocky Mountains, Sweden and Norway, are especially sensitive because they are poorly "buffered." Their soils are thin and their bedrocks do not contain enough alkaline substances (such as limestone and calcium carbonate) to counter the acidity. According to Gene Likens of Cornell University, Cayuga Lake in New York has not gone acid because it is located in a geological area rich in limestone. The limestone serves as a built-in

"Rolaids" to neutralize the acidity. However, in other areas where the buffering capacity is small, this Rolaids factor can be used up in a very few years.

Because many parks and wildernesses are in acid-sensitive mountains and forests, the NPS has set up air pollution monitoring stations in 16 parks throughout the nation. Great Smoky Mountains NP (GRSM) is one of them.

"Our monitoring program consists of three parts," Dr. Gary Larson of the NPS said. (Dr. Larson recently transferred to Omaha, NE, where he now is Midwest Regional Chief Scientist.) "First, we collect weekly rain and snow samples for pH analyses. Second, we study stream pH—how the acid precipitation changes the chemistry of streams in the park. And third, we study the effects of these chemical changes on a selected living organism—in our case, salamanders."

Ray Mathews, NPS biological technician, who works with Dr. Larson, explained why salamanders were chosen as environmental indicators. "Salamanders often spawn in pools or pockets of standing water along the streams," he said. These pools are formed by rainwater or melted snow and could be more acidic than the main body of the stream itself. Any problems may show up in the salamanders first. We think of them as living environmental barometers."

Mathews and Larson have installed specialized rain and snow collectors at five locations within the park... four at different elevations along the park perimeter and one near the top of Clingman's Dome, the park's highest point (6,642 feet above sea level.) Equipment at all five sites was designed and constructed by the Tennessee Valley Authority.

Stream water quality also is being monitored at two streams elsewhere in the park. One stream is located in a watershed that was cut over about 70 years ago; the other is in a virgin (unlogged) watershed. Although both watersheds are classified as cove hardwoods, the logged area has fewer large trees and a greater number of small trees, saplings and shrubs. The NPS team wants to compare differences in stream chemistry between logged and pristine areas, to see whether acid rain affects the two watersheds in different ways.

Hourly stream analyses are made using special remote sensing instruments. A sensor called a "Hydro-

lab Surveyor" is immersed in the stream. It contains probes for measuring pH, water temperature, dissolved oxygen and other water quality parameters. This sensor is connected to a convertible data collection platform (CDCP) that transmits the data to an orbiting Geostationary Operational Environmental Satellite (GOES). The CDCP also is connected to a weather instrument package that measures rainfall, air temperature, relative humidity, barometric pressure, and wind speed and direction. "The system has the ability to correlate changes in stream pH with changes in the weather," Mathews explained. "We are then able to see how major and minor rainstorms affect the streams' pH."

During the past year, the team has recorded rainfall at weekly average pH levels of slightly less than 4, with drops during the winter. "Contaminants in the snow are flushed out in the first melt and runoff into the streams causes steep drops in stream pH," Mathews said. "Also, runoff from heavy rainstorms contains a significant amount of acid water that has not been greatly buffered by the soil. Fortunately, the streams are able to recover within a few days."

A contract with the National Climatic Center seeks to produce data on what areas in the country are most responsible for the air pollutants that affect the Smokies. The study takes into account air mass trajectories and storm fronts of the U.S. weather system. Preliminary findings indicate that most trajectories are from areas east, south, and west of the park.

Paradoxically, one of the problems adding to today's acid rain dilemma is air quality standards set by the Clean Air Act in 1970. The standards then in effect called for reductions in emissions around local areas and communities surrounding factories. This resulted in construction of taller smokestacks. Such "superstacks" — some up to 1,200 feet high — reduced local pollution by pumping the chemicals higher into the



View of the Elkmont CDCP note the tube-shaped GOES antenna to the right of the platform. Weather information (wind speed and direction, relative humidity, rainfall, etc.) is collected by the CDCP and transmitted to the GOES satellite on a 24-hour basis.

atmosphere. Prevailing winds then carried them far and wide, changing the chemical composition of rain and snow over the nation and the world.

As the results of the testing at Great Smokies and elsewhere come in, measures with political and economic ramifications are sure to result. Whatever actions are taken, the condition of our National Parks will be affected, and park scientists are keeping close track of the situation.

Jim Wood is writer-editor with the Natural Science Division, SERO.

For a scientific description of acid rain and a report on its occurrence and monitoring on the west slope of the Northern Cascade Range, see Robert C. Wasem's summary of progress on pp. 33-34 of the 1980 Science Annual Report, Pacific Northwest Region, NPS, now in press. (Available through the PNW Region headquarters, Westin Bldg., 2001 6th Ave., Seattle, WA 98121.)