

Durham Field Office

Acid Rain

- This Cloud Has No Silver Lining

Twenty years ago, acid rain was the environmental cause du jour, a symptom of all that was wrong with humans and their relationship to the environment. Its discovery was accidental, ironic for what turned out to be such a wide-ranging problem. "Hub" Vogelmann, a University of Vermont botanist, noticed something troubling in the precipitation data he and his students were gathering at Camel's Hump in Vermont. They were getting pH readings as low as 2.9-as acid as vinegar or lemon juice. And there were a lot of dead and dying spruce.

Vogelmann's news that something was terribly wrong with red spruce-and it might be acid rain-was greeted with skepticism, even ridicule, by many scientists. Then similar observations were made elsewhere, most notably the Great Smoky Mountains in Tennessee. Eventually the issue made its way into the public's consciousness, leading to years of intense public debate. It was fueled by more disturbing discoveries-increasingly acid surface waters, particularly in the Adirondacks of New York, reproductive failures in fish, deformed frogs. Could there be a connection?

The economic stakes were high. The alleged culprits were large, coal-fired power plants in the Midwest and the Ohio Valley. It was theorized that sulfur from burning coal was converted to sulfuric acid in the atmosphere. Adding greatly to the problem were automobile emissions-nitrous oxide became nitric acid in the atmosphere. The prevailing air currents delivered these emissions directly to the Northeast.

Congress imposed stricter emissions standards despite protests that acid rain and its link to human-caused influences was unproven. How did we know whether rain had always been acid? Even if we could determine that the acidity had increased, how could we know human activities were the cause? And finally, how could we know that a change, if it had indeed occurred, would have such a dramatic effect on the environment? It's a big planet, after all, with plenty of checks and balances.

Since then, the acid rain issue has largely disappeared from the public's list of environmental concerns, replaced by its glitzier cousin, global warming. Interestingly, both problems may share a similar cause-the burning of fossil fuels. Perhaps because global warming potentially affects everyone, it has received more attention. Besides, the alleged evidence for global warming-wild weather fluctuations, more extreme weather events, and warmer temperatures-are more easily observable to the average person.

While acid rain has faded from public view, scientists have quietly been measuring, monitoring, researching, and posing hypotheses. The data are coming in and the news is not good. Little doubt now remains in the scientific community that acid rain is a legitimate problem that has observable, negative consequences for forests and waters in the Northeast. Studies carried out by numerous researchers using diverse methods and working on varying hypotheses show similar conclusions. Many researchers in the Northeast now agree.

"Normal" precipitation pH, in the absence of human influence or major natural event such as a volcano, is about 5.2.

Historical data such as precipitation records, ice cores, and tree borings show a striking increase in acid rain starting in the late 1940's to 1950's. So dramatic is the correlation between periods of high manufacturing activity and rain pH that the Depression of the 1930's and the gearing up of production for World War II can be clearly seen in the data.

Acidity causes aluminum, usually a harmless component in rocks and soil, to become soluble in water, where it is toxic to plants and fish. Calcium is being depleted in soils.

Acidity makes trees more susceptible to other stresses like freezing and insect

attack.

Sulfuric acid produced from smokestack emissions and nitric acid from vehicle exhaust have similar negative effects.

At a public workshop in Concord, New Hampshire, in late June, scientists from across the Northeast came to share these and other findings with about 300 attendees. The Society for the Protection of New Hampshire Forests and the Hubbard Brook Research Foundation sponsored the session, which was billed as a summary of what we know about acid rain plus a discussion about the policy implications of the data.

Dr. Gene Likens, Director of the Institute of Ecosystem Studies at Hubbard Brook in New Hampshire, noted that sulfur dioxide has declined steadily since the 1970's as a result of the Clean Air Act. However, nitrous oxide emissions from vehicles have been increasing and are expected to overtake sulfur emissions by 2010. Disturbingly, his work shows that forest soils at Hubbard Brook have lost 50 percent of their calcium since 1950. Calcium, which gives plant cells their rigidity, is essential for plant growth.

"Toxicity of inorganic aluminum is a serious problem," observed Dr. Greg Lawrence, a U.S. Geological Survey scientist from Troy, New York, when he explained how aluminum can replace calcium in the soil. "It affects brook trout, people, trees, and other plants."

Dr. Don DeHayes from the University of Vermont has been studying how acid rain affects the cold tolerance of red spruce and other trees. He thinks he understands why Vogelmann first observed problems with red spruce 20 years ago. His own experiments show that red spruce is more susceptible to cold injury than others, such as balsam fir. Under acid conditions, it appears that hydrogen ions replace calcium in the plant, making it more vulnerable to frost and other stresses. DeHayes has been able to observe this in both natural and artificially produced conditions.

As the acidity of soil worsens, "trees have to work harder to maintain homeostasis," or a balanced state, similar to the maintenance of human body temperature, explained Dr. Walter Shortle, a researcher at the USDA Forest Service Northeastern Station in Durham, New Hampshire. He predicts northeastern forests of the future could have fewer, smaller trees and fewer species, although the trees would be healthy. "You need to get the soil pH up to 4.5" to avoid this outcome, he added.

One of the components of fossil fuel emissions is nitrate, an essential plant nutrient. Early on, there was some speculation that increased levels of nitrate might actually be beneficial to plant growth. However, Dr. John Aber of Complex Systems at the University of New Hampshire has found that nitrate leaches through soils, taking calcium, potassium, and phosphorus, all critical to plants, with it. He has been able to induce this in forests by adding nitrates artificially. It took hardwood forests 9 years of heavy loading to show negative effects, but with softwood trees, especially white pine, the effects showed up much sooner. As nitrate levels increase, tree growth rates decrease because nutrients are lost.

Nitrates eventually wind up in streams, causing even more problems. Nitrate levels are elevated all across New York and New England, but are more concentrated in the eastern part of that region, apparently because the chemicals are "rained out" of the atmosphere as the clouds advance from west to east.

No one is sure about the long-term effects of acid precipitation on the Northeast's forests and waters. Soils vary greatly from one location to the next. Some have more calcium and other elements that can buffer or neutralize the harmful effects of acids. Scientists worry that once calcium has been depleted in the soil, the negative effects of acid rain could develop abruptly, with devastating consequences. In Europe, with its longer history of industrial development and denser settlements, Dr. Shortle says, "some trees are responding very differently to changes in climate in the last 50 years than they did in the previous 400 years." We may be looking at a future with fewer tree species, fewer trees, and some waters devoid of fish. Drinking water supplies could develop unacceptable levels of aluminum or could require extra treatment to adjust the pH level to prevent damage to plumbing.

So it would appear that these rain clouds have no silver lining. What's the long-term solution? Experts agree we need to stay the course on reducing sulfur emissions. The clean air regulations have clearly led to less sulfuric acid in rain; data show a steady decline since the early 1970's. Cleaner-burning fuels and technology to reduce emissions are readily available. New generating plants have come on line and older ones have been retrofitted.

Nitrous oxide produced by motor vehicles is a tougher problem. Americans continue their love affair with the automobile. Large, truck-like sport utility vehicles dominate the market. Sprawling development and migration away from urban areas mean cars are a necessity for most families. Broad scale adoption of automobiles that use alternative fuels is years away.

Experts have discussed applying lime to forests and ponds to raise the pH. Some researchers have tried it on a limited basis, with mixed results. However, it would most likely be impractical across a wide geographic region.

The solution will lay in new technology, energy conservation, and land use development patterns that promote walking, biking, and public transit. Such actions come at a high economic cost to society. Perhaps the public will be willing to bear these costs if they clearly understand the consequences of continuing on our present path.



