Acid Rain Revisited

What has happened since the 1990 Clean Air Act Amendments?

Since Congress passed the Clean Air Act Amendments (CAAA) in 1990, scientific understanding of acid precipitation has progressed rapidly. At a recent workshop, 40 experts discussed the state of the science, and then addressed the question—has the situation itself improved? Is the Act working? The response was that it has made important gains, but the problem is not yet solved.

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Is the Act Working?

Sulfur dioxide emissions were reduced by 25% between 1990 and 1995, largely as a result of changes mandated by the 1990 CAAA. And, emissions will continue to decline when the second phase of mandatory reductions begins in the year 2000. Since the atmospheric suphur cycle is fairly simple, reduced suphur emissions have resulted in declining sulfate deposition.

But scientists are not yet certain whether these reductions have been, or will be, sufficient.

This will depend on whether or not there is a positive ecological response to the changes in emissions. So far, the results have been mixed. Extensive research during the 1990s documented the status of different regions across America:

- **The news is best from parts of the Northeast and Upper Midwest,** where scientists are seeing reduced sulfate in rain and surface water. There has also been a decrease in toxic aluminum in surface water, a problem closely linked to acidification (acid groundwater leaches the normally stable aluminum from the soil, converting it into a toxic form in surface water).

  In parts of these regions, however, such as the **White Mountains of New Hampshire and the Adirondacks,** forests and streams are not showing signs of recovery (e.g. increased pH and acid neutralizing capacity) despite the declining sulfate concentrations.

- **In areas of the Southeast and Mid-Atlantic,** sulfate concentrations in water have not been decreasing, even as sulfur deposition declines.

- **In the West,** the problem has different roots. There, nitrogen is the primary cause of acidification, while sulfur is not as important. And nitrogen deposition has not declined.

Is the Environment Recovering?

These regional findings highlight two conclusions that scientists have drawn:

(1) Effects of acidification and degree of recovery vary widely from region to region. Scientists attribute this to differences in soil, climate, and exposure to acid precipitation.

(2) From forests to aquatic habitat, the environment is not responding to reduced emissions as everyone had hoped it might.

Two examples

- Fish populations are not recovering, even in the Northeast where sulfur levels in water have declined. In the Southeast, fish populations are declining.

- Forests are still stressed—red spruce and sugar maples especially are suffering from the effects of acid deposition.

So why are there still negative repercussions when emissions have been reduced?

Most scientists agree that the rate of recovery will be directly linked to the extent of emission cuts—the deeper the cuts, the faster the recovery. Some scientists believe that cuts mandated by the CAAA may not be significant enough to remedy the problem.

More importantly, even where the cuts have reduced sulfate in the soils and surface waters, there are other factors that seem to be hindering the recovery of ecosystems:

Nitrogen—Scientists have found that nitrogen plays a greater role in acidification than was once believed. So, although sulfur deposition is being reduced, nitrogen deposition continues to cause acidification.

Base Cation Depletion—All soils have a natural store of ions such as calcium, potassium, and magnesium that serve both as nutrients for plants and as a natural buffer against acidity. These base cations, as they are called, help soils neutralize the acidity in the rain, preventing it from tainting streams and lakes—but in the process they are transformed and washed from the soil. Scientists have found that past acid precipitation has depleted many soils' supply of base cations. The result is that these soils are now "weakened," providing fewer nutrients for trees that depend on them and becoming less effective at buffering current acid precipitation.

Dry deposition may be underestimated—A large portion of acid deposition occurs in either rain or snow. Scientists can measure this "wet" deposition accurately and see that it is being reduced. But a certain amount of acidification is the result of acidic gases and particles that fall to the ground, a phenomenon called "dry" deposition. This element is difficult to quantify, and scientists are not yet certain exactly how much it contributes to the problem.

The Nitrogen Issue: *Nitrogen deposition has not decreased since 1990*

When the CAAA was being written, nitrogen was not thought to play a large role in acid deposition, so the amendments focused primarily on reducing sulfur. But, scientists have found that nitrogen may be a far more important contributor than previously believed. It is more difficult to regulate because it comes from a variety of sources: nitrogen oxides (NOx) are emitted by cars and factories, and ammonium/ammonia (NHx) gases are a product of agricultural activity, especially feedlots and fertilizer use.

Some facts that have come to light:

- Nitrogen may account for 25%-50% of the acidity in rain and snow.
- In the West, nitrogen is the single most important cause of acidification. Nitrogen is doubly problematic because it also causes eutrophication (a condition that results in noxious algae blooms) in high lakes. While the total amount of acid deposition is far less than that of the East, western soils are more vulnerable to the problem.
- Changes in soil nitrogen levels have been observed to alter the species composition and functioning of entire alpine, forest, and grassland communities.
- Nitrogen deposition can negatively affect streams and lakes before it causes any obvious acidification. It also contributes to eutrophication in many estuaries and coastal waters.

Further Needs

Integrated monitoring. *The effects of acid deposition on plants, animals and ecosystems have led scientists to realize that studying atmospheric and soil chemistry is not enough—that further research must be interdisciplinary and incorporate biological indicators as well as chemical ones.*

Legislation that addresses nitrogen. *The 1990 CAAA called for a 10 million ton cut in sulfur dioxide emissions and only a 2 million ton cut in nitrogen oxide emissions. Future air quality legislation will need to consider recent findings about the role of nitrogen (both NOx and NHx) in acid deposition and eutrophication.*

Prepared by the Ecological Society of America
1707 H Street, NW, Suite 400, Washington, DC 20006
phone 202-833-8773 · fax 202-833-8775
http://www.esa.org · esahq@esa.org
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For more information please contact:

The Ecological Society of America
202-833-8773
http://www.esa.org

The Hubbard Brook Research Foundation
603-653-0390
http://://www.hbrook.sr.unh.edu/hbfound/hbfound.htm