ACID RAIN REVISITED

Advances in scientific understanding since the passage of the 1970 and 1990 Clean Air Act Amendments

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Summary

Acid rain is still a problem and has had a greater environmental impact than previously projected.

Many people believe that the problem of acid rain was solved with the passage of the 1990 Clean Air Act Amendments (CAAA). However, research from the Hubbard Brook Experimental Forest (HBEF) in New Hampshire and other study sites in the northeastern United States (hereafter the Northeast) demonstrates that acid rain (hereafter acid deposition) is still a significant problem. Although sulfur emissions that contribute to acid deposition have declined, nitrogen emissions have not changed substantially region-wide and have actually increased in some areas of the eastern United States.

Acid deposition delivers acids and acidifying compounds to the Earth's surface, which then move through soil, vegetation, and surface waters and, in turn, set off a cascade of adverse ecological effects. Recent research shows that the ability of some ecosystems to neutralize acid deposition has diminished over time, delaying the recovery of forests, lakes, and streams. Moreover, while the Clean Air Acts of 1970 and 1990 have improved air quality somewhat, the emissions reductions mandated in 1990 are not likely to bring about full ecosystem recovery in sensitive areas of the Northeast.

Acid deposition has altered soils in areas of the Northeast.

Until recently, limited understanding existed of the effects of acid deposition on soil. However, current research shows that acid deposition has altered, and continues to alter, soil in a number of ways:

- Acid deposition has accelerated the leaching of base cations — elements such as calcium and magnesium that help counteract acid deposition — from the soil in acid-sensitive areas of the Northeast. For example, the amount of available calcium in the soil at the HBEF appears to have declined more than 50 percent over the past several decades.
- A strong positive relationship exists between inputs of sulfur and nitrogen and the concentrations of these elements in forest soils. As a consequence, sulfur and nitrogen have accumulated in forest soils across the region.
- Acid deposition has increased the concentration of dissolved inorganic aluminum in soil waters. Dissolved inorganic aluminum (hereafter simply aluminum) is an ecologically harmful form of aluminum. At high concentrations, aluminum can hinder the uptake of water and essential nutrients by tree roots.

The alteration of soils by acid deposition has serious consequences for acid-sensitive ecosystems. Soils that are compromised by acid deposition are less able to neutralize additional amounts of acid deposition, provide poorer growing conditions for plants, and delay ecosystem recovery.

Acid deposition has stressed trees in areas of the Northeast.

The 1990 National Acid Precipitation Assessment Program (NAPAP) report to Congress concluded there was insubstantial evidence that acid deposition had caused the decline of trees other than red spruce growing at high-elevations. More recent research shows that acid deposition has contributed to the decline of red spruce trees throughout the eastern U.S. and sugar maple trees in central and western Pennsylvania. Symptoms of tree decline include poor crown condition, reduced tree growth, and unusually high levels of tree mortality. Red spruce and sugar maple are the species that have been the most intensively studied and research to date has shown that:

- Acid deposition leaches essential calcium from needles (i.e., foliage) of red spruce, rendering them more susceptible to freezing injury. Increased freezing injury has lead to the mortality of more than half of large canopy red spruce trees in some forests in the Northeast.
- Extensive mortality among sugar maples in Pennsylvania appears to result from deficiencies of base cations, coupled with other stresses such as insect defoliation or drought. The data show that sugar maples are most prone to die on sites where base cation concentrations in soil or foliage are lowest.

Acid deposition has impaired lakes and streams in the Northeast.

Acid deposition has impaired, and continues to impair, the water quality of lakes and streams in three important ways: lowering pH levels (i.e., increasing the acidity); decreasing acid-neutralizing capacity (ANC); and increasing aluminum concentrations. High concentrations of aluminum and increased acidity have reduced the species diversity and abundance of aquatic life in many lakes and streams in the Northeast. Fish have received the most attention to date, but entire food webs are often negatively affected. Recent water quality data show that:

- 41 percent of lakes in the Adirondack Mountain region of New York and 15 percent of lakes in New England exhibit signs of chronic and/or episodic acidification.
- Only modest improvements in ANC, an important measure of water quality, have occurred in New England. No significant improvement in ANC has been measured in the Adirondack or Catskill Mountains of New York.
- Elevated concentrations of aluminum have been measured in acid-impacted surface waters throughout the Northeast.

The Clean Air Act has had positive effects, but emissions and deposition remain high compared to background conditions.

Regulatory controls initiated in the 1970s and 1990s decreased sulfur dioxide emissions, yet these emissions remain high compared to background conditions. Controls on nitrogen oxides and ammonia have not been fully addressed; consequently, emissions of these compounds are high and have remained largely unchanged in recent years. In the period 1995-1997, wet deposition of sulfate in the Northeast was approximately 20 percent lower than levels in the preceding three years with implementation of the 1990 CAAA. However, wet deposition of nitrogen has not changed significantly since the 1980s. Importantly, the emission and atmospheric deposition of base cations that help counteract acid deposition have declined significantly since the early 1960s with the enactment of pollution controls on particulate matter.

The rate and extent of ecosystem recovery from acid deposition are directly related to the timing and degree of emissions reductions.

Given the loss of acid-neutralizing base cations and the accumulation of sulfur and nitrogen in the soil, many ecosystems are now more sensitive to the input of additional acids and recovery from acid deposition will likely be delayed. Research shows that emissions reductions mandated by the 1990 CAAA are not sufficient to achieve full ecosystem recovery in watersheds in the Northeast that are similar to the HBEF within the next 25-50 years. Analyses of policy proposals calling for an additional 40-80 percent reduction *in electric utility emissions* of sulfur beyond the levels set by the 1990 CAAA show that such proposals would result in measurable improvements in chemical conditions. Specifically, with an additional 80 percent reduction in sulfur emissions from electric utilities, streams such as those at the HBEF would change from acidic to non-acidic in approximately 20-25 years. *In sum, long-term research suggests that deeper emissions cuts will lead to greater and faster recovery from acid deposition in the Northeast.*

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For copies of the full report, please contact the Hubbard Brook Research Foundation at hbrook@hbresearchfoundation.org or visit the Web site http://www.hbrook.sr.unh.edu./hbfound/hbfound.htm or call us at (603) 653-0390.

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