SUMMARY: Acidic Deposition in the Northeastern U.S. BioScience, vol. 51, no. 3, 2001

North America and Europe are in the midst of a large-scale experiment. Sulfuric and nitric acids have acidified soils, lakes and streams, stressing or killing terrestrial and aquatic biota. It is, therefore, critical to measure and understand the recovery of complex ecosystems in response to decreases in acidic deposition. Long-term research from the HBEF and other sites across the northeastern US were used to synthesize data on the effects of acidic deposition and to assess ecosystem responses to reductions in emissions. Based on existing data, it is clear that in the northeastern US:

- Reductions of SO_2 emissions since 1970 have resulted in statistically significant decreases in SO_4^{2-} in wet/bulk deposition and surface water.
- Emissions of NO_x and concentrations of NO_3^- in wet/bulk deposition and surface waters show no increase or decrease since the 1980s.
- There is considerable uncertainty in estimates of NH_3 emissions, although atmospheric deposition of NH_4^+ is important for forest management and stream NO_3^- loss.
- Acidic deposition has accelerated the leaching of base cations from soils, delaying the recovery of ANC in lakes and streams from decreased emissions of SO_2. At the HBEF, the available soil Ca pool appears to have declined 50% over the past 50 years.
- Sulfur and N from atmospheric deposition have accumulated in forest soils across the region. The slow release of these stored elements from soil has delayed the recovery of lakes and streams from emissions reductions.
- Acidic deposition has increased the concentration of toxic forms of Al in soil waters, lakes and streams.
- Acidic deposition leaches cellular Ca from red spruce foliage, which makes trees susceptible to freezing injury, leading to over 50% mortality of canopy trees in some areas of the Northeast.
- Extensive mortality of sugar maple in Pennsylvania has resulted from deficiencies of Ca^{2+} and Mg^{2+}. Acidic deposition has contributed to the depletion of these cations from soil.
- 41% of lakes in the Adirondacks and 15 % of lakes in New England exhibit chronic and/or episodic acidification. 83% of these impacted lakes are acidic due to atmospheric deposition.
- There have been only modest increases in the ANC of surface waters in New England and no significant improvement in the Adirondack and Catskill regions following decreases in atmospheric S deposition in recent decades.
- Acidification of surface waters results in a decrease in the survival, size and density of fish, and loss of fish and other aquatic biota from lakes and streams.
- Emissions of air pollutants have important linkages to other large-scale environmental problems including coastal eutrophication, mercury contamination, visibility impairment, climate change and tropospheric ozone.

Further, it is anticipated that recovery from acidic deposition will be a complex, two-phase process in which chemical recovery precedes biological recovery. The time for biological recovery is better defined for aquatic than terrestrial ecosystems. For acid-impacted aquatic ecosystems, it is expected that stream macroinvertebrate and lake zooplankton populations would recover in 3-10 years after favorable chemical conditions were re-established, and fish populations would follow. For terrestrial ecosystems, trees would probably respond positively to favorable atmospheric and soil conditions over a period of decades.

Indicators of chemical recovery (soil % base saturation, soil Ca/Al ion ratios and surface water ANC) were used to evaluate ecosystem response to proposed policy changes in SO_2 emissions. Projections using an acidification model (PnET-BGC) indicate that full implementation of the 1990 CAAA will not result in substantial chemical recovery at the HBEF and many similar acid-sensitive locations. While uncertainties remain, our analysis indicates that current regulations will not adequately achieve the desired ecological outcomes of the 1990 CAAA. These desired outcomes include: increases in the ANC of lakes and streams, improvements in the diversity and health of fish populations, decreases in the degradation of forest soil and stress to trees. Model calculations indicate that the magnitude and rate of recovery from acidic deposition in the northeastern US is directly proportional to the magnitude of emission reductions. Model evaluations of policy proposals calling for additional reductions in utility SO_2 and NO_x emissions, year-round emission controls, and early implementation (2005) indicate greater success in facilitating the recovery of sensitive ecosystems and accomplishing the goals of the Clean Air Act than current 1990 CAAA targets. Note that until transportation emissions of NO_X are curtailed, there will be increased potential for a condition where improvements in acidic deposition from SO_2 controls by utilities will be offset somewhat by NO_X emissions. Specific emission reductions targets should be based on clear goals for the desired extent and schedule of recovery of sensitive aquatic and terrestrial ecosystems which are consistent with the goals of the Clean Air Act.