PROJECT UPDATE

August 2005

New York State Energy Research and Development Authority

Environmental Monitoring, Evaluation, and Protection Program

Deposition and Effects of Air Pollution in the Hudson Valley

PROJECT FOCUS

NYSERDA funding for this project supports the continuation of the long-term forest ecosystem research program at the Institute of Ecosystem Studies (IES) in southeastern New York State (NYS). The aim of the program is to measure the effects over time of the atmospheric deposition of energy-related pollutants on forest ecosystems in the Hudson Valley region. Specifically, the work involves the following activities:

- Measuring the wet and dry atmospheric deposition of sulfur (S), nitrogen (N), and other nutrients and pollutants to the research site;
- Determining the effects of these pollutants on the forest ecosystem; and
- Determining the interactions between air pollution and other forest stresses, in particular "exotic" forest pests.

Forest Ecosystem Monitoring at IES

Vegetation	Biogeochemistry	Animals
✦ Production	✦ Atmospheric Deposition	✦ Gypsy Moth
✦ Species Composition	✦ Throughfall	✦ Hemlock Woolly Adelgid
✦ Mortality	✦ Soil Solution	✦ Small Mammals
✦ Regeneration	✦ Litterfall	✦ Deer Browse
✦ Seed Production	✦ Foliar N Concentration	✦ Black-legged Ticks
✦ Crown Condition	✦ Soil C and N	✦ Lyme Disease Infection Rates
	✦ N Mineralization/Nitrification	

CONTEXT

Fossil-fuel combustion sources are major emitters of sulfur dioxide (SO_2) and nitrogen oxides (NO_x). These pollutants undergo complex reactions in the atmosphere to form nitric and sulfuric acids, which, through atmospheric deposition in forests and bodies of water, affect ecosystems in complex ways and contribute to the acidification of soils, lakes, and streams. Over the past 20 years, federal policies such as the Clean Air Act Amendments of 1990 (CAAAs) have resulted in decreased atmospheric emissions and deposition of sulfur in NYS. In the same period, atmospheric emissions of nitrogen, which were not capped by the CAAAs, have not changed significantly.

In 1983, a long-term environmental monitoring program was initiated at the IES in Millbrook, NY. This site hosts one of the few monitoring stations located in the lower Hudson Valley, a region that may be undergoing environmental change as a result of development of electricity generating facilities. Over the past two decades, the program has generated a valuable record of precipitation chemistry, air quality, meteorology, wet and dry deposition, forest growth, forest nutrient cycling, and stream chemistry.

METHODOLOGY

Beginning in 1992, two plots in the Cannoo Hills, a mixed oak forest that comprises 150 ha of the 800+ ha (2,000+ acre) IES property, have been regularly sampled to examine:

- Soil solution from below the rooting zone,
- Foliar and litter (fallen leaves) chemistry,
- Soil nitrogen mineralization and nitrification, and
- Throughfall, i.e., rain that falls through and is collected under the tree canopy (1993–1999 only).

Wet and dry deposition and climate variables have been measured since 1988. In 1996 an experiment to evaluate the response of the forest N cycle to the increasing availability of N was initiated in six pairs of plots distributed throughout the ridgetop forest at IES. Each pair of plots consists of (1) a control plot that is unfertilized and (2) a plot to which N fertilizer (ammonium nitrate [NH_4NO_3]) is added in four equal applications per year, for an annual rate currently totaling 50 kg N per hectare. In the N fertilization plots, the measurement scheme is the same as detailed above, but throughfall is not collected and the number of samples is reduced because of the smaller plot size. The experiment is designed to allow assessment of the long-term effects of chronic nitrogen deposition on the ecosystem.

Credit: Gary Lovett, IES

Collecting leaf litter at a long term monitoring plot and sampling foliage.

Principal Researchers

GARY M. LOVETT
Institute of Ecosystem Studies (IES)

Project Location

Millbrook

Contact Information

For more information on this project see:

http://www.nyserda.org/programs/environment/emep

or contact Mark Watson at:
mw1@nyserda.org

Keywords

- Acidic deposition
- Forest nitrogen cycle
- Litterfall
- Nitrogen mineralization
- Nutrient cycling

PROJECT UPDATE

August 2005

Credit: USDA Forest Service
Gypsy moth defoliation.

Credit: USDA Forest Service
Fifth instar gypsy moth larva.

Project Status

- Initiated 2002
- Completed 2005

New York Energy $mart℠
Public Service Commission — NYSERDA

Since 1975, the New York State Energy Research and Development Authority (NYSERDA) has developed and implemented innovative products and processes to enhance the State's energy efficiency, economic growth, and environmental protection. One of NYSERDA's key efforts, the Environmental Monitoring, Evaluation Protection (EMEP) Program, supports energy-related environmental research. The EMEP Program is funded by a System Benefits Charge (SBC) collected by the State's investor-owned utilities. NYSERDA administers the SBC program under an agreement with the Public Service Commission.

PROJECT FINDINGS

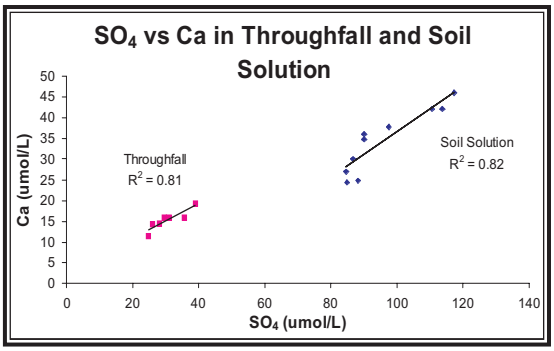
Atmospheric Deposition: This area has shown a decline in total (wet and dry) atmospheric deposition of both N and S since 1988.

- Total S deposition has declined substantially (1988–2000), as a result of reductions of regional SO_2 emissions. However, S emissions from power plants in the Hudson Valley area have decreased much less than emissions from power plants in the Northeast as a whole. Statistical correlations indicate that deposition trends at the site were more influenced by regional than by local emissions.
- Atmospheric deposition of N has also declined in this area since 1988, although it increased again in 2000.

S and N Trends and Cycling: Reduced deposition (1988–2000) has led to declines in the amounts of N and S in throughfall and of S in soil solution.

Sulfur: Sulfate concentrations in throughfall and soil solution indicate a lower flux of S through the ecosystem.

- Soil solution S concentrations are much higher than throughfall concentrations and indicate a substantial internal source of S in these forests, most likely from the weathering of the shale and slate bedrock in the area.
- Sulfate and calcium are highly correlated in throughfall and soil solution.
- The decline in atmospheric deposition of S has decreased the leaching of calcium from the canopy and soil, despite the fact that mineral weathering adds a substantial amount of S to this ecosystem.



Credit: Gary Lovett, IES
Sulfate and calcium are highly correlated in throughfall and soil solution. Changes in SO_4^{2-} flux produce corresponding changes in base cation flux.

Nitrogen: No decrease in inorganic N concentration in soil solution has been observed.

- Under current Nitrogen deposition conditions, there is minimal loss of N in drainage waters, suggesting almost complete retention of nitrogen. Nitrogen is strongly retained both in the forest canopy and in the soil, through complex plant, microbial, and abiotic processes.
- Overall, the N retention capacity for many forests in the Hudson Valley would be expected to be quite high, because of the area's history of widespread burning and harvesting in the 19th century and the dominance of oaks, which tend to have low rates of N cycling and loss.

Forest Dynamics and Exotic Pests: These forests are affected by multiple biotic stresses, primarily owing to the introduction of exotic pests. The two most problematic, the gypsy moth and the hemlock woolly adelgid, have substantial effects on N cycling and retention. Gypsy moth defoliation can radically alter the forest N cycle. While this perturbation usually causes little N loss from the forest in drainage waters, under certain conditions, such as N saturation, N losses can be significant.

N Cycling Experiment: Fertilized plots show signs of N enrichment. Foliar and litterfall N have increased significantly, as has NO_3 leaching. The surprisingly high NO_3 leaching indicates that N saturation may occur at this site much earlier than expected based on other studies, suggesting that the ecosystem is susceptible to N saturation. This accelerated trend toward N saturation may result from qualities of the site, which is an oak forest on thin soils in a ridgetop location. However, the site is representative of a major ecosystem type in southern NYS and is typical of sites attacked by the gypsy moth. This susceptibility to both N saturation and gypsy moth defoliation indicates that the interaction of these stresses should be further studied.

PROJECT IMPLICATIONS

This project has produced a valuable data set and tracked trends in the key indicators of forest ecosystem responses to atmospheric deposition. By tracing the effects of recent deposition changes on the forest ecosystem studied, the information will prove useful in evaluating the effectiveness of current legislation in reducing deposition to the Hudson Valley region. The long-term data accumulated will be beneficial in evaluating trends in response to the impacts of future legislation.

Results indicate that regional S emissions rates are more influential in determining local deposition than those of local sources, highlighting the importance of regional efforts to mitigate emissions. Recent reductions in regional S emissions have caused a decline in S deposition at this site, and that has reduced the loss of calcium, a critical plant nutrient, from the soils. With regard to nitrogen, it is important to note that while these oak forests do not leach N under ambient conditions, they appear to reach N saturation very quickly under conditions of elevated N input. Thus, increased N emissions could have a pronounced effect on the ecosystems studied. Currently, there are no caps in place on NO_X emissions from electrical utilities. Under present circumstances, N emissions and deposition are likely to increase in the future as the demand for electricity increases.