PROJECT UPDATE

December 2005

New York State Energy Research and Development Authority

Environmental Monitoring, Evaluation, and Protection Program

ASSESSING THE SENSITIVITY OF NEW YORK FORESTS TO CATION DEPLETION

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Project Locations

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Keywords

- Acidic deposition
- Base cation
- Liming
- Mineral weathering
- Soil calcium depletion

PROJECT FOCUS

To improve our understanding of the sensitivity of forests across New York State (NYS) to soil calcium (Ca) depletion, this project seeks to:

- Describe the distribution of Ca-bearing minerals in soil (or soil parent material, the material from which soil forms);
- Assess the relative ability of important tree species to access Ca from various sources, including trace minerals; and
- Assess how changes in soil Ca content resulting from nitrogen (N) deposition would affect the storage of carbon (C) in soil.

CONTEXT

Fossil-fuel combustion sources are major emitters of sulfur dioxide (SO_2) and nitrogen oxides (NOx). 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.

Credit: Ruth Yanai
Soil sample collection.

A major adverse effect of acid rain on forest health and productivity is a reduction in soil of the available supply of calcium and other base cations that are needed for forest growth. Scientific predictions of soil Ca depletion related to acid rain, however, have been based on the assumption that only salt-exchangeable Ca is available to plants. The influx of Ca from another possible source, the weathering of Ca-containing materials in soil, has been considered too gradual a process to play an important role in mitigating the acidifying effects of air pollution on soils. Because of these assumptions, the role of easily weathered trace minerals containing calcium, such as apatite and calcite, has been overlooked in assessments of Ca depletion from acid rain. In addition, recent research linking changes in levels of extractable cations to soil C and N content has raised the question of whether changes in soil Ca pools could in turn influence soil C and N storage.

Credit:http://www.hubbardbrook.org/
A helicopter flies low over trees, spreading Ca on the forest

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gears.tucson.ars.ag.gov
Maple leaf litter.

Project Status

- Initiated January 2005
- Project ongoing

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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.

METHODOLOGY

Distribution of Ca-bearing minerals: Based on bedrock geology and the distribution of soil types, 30 sites were selected in New York State for sampling of soils. A sequential extraction procedure is being used to quantify the amount of calcium that is exchangeable, readily weathered (such as apatite), and resistant to weathering (such as silicate minerals).

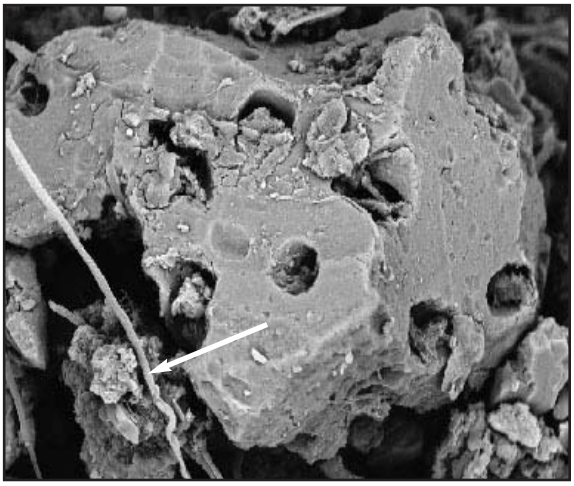
Tree Species: At the same sites, leaf litter is being collected from the dominant species present to determine how similar types of forest fare on soils formed from contrasting materials and how different tree species or forest types vary in accessing different sources of Ca from the same substrate. Strontium isotopes and the ratio of calcium to strontium will be used to determine the relative importance of atmospheric deposition, silicate weathering, and trace minerals as Ca sources for vegetation.

Carbon Storage: Additional samples, collected at sites where Ca was added in liming experiments 14 to 41 years ago, will be analyzed for C and N in order to determine whether patterns observed at the landscape level are likely to predict changes over time with the continued atmospheric deposition of N and leaching of Ca.

PROJECT FINDINGS

Findings thus far indicate that an accurate assessment of the threat of Ca depletion by acid rain and forest harvesting depends on understanding the contribution of apatite weathering to Ca cycling in forest soils. Apatite is important in granitoid parent materials (igneous rock) but not in sedimentary rocks. The soil parent materials derived from clastic sedimentary rocks averaged 80 ppm Ca from apatite, compared to 720 ppm in the parent materials derived from igneous rocks.

Parent material is likely more important than glaciation in determining apatite availability in soils. Sugar maple decline has been observed to occur on unglaciated soils of the Allegheny Plateau, while glaciers tend to rejuvenate reservoirs of fresh minerals available for weathering. Two sites in Pennsylvania were selected to bracket the southern extent of the Wisconsin glaciation. The fact that both sites had very little apatite, with the glaciated site having the least, suggests that the importance of apatite across the landscape should be predictable from bedrock composition and the glacial transport of parent materials, with crystalline bedrock providing more apatite than sedimentary rock.



Credit: Ruth Yanai
Mineral weathering

Roots and fungi, including mycorrhizae, play a role in mineral weathering, and it has been suggested that apatite weathering is at least in part under biotic control (see figure above). The spruce-fir forest site at Hubbard Brook appears to have greater access to apatite as a Ca source than does the hardwood forest.

PROJECT IMPLICATIONS

Information concerning the distribution of sources of Ca and the ability of tree species to access Ca is essential for predicting the sensitivity of forests across New York State to Ca depletion. The data accumulated through this project will provide a more accurate assessment of the likelihood that New York State forests will be adversely affected by the depletion of calcium and other exchangeable cations as a result of acidic deposition. This information is vital for the development of sound policies for managing and protecting New York's forest resources. Additionally, carbon storage in forest soils is of increasing interest because of the need to account for C storage in soils when using forests to offset emissions of CO_2.