ATMOSPHERIC DEPOSITION

PRINCIPAL RESEARCHERS

Kathleen Weathers
Cary Institute of Ecosystem Studies
Timothy Sullivan
E&S Environmental Chemistry, Inc.
Gregory Lawrence
U.S. Geological Survey

PARTNERS

Bernard Cosby, University of Virginia | **Todd McDonnell**, E&S Environmental Chemistry, Inc.

PROJECT LOCATION

Adirondack Park in New York. Source: E&S Environmental Chemistry, Inc.

CONTACT INFORMATION

For more information on this project, go to:
www.nyserda.org/programs/environment/emep/
or contact Greg Lampman at:
ggl@nyserda.org

PROJECT NUMBER 10658

KEYWORDS
- Acid deposition
- Adirondack
- Aluminum
- Critical load
- Surface waters

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New York Energy Smart℠ EMEP Environmental Monitoring, Evaluation, & Protection

NYSERDA New York State Energy Research and Development Authority

Empirical Estimation of the Critical Load for Inorganic Aluminum Mobilization in the Western Adirondack Region

PROJECT FOCUS

This project will calculate site-specific critical loads (CL) for inorganic aluminum (Al) mobilization from soils to low-order streams in the western Adirondack Mountains. Critical loads are threshold levels of exposure to pollutants, below which specific sensitive elements of an ecosystem show no significant negative impact. To calculate the CL for Al mobilization, the project team will use spatially explicit estimates of regional atmospheric deposition in combination with data from the recently-developed site-specific Base Cation Surplus (BCS) index. The BCS index relates consistently to inorganic aluminum (Al) concentrations in surface waters, and provides a useful reference point for assessing the effects of acid deposition.

CONTEXT

Inorganic Al is a critical factor in assessing ecosystem effects of acid deposition because it occurs in surface waters as a result of acid deposition. Inorganic Al is toxic to aquatic organisms at all levels of the food web, and can impair tree health by interfering with calcium uptake by roots. Increased mobilization of inorganic Al to lake and stream waters in the western Adirondack Mountains has been well documented for more than 25 years.

Collection of stream water at the Buck Creek Monitoring Watershed in the western Adirondack region during spring snowmelt when streams tend to be most acidic. Source: Greg Lawrence.

In this project, the CL to protect against mobilization of inorganic Al will be calculated for study watersheds. To apply this concept to an ecosystem, two things must be quantified: first, the capacity of the system to neutralize inputs of acidity; and second, the actual amount of atmospheric deposition over appropriate spatial and temporal scales.

During the period 2003 to 2005, the NYSERDA-funded Western Adirondack Stream Survey (WASS) sampled 188 streams in the Oswegatchie-Black River Basins. Soil sampling in 11 of the WASS watersheds showed that BCS was strongly related to base saturation of the Oa soil horizon[1], so that base saturation could be estimated for all WASS watersheds on the basis of this relationship.

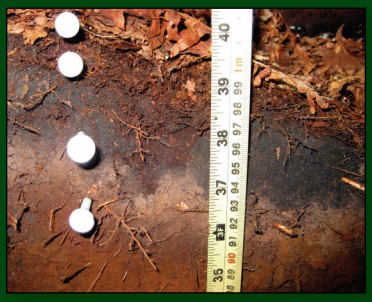
PROJECT IMPLICATIONS

Despite recent declines in the deposition of S (sulfur), and to a lesser extent N (nitrogen), acid deposition continues to impair a large number of surface waters in the Adirondack region. Mobilization of inorganic Al from soils is the most fundamental problem resulting from acid deposition. This project will estimate the reduction in acid deposition that would be required to reduce Al mobilization to levels that will protect sensitive biological resources in this region. Understanding spatial and temporal patterns in CL for inorganic Al mobilization will provide a better understanding of the ecosystem impacts of policy decisions. Application of new approaches and comparison with current methods for both static and dynamic modeling will increase the understanding of CL science.

[1]The Oa soil horizon is a layer of soil containing highly decomposed organic material.

PROJECT STATUS
Ongoing

Smaller streams, such as this one located within the High Peaks region in Adirondack Park, are especially sensitive to effects from acid deposition. Source: Todd McDonnell.



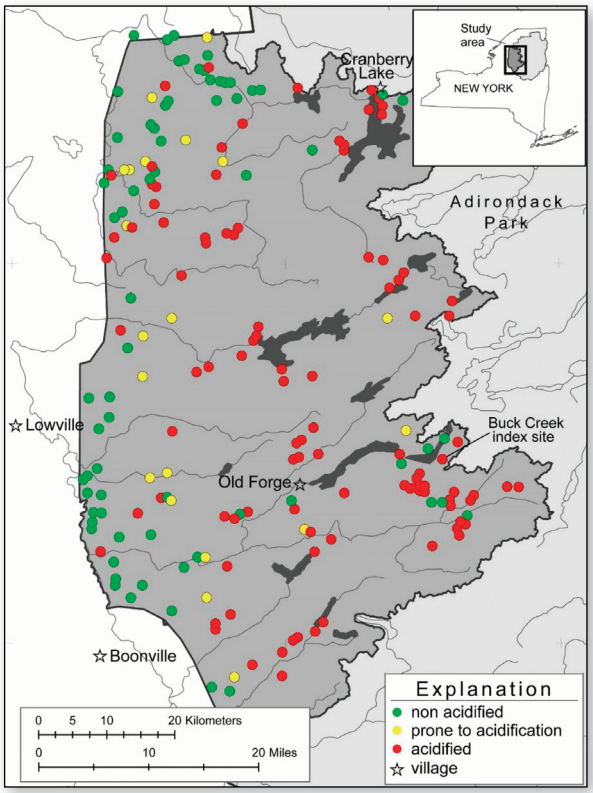
Critical loads modeling relies on soil chemistry data collected within the study watersheds. Source: Tyler McPherson.

New York Energy Smart
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, and 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

The relation of BCS to atmospheric deposition will be examined in the 188 WASS-sampled watersheds using the U.S. Geological Survey (USGS) elevation database, U.S. Forest Service (USFS) vegetation maps, WASS soils chemistry data, Environmental Protection Agency's (EPA) Clean Air Status and Trends Network (CASTNET), and National Atmospheric Deposition Program (NADP) data in landscape models. Based on the rates of deposition and BCS values, CL for mobilization of inorganic Al will be determined for the studied watersheds, and an estimate made of how far above or below the CL value each watershed is at present.



Acidification categories of watersheds sampled in the March 2004 Western Adirondack Stream Survey. Non acidified sites had base cation surplus (BCS) values > 25 μeq/L^{-1}; sites prone to acidification had BCS values > 0 μeq/L^{-1} but < 25 μeq/L^{-1}; acidified sites had BCS values < 0 μeq/L^{-1}. Each of these watersheds will be evaluated to determine if atmospheric deposition of sulfur and nitrogen exceed the critical load with respect to mobilization of toxic Al. Source: Greg Lawrence.

The Model of Acidification of Groundwater in Catchments (MAGIC) will then be run for the 11 WASS-sampled watersheds for which detailed soils data are available. The MAGIC model will be applied to estimate the CL for inorganic Al mobilization, the amount by which acid deposition exceeds or falls below the CL value, and the length of time required to achieve cessation of inorganic Al mobilization at various deposition levels. Empirical CLs will be calculated to achieve BCS equal to 0 and 25 μeq/L and acid neutralizing capacity (ANC) equal to 20 and 50 μeq/L. The model will be run for a scenario which will yield projections of future response for the 11 study watersheds under expected deposition rates, in the absence of additional regulations beyond those already mandated. The MAGIC model will also be run for a second scenario assuming more stringent emissions controls.

The CL values generated using the empirical Al mobilization approach will be compared with the more commonly used approach of applying MAGIC to determine the loading rate that will allow stream chemistry to reach certain target ANC levels within a specified time frame. Estimates will be developed of the time that it will take for these streams to reach designated benchmark chemistry values under loading rates identified as critical for Al mobilization.

FINDINGS

The empirically based, spatially explicit complex terrain deposition model, originally developed for Acadia and Great Smoky Mountain National Parks, has been adapted for use in the study region. Using the adapted model, deposition estimates for S and N (two components of acid deposition) have been developed for each of the 188 watersheds using:

- The digital elevation model (DEM) at 10 m resolution and delineations for the 188 watersheds;
- Vegetation coverages from the USDA Forest Service, Forest Inventory Analysis (FIA) database;
- Wet deposition data from National Acid Deposition Program (NADP) sites bracketing the study area, as well as from one site (Moss Lake) located near the center of the study area; and
- Dry deposition data from the Huntington Forest CASTNET site, approximately 50 km from the center of the study area.

Currently, input data for the MAGIC model are being assembled and model calibrations will be developed in the near future. In addition, deposition maps have been created and the researchers are exploring relationships between deposition and soil and water quality in the watersheds.