

Assessment of Extent to which Intensively Studied Lakes are Representative of the Adirondack Mountain Region

PROJECT FOCUS

This research represents a multi-disciplinary and multi-institutional effort to extrapolate research, monitoring, and modeling results, including physical, chemical, and biological findings, from intensively studied lakes to the regional population of acid-sensitive Adirondack lakes. The primary objectives were to:

- develop an approach for extrapolating spatially-limited but temporally-intensive knowledge regarding changes in the chemistry and biology of acid-sensitive lakes and their watersheds in order to conduct regional assessments of Adirondack ecosystems,
- estimate the extent to which impacted lakes and watershed soils may recover, both chemically and biologically,
- develop a statistically-representative soils database,
- provide a mechanism for further utilization of critical biological response data from a relatively small number of lakes,
- classify lakes according to their responsiveness to future changes in sulfur and/or nitrogen deposition, and
- provide the technical foundation for establishment of critical and target loads of acid deposition.

CONTEXT

Ecosystem damage from air pollution in the Adirondack Mountains is believed to have been substantial, mainly from the deposition of sulfur and to a lesser extent nitrogen. Most efforts to quantify damages and examine ecosystem recovery have focused on lakewater chemistry. However, relatively large decreases in regional upwind sulfur emissions and generally similar decreases in sulfur deposition in the Adirondacks over the past two decades have resulted in limited recovery of lakewater acid-base chemistry. Sulfate concentrations in lakewater have decreased markedly, but so have the concentrations of base cations. Therefore, measured increases in lakewater pH and acid neutralizing capacity (ANC) have generally been small.

Much of the acidic deposition effects research in the Adirondacks has focused on individual lakes and their watersheds. Management decisions require information regarding numbers and percentages of lakes that have behaved, or in the future will be expected to behave, in various ways. A mechanism has not been available with which to extrapolate results of long-term chemical and biological monitoring studies to the regional population of Adirondack lakes.

This research allows for fuller utilization of data from on-going chemical and biological monitoring and process-level studies.

METHODOLOGY

A group of Adirondack watersheds was selected for soil sampling using a random selection process based on the U.S. Environmental Protection Agency's (EPA) Environmental Monitoring and Assessment Program statistical design. An additional set of watersheds was selected for sampling from among those that are subjects of long-term chemical and biological monitoring efforts.

Intensively-studied watersheds were drawn from the Adirondack Lakes Survey Corporation's (ALSC) Adirondack Long-Term Monitoring Project (ALTM) and Adirondack Effects Assessment Program (AEAP) databases. Soil characteristics at 199 locations within the 70 study lake watersheds were sampled and measured. Results of soil analyses and model projections of lakewater chemistry were extrapolated to the watersheds of the 1,320 low-ANC lakes in the Adirondack lake population.

Acid-base chemistry modeling was conducted with the MAGIC and PnET-BGC models using 2001 as the Base Year. Three scenarios of future emissions reductions were selected for projecting future changes in lake and soil chemistry.

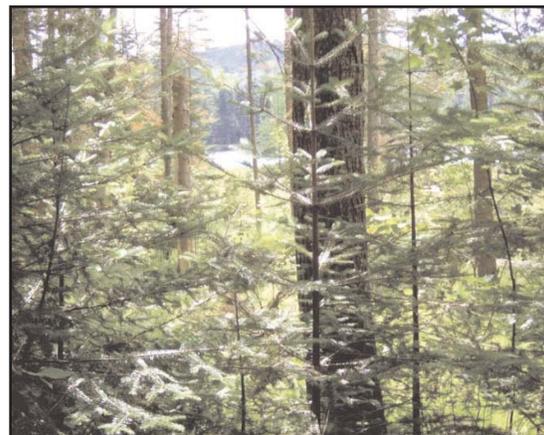
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Project Location



Adirondack mountain region outlined.



Credit: Tim Sullivan et al
Forest cover of the Adirondack Mountains

Contact Information

For more information on this project see:

<http://www.nyserra.org/programs/environment/emep/>

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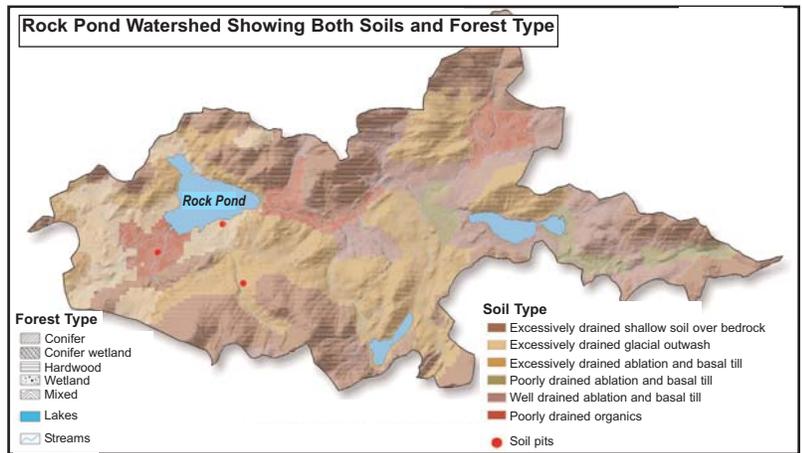
Keywords

- Acid deposition
- Acid neutralizing capacity
- MAGIC Model
- PnET-BGC Model
- Base saturation
- Watershed classification

PROJECT UPDATE

February 2007

These included a Base Case scenario which assumed that emissions levels will be capped on the basis of existing regulatory controls as of January 2004, a scenario which assumed moderate additional emissions controls above and beyond the Base Case, and a scenario which assumed more aggressive additional emissions controls.



FINDINGS

Soil - Sites having B horizon base saturation less than 10 percent were found throughout the western region of the Adirondack Park. This is important because concentrations of inorganic Al in soil solution increase as base saturation decreases, with the increase in dissolved Al being pronounced when the base saturation decreases below about 15 percent in the presence of sulfate or nitrate from acidic deposition. The watersheds draining into an estimated three-fourths of 990 Adirondack lakes having ANC < 200 $\mu\text{eq/L}$ contained average base saturation less than about 10 percent in the B horizon, with 5 percent having base saturation less than about 5 percent. Soil pH values were also very low. Median watershed-average soil pH was 4.3 in the B horizon and 3.5 in the O horizon.

Projections of Acidification and Recovery - Under future emissions and deposition rates estimated to occur in response to Base Case emissions regulations, future decreases in the ANC of most acidic and low-ANC Adirondack lakes were projected. Many lakes were projected to re-acidify rather than continue to recover chemically. Simulations that assumed further emissions reductions beyond the Base Case did not result in reacidification, but rather resulted in a continued chemical recovery as represented by simulated reductions in the numbers of acidic and low-ANC lakes in the future.

Linkages Between Water Chemistry and Aquatic Biota - The empirical relationship between fish species richness and ANC class was developed using ALSC data. Under chronically acidic conditions (annual average ANC less than 0 meq/L), Adirondack lakes are generally fishless. There is a marked increase in mean species richness with increases in ANC to values of 50 to 100 meq/L. Zooplankton taxonomic richness increased with increasing ANC. In general, lakewater ANC explained nearly half of the variation in total zooplankton and crustacean taxonomic richness, but less for large cladoceran and rotifer richness. These results provide the basis for estimating changes in zooplankton richness in response to past or future changes in lakewater ANC.

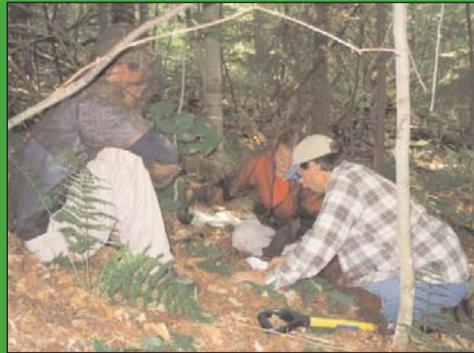
Lake Classification - The regression analysis of MAGIC model projections of future ANC change (1990 to 2100) identified 10 variables that were significant predictors of ANC change. Year 2000 lakewater sulfate, calcium, magnesium, silica, and percent mixed forest in the watershed were important predictor variables. The similar regression for PnET-BGC future ANC change also identified 10 significant variables. Of interest was that the MAGIC regression included current lakewater sulfate concentration as a significant variable whereas the PnET-BGC regression included lakewater nitrate concentration.

Comparison with Data from the 1980s - In order to compare distributions of watershed soil chemistry between this study and those of an EPA regional (northeastern U.S.) soil study in the mid-1980s, subsets of both datasets were constructed to define a common population of lakes and associated watersheds. The data suggest that while lakewater chemistry was improving subsequent to large decreases in acidic deposition, Adirondack soil acid-base chemical conditions may have been continuing to deteriorate in many of the acid-sensitive watersheds. This result was also consistent with the model projections. Such an effect would be expected to restrict the extent to which surface water chemistry might be able to recover from acidification in the future and could potentially contribute to future adverse effects on forest soils and vegetation.

PROJECT IMPLICATIONS

For resource managers and policymakers, it is of vital importance to have information on the extent to which current and future emissions reductions will lead to the chemical and biological recovery of Adirondack ecosystems. Historically, recovery has been quantified at certain intensively monitored sites, but these results cannot be directly extended to the Adirondack region as a whole. This study's findings have helped fill this critical gap by providing a mechanism for extrapolating specific findings from ongoing chemical and biological monitoring and process-level studies to the larger Adirondack region.

The modeling results reported here raise the possibility that Adirondack lakes that are currently recovering from past acidification might reacidify in the near future under emissions controls enacted prior to January 2004. The models predict near-term reacidification of the lowest-ANC lakes because of continued depletion of soil base saturation. Newly enacted emissions controls may affect the probability of future reacidification.



Credit: Tim Sullivan et al.
Research team conducting a soil survey.

Project Status

- Initiated 2003
- Completed 2006



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.