6-2018

Determining the Effectiveness of the Clean Air Act and Amendments for the Recovery of Surface Waters in the Northeastern U.S.

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Determining the Effectiveness of the Clean Air Act and Amendments for the Recovery of Surface Waters in the Northeastern U.S.

Basic Information

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Publications


Final five-year Report to
USGS WRD WRRI, Reston, VA
US EPA, CAMD, Washington DC
and US EPA, ORD, Corvallis OR

May 2018

Determining the effectiveness of the Clean Air Act and Amendments on the recovery of surface waters in the northeastern US

IAG 06HQGR0143

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¹Univ. of New Hampshire, ²Univ. of Maine

Overview of activities during 2013-2018. A schematic summary of progress on the project plan is provided below (Table 1) and discussed on the following pages. We have concluded the final year of five for the most current project agreement, which supports the continuing needs of EPA to assess the effectiveness of the Clean Air Act Amendments of 1990 (CAAA). Field work and data assessment continue on schedule. Project coordination as well as most analytical chemistry is conducted by the University of New Hampshire. Field sampling, some analytical chemistry, data quality assurance, and data reporting are conducted by the University of Maine. Also, one graduate student at the University of Maine was partly funded through this project and also supported by UMaine funds that leveraged this project. Since 2013, there have been seven publications by five graduate students who were partly supported or used LTM data. One research faculty at the University of Maine was partly supported during this project year to develop R code for data QA and analysis, and begin to transition data management to a new secure server. This project year, we contributed data to the LAGOS-NE database and were co-authors on a GigaScience paper that described this “multi-scaled geospatial and temporal database of lake ecological context and water quality for thousands of U.S. lakes” (Soranno et al. 2017). Over the course of this five-year period, we have contributed data to multiple synthesis efforts, including Crossman et al. (2016), Phelan et al. (2016), Lawrence et al. (2015), and current requests by Creed et al. Additionally, this project continues to fund a portion of the base program of stream chemistry monitoring at Bear Brook Watershed in Maine (BBWM), for the reference watershed, East Bear. During this project period, BBWM completed a three-year NSF DEB grant that is evaluating nitrogen dynamics in both watersheds using ^15^N tracer studies. The base funding through this IAG project created continuity that was key in securing the follow-on NSF award (via RAPID, beginning 01/01/2017, which is assessing the response to discontinuation of experimental acidification). 2016 was the final year for annual TIME lake sampling, both in the New England and Adirondack regions. Co-PI Nelson worked with Adirondack Lakes Survey Corporation staff to complete a compendium summarizing status and research regarding the Adirondack TIME lakes (Nelson et al. 2017). On May 16–17 2017, UMaine hosted the Annual LTM Project Partners meeting at Schoodic Institute in Acadia National Park.
Table 1. 2012-2018 Project plan progress to date.

<table>
<thead>
<tr>
<th>Project Activity</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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<td></td>
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<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
<td>Q1</td>
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<td>Q4</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
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<td>Q4</td>
<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
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<td>Q2</td>
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<td>Q1</td>
<td>Q2</td>
<td>Q3</td>
<td>Q4</td>
<td>Q1</td>
<td>Q2</td>
</tr>
</tbody>
</table>

- = project plan, ■ = in progress, □ = completed, ☐ = cancelled (weather)
**Project background**

**Objectives.** This research is part of EPA CAMD programs that are verifying the effectiveness of emission controls at reducing acidification of surface waters. Our approach is to collect long-term high-quality data that characterize the trends and patterns of response in low ionic-strength surface waters. We have specifically targeted waters that have been classified as being sensitive to acidic deposition and will represent lakes across the Northeast in varying landscape settings. The goals and methods are hierarchical, ranging from intensive site-specific investigations to regional assessment of sites that have been chosen to provide a statistically rigorous sample of regional surface waters. The objectives are to:

1) document the changes and patterns in aquatic chemistry for defined sub-populations and sites that are known to be susceptible to acidification or recovery;

2) evaluate the extent to which changes in surface waters, if any, can be linked to changes in deposition that are driven by regulatory actions;

3) characterize the effectiveness of the CAAA in meeting goals of reducing acidification of surface waters and improving biologically-relevant chemistry in the northeastern US;

4) provide information for assessment of the need for future reductions in atmospheric deposition based on the long-term trajectories of the systems under study; and

5) assess the extent to which increased variability in precipitation events will play a role in the long-term sustainability of CAAA success in these sensitive surface waters. This is leveraged through other funded research.

**Approach.** The schedule of tasks ranges from weekly to annual, continuing data records that now range from 23 to 35 years. We evaluate chemistry on a weekly basis year-round at the small watershed-scale at BBWM, quarterly in LTM, and annually during the historical index period for the HELM lakes. TIME lakes were last sampled in 2016; current plans are to re-survey these lakes once during the next five-year project period. These project components provided a statistical framework for inferring regional patterns in chemistry using TIME and LTM (and ELS-II under separate funding). The long-term records of LTM, HELM and BBWM provide information on seasonal and annual variability, and thus provide a seasonal context for the annual surveys.

**Expected Results.** This information is needed for EPA to meet its Congressional mandate to assess the effectiveness of the CAAA. The combination of site-specific data within the regional context provides a rigorous assessment of the effects of declining pollutant emissions on SO₄ concentrations, base cation depletion, and changes in N-saturation or DOC contributions to acid-base status. The results are also central to assessing whether additional emission reductions may be needed to produce recovery.

**Project Status: Water Chemistry**

**Field sampling.** All project field objectives in 2017 were accomplished as planned. A summary of the annual field schedule for this project is provided below (Table 2). Funding cuts resulted in the elimination of sampling of the TIME lakes. HELM sampling is normally done by helicopter
and due to funding the number of sites were cut from 25-30 to 9 for the 2nd year in a row and were done by hiking in via new project partner Julia Daly, UMaine-Farmington. However, a benefit to this new approach for HELM is that Daly has instrumented these lakes with temperature loggers, allowing for new research avenues regarding lake phenology.

Table 2. Annual project field schedule for lake sampling

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<td>RLTM-Maine</td>
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<td>3</td>
<td>UMaine</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td></td>
<td>drainage</td>
<td>10</td>
<td>3</td>
<td>UMaine/UNH</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>LTM lakes</td>
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<td>1</td>
<td>UMaine</td>
<td></td>
<td></td>
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<tr>
<td>HELM</td>
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<td>1</td>
<td>UMaine/UMF</td>
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</table>

**Analytical.** Analyses are complete for all samples collected through 2017. All laboratory analyses for LTM and HELM are conducted at the University of New Hampshire Water Quality Analysis Laboratory (WQAL) except for color and closed cell pH for RLTM samples (conducted at UMaine to meet holding time requirements) and aluminum. Total and organic aluminum samples are processed on an ICP at the USDA Forest Service Region 1 laboratory in Durham, NH. All analyses for RLTM and HELM continue to be conducted by, or under the supervision of, Jody Potter as has been the case since 2012.

Samples from East Bear Brook at BBWM, which are collected on a regular basis year-round, continue to be analyzed at the University of Maine Sawyer Water Research Lab. The LTM color and closed cell pH samples were also analyzed there.

The number of samples collected and processed over the last 5 years is 676, which includes all analytical analyses except the subset of lakes that are being analyzed for DOC quality (n = 400) and dissolved greenhouse gases (n = 221).

**Data reporting.** All data collected through 2016 have been delivered to EPA. The next delivery of data to EPA is expected before August 2018, after evaluation of inter-laboratory comparisons and regular QA analyses by UNH and UMaine, pending receipt of continued funding.

**Presentation of findings.** Several publications and presentations continue to result from this project and are listed at the end of this report. This project year, leveraged funding supported most of one M.S. thesis nearing completion (A. Gavin) and a Ph.D. dissertation nearing completion (K. Patel) at UMaine under the supervision of co-PI Nelson and BBWM PI Fernandez, respectively; results of those projects are now published (Gavin et al. 2018) or in review (Patel et al. 2018a, 2018b).
New developments. During the past five years we were able to make routine two new sets of analyses to continue to extract new and innovative information from these study sites. A subset of lakes were analyzed for DOC quality using SUVA and fluorescence (EEMS) analysis, and tested methods for measurement of dissolved greenhouse gases (CH₄, CO₂, and N₂O) in surface waters. Moving forward, these data will provide valuable insight into changes in organic sources to acid-base status as well as the influence of precipitation event variability on long-term changes in surface water chemistry. Graduate student Amanda Gavin (UMaine) instrumented a subset of LTM and HELM lakes with Hobo Temperature Loggers to support her research regarding how changing DOC concentrations could affect coldwater refugia for fish. Results of this investigation are currently in preparation for submission as a journal article and final M.S. thesis chapter, to be completed August 2018. Temperature loggers were re-deployed in several lakes to continue this investigation with funding that will begin in summer 2018.

Publications using related project information (2017-2018 publications in bold):


Dissertations/theses:


* Not directly funded by this project but uses Bear Brook data and an LTM co-PI is on committee

Presentations using related project information (recent presentations in bold):

Gavin, A., 2018. Physical & chemical response of small, north temperate lakes to recovery from acidification & climate change. University of Maine College of Natural Sciences, Forestry, and Agriculture Graduate Student Awards Competition, March 9, 2018. Award-winning presentation; George F. Dow Graduate Scholarship.


Carbon (DOC) and Water Clarity in Maine’s Lakes. First Annual Lake Monitoring Summit, Feb. 15, 2017. Augusta, ME.


Strock, K.E., Saros, J.E., Nelson, S.J. & S. Birkel. 2014. Interactive effects of extreme weather and reduced sulfate deposition: accelerated recovery from acidification and increased


Kahl, J.S., 2005 (invited). The intersection of environmental science and environmental policy. NH Charitable Foundation Lakes Region annual meeting, Meredith, NH, September, 2005.


Kahl, J.S., and Catherine Rosfjord, 2005 (invited). Acid rain and the Clean Air Act in the northeastern US. Annual meeting of the NH-ME Androscoggin River Watershed Council, Bethel, June, 2005


Kahl, J.S., 2004 (invited). The Clean Air Act Amendments of 1990; testing a program designed to evaluate environmental policy. Lecture, Colby College. April, 2004


Recent Bear Brook publications and presentations that include “base program” data (East Bear Brook stream chemistry partly funded through this grant):


MacRae, J.D., C. Tatariw, D. Rothenheber, S. Nelson, I.J. Fernandez. The effects of nitrogen enrichment on forest soil microbial communities and their activities, 2013 AEESP 50th Anniversary Conference, July 14-16, Golden, CO.


Minocha, Rakesh, Swathi A. Turlapati, Stephanie Long, Mohammad M. Bataineh, Aaron Weiskittel, Ivan Fernandez, and Lindsey Rustad. 2013. Chronic N and S additions impact foliar physiology of forest trees at the Bear Brook Watershed in Maine, USA. Hubbard Brook Experimental Forest Annual Meeting, Thornton, NH.


