ANNUAL REPORT: JULY – OCTOBER 2002 (YEAR 1, QUARTER 3)

Title: Correlating predictive contaminant deposition maps with streamwater chemistry at Acadia National Park

Project Period: July 1, 2002 – June 30, 2005

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Collaborators: Kathleen C. Weathers, Institute of Ecosystem Studies, Millbrook, NY

Location of Research: Acadia National Park, Maine

OVERVIEW

We will develop a predictive park-scale contaminant deposition map for Acadia National Park using empirically determined landscape-input relationships. This model is a collaborative extension of current PRIMENet research by Kahl and co-workers at the *watershed-scale* for numerous atmospheric constituents, and Weathers and co-workers at the *park-scale* for sulfur and nitrogen. The integration of the two spatial scales, combined with measured deposition data, is designed to yield a predictive tool to allow managers to identify areas of the park that are most vulnerable to such environmental problems as acidification, forest nitrogen saturation, or toxic mercury bioaccumulation. The scope of work includes continued monitoring of the PRIMENet gauged watersheds and streamwater spatial surveys to verify the performance of the model.

OBJECTIVES

The next logical step in our collaborative research program is to compare the data collected at different spatial scales to see how a general model of contaminant deposition, appropriate for both landscape and watershed scales, can be created. This information will be compared to stream chemistry that integrates the processes occurring in watersheds. Our goal is to move towards the development of a model based on throughfall deposition that can predict inputs to the watershed using stream export as a primary and integrated correlate to compare inputs and outputs. While we do not propose to investigate mechanisms of processing and transport through the terrestrial ecosystem through this funding, the model and its implementation in conjunction with streamwater chemistry, would determine where there are direct or indirect linkages between throughfall deposition and export for some substances.

The main objectives are twofold: *develop a deposition model* to provide park management with predictions for the regions and watersheds at greatest risk from high loading of specific contaminants, and thus at risk from ecological effects such as acidification, forest nitrogen saturation, or mercury bioaccumulation, and *compare the model results* to streamwater chemistry surveys. To realize this objective, we propose to:

1) *Compare and contrast the Weathers et al. park-scale deposition map for sulfur and nitrogen deposition to our intensive small watershed throughfall network data.*

Specifically, the Kahl *et al*. research was conducted in two watersheds, but with very fine temporal and spatial resolution in terms of throughfall and streamwater sampling. The Weathers *et al*. research was conducted on an area with larger extent, the whole Park, but also at coarser resolution, sampling less frequently and at sites much farther apart. Using a nested design, we can improve model predictions across the larger scale, and we can make predictions across scales correlations with variables common to each spatial approach utilized to date.

2) *Scale this refined and merged GIS model to the entire Park for all 17 PRIMENet analytes, including mercury*. Research conducted at Acadia during 1999 and 2000 showed that mercury (Hg) deposition is related to specific landscape factors in the small watersheds (Johnson, 2002). Mercury deposition for the pair of PRIMENet study watersheds (Cadillac and Hadlock Brook) varied according to aspect and vegetation. Mercury deposition was the highest for sites with a southwest aspect and lowest for sites facing southeast. The order of decreasing mercury deposition by site aspect was SW> W>S=E>SE. Mercury deposition was higher under softwoods (conifers) than under hardwoods (broadleaf). Hadlock Brook watershed faces southwest and vegetation is dominated by softwoods. This combination of factors led to higher mercury deposition than in Cadillac Brook watershed, which faces southeast to east with hardwood vegetation and areas of exposed bedrock. Landscape factors found in the earlier work to enhance deposition of mercury would be further investigated in the project proposed here. Sites that were not vegetated received the lowest wet deposition of mercury of any of the sites.

3) Use a field season of stream chemistry to compare watersheds predicted to have low deposition loading with watersheds predicted to have high deposition loading.
After developing maps of deposition and throughfall fluxes, we propose to determine whether there is any relationship between patterns of atmospheric deposition and surface water chemistry. This research will build a model (or models) on the assumption that there is a direct and detectable linkage between rates of deposition and surface water chemistry. By examining the strength of the relationship, we will look for connections between atmospheric fluxes and streamwater chemistry, and define sites at Acadia where subsequent studies of mechanistic linkages should be focused. The proposed work would provide an inventory of both total deposition to the Park and streamwater chemistry across the Park, at once integrating the past research efforts of Kahl and Weathers and helping to identify future research needs for the Park.

4) Continue the PRIMENet intensive watershed monitoring for stream chemistry and flow to quantify ecosystem elemental mass balances.
Continued monitoring at the paired watershed sites will allow Park resource managers to evaluate the influence of atmospheric deposition on Park resources. In particular, the continuous monitoring of mercury at the paired watersheds is a powerful framework for Park management and research initiatives. Because of its ecological sensitivity and relatively high levels of atmospheric deposition, Acadia has become a locus for mercury research, and the paired watershed streams will provide the necessary baseline by which to determine the effects of emissions increases or reductions over time.

YEAR 1, QUARTER 3 SUMMARY

This first project period has served as a time for planning and for continued calibrated watershed monitoring. Graduate student Katherine Sheehan has been recruited to work on this research project. Sheehan has a strong geochemistry background and has significant field experience. Sheehan proposes to investigate the contribution of litterfall to the mercury budget for each of the two gauged watersheds (Appendix A).

EQUIPMENT INSTALLATION AND FIELD SAMPLING

- Katherine Sheehan and Sarah Nelson updated sampling permits with David Manski of the National Park Service. The current permit allows streamwater and litterfall sampling for the remainder of calendar year 2002.

- Eight streamwater samples were collected in the gauged watersheds in the first quarter of FY 2003. The relatively small number of samples collected reflects the severe drought that occurred in the region this summer.

- Kenneth Johnson has established and coordinated a photographic record of the two stream gages, as a resource for USGS and UMaine scientists for comparison of numeric flow data to actual conditions, and to identify possible changes in the stream channel, ice conditions, or debris conditions. A digital camera is available for this purpose, and photos are taken at each sampling outing, so there is no additional cost in acquiring the photographic data.

- Kenneth Johnson and Sarah Nelson re-deployed ISCO automated samplers on July 17, 2002 at each stream gauging station. ISCOs had been removed from the field for repairs and new batteries were purchased and deployed.

YEAR 1, QUARTER 3 SAMPLE REPORT

- Sarah Nelson has compiled and performed quality assurance checks on water year 2001 streamwater chemistry data for the two gauged streams, Cadillac Brook and Hadlock Brook, received from the laboratory in June of 2001. Research assistant Ken Johnson performed quality assurance checks of total mercury data for streamwater samples and added mercury data to the database. The USGS in Augusta, Maine delivered daily and hourly discharge data for the two streams for water year 2001 during the summer of 2002. Chemical fluxes will be calculated once the hourly instantaneous data are adjusted to reflect estimated flow values on days in which ice or damage caused erroneous measurements.

- Sarah Nelson received major ion chemistry data from UMaine's Environmental Chemistry Lab in September of 2002 for 175 throughfall solutions collected during 2001, funded by ongoing support from the USGS-BRD. These data are currently being evaluated for quality assurance checks and fluxes will be calculated when laboratory results pass the required QA protocol.

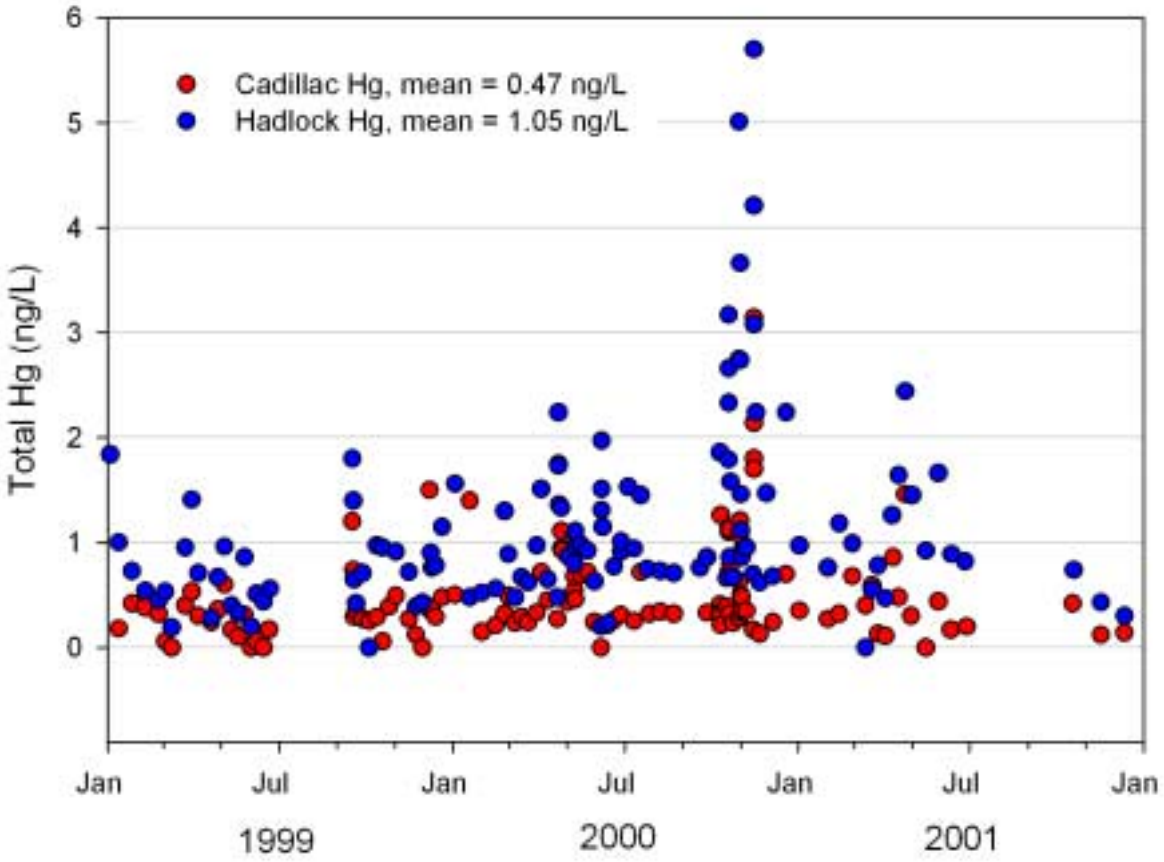

Figure 1. Mercury concentration in streamwater in the paired Acadia watersheds. In 2001 as in prior project years, total Hg was consistently lower in Cadillac Brook than in Hadlock Brook streamwater. Values of zero indicate values less than the laboratory method detection limit.

PROJECT PLANNING AND MEETINGS

- Steve Kahl, Ivan Fernandez, Sarah Nelson, Kenneth Johnson, Katherine Sheehan, and mercury researcher Aria Amirbahman met at UMaine on October 7, 2002 to discuss project objectives, timeline, and budgeting, in the first of a series of quarterly project meetings for the UMaine research team. The major foci of the meeting were the following:
  1. An outline of project objectives and timeline.
  2. Discussion of timing of throughfall and streamwater surveys as related to model verification.
  3. Identification of issues to be discussed with Weathers regarding model integration.
  4. Discussion of limitations, including the need for more travel funding in the absence of USGS vehicle used in the past.
  5. Discussion of M.S. research focus for Katherine Sheehan. Sheehan outlined three central questions regarding mercury fluxes in the two watersheds: 1) what is the contribution of litterfall on a year-round basis? 2) What is the flux of Hg to streamwater from the actual

physical transport of leaves to each stream? and 3) How is Hg partitioned (stems, leaves, etc.) in litter? Her research will focus on the first two questions, by determining the mass balance of Hg in litter both as a watershed outflux in streamwater and defining the Hg content of litter that moves from the canopy to the watershed soils.

- Sarah Nelson contacted NPS Resource Management personnel to begin assembling the Park Surface waters database. In 2002, Kahl sent chemistry data from a number of lakes sampled by Mitchell Center staff since the 1980s to NPS-Acadia data manager Bill Gawley. Sarah Nelson and Bill Gawley have discussed integrating the existing park Lakes database with streamwater chemistry data collected by the Mitchell Center, UMaine researchers, and other research teams.

PRESENTATIONS AND ABSTRACTS BASED ON THIS RESEARCH

- Sarah Nelson and Kenneth Johnson were interviewed in the field in July of 2002 by Naomi Schalit, science reporter for Maine Public Radio (MPR), as part of a series on research in Acadia. A seven-minute segment on the watershed research project was aired on MPR in late July.

Related presentations occurring before the project start date of July 1 included:

- Sarah Nelson, Kenneth Johnson, and Bill Gawley (NPS) presented a public seminar in June of 2002 as part of the Resource Acadia program, designed to educate residents of Mount Desert Island about research and resource issues that affect the park. The Saturday seminar included a field visit to Hadlock Brook Watershed as well as a short lecture series at Resource Management headquarters.

- Presentation of PRIMENet and NRPP research at Acadia in a regional context, highlighting the objectives of the NRPP project, at the NERAQC meeting at Hubbard Brook Experimental Forest, West Thornton, NH, in June of 2002.

- Presentation of a poster highlighting pilot modeling work done by Sarah Nelson at both the UMaine Graduate Research Expo and the Maine Water Conference in April and May of 2002, respectively.

YEAR 1, QUARTER 3 PROGRESS REPORT AND PROJECT TIMELINE

Calendar Year	2001		2002				2003				2004				2005	
Project Activity	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**
Funding Status																
Paired Watershed Stream Sampling																
Stream Gauging																
Sample Analyses																
Annual Watershed Mass Balances																
Litter Hg Fluxes *(Sheehan, M.S.)*																
Throughfall Collection																
Equipment Installation																
GIS Mapping																
Modelling																
Deposition Maps of Park																
Chemistry Database Synthesis																
Surface Water Survey																
Progress Report																

PRIMENet Funding Project Plan

Completed In Progress

Figure 2. Year 2002, Quarter 3 project progress and schedule.

Appendix A:

Proposed Litterfall Research:

Correlating predictive contaminant deposition maps with streamwater chemistry at Acadia National Park

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Recent research by Nelson (2002) and Johnson (2002) has identified factors controlling the deposition and cycling of ions considered to have adverse ecological effects on the ecosystems of Acadia National Park, by monitoring two watersheds within the park. Specifically, litterfall has been identified as a large transport vector of mercury to the forest floor. New research funded by the National Park Service Natural Resource Challenge-NRPP focuses on following up the research findings by creating a model to be used as a predictive tool to identify watersheds that have high deposition of atmospheric pollutants within Acadia National Park. As a graduate assistant involved in the NRPP project I propose to calculate mercury in litterfall by collecting over the entire year. By collecting and analyzing the mercury content of litterfall I hope to quantify this flux, further refining the model. This information will add to the database previously established through EPA's PRIMENet (Park Research and Intensive Monitoring of Ecosystems Network) project.

Sampling of litterfall will involve the placement of up to forty collectors, 43.8 cm x 33.6 cm x 12.7 cm deep polyethylene bus tubs, throughout each of the two watersheds, Hadlock Brook and Cadillac Brook. The collectors will be placed at previously established soil plots, where Johnson (2002) collected litterfall samples, and along previously established throughfall transects (Nelson, 2002), for comparative purposes. The collectors have drilled holes in the bottom to allow for drainage and limiting the sampling to twigs and leaf/needle litter. Litter will be collected once a month. The litter will then be analyzed for total mercury at the Environmental Chemistry Lab at the University of Maine.