8-10-2000

Does Elevated Nitrogen and Sulfur Deposition Lead to Net Base Cation Losses in Northern New England Forest Soils?

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Final Report for Period: 08/1997 - 03/2000 **Submitted on:** 08/10/2000

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Organization: University of Maine

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Project Participants

Senior Personnel

Name: Fernandez, Ivan
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Norton, Stephen
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Kahl, Jeffrey
Worked for more than 160 Hours: Yes
Contribution to Project:

Name: Rustad, Lindsey
Worked for more than 160 Hours: Yes
Contribution to Project:

Post-doc

Graduate Student

Name: Evans, Jennifer
Worked for more than 160 Hours: Yes
Contribution to Project:
A graduate student who assisted in the soil sampling effort and included a portion of the data from this project in her thesis which also included other watersheds in Maine.

Name: Pellerin, Brian
Worked for more than 160 Hours: Yes
Contribution to Project:
This person was a graduate student who assisted in the field sampling and then developed his own thesis project off of other non-NSF funding that expanded on the question of cation dynamics in the watershed.

Undergraduate Student

Name: Haines, Beth
Worked for more than 160 Hours: Yes
Contribution to Project:
Laboratory staff.

Name: Morris, Laura
Worked for more than 160 Hours: Yes
Contribution to Project:
Laboratory staff.

Name: Tisdale, Jessica
Worked for more than 160 Hours: Yes
Contribution to Project:

Laboratory staff.

Name: Shaw, Geoffrey
Worked for more than 160 Hours: Yes
Contribution to Project:
Laboratory staff.

Name: Martin, Scott
Worked for more than 160 Hours: Yes
Contribution to Project:
Field crew member.

Name: Hill, Randy
Worked for more than 160 Hours: Yes
Contribution to Project:
Field crew member.

Name: Sargent-Michaud, Jessica
Worked for more than 160 Hours: Yes
Contribution to Project:
Field crew member.

Name: Ware, Kristen
Worked for more than 160 Hours: Yes
Contribution to Project:
Field crew member.

Organizational Partners

Maine Agric. and Forestry Exp. Station

US Geological Survey
USGS provides support through their hydrological monitoring station at the experimental watersheds.

Water Research Institute (U of Maine)
The Water Research Institute at the University of Maine houses analytical facilities and programs central to this project. The WRI administers the Maine USGS water research program and countless contracts dealing with surface waters and environmental quality.

Other Collaborators or Contacts

The Bear Brook Watershed in Maine is a site used by a number of researchers with a long history of study. Some of the findings from this project will be supportive for work done by other researchers at the University of Maine as well as other instutions such as the Woods Hole Oceanographic Institute ecosystem group, the US Geological Survey, University of Virginia, and the US Forest Service to name a few.

Activities and Findings

Project Activities and Findings:
This contract supported research to determine the base cation composition of soils supporting West Bear and East Bear watersheds at the Bear Brook Watershed in Maine (BBWM). West Bear watershed has been treated bimonthly with N and S since the fall of 1989. This contract supported intensive soil sampling of 40 quantitative soil pedons and 40 mini-pedons across the two watersheds to determine potential differences due to the history of treatment.

The project included technicians, graduate students and undergraduate students who carried out this extensive sampling campaign and soil chemical analyses back at our laboratories. Resources to support the overall soil sampling were a combination of this contract and others. This contract was specifically focused on completing the soil cation analyses associated with this sampling.

Several graduate student theses were completed during this contract and presentations given that are reflected in the published abstracts. Manuscripts from these theses are in preparation. Output from the overall study will include several manuscripts by the principal investigators detailing the contrasts between watersheds in soil cation composition. There are currently in preparation. In addition, the soil data base developed for BBWM will be available to the numerous other scientists who utilize this site for their research.

Project Training and Development:
Data sets on soil physical properties and cation chemistry are assembled and interpretation and manuscript development is currently underway. The primary objectives of the contract were to determine if there was evidence of base cation decline in these forest soils that had been subjected to 8 years of experimentally elevated N and S deposition. In light of the concerns for base cation depletion in the northeastern U.S., our goals were to take advantage of a whole-ecosystem manipulation to see if base cation declines would be evident under those conditions, and would shed light on the ambient processes occurring in the region.

Focusing on Ca as the most critical of the base cations, our preliminary findings suggest that exchangeable soil Ca pools were reduced by chronic elevated N and S deposition. The levels of elevated N and S deposition were 1800 eq/ha above ambient, not unreasonable compared to more heavily polluted regions in the eastern U.S. and Europe. These preliminary results appear to lend support to the idea that base cation declines are plausible, and bracket one end of the spectrum for the degree of change expected in this type of soil and forest type. An abstract for an upcoming scientific meeting in the fall of 2000 states the following.

The Bear Brook Watershed in Maine (BBWM) is a long-term, whole-ecosystem chemical manipulation experiment. Treatments consist of bimonthly aerial applications of (NH4)2SO4 resulting in a ~4X loading above ambient of N and S, respectively in 2000. The site consists of two adjacent ~10ha forested stream watersheds with contrasts of spruce and hardwood forest types. Soils were sampled in 1998 after 8 years of treatment. Stream chemistry over the period indicated an increase and then decline in Ca export over time suggesting increased export and then depletion of soil reserves. Elevated export of Ca in the treated watershed over the time period studied was of comparable pool size to soil exchangeable Ca pools. Quantitative soil pit excavations and analyses indicated that the treated watershed soils had ~65 to 80% of the exchangeable Ca pool compared to the reference watershed. Although stream chemistry suggested that the relative declines in watershed labile Mg might be greater than Ca, soil data do not show this to be true. Red spruce stands showed much larger differences in soil Ca pools compared to northern hardwoods between treated and reference watersheds. Differences in soil exchangeable Ca were evident throughout the pedon with O horizons and lower mineral soils showing the largest differences.

Research Training:
As mentioned, two graduate students were partly supported by this research and were involved in all aspects of the project from field collections of soils to laboratory analysis. They were also involved directly with data generated in support of their own thesis projects, and in writing the theses and manuscripts for publication based upon their work.

A series of undergraduate students worked both in the field and laboratory as student workers under this contract. The mostly were majors in natural resources, forestry, and geology. They learned about forest soils, how watersheds work, sampling protocols and concerns for quality control, laboratory methodology and good laboratory practices, and the importance of their individual tasks to the overall project and team effort.

The technicians who worked on this project continued to expand their expertise in forest soils through this experience, and gained significant experience in managing student workers as a team.

Outreach Activities:
The Bear Brook Watershed in Maine project is periodically the subject of public tours, classes, and media coverage. As part of this exposure, the key findings of the project and their relevance to public policy are regularly highlighted and discussed. In addition, the BBWM site is on private industry land and all of our findings and their implications are regularly conveyed to the company and other land companies through dissemination of publications, meetings, and individual discussions. The University Public Affairs division will likely develop a press release on the findings of this contract once the data interpretation work is completed in the coming year.

Journal Publications

Books or Other One-time Publications

Brian A. Pellerin, "Inferences from Soil Chemical Properties on Linkages Between Soil and Surface Water in Maine Forested Watersheds

", (2000). *Thesis*, Published
Bibliography: University of Maine MS Thesis

Jennifer L. Evans, "Forest Soil C and N in Watersheds Influenced by Wildfire, Harvesting, and N Enrichment", (2000). *Thesis*, Published
Bibliography: University of Maine MS Thesis

Web/Internet Sites

URL(s):
http://www.umaine.edu/DrSoils/bbwm/bbwm.html
Description:
This site is a personal site for the lead PI"s program at the University of Maine. As the results of this project are developed they will be used to update this site with findings from this project.

Other Specific Products

Product Type: Physical collection (samples, etc.)
Product Description:
As a result of this contract we have a complete archived collection of soil samples from all soil pedons excavated by the sampled soil horizon or increment. These may be used for long-term research and in support of other research initiatives that can rely on the newly developed soil data base.

Sharing Information:
The data from the soils analyses will be made available through scientific publications and summary worksheets. On a case by case basis we will work with researchers to meet their soil sampling needs that compliments the overall BBWM program.

Contributions

Contributions within Discipline:
The findings from this research have contributed to our understanding of the importance of the soil component in forested watershed ecosystems. Using quantitative soil sampling we are able to obtain unusually precise estimates of soil fine earth (where most of the chemically reactive materials are stored), coarse fragments, coarse roots and pore space. We can utilize this information to better calculate the total amount of soil and chemical constituents within a watershed. While this is not the only example of this approach, it is one of the few that have been used in this soil and forest type, and represent only a handful of experimental watersheds in the world to be able to use these techniques in the context of whole watershed manipulations.

Our findings allow us to build a better chemical budget for the watersheds to know how and if the pool of cations in the soils differ or have changed. Our findings help define the ability of the watershed to store water and chemical constituents and the spatial variability of some of the key soil physical and chemical properties as they occurred within this watershed. This information is of use to those in ecosystem sciences, hydrology, earth science, water science and forestry.

Contributions to Other Disciplines:
As suggested above, the quantitative data on soil physical and chemical properties from this project provide for a greater degree of precision in estimating the importance of soils in forested watershed ecosystems than is often found in the literature. This is of interest to those in hydrology, watershed science, and forestry as they rely on others to provide information on soil properties in the systems in which we all work.
Contributions to Human Resource Development:
This project provided the opportunity for numerous undergraduate and graduate students, technicians and senior scientists such as faculty to be involved in the research. Clear examples of contributions to the science would include the experiences in field and laboratory research experienced by the undergraduate and graduate students on this project. Most felt they benefited by the experience and it contributed to their understanding of classroom learning and career development objectives. They also better understood the complexities and realities of doing research in the field, and the related sample processing, handling and analyses. Of the students, 7 of the 11 involved in this project directly were women which helped to promote the involvement of women in soil and related sciences.
Contributions to Science and Technology Infrastructure:
No new instrumentation was purchased under this contract. However, the Bear Brook Watershed in Maine is used in a wide array of research and teaching contexts. We hope for even more so in the future. This contract was part of the first thorough investigation of soil properties on this experimental watershed. As such, a critical data set now exists for use by other researchers, and for insight in describing the components and function of the watershed.

Beyond Science and Engineering:
This intensive soil investigation of commercially owned a commercially owned forested watershed in Maine will potentially contribute to the debate and public policy decisions on (a) the long-range transport of air pollution in the northeastern U.S., (b) the potential effects of forestry practices on forest sustainability and nutrient depletion, (c) the function of near-stream or riparian zones in small stream catchments of northern forest lands, and (d) the potential for regional declines in base cations from land use, climate change, or other factors. The forest products industry, environmental groups, and state governments are keenly interested in the character of the forest resource and how we manage it. These data clearly contribute to those debates.

Categories for which nothing is reported:

Any Journal