Report as of FY2004 for 2004ME31B: "Nutrient cycling within the Meduxnekeag River and the use of periphytic algae as an indicator of nutrient loading "

Publications

- Dissertations:
  - Fretwell, E., 2006. The Temporal and Spatial Relationship Between Phosphorus and Nitrogen Concentrations, Algal Growth, and Nutrient Sources in the Meduxnekeag River Watershed. M.S. Thesis. University of Maine.
- Other Publications:
  - Fretwell, L., D.B. Dail, K.E. Webster, and S.H. Brawley. The relationship between phosphorus and nitrogen concentrations, algal growth, and land use in the Meduxnekeag River watershed. Poster presented at the 2005 Graduate Student Research Exposition, April 11-12, 2005. Orono, Maine.
  - Fretwell, L., D.B. Dail, K.E. Webster, and S.H. Brawley. The relationship between phosphorus and nitrogen concentrations, algal growth, and land use in the Meduxnekeag River watershed. Poster presented at the 2005 Maine Water Conference, March 22, 2005. Augusta, Maine.
  - Fretwell, L., D.B. Dail, K.E. Webster, J.S. Kahl, S.H. Brawley, and L. Wilson. Periphytic algae as an indicator of nutrient loading to the Meduxnekeag River. Poster presented at the 2004 Maine Water Conference, April 21, 2004. Augusta, Maine.
  - Fretwell, L., D.B. Dail, K.E. Webster, J.S. Kahl, S.H. Brawley, and L. Wilson. Periphytic algae as an indicator of nutrient loading to the Meduxnekeag River. Poster presented at the 2004 Graduate Student Research Exposition, April 12-13, 2004. Orono, Maine.

Report Follows

j) **Statement of critical regional or state water problem:**

Although environmental regulations have drastically reduced point source pollution, non-point source pollution remains a leading cause of water quality problems nationwide. State inventories indicate that agriculture impacts 48 percent of impaired rivers and streams (EPA, 2002). One of the major constituents of non-point source pollution is sediment, which is transported from agricultural and urban areas and carries heavy metals, pesticides, oils, and nutrients. High nutrient concentrations are a leading cause of impairment and eutrophication, a symptom of which is oxygen-depleting algal blooms.

The algal blooms in the Meduxnekeag River depress dissolved oxygen (DO) levels and alter the habitat of fish and other biota. Throughout the state, rivers are being altered to such an extent that they are losing native fish populations. Tribal members have observed non-native fish (bass, sucker, pickerel) becoming dominant while native trout numbers are declining (Ellis, pers. comm. 2003). The Maine State Planning Office's River Study lists the Meduxnekeag River as having natural and recreational values of statewide significance. However, the algal blooms and resulting low DO levels are threatening this status. A 6-mile segment of the river downstream of Houlton is listed on the state's 303d and 305b list for non-attainment of water quality standards because of high nutrient loads and low DO levels.

Although its presence on the impaired list legally requires corrective measures to be taken, so little is known about nutrient sources and cycling in the Meduxnekeag River that the any solution would be speculative at this point in time. Moreover, an evaluation of the Meduxnekeag River eutrophication, which is rare for Maine, will be useful for our understanding of processes statewide, because of increasing pressures on many Maine waters. Also, since the project will quantify the relative inputs from point and non-point sources, our research will be applicable to other areas with non-quantified point and non-point sources of nutrient enrichment.

Several states are battling eutrophication problems that became widespread before they were well understood, forcing a reactive approach; Maine, on the other hand, has an opportunity to be proactive and address the issue while it is still relatively small scale. We can gain an understanding of nutrient cycling in the river and use that knowledge to drive a restoration plan that will be a model for other areas of the state and beyond.

k) **Statement of results and benefits:**

This research will fill the gaps in the existing data and provide a portrait of nutrient loading and cycling within the river. It will also explore the use of periphytic algae as an indicator of nutrient loading. By linking temporal and spatial algal bloom data with the nutrient dynamics of the water column and sediment, the research can be used to target and further investigate problematic areas (i.e. major nutrient contributors) in the watershed. We will explore the possibility that isotope abundance of N in source waters and PS and NPS pollutants can corroborate stream chemistry in explaining algal production patterns.

Not only will the project serve as a model that can be applied to other rivers with nutrient enrichment problems, it can be used to help shape land use management within the Meduxnekeag watershed. HBMI was awarded a Watershed Initiative Grant during summer 2003 to improve water quality in the watershed, and a large portion of the grant is appropriated to working with farmers to decrease erosion and non-point source pollution resulting from agriculture. Our proposed research complements that grant by indicating relative input contributions and identifying problem areas that need extra attention. This research is the essential first step in a process that could restore the aesthetic and recreational value of the river, remove the river from the state's impaired list, and reduce dangerous DO levels currently threatening the river's biota.

3) **Introduction and objectives:**

Algal blooms in the Meduxnekeag are mostly periphytic and peak in mid-summer (Fig 1). The filamentous algae washes downstream during high flow events but quickly re-establishes and forms a dense green carpet along the shallow river bottom (Ellis, pers. comm. 2003). The Meduxnekeag River watershed is the most intensively farmed watershed in southern Aroostook County, but the segment affected by algae blooms also flows through downtown Houlton and receives discharges from the Houlton Wastewater Treatment Plant (WWTP) and AE Staley Manufacturing Co. (a starch plant). The Meduxnekeag is generally considered a Class B river (i.e. good water quality) but has had non-attainment problems in regards to DO and excess nutrients. The 2000 TMDL study cited the algae blooms as a direct cause of depressed DO levels.

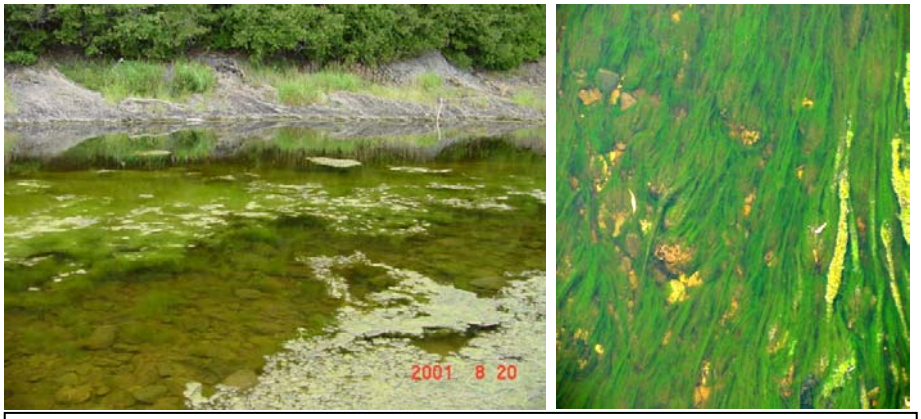


Fig. 1. Algal blooms in the Meduxnekeag River.

Although "hot spots" (i.e. areas where dense algae mats consistently form) exist in several locations, including downstream of the WWTP and of AE Staley's, algae blooms are also present *upstream* of these discharge points. Thus, both point and non-point sources are contributing excess nutrient loads in the river. The TMDL study noted large contributions from agricultural sources, but it did not quantify agricultural inputs or relate the relative contributions of point and non-point sources. While there is a substantial amount of baseline data for the river, several questions remain:

- Can the algal blooms be used as an indicator of nutrient loading within the watershed?
- How does algal biomass vary spatially and temporally?
- How do nutrient levels fluctuate seasonally within the sediment and water column, and how do those levels correlate to algal growth and its degree of nutrient limitation?
- What are the relative input contributions from point and non-point sources?

The purpose of this study is to determine how nutrients cycle through the Meduxnekeag River and how that cycling relates to land uses within the watershed and the seasonal occurrence of algal blooms. This will be achieved by completing the following objectives:

- Link historical water column monitoring data with other pertinent research, and then determine gaps in the data to design an appropriate sampling plan
- Map the spatial and temporal occurrences of algae within the affected 20-mile segment of the Meduxnekeag River and determine variations in algal biomass
- Quantify seasonal changes of nitrogen and phosphorus in the sediment and water column
- Seasonally analyze nutrient limitation, including shifts in the degree of limitation
- Utilize land use maps, algal occurrence and biomass, and nutrient data from sediments and the water column to quantify the relative nutrient contributions of point and non-point sources
- Establish the relationship between nutrient inputs and algal distribution so algae can be used as an indicator of nutrient loading

Project Timeline

Fall/Winter 2003-2004	Spring/Summer 2004	Fall/Winter 2004-2005	Spring/Summer 2005	Fall 2005
-Utilize current funding to compile existing data and conduct gap analysis -Devise sampling plan/ Quality Assurance Plan	-Begin sampling -Evaluate sampling plan after Spring and modify as necessary	-Continue sampling -Analyze trends and relationships	-Continue sampling -Analyze trends and relationships -Present results to HBMI and the Maine Water Conference	-Finalize analysis -Write thesis -Write peer-reviewed journal article -Submit report to HBMI

4) **Impact of project:**

Since the Meduxnekeag is currently one of only a few major rivers in Maine with abundant algal blooms, this is a unique opportunity to gain an understanding of factors contributing to the bloom and develop a model for assessing other nutrient enriched rivers. This project seeks to explain nutrient dynamics in the sediment and water column of the river as well as the life cycle of the blooms, and it will quantify sites of nutrient loading and relative importance of point and non-point sources within the watershed. This project will serve as a foundation for future research into problem areas of the St. Johns watershed, which could in turn lead to a remediation plan that would improve DO levels and remove the river from the state's non-attainment list. Additionally, the project will serve as a guide for studying and managing other rivers with algae blooms and could help shape land use planning to prevent algae blooms in other areas of the state.

5) **Methods, procedures, and facilities available:**

The watershed will be divided into three zones as shown in the conceptual model below. Zone 1 will extend from the headwaters at Meduxnekeag Lake to just upstream of AE Staley's (a starch plant) and contains predominantly agricultural land. Zone 2 contains AE Staley's, the confluence with the South Branch of the Meduxnekeag River, and downtown Houlton. Zone 3 contains the WWTP and HBMI tribal lands.

The first step will be to compile and analyze existing data, determine gaps in the data, and devise a detailed sampling plan. After reviewing existing data (including historical "hotspots") and land use maps, two to three sampling sites will be selected in each zone. Sampling will begin in spring 2004 and continue through summer 2005. Water samples and DO measurements will be collected at each site once during the day and at night (to capture diurnal fluctuations) on a monthly or bi-monthly basis. A river segment at each site will be divided into a grid and algal biomass samples will be collected from randomly selected grid points on a monthly basis. Algal samples will be tested seasonally (4 to 6 times per year) via an in-situ method or in the lab for possible phosphorus limitation using (a) alkaline phosphatase activity assay and (b) P content. Multiple water column sediment collectors will be placed at each site and sediment will be retrieved on a monthly or bi-monthly basis. We will make equilibrium P concentration measurements to assess the extent to which sediment P is a source or sink of P to the water column. In addition, we will use oxalate extractable Al, Fe and P to determine P saturation of the sediment. Sediment samples will be analyzed for TP, TN, and sediment oxygen demand (SOD). Algal blooms will be visually assessed and quantified seasonally for all three zones. This additional parameter will provide a temporal and spatial understanding of the algal blooms and will help us determine the necessity for additional sites and allow us to complete the link between nutrient levels and algae so the blooms can be used an indicator of nutrient inputs.

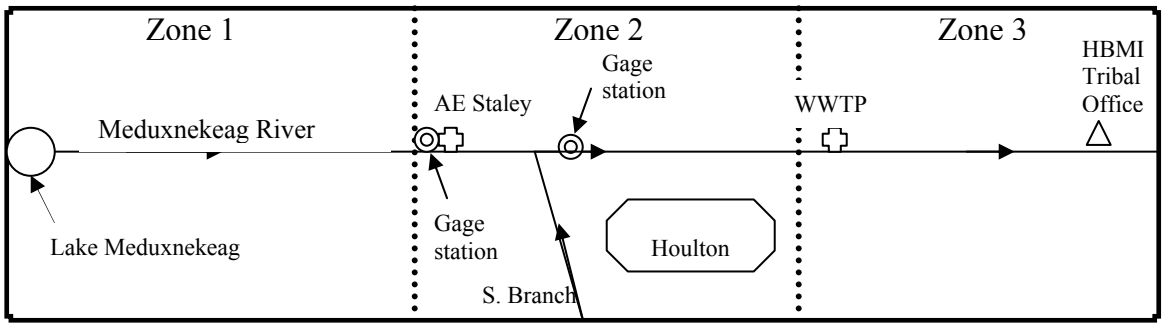
USGS will provide real-time flow data and a stage discharge curve from its two gaging stations in the river. During water sampling, temperature and DO measurements will be taken with a YSI meter. After collection, water samples will be analyzed for pH, total phosphorus (TP), soluble reactive phosphorus (SRP), total nitrogen (TN), nitrate (NO_3), ammonium (NH_4), and major cations (including Ca, Mg, and K). Algal biomass will be quantified ash free dry weight of the algal samples. We may compare these

biomass data with Chlorophyll a method and plan to compare with those data gathered by the USGS in their remote sensing campaign slated for spring, 2004.

Nutrient Dynamics: Grab samples of stream water, algae and effluent waters are to be used in conjunction with hydrograph data to estimate nutrient supply and loading. Total N and total P analysis will be performed and subsamples will be prepared for N Isotope Ratio Mass Spectroscopy (IRMS). Algal samples will be freeze dried and submitted directly to isotope ratio mass spectrometry. Stream water and sediment extracts will be collected for nitrogen isotope determinations per Downs et al., 1999. The soluble fractions will be concentrated via the modified (Sigman et al., 1997) diffusion procedure of Sorensen and Jensen (1991) for solid state IRMS. The natural abundance isotope ratio (^{14}N:^{15}N or $\delta^{15}N$) of nitrate and ammonium in water will be used to analyze for isotope signatures that may help to identify the source of N supporting algal blooms, applicable even in the circumstance that N may not be a limiting nutrient. These natural abundance isotope methods of linking algal production to nutrient sources will be an exploratory element of this proposal due to the needs to keep costs reasonable.

Prior to sampling, a Quality Assurance Plan will be submitted to the EPA for approval. Therefore, all sampling methods and laboratory protocols will meet EPA standards.

Conceptual Diagram



Facilities

The primary laboratory facility will be The Mitchell Center (co-PI Kahl, Director). This research group has been involved for nearly 20 years in watershed research, developing new methods, and operating under EPA QA/QC guidelines and reporting requirements. The secondary facility is the HBMI laboratory. The lab has analyzed water samples in accordance with EPA and DEP standards for the duration of the HBMI monitoring program (since 1995). Instrumentation includes a spectrophotometer, autoclave, muffle furnace, fluorometer, and ion chromatograph (Mitchell Center). Analytical balances, isotope diffusion equipment, milling equipment and freeze dryer are available in the Dail Lab.

6) **Summary of closely related research:**

The linkage between nutrient loading and algal blooms is firmly ensconced in the minds of both the public and aquatic ecologists. However, the conditions that give rise to large, persistent algal blooms are more complex than simply nutrient supply. Information on riverine algal ecology is limited in the state of Maine, but this proposal builds on decades of research on stream and river algae. Previous research on streams in the northern part of the U.S. and Canada suggests that freshwater algae in this region are primarily limited by the supply of phosphorus (Huntsman, 1948; Peterson et al., 1985) but that N alone and in combination with P can also relieve nutrient limitation upon growth (Pringle and Bowers, 1984; Burton et al., 1991)

. Numerous studies have also shown that stream flow rates can greatly alter algal populations either physically by scour (Fisher et al., 1982) or by moderating the availability of nutrients and oxygen (Biggs and Close 1989; Dodds, 1991). Temporal patterns of flow, nutrient load, and algal production need to be considered when assessing the influence of nutrients on stream ecosystems. A recent study by Francoeur et al. (1999) concluded that nutrient limitation can shift seasonally and fluctuations should be validated with algal biomass measurements. Nutrient limitation can be analyzed by measuring the nitrogen to phosphorus ratio, measuring alkaline phosphatase activity (Rengefors et al. 2003), or by using an in-situ growth medium (Matlock et al. 1998)

Point and non-point sources play a large role in nutrient loading, but biogeochemical reactions within the water column also greatly impact nutrient concentrations within rivers. For instance, House (2003) found that in-river (sediment) storage of phosphorus can account for greater than 30 percent of the load throughput. In addition, House and Denison (2002) conducted an experiment that illustrated the importance of sediment-water column interactions; they observed a high level of soluble reactive P exchange between the sediment and water column.

Much work has been conducted regarding nutrient criteria in streams and the EPA and USDA have been directed to set criteria in rivers, lakes, and estuaries. Several models have directly linked TN and TP to algal biomass (Lohman et al. 1992; Dodds et al. 1997; Bourassa and Cattaneo 1998; Chetelat et al. 1999). These models have also been extended to link in-stream nutrient concentrations to known sources of nutrient loading (Dodds et al. 1997). Also, Welch et al. (1988) found a positive correlation between algal biomass and coverage by filamentous algae.

The value of algae as a bioassessment tool for nutrient management is a recent, but promising approach. For instance, in the Clark Fork River in Montana, Watson and Gestring (1996) have used algal biomass to evaluate trends in algal levels associated with changes in nutrient loads. The use of stable isotopes, either N alone or in combination with oxygen (^{18}O) is gaining in popularity as a tool to discriminate between sources of pollutants (Chang et al., 2002). This tool is of particular value in watersheds like the Meduxnekeag that are subject to agricultural inputs.

7) **Student training:**

This project will support an MS graduate student (Fretwell) and provide training opportunities for one undergraduate student assisting with the project. The graduate student will complete a thesis and peer-reviewed journal article as part of this project, and will have the opportunity to interact with University of Maine researchers, USGS staff, state agency staff, and the Houlton Band of the Maliseet Indians.

8) **Expected deliverables:**

The project will result in a more complete understanding of nutrient cycling and chemical processes within the Meduxnekeag River and will detail sites of nutrient loading and the relative contributions of point and non-point sources. The research will yield an MS thesis, and will link previous and new monitoring data with the 2000 TMDL Report and the 2003 USGS sediment study. Additionally, the project will set the stage for a focused analysis of factors contributing to the algal bloom. More specifically, the project will result in:

- An annual report to USGS
- A M.S. level thesis
- Publication(s) in a peer-reviewed journal
- A presentation at the Maine Water Conference
- A final report including a summary and recommendations

9) **Investigators qualifications:**

Bryan Dail is an assistant professor of Soil Microbiology and specializes in the use of isotopes at natural abundance and tracer levels to investigate nutrient cycling in both soil and aquatic environments. Current research includes nitrogen biogeochemistry in forest watersheds and groundwater fed seeps in Maine and Massachusetts.

Katherine Webster is an assistant professor at the University of Maine with research in monitoring design, lake classification, effects of land use alteration on lakes, and assessment of landscape effects of shoreline development, climate change and acid rain on lake ecosystems.

J.S. Kahl is the Director of the George Mitchell Center for Environmental and Watershed research; his research interests include the fate of deposition N, Ca, Hg and acidification in forest watersheds, and numerous water quality investigations of Maine industries including fisheries.

C. Ellis is the Maliseet tribe Water Quality Specialist; She is responsible for water quality testing and data management for the tribal lands Meduxnekeag reach.

L. Wilson, Water Quality Office, UMCE. Laura is an Assistant Scientist in the University of Maine's Extension Office with areas of expertise that include best management practices for the control of nonpoint source pollution, and outreach and education around NPS issues.

10) **Project management and organization:**

D.B. Dail, Assistant Professor, Department of Plant, Soil, and Environmental Sciences, will advise student in the design and methodology of the nitrogen isotopes element of the proposal. He will serve as co-advisor for the Graduate master's student.

K.E. Webster, Assistant Professor, Department of Biological Sciences, will advise the student in the design and sampling plan for water and algal samples.

C. Ellis, Water Quality Specialist, Houlton Band of Maliseet Indians (HBMI) will coordinate the sharing of HBMI data sets

E.A. Fretwell, George Mitchell Center for Environmental and Watershed Research, University of Maine. Graduate student Fretwell will perform sampling and data management duties as well as carry out chemical analysis on samples and prepare isotope samples.
L. Wilson, Water Quality Office, UMCE. Will assist in identifying likely non point source pollution in zone 1 of the Meduxnekeag.
J.S. Kahl, Director, George Mitchell Center for Environmental and Watershed Research, University of Maine. Kahl will serve as liaison for tribal cooperators, graduate student advisory committee and advisement on experimental design and analysis.

11) **Statement of collaboration:**

The research will include a high level of collaboration with the HBMI, who have agreed to share all historical monitoring data, take an active role in the development of the Quality Assurance Plan, and participate in field sampling and laboratory analyses. See attached supporting letter. We will collaborate with USGS to obtain flow data and discuss the methodology and results of its sediment study. Also, in spring 2004, USGS is scheduled to conduct an aerial infrared surveillance and mapping of the algae in the Meduxnekeag and all resulting data will be shared with us (Culbertson, pers. comm. 2003). We will collaborate with DEP in multiple ways: utilization of its land use data and GIS resources, consideration of its TMDL study in regards to project design and development, and project results that mesh with DEP data and can be utilized by the agency for watershed management statewide.

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13) **CVs/Resumes:**

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EMPLOYMENT

Assistant Professor: Dept. of Plant Soil and Environmental Science, University of Maine. August , 2000.

Research Associate: Dept. of Agronomy, The Pennsylvania State University. January 1999 to September, 2000.

Post-Doctorate Research Associate: Dept. of Geosciences/Dept. of Agronomy, The Pennsylvania State University. January 1998 to December 1998.

EDUCATION

Post-PhD. The Energy Institute, The Pennsylvania State University

Ph.D. 1997. Dept. of Microbiology, The University of Georgia.

B.S. 1991. Dept. of Biology, The University of New Mexico

PROFESSIONAL ACTIVITIES

Reviewer:

Ecosystems Soil Biology& Biochemistry

RECENT PUBLICATIONS

E.A. Davidson, J. Chorover and D.B. Dail (2003). A mechanism of abiotic immobilization of nitrate in forest ecosystems: the ferrous wheel hypothesis. Global Change Biology **9**:228-236.

D.B. Dail, E.A. Davidson and J.D. Chorover (2001). Rapid abiotic immobilization of nitrate in an acid forest soil. Biogeochemistry **54**:131-146.

D.B. Dail and J.W. Fitzgerald (1999). S cycling in soil and stream sediment: Influence of season and in situ concentrations of carbon, nitrogen and sulfur. *Soil Biology and Biochemistry* **31**: 1395-1404.

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Current Appointment:
Assistant Professor, Department of Biological Sciences University of Maine (2001 to present)

Past Appointments:
Aquatic Ecologist, Wisconsin Department of Natural Resources (1980 to 2001)
Honorary Fellow, Center for Limnology, University of Wisconsin (1998 to 2001)

Education:
1998 University of Wisconsin-Madison, Ph.D. Oceanography and Limnology
1983 University of Wisconsin-Madison, M.Sc. Zoology
1980 University of Wisconsin-Madison, M.Sc. Water Resources Management
1976 McGill University, Montreal, Canada, B.Sc. Biology/Ecology (with Great Distinction)

Research Interests: Regional limnology; long-term ecological research; hydrologic and biogeochemical cycles in lakes; lake-watershed interactions; temporal trends in aquatic ecosystems; effects of acid deposition, land use change, and climate change on aquatic ecosystems

Selected Peer-Reviewed Publications:
Stoddard, J.L., J.S. Kahl, F.A. Deviney, D.R DeWalle, C.T. Driscoll, A.T. Herlihy, J.H. Kellogg, P.S. Murdoch, J.R. Webb, and K.E. Webster. 2003. Response of surface water chemistry to the Clean Air Act Amendments of 1990. EPA 600/R-03/001.

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northern Wisconsin. *Ecology* 81:815-825.
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Webster, K.E., A.D. Newell, L.A. Baker, and P.L Brezonik. 1990. Climatically induced rapid acidification of a softwater seepage lake. *Nature*. 6291:374-376.

Grants:

USGS, Water Resource Institute University of Maine. *Defining 'natural' reference conditions and indicators to assess cumulative impacts of shoreline development on lakes in Maine.* (PI 2003-2005)

USDA Cooperative State Research, Education and Extension Service (MAFES).

Application of a Landscape Framework for Evaluating the Impacts of Regional and Local Stressors on Lakes in Maine. (Principal Investigator 2002-2005)

Current Professional Activities:
Journal peer reviewer for ES&T, Environmental Pollution, Limnology & Oceanography,

J. NABS, Freshwater Bio., Climatic Change, Environmental Monitoring and

Assessment

Session organizer for NALMS 2003 conference
Member: ASLO, ESA, NABS, NALMS, AIBS

Teaching:
BIO 468 – Limnology; BIO 469 – Field Limnology; BIO 446 – Landscape Perspectives on Aquatic Ecosystems.

ELIZABETH ANN FRETWELL
Senator George Mitchell Center for Watershed and Environmental Research
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University of Maine, Orono ME 04469
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Education:

M.S., Ecology and Environmental Science, Water Resources Option, University of Maine, Orono, ME. Expected December 2005.

B.S., Environmental Science with a Chemistry minor, Magna cum laude, Virginia Tech, Blacksburg, VA. December 2000.

National Student Exchange, University of West Florida, Pensacola, FL. Fall 2000

Professional Experience:

Graduate Research Assistant, University of Maine, Orono, ME. 2003-present.
Collects water samples in accordance with EPA standards from streams and lakes throughout Maine and conducts water quality analyses including closed-cell and air equilibrated pH, specific conductivity, color, and organic aluminum.

Environmental Scientist/Consultant, URS, Gaithersburg, MD. 2001-2003.
Served as the technical lead on several Environmental Assessments and numerous Categorical Exclusions. Sorted benthic macroinvertebrate samples, conducted water quality testing, and assisted with the electroshocking and identifying of fish as part of a stream monitoring project. Conducted structural inventories for flood mitigation purposes and helped produce floodplain maps for the Federal Emergency Management Agency.

Education Intern, North Carolina Aquarium, Roanoke Island, NC. Summer 2000.
Revised 12 marine programs and presented them to public groups of over 200 people. Educated visitors at various exhibits and assisted in other departments such as animal husbandry and outreach.

Research Assistant, VA Water Resources Research Center, Blacksburg, VA. 1999-2000.
Worked with local organizations and officials to coordinate a plan of action for the research and educational outreach of an impaired watershed. Constructed and maintained a web page to serve as a database for watershed information. Researched the history of a watershed and summarized the information in a form comprehensible to the public.

Training/Certifications:

- Certified Floodplain Manager (CFM)
- 40-hour HAZWOPER Training
- Maine Watershed Steward Training

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CARA M. ELLIS

EDUCATION

- ***B.S. Watershed Science***
  1999 - 2001 Colorado State University - Fort Collins, CO

- 1998 - 1999 University of Southern Colorado - Pueblo, CO
  Studies focused on Chemistry

WORK EXPERIENCE

- ***Water Resources Specialist*** Houlton Band of Maliseet Indians - Houlton, ME
  Jan 2003 - current
  Work emphasis is on design and implementation of baseline water quality sampling throughout the Meduxnekeag River Watershed, and maintaining compliance with current Quality Assurance Project Plans and Standard Operating Procedures. Other current projects include a Fish Habitat Assessment, Storm Event Sampling, collaboration with the USGS on a Sediment and Nutrient Study and a Microbial Source Tracking Study, Aquatic Invertebrate sampling in conjunction with the Maine DEP and other colloborative efforts on local environmental issues.

- ***Research Intern, Salt Marsh ecology*** Wells National Estuarine Research Reserve - Wells, ME
  Summer 2002
  Worked on a research project tracing nitrogen pathways through the food web of a salt marsh ecosystem. Installed salt marsh treatments, added isotope tracers, measured abundance and changes in biomass, and gathered chlorophyll a and meiofauna samples.

- ***Forestry Technician Wildland Fire Fighter Type II*** Rocky Mountain National Park - Estes Park, CO
  Summer 2001
  Carried out initial attack operations with the fire crew on wildland fires and assisted with hazardous fuels reduction projects.

- ***Water Quality Data Analyst*** National Park Service - Fort Collins, CO
  September 1999 - April 2001
  Communicated with researchers, professors, and municipalities in order to gather baseline water quality data for various parks. Read scientific papers and publications, followed format protocols, and digitized station locations in order to compile comprehensive data sets. Worked with the computer programs ATLAS GIS, EXCEL, MS-DOS and the EPA database STORET.

COMMUNITY OUTREACH

- Currently assist the Meduxnekeag River Watershed Coalition with co-ordinating monthly lecture series to educate the public on issues topics including mapping, aquatic inverts, geology of the .

- Worked to raise funds for Colorado Public Interest Research Group. Contacted citizens to gain support and increase activism and awareness for various environmental campaigns.

PAPERS AND PRESENTATIONS

- Presented at the 1999 Colorado State University Student Water Symposium on the “Affects of Heavy Metals on Food Webs in Rocky Mountain Streams". Took stream flow measurements, performed mass spectrometry and gut content analysis on aquatic inverts for Daren Carlisle at the CSU eco-toxicology lab.

- Wrote and presented - “Mining Impacts on the Hydrology of Watering Trough Gulch Watershed, Routt County, CO.". Project included, site layout, hydrologic engineering, erosion calculations, computer modeling and water quality monitoring plans.

- Wrote a Scientific paper on the "Impacts of Mine Tailings on Water Quality and Snow Making at Keystone Ski Resort in Keystone, CO." Collected physical data as well as water quality and metal samples at strategically chosen sites, and analyzed samples in both field and lab settings.

Laura R. Wilson

University of Maine Cooperative Extension
Water Quality
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Orono, ME 04473
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Education

1998 – present University of Maine Orono, ME
M.S. in Ecology and Environmental Science, Water Resources Concentration (Expected December 2003)

Thesis: *Evaluation of a Constructed Dry Swale for Treatment of Stormwater Runoff*
Focus of study: Best Management Practices for reducing nonpoint source pollution of surface waters

1990 – 1994 University of New Hampshire Durham, NH
B.S. in Water Resources Management (December, 1994)

- *Magna cum Laude*

Professional Experience

2001 – Present University of Maine Cooperative Extension Orono, ME
Assistant Scientist

- Provide education and outreach related to lake and watershed protection
- Organize "Watershed Stewards Program", act as liaison to all program participants
- Coordinate "Watershed Stewards Program" evaluations and impact reporting
- Maintain water quality website
- Produce quarterly newsletters in support of Watershed Stewards Program

1999 – 2001 Sen. George Mitchell Center Orono, ME
Scientific Technician

- Assisted surface drinking water suppliers with watershed management plan activities
- Performed quality assurance checks of data before reporting to clients
- Performed several standard chemical analyses of water, including total, ortho-, and NaOH-extractable phosphorus and acid neutralizing capacity

1997 - 1998 Sen. George Mitchell Center Orono, ME
AmeriCorps/SERVE/Maine Volunteer Leader

- Recruited and arranged training for new volunteers for the Maine Volunteer Lake Monitoring Program
- Assisted the Branch Pond Association in the training for and completion of a Lake Watershed Survey
- Recruited volunteers for the University of Maine Cooperative Extension's Watershed Stewards Program
- Provided BMP recommendations for eroding sites in the Branch Pond watershed, and participated in follow-up activities in the Swan Lake watershed
- Acted as primary landowner and media contact for the Branch Pond watershed survey
- Organized "Buffer plant give-away" in cooperation with City of Ellsworth, Maine

Additional professional activities

- Provided watershed survey training and performed follow up activities (including BMP recommendations) for Center Pond residents, Sangerville, Maine, 1999
- Presented "Sediment and Phosphorus Basics" at a Camp Road Workshop, 1999
- Assisted the Branch Pond Association by providing educational programs, coordinating Lake Week activities, and proposal writing, 1999-2000
- Maine Water Conference Planning Committee member, 2001,2002, 2003; Co-Chair 2003; Poster Coordinator 2004
- Presented "Partnership Building" at the New England Water Works Association conference: Protecting Maine's Drinking Water, 2000
- Presented "Maine's Watershed Stewards Program – Are We Making a Difference" at the national meeting of the American Water Resources Association, 2002

Community activities	▪ UMaine Children's Water Festival, 1998, 2000, 2002, 2003 ▪ Penobscot River Festival, 1999 and 2000 ▪ Hermon Middle School Watershed Festival, 1998 ▪ John Bapst High School Watershed Festival, 2000
Relevant Publications/non-refereed	▪ 2003 Pushaw Lake Watershed Survey Report ▪ (Submitted to Journal of Extension) Jemison, J.M., L.R. Wilson and J. Graham. *Effecting Land-use Changes Through Education and Implementation: Assessing the Effectiveness of the Watershed Stewards Program.*

JEFFREY S. KAHL
Professor of Water Resources and *Director*

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PRESENT POSITIONS

Founder and Director (2000-);	Mitchell Center for Environmental and Watershed Research
Coordinator & founder	Water Resources graduate option (1998 -);
Coop. Assoc. Professor	Dept. of Civil and Environmental Engineering (2000 -)
Director	Maine USGS Water Resources Research Institute (1994 -)
President-elect	National Institutes for Water Resources (2003-04)

EDUCATION

Ph.D. Watershed Geochemistry, University of Maine
M.S. Geological Sciences, University of Maine
B.A. Zoology (*Chemistry minor*), University of Maine, 1977.

RESEARCH INTERESTS: Regional and global patterns in environmental chemistry; limnology, watershed geochemistry, environmental monitoring methods; paleo-inferential methods; the intersection of science and public policy; information accessibility for the public.

HISTORY OF EXTRAMURAL SUPPORT: Principal Investigator on 46 extramural grants, funded at $8.3 million. Co-PI on 22 other grants, funded at an additional $7.7 million. These grants have supported 59 graduate students and countless undergraduates.

RECENT PROFESSIONAL EXPERIENCE

Sabbatical with EPA (2002)	*Co-leader,* Trend assessment report for the Clean Air Act
Development Advisor 2003)	Schoodic Education & Research Consortium (NPS, 2001-
Assoc. Research Prof. ('98-02).	Department of Geological Sciences, University of Maine
Manager (1989-95).	Environmental Chemistry Laboratory, Univ. of Maine

STUDENT ADVISING: 45 graduate student committees since 1985

EXAMPLE AWARDS and RECOGNITION:

2003 President-elect, National Institutes for Water Resources
2003 Invited speaker, National Academy of Sciences panel on the future of water research
2002 Chair, review panel, Western Airborne Contaminants Assessment Project (NPS/EPA) 2002 *Environmental Policy Advisory Committee,* gubernatorial candidate John Baldacci
2001 UMaine Research Honor Role *(top 25 ranking of 650 faculty).*
2001 UMaine nomination, NSF Presidential award for student mentoring

2000 *Mercury Products Advisory Commission* (Gubernatorial appt, 2000 – 03)
1999 USGS ranking as one of the top four national water institutes of the past five years
1999 Governor's Award for Excellence in Environmental Education
1998 Legislative Proclamation for Achievement
1998 EPA New England Environmental Merit Award
1998 *River Flow Management Commission* (Gubernatorial appt, 1998 -)
1996 *Great Ponds Task Force*, 1995-97 (Gubernatorial appointment).
1979 'Teacher of the Year'*, Bunnell High School, Stratford CT*

EXAMPLE PEER-REVIEWED PUBLICATIONS and REPORTS (n = 106)

Kahl, J.S., J. Stoddard, R. Haeuber, S. Paulsen, and others, in review. Response of surface water chemistry to changes in acidic deposition: implications for the upcoming debate on the federal Clean Air Act. Environmental Science and Technology, Feature Article in review.

Peckenham, J., J.S. Kahl, and B. Mower, 2003. Background Mercury Concentrations in River Water in Maine, USA. Environ. Monitoring and Assessment, in press.

KAHL, J.S., AND 19 CO-AUTHORS, 2003. INFERRING REGIONAL PATTERNS AND RESPONSES IN N AND HG BIOGEOCHEMISTRY USING TWO SETS OF GAUGED PAIRED-WATERSHEDS. FINAL REPORT TO EPA AND NATIONAL PARK SERVICE, MITCHELL CENTER, UNIVERSITY OF MAINE, ORONO, ME. 171 P.

Norton, S., I. Fernandez, J.S. Kahl, and R. Reinhardt, 2003. Acidification trends and the evolution of neutralization mechanisms through time at the Bear Brook Watershed, Maine, USA. Water, Air, Soil, Pollut., in press.

Fernandez, I, L. Rustad, S. Norton, J.S. Kahl, and B.J. Cosby, 2003. Experimental acidification causes soil base cation depletion at the Bear Brook Watershed in Maine. J. Soil Soc Assoc Am., in press.

Neilsen, M.G., and J.S. Kahl, 2003. Nutrient export from watersheds on Mount Desert Island; differences in export as a function of fire history. J. Am Water Resources Assoc. in press.

Campbell, J, J. Hornbeck, M. Mitchell, M. Adams, M. Castro, C. Driscoll, J.S. Kahl, and others, 2003. Input-output budgets for inorganic nitrogen for 24 watersheds in the northeastern United States. Water Air Soil Pollut., in press.

Kahl, J.S. Norton, I. Fernandez, L. Rustad, and M. Handley, 1999. Nitrogen and sulfur input-output budgets in the experimental and reference watersheds, Bear Brook Watershed in Maine (BBWM). Environ. Monitoring and Assessment 55:113-131.

Mitchell, M.J., C.T. Driscoll, J.S. Kahl, G.E. Likens, P.S. Murdoch, and L. Pardo, 1996. Climatic control of nitrate loss from forested watersheds in the northeastern United States. Environ. Sci. Technol. 30:2609-2612.

Kahl, J.S., S.A. Norton, I.J. Fernandez, K.J. Nadelhoffer, C.T. Driscoll, and J.D. Aber, 1993. Experimental inducement of nitrogen-saturation on a watershed-scale. Environ. Sci. and Technol. 27:565-568.

Kahl, J.S., T.A. Haines, S.A. Norton, and R.B. Davis, 1993. Recent temporal trends in the acid-base chemistry of surface waters in Maine, USA. Water, Air, and Soil

Pollution, 67:281-300 (and reply to comment by Mattson and Likens; WASP 83:101-104, 1995).

Kahl, J.S., S.A. Norton, T.A. Haines, E.A. Rochette, R.H. Heath, and S.C. Nodvin, 1992. Mechanisms of episodic acidification in low-order streams in Maine, USA. Environ. Pollut. 78:37-44.

Kahl, J.S., S.A. Norton, C.S. Cronan, I.J. Fernandez, T.A. Haines, and L.C. Bacon, 1991. Chemical relationships of surface water chemistry and acidic deposition in Maine. Chapter 7 in: Regional Case Studies: Acid Deposition and Aquatic Ecosystems, D. Charles, ed., Springer-Verlag. NY.