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Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds

Statement of Critical Regional or State Water Problem

New Hampshire's surface waters are a very valuable resource, contributing to the state's economic base through recreation (fishing, boating, and swimming), tourism and real estate values. Many rivers and lakes also serve as local water supplies. New Hampshire currently leads all New England states in the rate of development and redevelopment (2000 Census). The long-term impacts of population growth and the associated changes in land use to New Hampshire's surface waters are uncertain. Of particular concern are the impacts of non-point source pollution to the state's surface waters (e.g. septic, urban run off, road salt application, deforestation and wetland conversion). Long-term datasets that include year-to-year variability in precipitation, weather patterns and other factors will allow adequate documentation of the cumulative effects of land use change and quantification of the effectiveness of watershed management programs.

Statement of Results or Benefits

The proposed project will provide detailed, high-quality, long-term datasets which will allow for a better understanding of the impacts of land use change and development on surface water quality. This could occur through the development, testing and refinement of predictive models, accurately assessing the impacts of watershed management practices, and potentially early warning of dramatic changes to surface water quality in the region resulting from rapid development.

Objectives of the Project

This project allows for the continued collection of long-term water quality data in New Hampshire. It will use UNH staff, students and volunteers from local communities to collect samples from the College Brook watershed (Durham, NH), the Lamprey River Watershed, the Oyster River watershed, and the Ossipee Watershed.

The College Brook watershed, which is dominated by the University of New Hampshire, receives a variety of non-point pollution from several different land uses. Suspended sediments, pH, conductivity, biological oxygen demand (BOD) and nutrient concentrations (Cl^- , SO_4^{-2} , Na^+ , K^+ , Mg^{+2} , Ca^{+2} , NO_3 , NH_4 , PO_4 , DOC, TDN) will be measured to assess water quality. Samples from 7 sites will be collected monthly throughout the year. Sampling of College Brook began in 1991. Sample collection will be done by UNH staff and/or students, with analyses done by UNH staff at the Water Quality Analysis Lab (WQAL) of the WRRC.

The Lamprey River will be sampled weekly throughout the year and during major storm events. Samples will be measured for suspended sediments, pH, conductivity, and nutrient concentrations (Cl^- , SO_4^{-2} , Na^+ , K^+ , Mg^{+2} , Ca^{+2} , NO_3 , NH_4 , PO_4 , DOC, TDN). Sampling and analyses will be done by UNH staff. Weekly sampling of the Lamprey River began in 1999.

Samples will also be collected monthly (when surface streams are present) at Moore Fields, a 42 acre agricultural property near the Oyster River. Moore Fields is owned by UNH and is used for soil science courses and research as well as growing feed for the university's livestock. Sampling began here when a land use change to soccer fields was proposed. This proposal has since been withdrawn. Samples will be collected and analyzed by UNH staff at the WQAL.

Streams within the Ossipee watershed of New Hampshire will be sampled by volunteers of the Green Mountain Conservation Group. Samples will be collected every 2 weeks from May to November. Water chemistry (Cl^- , SO_4^{-2} , Na^+ , K^+ , Mg^{+2} , Ca^{+2} , NO_3 , NH_4 , PO_4 , DOC, TDN) will be measured by the WQAL at a per sample cost. WRRC staff will assist in data interpretation.

Principal Findings and Significance

College Brook

Samples have been collected from College Brook as planned during 2005-2006. However, data analysis was not complete at the time this report was due. Previous work on College Brook in the early 1990's (McDowell unpublished) shows that the UNH campus had a severe impact on water quality and was negatively affecting stream biota and the integrity of downstream ecosystems. By any yardstick, campus operations could not be considered sustainable. There was clear evidence that the UNH incinerator was causing excessive organic matter loading, resulting in high biochemical oxygen demand (BOD) and low dissolved oxygen in stream water. Other practices, such as washing of waste art materials (slip, poster paint, etc.) into street drains near the Service Building, were also impacting College Brook.

Comparisons between data collected in 1991 and 2000-present have indicated that overall water quality has improved in College Brook with the closing of the UNH incinerator and greater ecological awareness on campus. Recent water quality analysis (2000-2003) indicates that the drought of 2001 has a significant effect on water quality. It was the third driest year for the state of New Hampshire for 1895-2003 and water chemistry indicated that the health of the stream was at its lowest for some parameters (TDN, nitrate, ammonium, BOD, etc...). Construction on campus has also likely had an impact on stream quality and in 2001 construction occurred in close proximity to the stream in the watershed. Construction accidents (i.e. - water main break) caused large runoff discharges into College Brook and likely had effects on the stream, which further complicates the picture. Further analysis of the data and continued monitoring of College Brook is scheduled to continue. The College Brook web site can be viewed at http://www.wrrc.unh.edu/current_research/collegebrook/collegebrookhome.htm.

Weekly Lamprey Sampling and the Lamprey River Hydrologic Observatory

We have continued to sample the Lamprey River at the USGS gauging station in Durham, NH (referred to as "LR 73.3"), the North River at the USGS gauging station in Epping, NH (NR 26.9) and a small tributary to the Lamprey River in Lee, NH (WHB 1.03) for DOC, DON, $\text{NO}_3\text{-N}$, $\text{NH}_4\text{-N}$, $\text{PO}_4\text{-P}$, pH, DO, temperature and conductivity on

a weekly basis. In addition to these parameters, station LR 73.3 is also sampled for DIC, major cations (Na, Ca, Mg, K), major anions (Cl, SO₄), SiO₂, TSS, Particulate C and Particulate N. Our goal for this long-term water quality monitoring program is to document changes in water quality as the Lamprey watershed becomes increasingly more developed. We continue monitor stream flow at WHB 1.03 with an electronic distance meter and are now developing a rating curve for this site. We continue to collect precipitation at Thompson Farm (UNH property located in Durham, NH) and work with NOAA/AIRMAP in an attempt to link to precipitation chemistry to air mass chemistry.

Results of stream chemistry to date show an increase in peak NO₃-N concentration over time in the Lamprey and a link between population density and NO₃-N concentration and export. Dissolved organic matter (DOM) in the Lamprey watershed is related to wetland cover, but there are no clear trends in DOM over time nor is there a consistent relationship between DOM and stream discharge. Results of precipitation monitoring show that DOC and DON in precipitation are related to atmospheric black carbon. Several atmospheric volatile organic carbons (VOCs) appear to be strong predictors of DOC, TDN and NH₄.

Other projects in the Lamprey watershed include linking groundwater chemistry (by way of homeowner well analysis) to landscape characteristics and documenting changes in nitrogen concentrations in riparian zones. We found a positive relationship between average sub-basin NO₃-N concentration and sub-basin population density/urban land use and that average sub-basin groundwater NO₃-N is higher than NO₃-N in the stream water. Arsenic concentrations in individual wells vary in response to bedrock type and vary by sub-basin in response to the percentage of agriculture. There was one homeowner well that exceeded the current MCL for nitrate and 16 homeowner wells that exceeded the current Arsenic MCL. In riparian zones, there is a large reduction in NO₃-N (approximately 4.5 mg NO₃-N upslope to 0.2 mg/L NO₃-N near the stream) and an increase in NH₄-N (approximately 0.02 mg NH₄-N upslope to 0.2 mg/L NH₄-N near the stream) over a small distance (approximately 10 m).

Ossipee River watershed sampling

Collaboration with the Green Mountain Conservation Group and their sampling of the Ossipee River watershed has continued to be beneficial. Volunteers sampled streams within the watershed every 2 weeks from May to November, with approximately 340 samples collected from 14 sampling locations. Many presentations were made to planning boards, conservation commissions and other local government groups (see Publication, presentations and awards section below).

Presentations:

Buyofsky, L.A. 2006. Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed. M.S. Thesis Defense, Department of Natural Resources, University of New Hampshire, March 2006.

McDowell, W.H. 2006. Biogeochemistry of suburban basins. University of Puerto Rico, February 2006.

McDowell, W.H., Daley, M.L. and Gettel, G. 2005. Nitrogen inputs, output, and retention in a coastal suburban basin. American Geophysical Union fall meeting, San Francisco, December 2005.

Buyofsky, L. 2005. The relationship between groundwater quality and land use in the Lamprey River watershed. Research to Practice: Science for Sustainable Water Resources Conference, Amherst, Massachusetts, October 2005.

McDowell, W.H. 2005. Biogeochemistry of suburban basins – putting people into the landscape. University of Colorado seminar series, November, 2005
McDowell, W.H. 2005. Biogeochemistry of suburban basins- putting people into the landscape. University of Vermont, Water in the Environment seminar series, April 2005

McDowell, W.H. 2005. Biogeochemistry of suburban basins- putting people into the landscape. Institute of Ecosystem Studies, Millbrook NY, March 2005

McDowell, W.H., M.L. Daley, T.E. O'Donnell, and L.A. Buyofsky. 2005. Biogeochemistry of a Suburban Basin. Emerging Issues Along Urban/Rural Interfaces: Linking Science and Society. Atlanta, GA. March 2005.

Information Transfer:

Buyofsky, L. “Drinking Water in Your Watershed.” Oyster River Adventure Camp, July 2005

Buyofsky, L. "Groundwater Quality in the Lamprey River Watershed (homeowner version)", given 3 times: Northwood Conservation Commission, Northwood, NH; Henry Moore School, Candia NH, and UNH, April-May 2005

Buyofsky, L. "Groundwater Quality in the Lamprey River Watershed (broader high school version)" Souhegan High School, June 2005

Presentations related to the Green Mountain Conservation Group collaboration.
August 17th: "Water Quality in the Ossipee Watershed", Camp Calumet (20p.)

November 28th: Freedom WQM Presentation 7:00 Freedom Cons. Com, Selectmen, residents (15p.)

December 5th: Ossipee WQM Presentation 4:15 @ Ossipee Town Hall Ossipee Cons. Com, Selectmen, Planning Board, residents (25p.)

December 6th: Madison WQM Presentation 5:00 @ Madison Town Hall Madison Selectmen,, Cons. Com, Planning Board, residents (20p.)

December 12th: Sandwich WQM Presentation 7:30 @ Sandwich Town Hall Sandwich Selectmen, Cons. Com (10p.)

December 13th: Effingham WQM Presentation w/ Bob Craycraft 5:00pm @ Effingham Town Hall Effingham Selectmen, Planning Board, Cons. Com., residents (35p.)

December 15th : Tamworth WQM Presentation w/ Michelle Daley 4:00 @ Tamworth Town Hall Tamworth Cons. Com, Selectmen, Planning Board, residents (15p.)

January 1st: Annual Meeting w/ WQM Presentation (70 p.)

January 11th: Ossipee Conservation Commission WQM presentation 7:00-8:00pm (10 p.)

Approximately 20 programs with summer camps last year to teach about the program and collect data with campers.