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Water Quality and the Landscape: Long-term monitoring of rapidly developing suburban watersheds 2015

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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, and drinking water supplies. New Hampshire is experiencing rapid growth in several counties and from 1990 to 2004 the state grew twice as fast as the rest of New England, with a state-wide average population increase of 17.2% during that period (Society for Protection of NH Forests 2005). New Hampshire watersheds rank among the most highly threatened watersheds in the nation because of the high potential for conversion of private forests to residential development. In fact, three of the four most threatened watersheds in the US which could experience the largest change in water quality as a result of increased residential development in private forests occur at least partially in New Hampshire (Stein et al. 2009).

The long-term impacts of this rapid population growth and the associated changes in land use on New Hampshire's surface waters are uncertain. Of particular concern are the impacts of non-point sources of pollution such as septic systems, urban runoff, stormwater, application of road salt and fertilizers, deforestation, and wetland conversion. Long-term datasets that include seasonal and year-to-year variability in precipitation, weather patterns and other factors are needed to adequately document the cumulative effects of land use change and quantify the effectiveness of watershed management programs. No other agency or research program (e.g. NH Department of Environmental Services (NH DES), US Geological Survey (USGS) or Environmental Protection Agency (EPA)) has implemented such a long-term program.

Statement of Results or Benefits

This project provides detailed, high-quality, long-term datasets which allow for a better understanding of the impacts of land use change and development on surface water quality. These surface water datasets could support the development, testing and refinement of predictive models, accurately assess the impacts of watershed management practices on drinking water supplies, assess efforts to reduce surface water quality impairments, and be potential early warning signs of dramatic changes to surface water quality in the region resulting from rapid development. Long-term datasets from this project will be essential to adaptive management strategies that strive to reduce non-point sources of nitrogen pollution in New Hampshire's Great Bay watershed which is currently impaired by elevated nitrogen and in violation of the Federal Clean Water Act. A list of selected recent presentations, publications and press releases that utilize long-term datasets supported by NH WRRC funding for this project is included at the end of this report.

Objectives of the Project

This project allows for the continued collection of long-term water quality data in New Hampshire. It will use University of New Hampshire (UNH) staff, students and volunteers from local communities to collect samples from the Lamprey and Oyster River watersheds located in southeast NH and the Ossipee River watershed in central NH. All three watersheds are located in counties experiencing high population growth rates (Figure 1). Both the Lamprey and Ossipee watersheds are predicted to more than double in population from 1998 to 2020 (Sundquist and Stevens 1999). Surface water sites within each of the 3 watersheds and details on long-term datasets collected are described below. Together these 3 watersheds capture a broad range of urban, rural and agricultural land uses as well as a range of forests and wetland cover types.

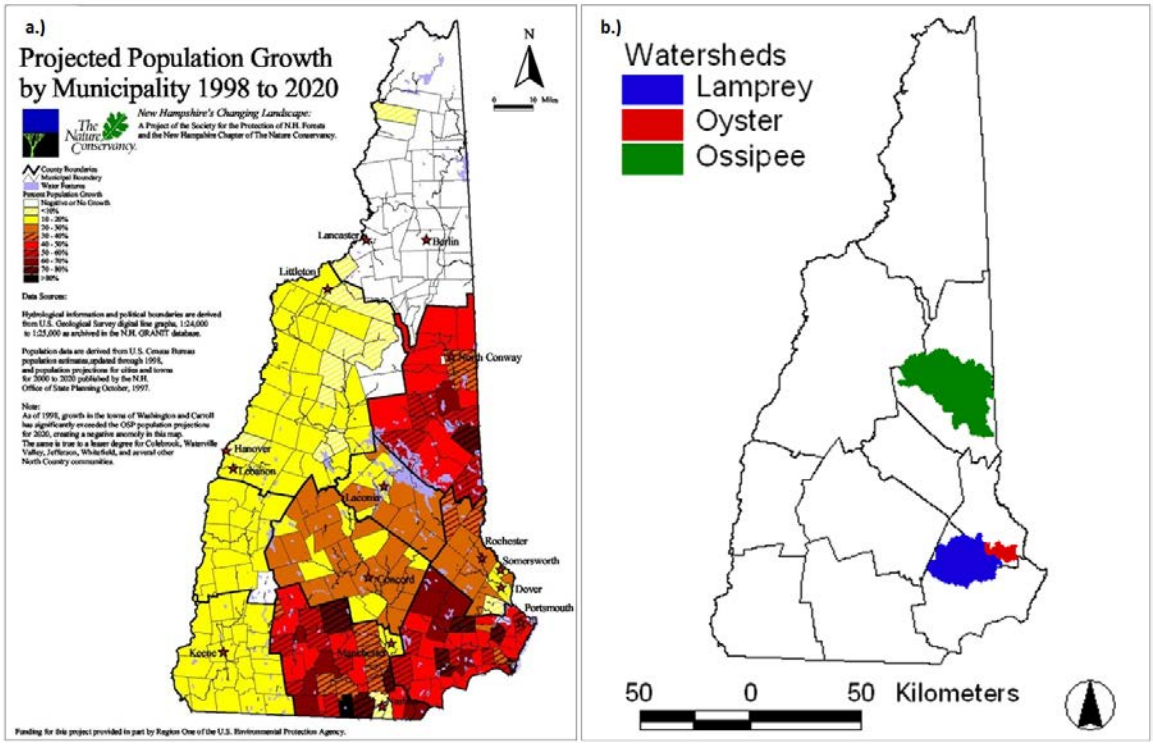

Figure 1. Projected population growth in New Hampshire (Figure from Sundquist and Stevens 1999; A) and study watersheds experiencing high population growth (B).

Methods, Procedures and Facilities

Lamprey River Hydrologic Observatory

The Lamprey River watershed (479 km^2) is a rural watershed located in southeastern NH and is under large development pressure as the greater area experiences the highest population growth in the state. The Lamprey River Hydrologic Observatory (LRHO) is a name given to the entire Lamprey River basin as it serves as a platform to study the hydrology and biogeochemistry of a suburban basin and is used by the UNH community as a focal point for student and faculty research, teaching and outreach. Our goal for the long-term Lamprey water quality monitoring program is to document

changes in water quality as the Lamprey watershed becomes increasingly more developed and to understand the controls on N transformations and losses.

The Lamprey River has been sampled weekly and during major runoff events since September 1999 at site LMP73 which is co-located with the Lamprey River USGS gauging station (01073500) in Durham, NH. Two additional sites were added to the long-term Lamprey River monitoring program in January 2004. One site (NOR27) was located on the North River, the Lamprey River's largest tributary, less than 1 km downstream from the USGS gauging station (01073460) in Epping, NH. The other site (Wednesday Hill Brook; site WHB01) drains a small suburban area in Lee, NH where residents rely solely on private wells and private septic systems for water supply and waste disposal. A stream gauge at WHB01 is operated by UNH staff and/or students. Sites NOR27 and WHB01 were sampled on a weekly basis through 2010 and in January 2011, the North River sampling frequency (site NOR27) was reduced to monthly because accurate measures of river discharge were no longer possible. Site WHB01 along with LMP73 remain at a weekly and major storm event sampling frequency. Several other sites have been sampled for multiple years on a less frequent basis to assess the spatial variability of water quality in sub-basins with various land uses and development intensities. In the past year, 14 additional sites were sampled on a monthly basis. All LRHO stream water samples are collected by UNH staff and/or students.

Oyster River watershed

The Oyster River watershed (80 km^2) is a small watershed in southeast NH where land use ranges from rural to urban. Two urban sub-basins, College Brook (CB) and Pettee Brook (PB), were selected for long-term sampling in January 2004. Both sub-basins are dominated by the University of New Hampshire (UNH) and receive a variety of non-point pollution from several different land uses. Three sites (CB00.5, CB01.5 and CB03.0) are sampled along College brook which drains the center of campus and one site (PB02.0) is located on Pettee Brook which drains the northern section of campus. Both sub-basins drain areas with high amounts of impervious surface and College Brook also drains the UNH dairy farm and athletic fields. Historic water quality data for these two sites are available from 1991. UNH staff and/or students currently sample these sites on a monthly basis.

Ossipee River watershed

The entire Ossipee River watershed (952 km^2) is classified as rural due to its low but increasing population. Seven sites in the watershed were selected for long-term monitoring in May of 2004. These sites are monitored monthly by volunteers and staff of the Green Mountain Conservation Group (GMCG) and were chosen to capture the areas of concentrated growth and monitor the major inputs and outputs from Ossipee Lake. Additional sites are selected by GMCG for volunteer monitoring during non-winter months (May to November). WRRC staff assist GMCG in site selection and data interpretation. In 2006, the GMCG worked with the Department of Environmental Services to establish a Volunteer Biological Assessment Program (VBAP) for the Ossipee Watershed. Numerous volunteers, including students from five local schools, assist with invertebrate sampling at a total of eleven sites.

Water Quality Analysis

Field parameters (pH, conductivity, dissolved oxygen (DO) and temperature) are measured at all sites. Water samples are filtered in the field using pre-combusted glass fiber filters (0.7 µm pore size), and frozen until analysis of dissolved constituents. Samples collected at all LRHO, CB, PB and the 7 long-term GMCG sites are analyzed for dissolved organic carbon (DOC), total dissolved nitrogen (TDN), nitrate (NO_3-N), ammonium (NH_4-N), dissolved organic nitrogen (DON), orthophosphate (PO_4-P), chloride (Cl^-), sulfate (SO_4-S), sodium (Na^+), potassium (K^+), magnesium (Mg^{+2}), calcium (Ca^{+2}), and silica (SiO_2). Water chemistry is also analyzed on a sub-set of the GMCG seasonal sites and turbidity is measured in the field at all GMCG sites. Samples collected since October 2002 from LMP73 are also analyzed for total suspended sediment (TSS), particulate carbon (PC), particulate nitrogen (PN) and dissolved inorganic carbon (DIC). All samples are analyzed in the Water Quality Analysis Laboratory (WQAL) of the NH WRRC on the campus of UNH, Durham, NH. Methods for analyses include ion chromatography (Cl^-, NO_3^-, SO_4^{-2} and Na^+, K^+, Mg^{+2}, Ca^{+2}), discrete colorimetric analysis (NH_4, PO_4, NO_3/NO_2), and High Temperature Oxidation (DOC, TDN). All methods are widely accepted techniques for analysis of each analyte.

The WQAL was established by the Department of Natural Resources in 1996 to meet the needs of various research and teaching projects both on and off the UNH campus. It is currently administered by the NH Water Resources Research Center and housed in James Hall. Dr. William McDowell is the Laboratory Director and Mr. Jody Potter is the Laboratory Manager. Together, they have over 41 years of experience in water quality analysis, and have numerous publications in the fields of water quality, biogeochemistry, and aquatic ecology.

Principal Findings and Significance

Lamprey River Hydrologic Observatory

Analysis of samples collected in 2015 from the LRHO is 75% complete. Results of stream chemistry to date show a significant increase in weekly nitrate concentrations during the first 10 years (Water Years (WY) 2000-2009) of monitoring at LMP73 based on the Seasonal–Kendall Test (SKT; seasons set to 52) flow-adjusted nitrate concentrations (SKT $t = 0.28$, $p < 0.01$). However, there is no statistically significant change in nitrate concentrations at LMP73 (Figure 2) or WHB01 over the entire study period (2000-2015). We have shown previously that stream water nitrate is related to watershed population density (Daley 2002) and since suburbanization continues to occur throughout the greater Lamprey River watershed, population growth is likely responsible for the increase in stream water nitrate over the initial 10-year period. The watershed population density increased from 53 to 60 people/km^2 or by 12% from 2000 to 2010 (2000 and 2010 Census). The highest levels of nitrate at LMP73 occurred in 2014. We are uncertain if nitrate levels in LMP73 will remain relatively constant, increase or decrease with changing climate, land use and management in the watershed. Wednesday Hill Brook watershed is near its development capacity, unless the Town of Lee, NH changes its zoning regulations, and the lack of increase in WHB01 nitrate may be due to the limited population growth in this watershed, that this watershed has reached nitrogen saturation or that the current time period of data collection is not reflective of long-term

trends. Changes in Lamprey River nitrogen, especially nitrate, can have significant impacts for the downstream receiving water body, the Great Bay estuarine system which is impaired by elevated nitrogen and is currently in violation of the Federal Clean Water Act. Tidal tributaries to the bay are experiencing dangerously low dissolved oxygen levels and the bay is experiencing a significant loss of eelgrass which provides important habitat for aquatic life. The Lamprey River is the largest tributary to Great Bay, and thus the long-term data provided by the NH WRRC from the LRHO are of considerable interest for watershed management.

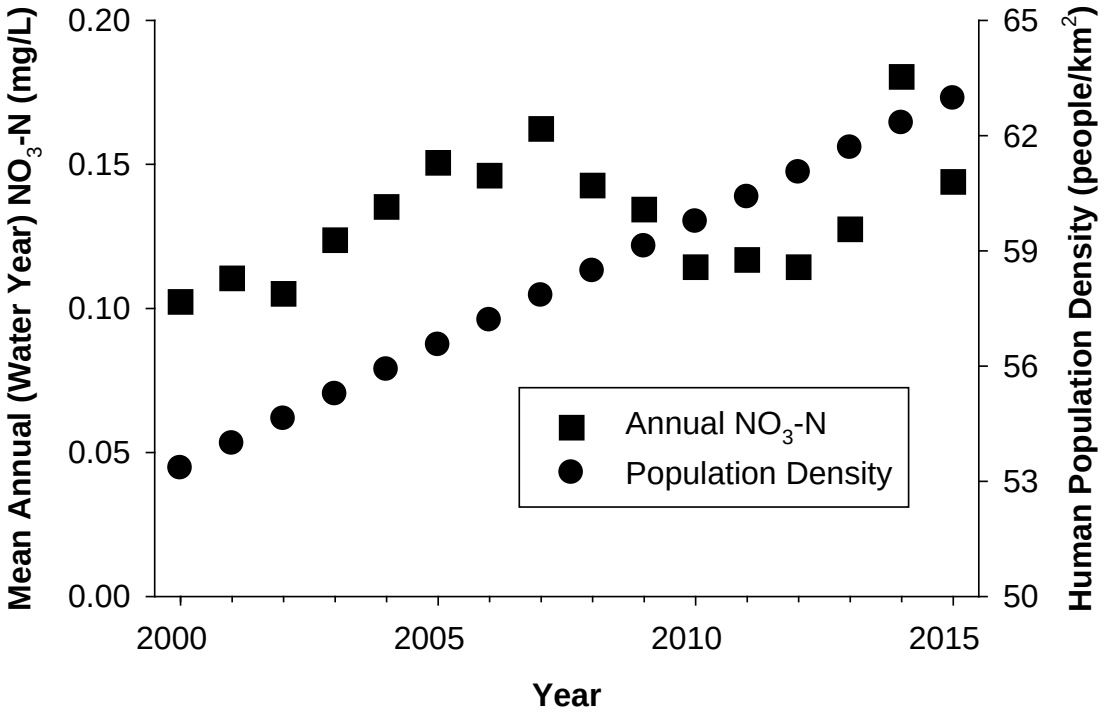

Figure 2. Annual (water year) mean nitrate concentration and estimated annual human population density from 2000-2015 (2000 and 2010 Census) in the Lamprey River basin. There is no statistically significant change in annual nitrate concentrations over the entire study period (2000-2015). Note that nitrate analysis for 2015 is 75% complete.

When we combine our specific conductance data (2003 – 2015) with data collected by the USGS (1978 - 1999), we see a long-term increase in specific conductance in the Lamprey River with a slight decline in recent years (Figure 3). Sodium and chloride concentrations are directly related to specific conductance (r^2 = 0.95, $p<0.01$ for Na^+; $r^2 = 0.93$, $p < 0.01$ for Cl^-) and we conclude that this increase in specific conductance indicates a corresponding increase in Lamprey River NaCl. Since Na^+ and Cl^- are strongly correlated with impervious surfaces in southeast NH (Daley et al. 2009) and road pavement among southeastern and central NH basins, we conclude that the associated road salt application to these surfaces is responsible for this long-term increase in stream water NaCl. The slight decline in recent years is likely due to the flushing effect of the 2006 and 2007 100-year flood events (Daley et al. 2009), but we are

uncertain how long this slight decline will persist and thus continued monitoring is necessary to better understand how the interaction between human activities and climate variability affects water quality.

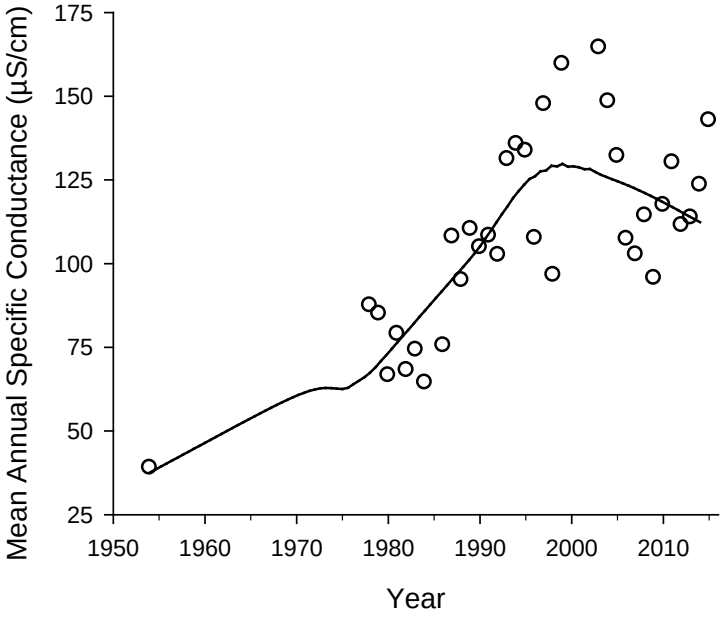

Figure 3. Mean annual specific conductance in the Lamprey River at LMP73 (co-located with the USGS gauging station in Durham, NH. (modified from Daley et al. 2009).

Oyster River watershed

Laboratory analysis of the monthly CB and PB samples collected in 2015 is approximately 90% complete. Recent data show that DO is lowest at the CB upstream station (CB00.5) where it does drop below 5 mg/L (level that is necessary to support in-stream biota) during the summer months. The downstream stations do not drop below 5 mg/L and this difference is due to the hydrologic and biogeochemical properties of the upstream sampling location which has slow stream flow, high dissolved organic matter content and resembles a wetland. DO increases downstream as flow becomes faster and the stream is re-aerated.

Data from 2000 until now indicate that the steam is strongly impacted by road salt application at its origin, which is essentially a road-side ditch along the state highway leading to a wetland area, and by road salt applied by UNH and the town of Durham which drains to the middle and lower reaches of the brook (Figure 4). Average sodium and chloride concentrations, as well as specific conductance, appear to have remained reasonably constant since 2001, but are much higher than in 1991 (Daley et al. 2009). Concentrations are highest at the upstream stations and tend to decline downstream as the stream flows through the campus athletic fields and then increase as the stream passes through the heart of campus and downtown Durham. Concentrations are also highest during years of low flow. Data from this project have been used to list College Brook as impaired for excess chloride.

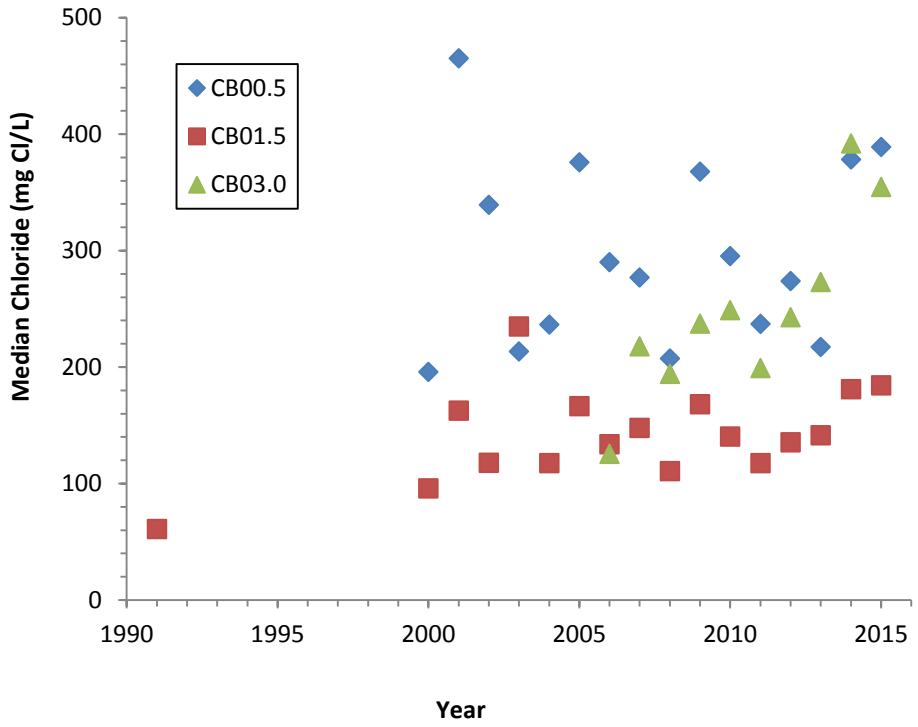

Figure 4. Median annual chloride in College Brook from the headwaters (CB00.5) to the mouth (CB03.0).

College Brook and Pettee Brook have noticeably higher nitrogen concentrations than many other local streams draining less developed or undeveloped watersheds. As College Brook flows from upstream to downstream where it becomes more aerated, ammonium decreases and nitrate increases (Figure 5) indicating that nitrification is occurring in the stream channel. However, an increase in total dissolved nitrogen (Figure 6) indicates that there are additional sources of nitrogen entering the stream as it flows downstream though UNH and Durham. This is possibly from fertilization of the athletic fields, storm water runoff or exfiltration from sewage lines. There is no statistically significant change in nitrate or TDN concentrations from 2000 to 2015 at the station with the longest record (CB01.5).

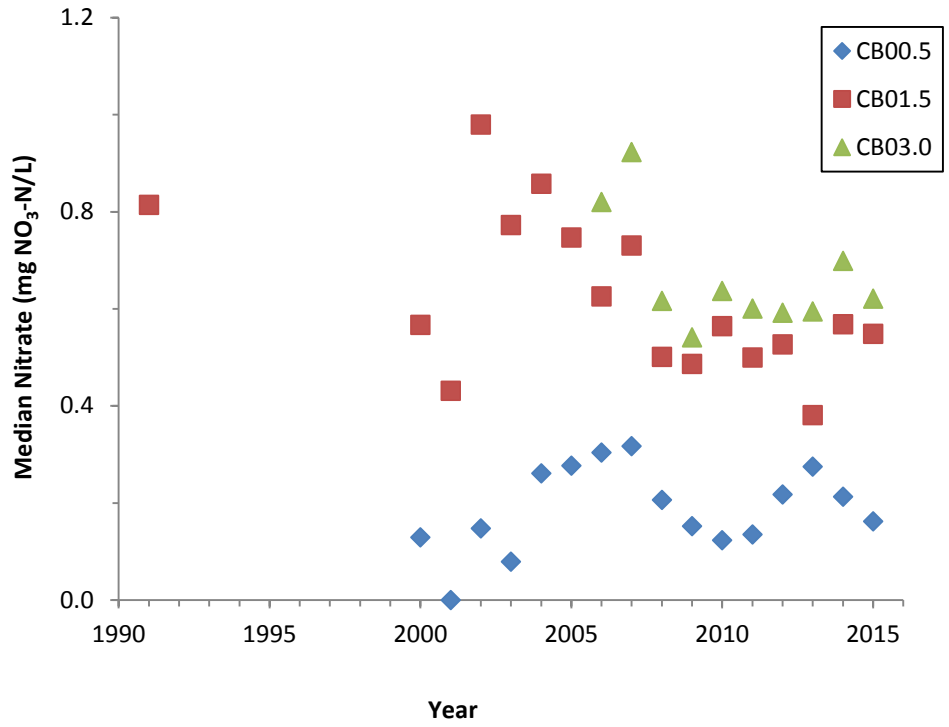

Figure 5. Median annual dissolved inorganic nitrogen (DIN) in College Brook from the headwaters (CB00.5) to the mouth (CB03.0).

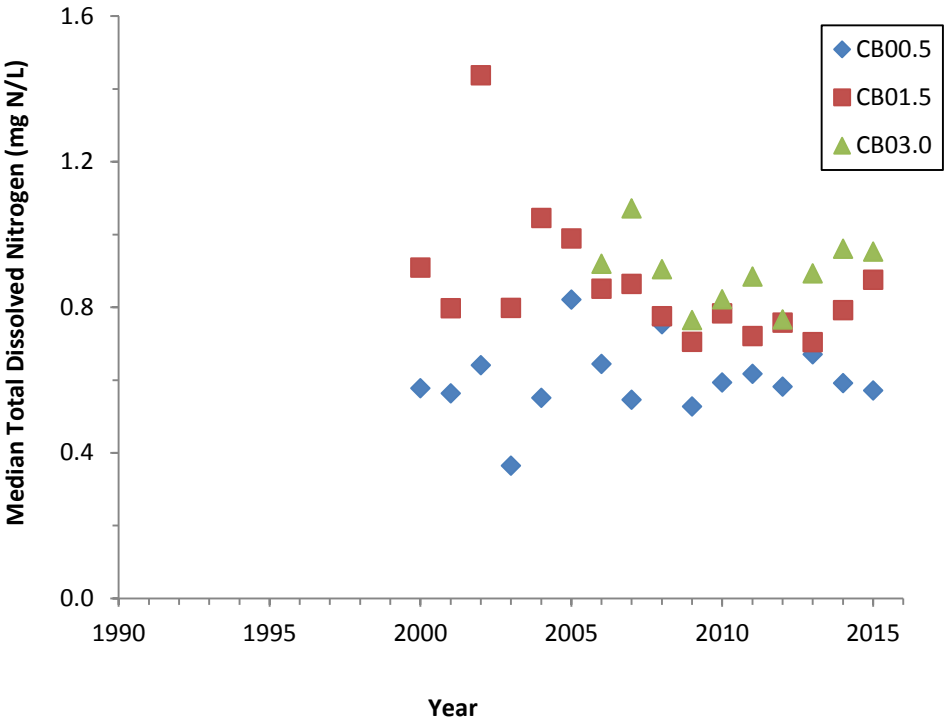

Figure 6. Median annual total dissolved nitrogen (TDN) in College Brook from the headwaters (CB00.5) to the mouth (CB03.0).

Ossipee Watershed

Collaboration with the Green Mountain Conservation Group (GMCG) and their sampling of the Ossipee River watershed provides much benefit to the NH WRRC and the long-term monitoring of rapidly developing suburban watersheds. Volunteers sampled streams within the watershed every 2 weeks from April through October, and monthly winter sampling was conducted by volunteers and GMCG staff at 9 sites. Over 100 samples were collected for analysis in the WQAL and additional field data were collected at over 40 sites throughout 6 towns using the help of many volunteers. Many presentations were made to planning boards, conservation commissions and other local government groups (see information transfer section below). The impact of road salting in this central NH watershed is similar to what we see in coastal NH (Daley et al. 2009). Data have been used to heighten awareness of the impacts of excessive road salting and snow dumping in local streams. Communication with local road agents has led to the remediation in one development where road salting was an issue. Samples collected and data generated from this funding have shown an improvement in water chemistry following reduced salting and snow dumping. Data have also been useful in promoting low impact development techniques and best management practices where new development has been proposed in proximity to lakes, rivers and streams within the watershed.

Notable awards and achievements

Currently NH has 49 watersheds listed as impaired due to elevated chloride levels resulting from salt use in winter road maintenance with the majority of those watershed located in the southern part of the state. College Brook is one of the impaired watersheds and the impairment listing was based on data produced from this project.

Two former undergraduate students at the University of New Hampshire supported previously be this NH WRRC grant are now pursuing a PhD. Chelsea Varrio is pursuing a PhD in Ecology & Evolutionary Biology Dartmouth College and Valerie Schoepfer is pursuing a PhD in Environmental Services at Southern Cross University in Lismore, New South Wales, Australia.

Number of students supported

One Master's student (Bianca Rodriguez), two PhD students (Lauren Koenig and Bianca Rodriguez) 10 undergraduate hourly employees from the Department of Natural Resources & the Environment (Matthew Bosiak, Katie Swan, Shannen Miller, Colleen Dumphy, John Little, John Ciaburri, Casey McGrath, James Casey, Margaret Phillips, Christina Mroz) and 1 undergraduate hourly employee from the Engineering Department (Thomas Brigham). Three post-doctoral students were also supported by this project (Alison Appling, Adam Wymore and Ashley Coble).

References

Daley, M.L. May 2002. Export of Dissolved Organic Carbon, Dissolved Organic Nitrogen and Nitrate from the Lamprey River Watershed, New Hampshire: Examining Relationships with Watershed Characteristics. Master's Thesis, University of New Hampshire, Durham, NH.

Daley, M.L., J.D. Potter and W.H. McDowell. 2009. Salinization of urbanizing New Hampshire streams and groundwater: impacts of road salt and hydrologic variability. Journal of the North American Benthological Society 28(4):929–940.

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Stein, S.M., McRoberts, R.E., Mahal, L.G., Carr, M.A., Alig, R.J., Comas, S.J., Theobald, D.M. and Cundiff, A. 2009. Private forests, public benefits: increased housing density and other pressures on private forest contributions. Gen. Tech. Rep. PNW-GTR-795. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 74 p.

Sundquist D and Stevens M. 1999. New Hampshire's changing landscape. Population growth, land use conservation, and resource fragmentation in the Granite State. Society for the Protection of New Hampshire Forests, Concord, New Hampshire. 110 pp.

Information transfer activities that utilize long-term datasets supported by NH WRRC and matching funds

Publications

Appling, A.P., Leon, M.C. and McDowell, W.H. 2015. Reducing bias and quantifying uncertainty in watershed flux estimates: The R package loadflex. Ecosphere. 6(12): Article 269. DOI: 10.1890/ES14-00517.1.

Kaushal, S.S., McDowell, W.H., Wollheim, W.M., Newcomer Johnson, T.A., Mayer, P.M., Belt, K.T. and Pennino, M.J. 2015. Urban Evolution: The Role of Water. Water. 7:4063-4087. doi: 10.3390/w7084063.

McDowell, W.H. 2015. NEON and STREON: opportunities and challenges for the aquatic sciences. Freshwater Science. 34:386-391. DOI: 10.1086/679489.

Rodriguez-Cardona, B. 2015. Nitrate uptake kinetics in streams: Is carbon the driver? M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 67 pages.

Rodriguez-Cardona, B., Wymore, A.S. and McDowell, W.H. 2016. DOC:NO_3 ratios and NO_3 uptake in forested headwater streams. Journal of Geophysical Research: Biogeosciences. 121(1):205-217. doi:10.1002/2015JG003146.

Wymore A.S., Rodriguez-Cardona B. and McDowell, W.H. 2015. Direct response of dissolved organic nitrogen to nitrate availability in headwater streams. Biogeochemistry. 126:1-10. DOI 10.1007/s10533-015-0153-9.

Conference Proceedings & Abstracts:

Appling, A., Leon, M. and McDowell, W.H. 2015. Optimizing watershed flux estimates: the R package 'loadflex'. Society for Freshwater Science Annual Meeting. Milwaukee, WI. May 17-21, 2015.

Contosta, A., A.C. Adolph, D. Burchsted, M. Green, W.H. McDowell, and the New Hampshire EPSCoR Ecosystems & Society Sensor Team. The Vernal Window Flow Path: a Cascade of Ecological Transitions Delineated at Scales from Points to Pixels. American Geophysical Union Fall Meeting. San Francisco, CA. December 2015.

Koenig, L., L.E. Snyder, W.H. McDowell and C.W. Hunt. 2015. The contribution of aquatic metabolism to CO_2 emissions from New Hampshire streams. American Geophysical Union Fall Meeting. San Francisco, CA. December 2015.

McDowell, W.H. 2015. Aquatic sensor networks: Is there regional coherence in the response of stream chemistry to seasonal and hydrologic drivers? (abstract #90) HydroEco 2015, 5th International Conference on Hydrology and Ecology. Vienna, Austria, 13-16 April 2015.

McDowell, W.H., Potter, J, Snyder, L, Daley, M., Appling, A., Koenig, L, Rodriguez-Cardona, B., Wymore, A. and Brereton, R. 2015. Using a sensor network to understand drivers of nutrient and organic matter concentrations at multiple spatial and temporal scales. Society for Freshwater Science Annual Meeting. Milwaukee, WI. May 17-21, 2015.

Potter, J, McDowell, W.H. and Snyder, L. 2015. Patterns and drivers of specific conductance in New Hampshire rivers. Society for Freshwater Science Annual Meeting. Milwaukee, WI. May 17-21, 2015.

Rodriguez-Cardona, B. and McDowell, W.H. 2015. Influences of DOC on nitrate uptake in suburban streams. Society for Freshwater Science Annual Meeting. Milwaukee, WI. May 17-21, 2015.

Rodriguez-Cardona, B., A. Wymore, L. Koenig, A.A. Coble and W.H. McDowell. 2015. Response of non-added solutes during nutrient addition experiments in streams. American Geophysical Union Fall Meeting. San Francisco, CA. December 2015.

Schade, J.D., J. Bailio, and W.H. McDowell. Nitrate loading and CH_4 and N_2O Flux from headwater streams. American Geophysical Union Fall Meeting. San Francisco, CA. December 2015.

Shattuck, M.D. 2016. Non-Point Nitrogen Sources and Transport in the Great Bay Watershed. NH Water and Watershed Conference. Plymouth, NH. March 18, 2016.

Snyder, L. 2015. NH EPSCoR Intensive Aquatic Sensor Network. Joint NEAEB/NH Water & Watershed Conference: Partnerships for Environmental Progress. Bartlett, NH. March 19, 2015.

Wymore, A., Rodriguez-Cardona, B. and McDowell, W.H. 2015. Patterns of dissolved organic nitrogen (DON) production and consumption with the addition of nitrate (NO_3): Insights into the controls on DON cycling. Society for Freshwater Science Annual Meeting. Milwaukee, WI. May 17-21, 2015.

Zeglin, L., Cooper, S, Utz, R., Ardon-Sayao, M., Bixby, R., Burdett, A., Dodds, W., Griffiths, N.A., Harms, T., Johnson, L., Johnson, S., Jones, J., Kominoski, J., McDowell, W.H., Rosemond, A.D., Trentman, M., Follstad Shah, J., Van Horn, D. and Ward, A. 2015. Synthesis of stream ecosystem responses to nutrient enrichment at multiple trophic levels. Society for Freshwater Science Annual Meeting. Milwaukee, WI. May 17-21, 2015.

Presentations/Information Transfer

Coble, A., Shattuck, M.D., Potter, J.D., McDowell, W.H. 2016. Concentration discharge relationships and long-term trends of solute fluxes vary among flood periods. Annual Lamprey River Science Symposium. University of New Hampshire, Durham, NH. January 8, 2016.

Koenig, L. 2015. Served as the instructor for the STEM mini-course offered August 24-28th through the CONNECT program at UNH (http://www.unh.edu/connect/). The objective of the course is to provide an opportunity for incoming freshmen that come from groups with historically low retention in STEM majors (e.g. low-income, multicultural, first-generation college students) to build community, discover college resources, and bolster skills that are needed to succeed in their academic programs (e.g. writing of lab/research reports, basic math and statistics for analyzing scientific data). There were 7 students in the class, but the broader CONNECT program serves approximately 100 students.

- Students learned about best management practices (BMPs) and discussed how these engineering solutions may help mitigate local nutrient pollution and eutrophication in Great Bay, NH. They measured nitrogen and phosphorus concentrations in stormwater collected at the inflow and outflow of two different stormwater management structures operated by the UNH Stormwater Center (http://www.unh.edu/unhsc/). The students found that the BMPs surrounding the UNH campus were effective in reducing nutrient concentrations in stormwater, and presented these results to the entire CONNECT program at the end of the week.

Koenig, L., L.E. Snyder, C.W. Hunt, and W.H. McDowell. 2016. The contribution of aquatic metabolism to CO_2 emissions from New Hampshire streams. Annual

Lamprey River Science Symposium. University of New Hampshire, Durham, NH. January 8, 2016.

Shattuck, M.D. 2015. Led field trip for undergraduate and graduate students to sites in the Lamprey River Hydrologic Observatory. September 22, 2015.

Shattuck, M.D. 2015. Water Quality Research in the Lamprey River Hydrologic Observatory. Presentation to University of New Hampshire undergraduate class: Studio Soils. October 28, 2015.

Shattuck, M.D. 2015. Urbanization and suburbanization in New Hampshire watersheds. Presentation to University of New Hampshire class: Watershed Water Quality Management. October 6, 2015.

Shattuck, M.D. 2015. Understanding Water Quality Impacts of Farm Practices in Groundwater and Stream Water. Research field day at the University of New Hampshire Organic Dairy Research Farm. Lee, NH. November 4, 2015.

Shattuck, M.D. 2015. Watershed management in practice: Great Bay. Presentation to University of New Hampshire class: Watershed Water Quality Management. December 1, 2015.

Shattuck, M.D., Potter, J., Snyder, L. and McDowell, W.H. 2016. Hydrologic controls on nitrate and specific conductivity in NH streams: New insights using sensor data. Annual Lamprey River Science Symposium. University of New Hampshire, Durham, NH. January 8, 2016.

Wymore, A., Rodriguez-Cardona, B. and McDowell, W.H. 2016. Direct response of dissolved organic nitrogen to nitrate (NO3-) availability in headwater streams. Annual Lamprey River Science Symposium. University of New Hampshire, Durham, NH. January 8, 2016.

Press Releases

Daley, M.L. 2015. Understanding Nitrogen Sources in the Great Bay Watershed. Great Bay Matters. Spring/Summer 2015. http://greatbay.org/documents/gbmspring2015.pdf

Green Mountain Conservation Group meetings, workshops and presentations supported by matching funds

2015

- Thursday, March 26, 6-8pm "What goes up must come down" a moderated forum to celebrate World Water Day, Runnells Hall, Chocorua.
- Saturday April 11 4-8 pm GMCG ANNUAL MEETING—"Raptor Encounter" Sunny Villa Restaurant, Route 16 Ossipee.
- Thursday May 12th 6 pm—Natural Resource Planning—Healthy Septic Systems, Runnells Hall, Chocorua.
- Saturday June 6—Community Kick-off meeting for the "Big Lake" phase of Ossipee Watershed Management Planning Process!
- Thursday June 18, 2-6pm "Bikers for Clean Water", Windows to the Ossipees overlook Route 16, Ossipee.
- Saturday July 18, 3-6pm Heron House Conservation Center Groundbreaking Ceremony 196 Huntress Bridge Road, Effingham.
- Saturday August 15 4-7:30pm Annual Fundraiser Dinner and Auction, Province Lake Golf Club. Thursday August 20, 5 pm Volunteer Celebration 196 Huntress Bridge Road, Effingham.
- Saturday August 22, (rain date: Sunday August 23) Explore Green Mountain with Society for the Protection of New Hampshire Forests. Afternoon hike via High Watch Trail to summit of Green Mountain. Meet at High Watch Road. Please register to receive directions and details at 539-1859.
- Sunday September 20, 3-7pm Fall Music Festival "Loons, Tunes and Spoons", Freedom.
- Thursday October 29, 6:30-8 pm BAT CHAT—What's Up With Bats in New Hampshire?
- Thursday December 3 6-8 pm Youth Water Quality presentation, Ossipee Town Hall

2016

- Wednesday January 13, 4:00pm - Education Steering Committee meeting to help create Water Literacy Curriculum.
- Tuesday, January 19th 4:00pm Watershed Management Plan Phase 2– Ossipee Lake and the Lovell River Watershed Steering Committee Meeting at Indian Mound Golf Club in Ossipee
- Saturday February 6, 10:30am-1:00pm Family Winter Animal Tracking with naturalist Barb Bald!
- Saturday February 27 GMCG 18th ANNUAL MEETING with Project Coyote presenter Chris Schadler