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

Basic Information

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Principal Investigators:	William H. McDowell

Publications

1. Buyofsky, L.A. 2006. Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed. M.S. Dissertation, Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH
2. Proto, Paul J. 2005, The Significance of High Flow Events in the Lamprey River Basin, New Hampshire, for Annual Elemental Export and Understanding Hydrologic Pathways. M.S. Dissertation, Department of Earth Sciences, College of Engineering and Physical Sciences, University of New Hampshire, Durham, NH, 176 pages.
3. Buyofsky, Lauren A. May 2006. Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, MS Dissertation, Department of Natural Resources, College of Life Sciences and Agriculture , University of New Hampshire, Durham, NH, .
4. Legere, K.A. September 2007. Nitrogen loading in coastal watersheds of New Hampshire: an application of the SPARROW model. Masters Thesis, University of New Hampshire, Durham, NH. 75 pages.
5. Traer, K. December 2007. Controls on denitrification in a northeastern coastal suburban riparian zone. Masters Thesis, University of New Hampshire, Durham, NH. 97 pages.
6. Buyofsky, Lauren A., 2006, Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, "MS Dissertation", Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 176 pages.
7. Daley, M.L., J.D. Potter, 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, submitted.
8. Buyofsky, Lauren A., 2006, Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, "MS Dissertation", Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 176 pages.
9. 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.

10. DiFranco, E. 2009. Spatial and temporal trends of dissolved nitrous oxide in the Lamprey River watershed and controls on the end-products of denitrification. M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 108 pages.
11. Daley, M.L. and W.H. McDowell. In Preparation. Nitrogen saturation in highly retentive coastal urbanizing watersheds. Ecosystems.
12. Daley, M.L. 2009. Nitrogen Sources and Retention within the Lamprey River Watershed and Implications for Management. State of the Estuaries Conference. Somersworth, NH. October 2009.
13. Daley, M.L. 2009. Water Quality of Private Wells in Suburban NH and Impacts of Land Use. Northeast Private Well Symposium. Portland, ME. November, 2009.
14. Daley, M.L. 2009. Spatial and Temporal variability in nitrogen concentrations, export and retention in the Lamprey River watershed. Joint NH Water and Watershed Conference. Concord, NH. November, 2009.
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16. Buyofsky, Lauren A., 2006, Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, "MS Dissertation", Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 176 pages.
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18. Dunlap, K, 2010, Seasonal Nitrate Dynamics in an Agriculturally Influenced NH Headwater Stream, M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 102 pages.
19. Galvin, M, 2010, Hydrologic and nutrient dynamics in an agriculturally influenced New England floodplain, M.S. Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 94 pages.
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22. Davis, J.M., W.H. McDowell, J.E. Campbell and A.N. Hristov, 2010, Hydrological and biogeochemical investigation of an agricultural watershed, southeast New Hampshire, USA, American Geophysical Union Fall Conference, San Francisco, CA, December, 2010.
23. Hope, A.J. 2010. Ecosystem Processes in a Piped Stream. Plum Island Ecosystems Long Term Ecological Research All Scientists Meeting, Woods Hole, MA. April 8, 2010.
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25. Buyofsky, Lauren A., 2006, Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, "MS Dissertation", Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 176 pages.
26. McDowell, W.H., M.L. Daley and J.D. Potter, 2011, Dissolved organic matter dynamics in a suburban basin: wetlands and people drive quantity and quality, North American Benthological Society Meeting, Providence, RI, May 2011.
27. McDowell, W.H. and M.L. Daley, 2011, Net Manageable Nitrogen: Definition and Rationale for a new approach to nitrogen management in moderately impacted watersheds, American Geophysical Union Fall Conference, San Francisco, CA, December, 2011.
28. McDowell, W.H. and M.L. Daley, 2011, Net Manageable Nitrogen: Definition and Rationale for a new approach to nitrogen management in moderately impacted watersheds, National Academy Keck

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30. Baillio, J., 2012, Controls on variability of dissolved greenhouse gas concentration and emissions from small streams in southeastern New Hampshire, MS Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 111 pages.
31. Daley, M.L. and W.H. McDowell, In Preparation, Human impacts on stream nitrogen chemistry and watershed N retention across a wide range of rural to urban catchments, Ecological Applications.
32. Liptzin, D., M.L. Daley, and W.H. McDowell. Accepted. A comparison of wet deposition collectors at a coastal rural site. Submitted to Water, Air, & Soil Pollution. April 2013.
33. Parham, L., 2012, Spatial and temporal variation in degradation of dissolved organic carbon on the main stem of the Lamprey River, MS Dissertation, Department of Natural Resources & the Environment, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 66 pages.
34. Hope, A.J., W.H. McDowell, W.M. Wollheim, Submitted, Ecosystem metabolism and nutrient uptake in an urban, piped headwater stream, Biogeochemistry.
35. Buyofsky, Lauren A., 2006, Relationships between groundwater quality and landscape characteristics in the Lamprey River watershed, "MS Dissertation", Department of Natural Resources, College of Life Science and Agriculture, University of New Hampshire, Durham, NH, 176 pages.
36. Hope, A.J., W.H. McDowell, W.M. Wollheim. 2013. Ecosystem metabolism and nutrient uptake in an urban, piped headwater stream. Biogeochemistry. September 2013. DOI 10.1007/s10533-013-9900-y
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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

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. 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 proposal.

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.

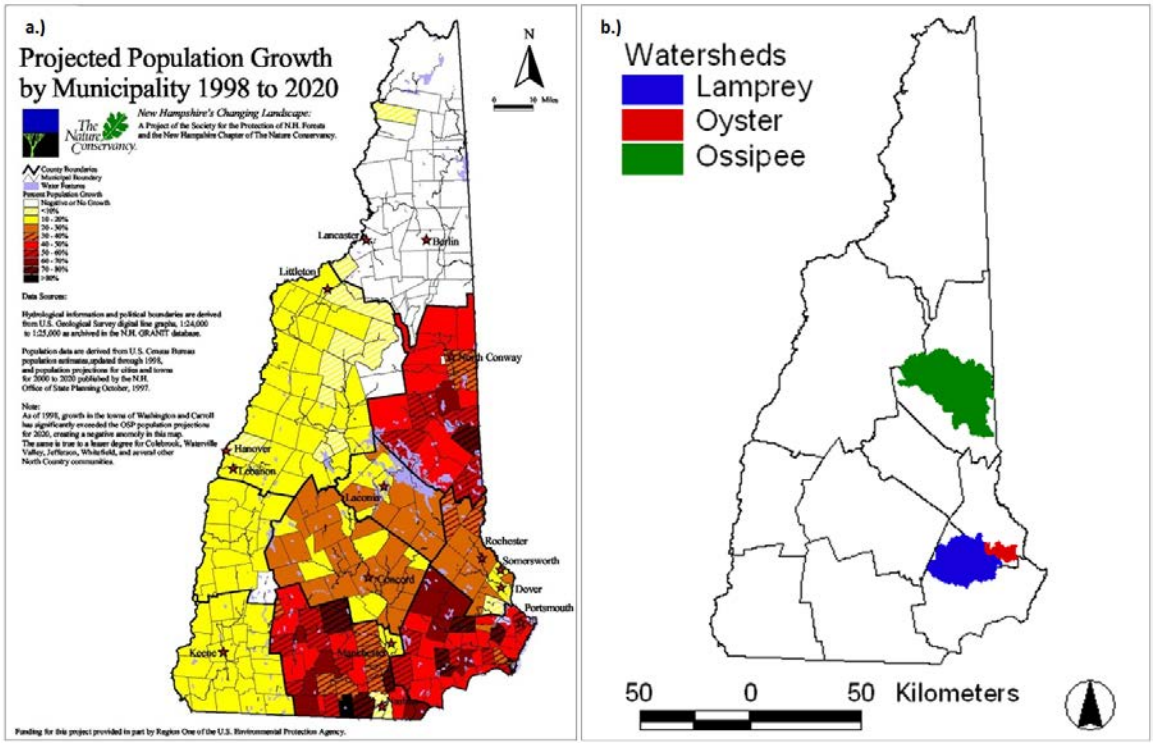

Figure 1. Projected population growth in New Hampshire (Figure from Sundquist and Stevens 1999; A) and study watersheds experiencing high population growth (B).

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, 15 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 also 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 has served as the Laboratory Director and Mr. Jody Potter is the Laboratory Manager. Together, they have over 40 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 from the LRHO has been completed through 2013 and we are in the process of updating the LRHO website (http://www.wrrc.unh.edu/lamprey-river-hydrologic-observatory). Results of stream chemistry to date show a significant increase in nitrate concentrations during the first 10 years (Water Years (WY) 2000-2009) of monitoring at LMP73 and a slight decrease in nitrate concentrations in recent years (Figure 2). There was no significant change in nitrate concentrations at NOR27 or WHB01 over the last 10 years (2004-2013). 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 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). We are unsure if the lower nitrate levels measured in LMP73 during 2010 to 2013 will persist, 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.

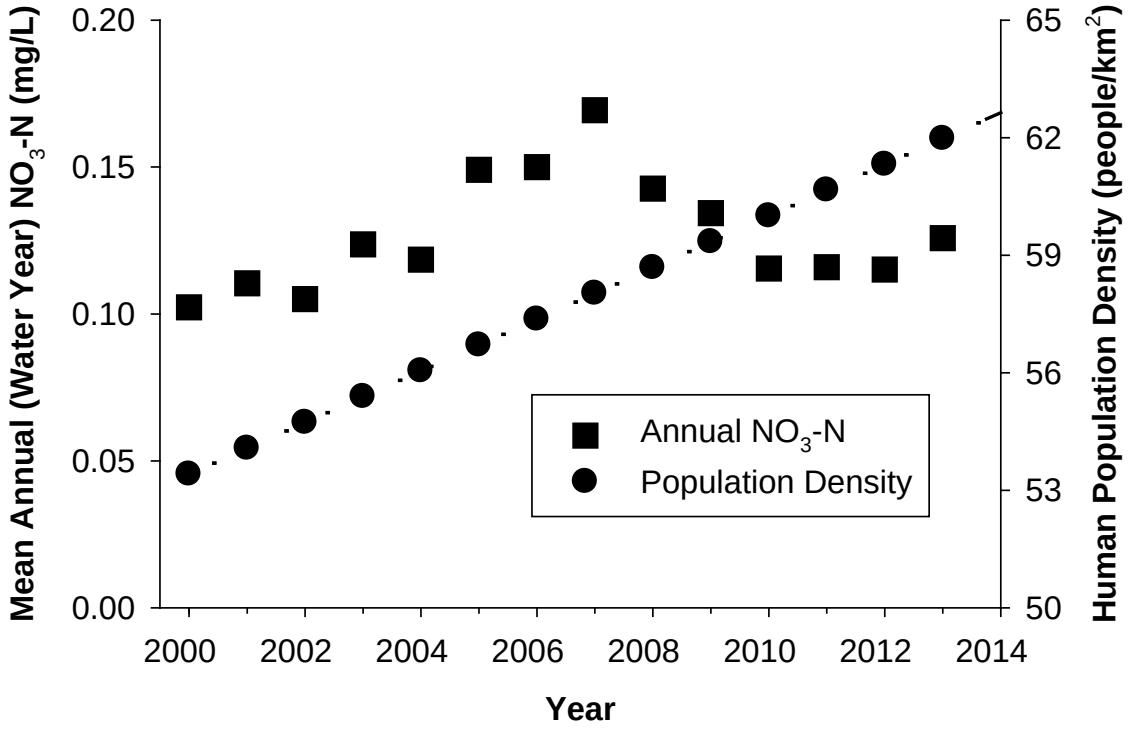

Figure 2. Annual (water year) nitrate concentration and estimated annual human population density from 2000-2013 (2000 and 2010 Census) in the Lamprey River basin. We have applied the Seasonal–Kendall Test (SKT; seasons set to 52) to weekly data from September 1999 through September 2009 and flow-adjusted nitrate concentrations have increased significantly over this time period (SKT $t = 0.28$, $p < 0.01$).

When we combine our specific conductance data (2002 – 2013) with data collected by the USGS (1978 - 1999), we see a long-term increase in specific conductance in the Lamprey River (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 NaCl. Sine 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 temporal change in streamwater NaCl.

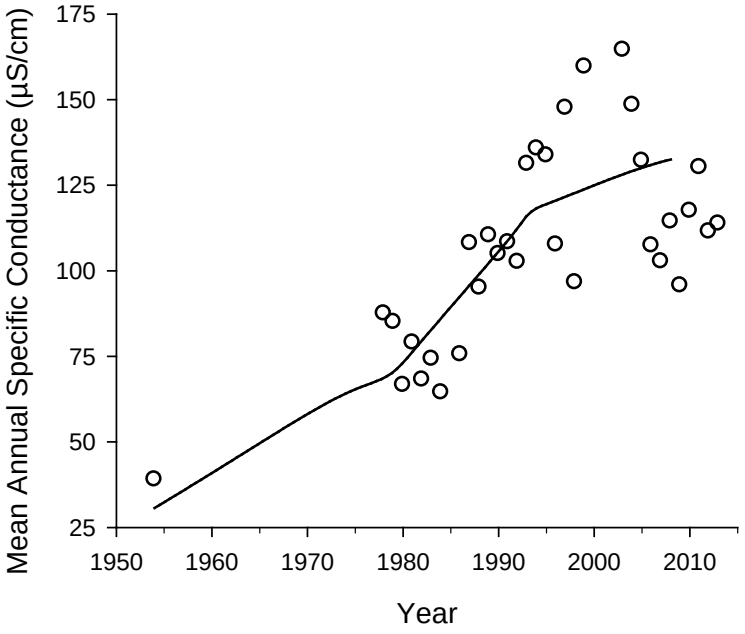

Figure 3. Mean annual specific conductance in the Lamprey River at LMP73 (co-located with the USGS gauging station in Durham, NH. (modified from Daley et al. 2009).

Oyster River watershed

Laboratory analysis of the monthly CB and PB samples is completed through 2013. 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. It is highly unlikely that historical incinerator operations are impacting present day DO levels in this brook as they have in the past.

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. 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.

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 4) indicating that nitrification is occurring in the stream channel. However, an increase in total dissolved nitrogen (Figure

5) 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 2013 at the station with the longest record (CB01.5).

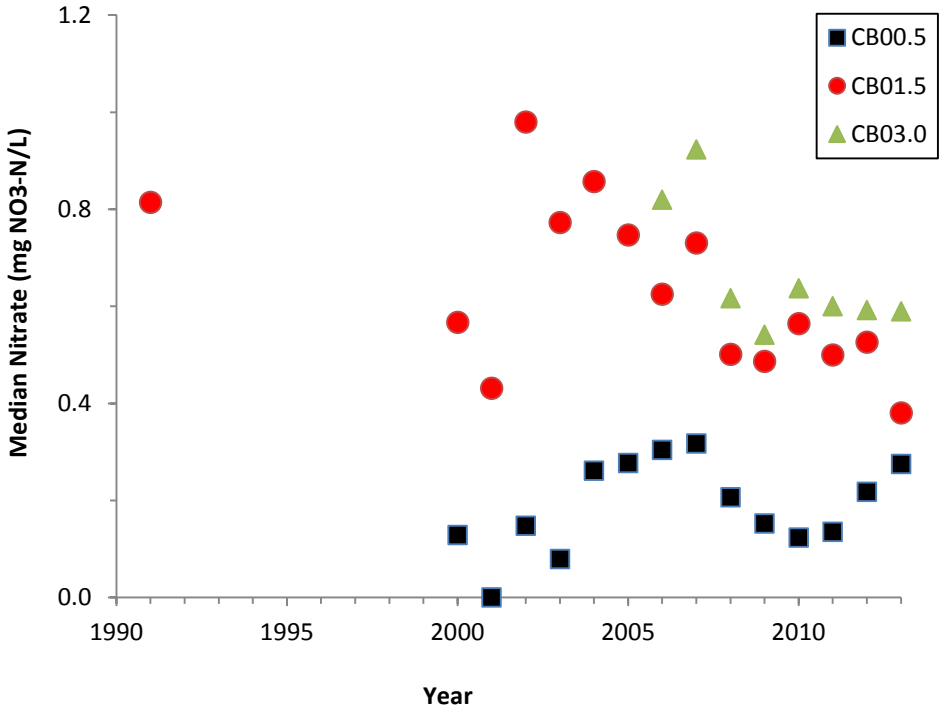

Figure 4. Median annual dissolved inorganic nitrogen (DIN) in College Brook from the headwaters (CB00.5) to the mouth (CB03.0).

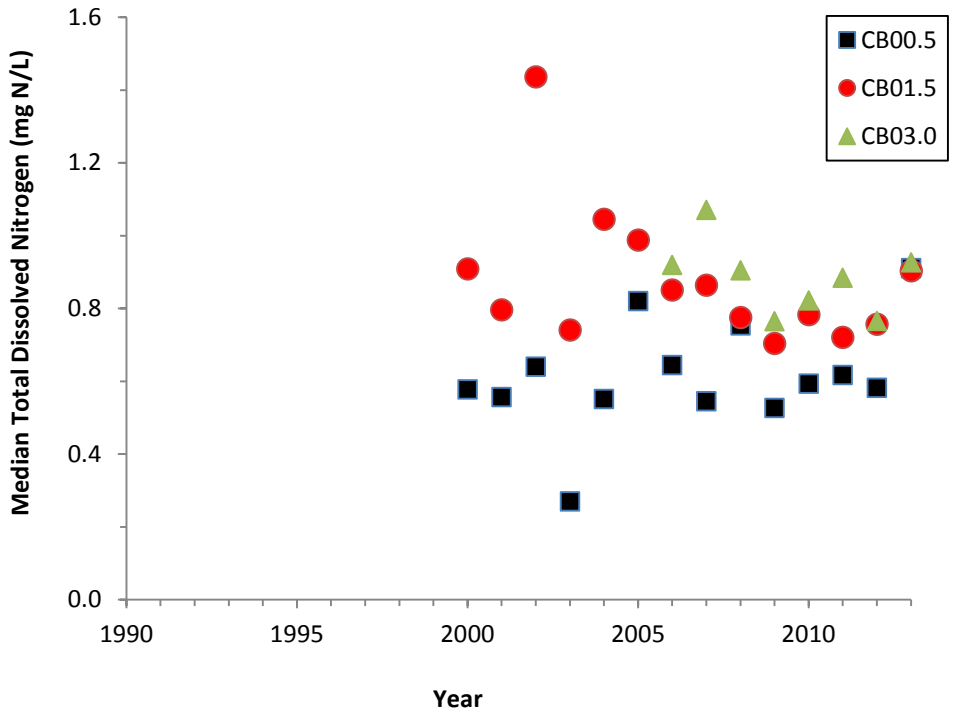

Figure 5. Median annual total dissolved nitrogen (TDN) in College Brook from the headwaters (CB00.5) to the mouth (CB03.0).

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 7 sites. Over 100 samples were collected for analysis in the WQAL and additional field data was 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). Data have been used to heighten awareness of the impacts of excessive road salting and snow dumping in local streams. The impact of road salting in this central NH watershed is similar to what we see in coastal NH. 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

N/A

Number of students supported

Three Master's students (Bianca Rodriguez, Nicholas Shonka and Marleigh Sullivan), 5 undergraduate hourly employees from the Department of Natural Resources & the Environment (Matthew Bosiak, Katie Swan, Shannen Miller, Sarah Tierney and Jessica Pierce) and 1 undergraduate hourly employee from the Engineering Department (Thomas Brigham).

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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.

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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

Daley, M.L. and W.H. McDowell. In Preparation. Human impact on N chemistry in streams visible at lowest population density in a range of suburbanizing basins. In Preparation for Ecological Applications.

Hope, A.J., W.H. McDowell, W.M. Wollheim. 2013. Ecosystem metabolism and nutrient uptake in an urban, piped headwater stream. Biogeochemistry. September 2013. DOI 10.1007/s10533-013-9900-y

Liptzin, D., M.L. Daley, and W.H. McDowell. 2013. A comparison of wet deposition collectors at a coastal rural site. Water, Air, & Soil Pollution. 224(5):1558. 2013.

Conference Proceedings & Abstracts:

Daley, M.L. and McDowell, W.H. 2013. Non-Point Nitrogen Sources and Transport Pathways in the Great Bay Watershed. NH Water and Watershed Conference. Plymouth, NH. March 2013.

Koenig, L. E.; Baumann, A. J.; McDowell, W. H. 2013. Improving automated phosphate analysis to eliminate silicate interference. (Abstract ID: 8116). Annual Meeting of the Society for Freshwater Science, Jacksonville, FL, May 2013

McDowell, W.H. 2013. Soils and stream chemistry: When, where and why are they linked? European Geophysical Union Annual Meeting, Vienna, Austria April 2013 (invited keynote presentation).

McDowell, W.H. 2013. Soils and stream chemistry: When, where and why are they linked? University of Amsterdam, Amsterdam, Netherlands. April 2013.

McDowell, W. G.; Rosemond, A. D.; McDowell, W. H.; Byers, J. E. 2013. Impacts, dead or alive: Effects of mass mortality of an abundant invasive species on ecosystem function. (Abstract ID: 7715). Annual Meeting of the Society for Freshwater Science, Jacksonville, FL, May 2013.

McDowell, W.H. 2013. Linkages between organic matter and carbon levels in surface waters and soils. UNESCO IHE Ecohydrology. Delft, Netherlands. June 2013.

Price, A. J.; Wollheim, W. M.; Mulukutla, G.; and McDowell, W. H. 2013. Headwater catchment nitrogen flux and storm response among land use types through seasons. (Abstract ID: 8050). Annual Meeting of the Society for Freshwater Science, Jacksonville, FL, May 2013.

Smith, Thor E., McDowell, William H., Wollheim, Wilfred M., Daley, Michelle, Mulukutla, Gopal, Baumann, Adam J., Snyder, Lisle, and Price, Allison. 2013. Sampling the Lamprey River watershed across space and time; New data collection efforts toward understanding nitrogen sources. The Geologial Society of America Northeastern Section - 48th Annual Meeting. Omni–Mount Washington Hotel, Bretton Woods, New Hampshire. March 2013. *Abstract accepted but not presented due to federal employee travel restrictions.*

Presentations/Information Transfer

Cripps, M.L. and Daley, M.L. 2013. Ossipee watershed: ten years of water monitoring. Presentation to Green Mountain Conservation Group (GMCG) Research

Committee, Watershed Management Plan Steering Committee, Water Quality Monitoring Volunteers and GMCG Board, Freedom Village, NH. May 15, 2013.

Daley, M.L. and McDowell, W.H. 2013. Aquatic Sensor Networks, Ecosystem Function and Management. NH EPSCoR all hands meeting. Durham, NH. March 28, 2013.

Daley, M.L. 2013. Water Quality: How do you know if it is good or bad? Kingston, NH High School presentation to 180 high school students (9 groups of 20, 20 min each). June 4, 2013.

Daley, M.L. 2013. Non-point nitrogen research in the Lamprey and Great Bay watershed. Great Bay boat tour with the NH House of Representatives Resources, Recreation and Development Committee. June 15, 2013.

Daley, M.L. 2013. Research on nitrogen in the Great Bay watershed: Learn how diffuse sources of nitrogen pollution travel from our communities to the Great Bay. Scheduled for Contemporary Coastal Issues sail on the Gundalow in Portsmouth, NH on August 28, 2013. but sail was cancelled last minute due to fog. Will reschedule.

Daley, M.L. Nitrogen Sources and Transport Update. Nitrogen Sources Collaborative Advisory Board. Lee, NH. August 29, 2013.

Daley, M.L. 2013. Water Quality Research in the Lamprey River Hydrologic Observatory. Presentation to University of New Hampshire undergraduate class: Studio Soils. October 25, 2013.

Daley, M.L. 2013. Presentation on "What it's like to be a scientist and how I became a water quality scientist" to 40 6-8th graders from Epping Middle School during their visit to the University of New Hampshire. November 15, 2013.

Daley, M.L. 2013. Presented preliminary Great Bay N Sources and Transport NERRS Science Collaborative project results to Durham-UNH Integrated Permit and Planning Technical Advisory Committee. Oct 29, 2013.

Daley, M.L. 2014. Presented preliminary Great Bay N Sources and Transport project results to members (Allison Watts and Paul Stacey) of the Water Integration for Squamscott-Exeter (WISE) NERRS Science Collaborative project to aid the project team in designing a water quality monitoring program. January 17, 2014.

Daley, M.L. 2014. Presented preliminary Great Bay N Sources and Transport NERRS Science Collaborative project results to Laura Byergo and Peter Wellenberger from Great Bay Stewards to discuss how this project might inform site locations chosen for the Great Bay Stewards "soak up the rain" effort. Jan 31, 2014

Daley, M.L. 2014. Presented preliminary Great Bay N Sources and Transport NERRS Science Collaborative project results to Mark Zankel and Peter Steckler from The Nature Conservancy (TNC) to discuss how the project can inform the next version of the TNC Land Conservation Plan for New Hampshire's Coastal Watershed. February 26, 2014.

Kobylinski, A. 2013. Gave tour of Thompson Farm AIRMAP facility and demonstrated precipitation collection form a wet-only collector on top of an 80 foot tower to 10 senior environmental chemistry students from Phillip's Exeter Academy. Durham, NH. April 16, 2013.

Koenig, L. 2013. Led 27 Dover High School students on a field trip to assess water quality in an urban stream draining the University of New Hampshire and to tour the UNH Water Quality Analysis Laboratory. May 30, 2013.

McDowell, W.H. and M.L. Daley. 2013. Nonpoint nitrogen sources and transport in New Hampshire's Great Bay watershed. Presented at Nitrogen in Stormwater: Sources and Solutions Workshop, NH DES, Portsmouth, NH May 2013.

- May 16, 2013 Shared Great Bay N stormwater presentation with Carl Delo from EPA

Swan, K. 2013. Spoke to students from the Stream Safari program at McLaughlin Middle School in Manchester, NH on "Why I became a scientist, what I do each day for work and how scientists monitor stream quality". November 13, 2013.

Wollheim, W.W., A. Price, R. Careyu, G. Mulukutla, and W.H. McDowell. 2013. Storm event nutrient monitoring in river networks. Presented at Nitrogen in Stormwater: Sources and Solutions Workshop, NH DES, Portsmouth, NH May 2013.

Press Releases

Daley, M.L. 2013. Clean water: It's everyone's responsibility to reduce pollution and properly manage New Hampshire's land areas to protect our water resources. Blog June 18, 2013. http://ecosystemsandsociety.blogspot.com/2013/06/clean-water-its-everyones.html

Forester Courtland, V. 2013. Upstream Impact: Graduate Students Inspire the Next Generation of STEM Scholars. UNH Today. May 30, 2013. http://www.unh.edu/unhtoday/2013/05/upstream-impact?utm_source=Team+Update%3A+Ecosystems+and+Society+05%2F31%2F2013&utm_campaign=Team+Update&utm_medium=email. Koenig, L. featured in article.

Gillies, J. 2014. New Hampshire stream monitoring network tracks Great Bay nutrient loading. Environmental Monitor. January 16, 2014. http://www.fondriest.com/news/great-bay-new-hampshire-stream-monitoring.htm. McDowell, W.H. interviewed for article.

Morrill, D. 2013. Dogs who really know their business: Trained to find human waste in waterways. Foster's. Aug 2, 2013. http://www.fosters.com/apps/pbcs.dll/article?AID=/20130802/GJNEWS_01/130809822. Daley, M.L. included in article.
Nilsen, E. 2013. New Hampshire Pubic Radio "Statewide Project Looks At Ecosystems and Climate Change." August 21, 2013. http://nhpr.org/post/statewide-project-looks-ecosystems-and-climate-change. Snyder, L. interviewed for article.
Potter, J.D., Godbois, A., Snyder, L. 2013. Cutting edge environmental monitoring comes to New Hampshire. Blog July 17, 2013. http://ecosystemsandsociety.blogspot.com/2013/07/cutting-edge-environmental-monitoring.html.

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

2013

March 23, 9:00am-Noon (field visit from 12:00-1:00pm). Gravel Road Maintenance workshop with Russ Lanoie. Freedom Town Hall, Elm St., Freedom, NH.
March 28, 6:00-8:00pm. Black Bear Presentation. Ossipee Public Library, Main St., Ossipee, NH.

April 6, 10:00am-2:00pm. Well Water testing - Tractor Supply Community Event, Ossipee, NH.
April 13, 10:00am-12:30pm. Volunteer Water Quality Monitoring Training. GMCG Offices, 196 Huntress Bridge Road, Effingham, NH.
April 24 - May 22, 7:00am. Guided morning bird walks hosted by the Tamworth Conservation Commission, Tamworth Town House, Tamworth, NH.
May 23. Well-water testing in Madison. Bring a sample of your well water for a limited but informative analysis.
June 15th Macroinvertebrate stream survey in Eaton.
July 24 th Well Water testing at White Mountain Hypnosis Center, Madison, NH.
July 25, 6:30-8:30 pm. Invasive Insects. GMCG Office, 196 Huntress Bridge Rd., Effingham, NH.
July 30 & Wednesday July 31, 9:00-4:00 pm. Water Topics for Teachers: a water literacy training opportunity for teachers. The Community School, Tamworth, NH.
August 3, 8:30 am-Noon Household Hazardous Waste Day. Ossipee Town Hall, Ossipee, NH.
August 10:00 am-3:00 pm. Get Wild at Sumner Brook, Ossipee NH. GMCG will partner with the Ossipee Conservation Commission to celebrate the natural resources in the Watershed—and come "fish the trout pond."
August 21, 10:00 am-1:00 pm.Volunteer Biological Assessment Training (VBAP). The Community School, Tamworth, NH.
August 22, 10:00am-1:00 pm. Well Water Screening. GMCG Office, 196 Huntress Bridge Rd., Effingham, NH.

September- four schools participate in volunteer Biological Assessment Program (VBAP)

September 13th Freedom Elementary Students help install rain garden at Camp Huckins VBAP stream study with 4 schools September 2013

VBAP Community Presentation with 4 shcools December 6th 2013

2014

Trout in the Classroom- 4 schools raise Eastern Brook trout for release in approved streams

February 13 4-6 pm. Valentines for volunteers- Join us to learn more about volunteering at the Huntress House