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

Basic Information

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Descriptors:	
Principal Investigators:	William H 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.
15. Daley, M.L. and W.H. McDowell. 2009. Nitrogen Saturation in Highly Retentive Watersheds? American Geophysical Union Fall Conference, San Francisco, CA. December, 2009.
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.
17. Daley, M.L., J.D. Potter and W.H. McDowell, 2010, Nitrogen Assessment for the Lamprey River Watershed, Report prepared for the New Hampshire Department of Environmental Services. http://des.nh.gov/organization/divisions/water/wmb/coastal/documents/unh_nitrogenassessment.pdf
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.
20. Daley, M.L., W.H. McDowell, B. Sive, and R. Talbot, In Preparation, Factors controlling atmospheric deposition at a coastal suburban site, Journal of Geophysical Research (Atmospheres).
21. Daley, M.L. and W.H. McDowell, 2010, Landscape controls on dissolved nutrients, organic matter and major ions in a suburbanizing watershed, American Geophysical Union Fall Conference, San Francisco, CA, December, 2010.
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.
24. Hope, A.J. and W.H. McDowell, 2010, Ecosystem Processes in a Piped Stream, Aquatic Sciences: Global Changes from Center to Edge, ASLO & NABS Joint Summer Meeting, Santa Fe, NM, June 2010.
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

Futures Initiative Ecosystem Services Conference, Irvine, CA, November, 2011.
29. Daley, M.L. and W.H. McDowell, In Preparation, Nitrogen saturation in highly retentive coastal urbanizing watersheds, Ecological Applications.

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.

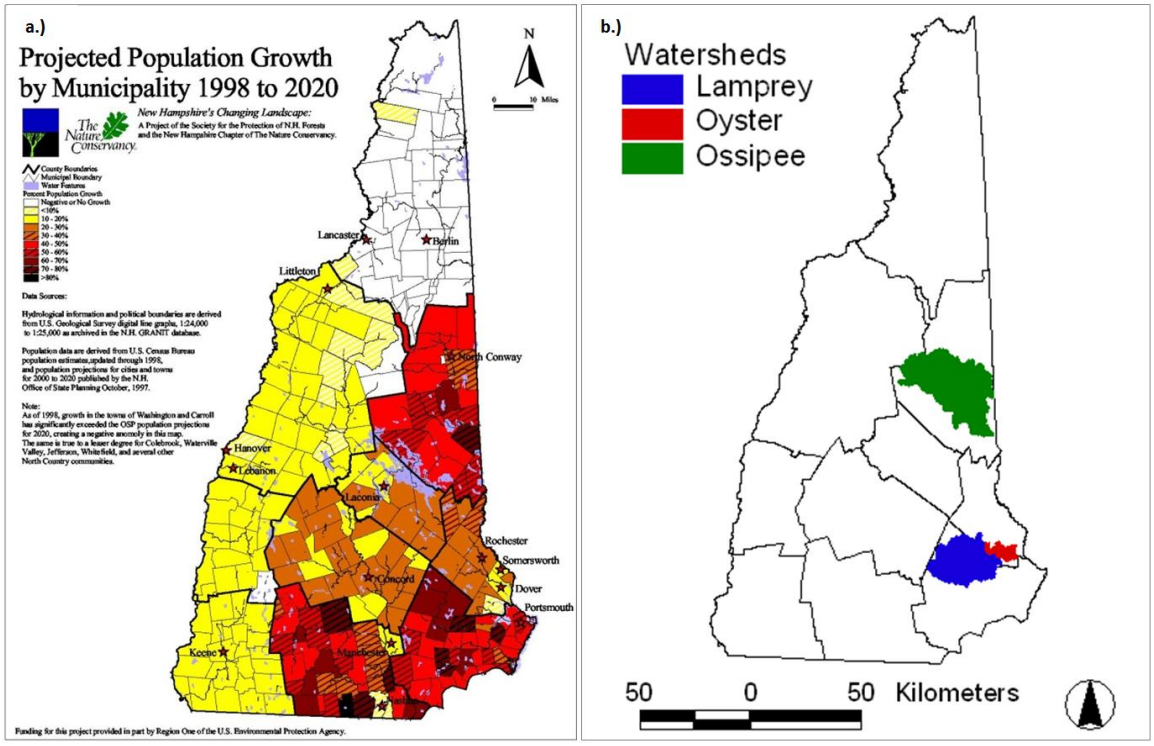

Figure 1. Projected population growth in New Hampshire (Figure from Sundquist and Stevens 1999; A) and study watersheds experiencing high population growth (B).

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, 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 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 is the Laboratory Director and 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 2011 and we are in the process of updating the LRHO website (http://www.wrrc.unh.edu/lrho/index.htm). 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, but nitrate levels have not declined to levels initially measured in 2000 (Figure 2). There was no significant change in nitrate concentrations at NOR27 or WHB01 over a shorter time period (2004-2011). 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. We are unsure if the lower nitrate levels measured in LMP73 during 2010 and 2011 will persist, increase or decrease with changing 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 relatively short period of data collection is not reflective of long-term trends. The long-term increase in nitrate in the

Lamprey River from 2000-2009 has 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. The bay is experiencing dangerously low dissolved oxygen levels and 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. In fact, the NH WRRC recently provided the Town of Newmarket, NH and Underwood Engineers, Inc. with monthly average nitrogen concentrations in the Lamprey River to inform the town's comments to EPA on the draft National Pollutant Discharge Elimination System (NPDES) permit for Newmarket's wastewater treatment facility that would limit nitrogen in the effluent to 3 mg/L.

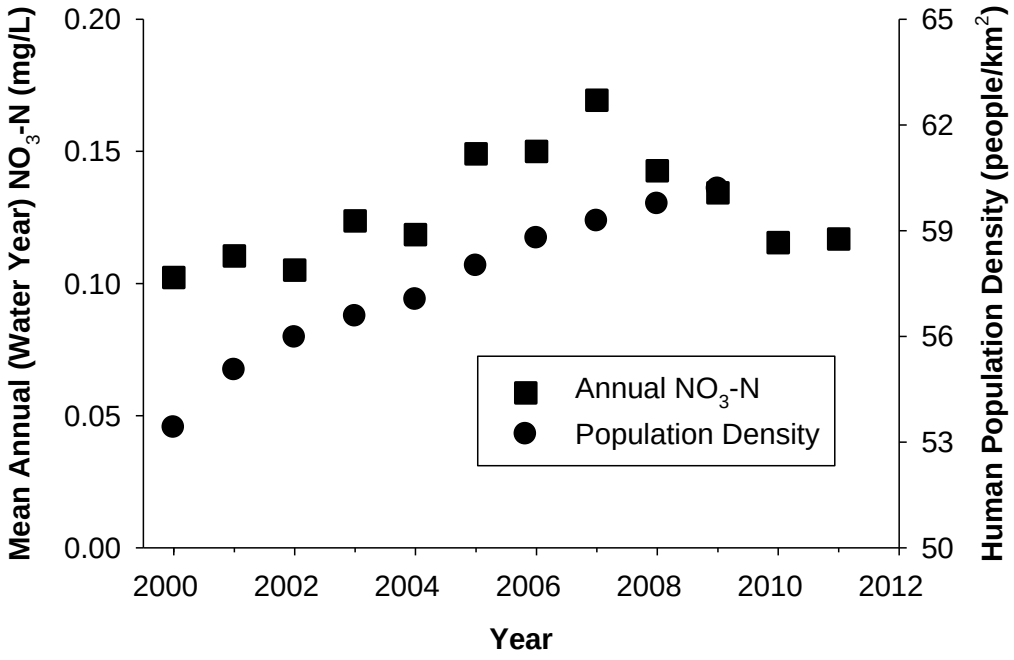

Figure 2. Annual (water year) nitrate concentration and estimated annual human population density over time in the Lamprey River basin. We have applied the Seasonal–Kendall Test (SKT; seasons set to 52) to weekly data from September 1999 through September 2009 and flow-adjusted nitrate concentrations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

When we combine our specific conductance data (2002 – 2011) 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.

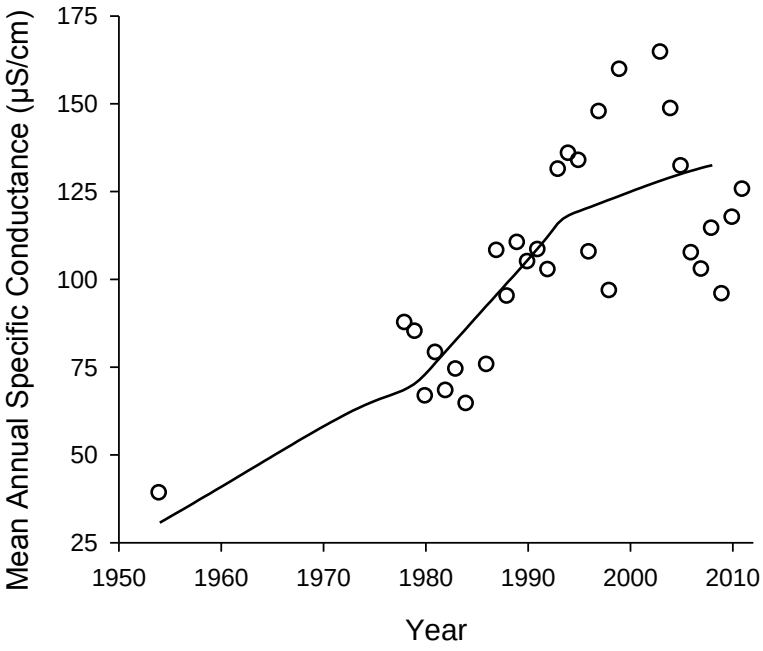

Figure 3. Mean annual specific conductance in the Lamprey River at LMP73 (co-located with the USGS gauging station in Durham, NH. (modified from Daley et al. 2009).

Oyster River watershed

Laboratory analysis of the monthly CB and PB samples is completed through 2010 and partially completed for 2011. We are now in the process of finalizing the 2011 analysis and updating our website: http://www.wrrc.unh.edu/current_research/collegebrook/collegebrookhome.htm.

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.

College Brook and Pettee Brook haves 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 indicating that nitrification is occurring in the stream channel. However, an increase in dissolved inorganic nitrogen (DIN; the sum of ammonium and nitrate) and total nitrogen indicates that there are additional sources of nitrogen to the stream as it flows though UNH and Durham. This is possibly from fertilization of the athletic fields and/or storm water runoff. There also appears to be a slight, but insignificant, increase in nitrate over time. This will need to be closely monitored as managers strive to reduce the nitrogen loading to Great Bay and Little Bay, which are impaired by elevated nitrogen. Excess nitrogen (especially in the form of nitrate) exported from the Oyster River watershed and its urban sub-basins (CB and PB) into Little Bay is cause for concern for watershed managers.

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 rivers and streams within the watershed.

Notable awards and achievements

Results from long-term water quality monitoring in the LHRO have helped leverage funding for additional research on nitrogen cycling in NH's suburbanizing watersheds. Because of the significant interest in nitrogen loading to Great Bay, existing information on the spatial and temporal variability of nitrogen concentrations in the LRHO that are driven by population growth and land use change and the relationships that the NH WRRC has formed with various stakeholders in NH, the NH WRRC faculty and staff (along with other UNH faculty and USGS colleagues) received a grant from NH Sea Grant. The objective of the new research project is to understand the mechanisms that control N exports from the Lamprey River watershed to the Great Bay over a range of climate/flow conditions and to share this understanding with local land use planners and decision makers to inform possible mitigation strategies for reducing locally

generated N inputs. This project will make use of newly developed *in situ* sensors to understand the large variability we have observed in N concentrations measured in weekly grab samples.

Number of students supported

Four Master's students (Michelle Galvin, Amanda Hope, Lucy Parham and Jason Bailio) and 3 undergraduate hourly employees (Sarah Brown, Daniella Williams, Marleigh Sullivan, Katie Swan and Katerina Messologitis).

References

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.

Society for Protection of NH Forests. 2005. New Hampshire's Changing landscape. Population growth and land use changes: What they mean for the Granite State. (Available at: http://www.spnhf.org/research/papers/nhcl2005es.pdf).

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, 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

Publications

Daley, M.L. and W.H. McDowell, *In Preparation*, Nitrogen saturation in highly retentive coastal urbanizing watersheds, Ecological Applications.

Conference Proceedings & Abstracts

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.

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 Futures Initiative Ecosystem Services Conference, Irvine, CA, November, 2011.

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.

Presentations

Daley, M.L., McDowell, W.H. and Bucci, J. 2011. Nitrogen inputs, outputs, retention and concentrations in watersheds of the Great Bay Estuary system. NH Water and Watershed Conference. Plymouth, NH. March 2011. Shared slides with an EPA employee and discussed nitrogen cycling with NHDES employees and a university professor.

Daley, M.L. and McDowell, W.H. 2011. Nitrogen Research in the Lamprey River Watershed and the Great Bay Estuarine Ecosystem. Southeast Watershed Alliance Science Symposium. Portsmouth, NH. May 2011. Shared slides with Zach Henderson for a presentation on nitrogen in the Great Bay watershed given by Woodard & Curran to the Southeast Watershed Alliance.

Daley and McDowell. 2011. Human induced threats to surface and groundwater supplies in NH: a focus on nitrogen and sodium chloride. Drinking Water Source Protection Workshop. Concord, NH. May 2011.

Daley, M.L. 2011. Shared PowerPoint slides on nitrogen cycling, a manuscript on road salt impacts and a nitrogen report from the Lamprey River watershed with Tom Irwin from the Conservation Law Foundation in New Hampshire. May 2011.

Daley, M.L. 2011. Previous Nitrogen Research in the Lamprey Watershed and Current research in the Great Bay Watershed. University of New Hampshire Balancing Resource Management, Land Use and Development Class. Durham, NH. June 23, 2011.

Daley, M.L. and McDowell, W.H. 2011. Identifying Non-Point Nitrogen sources in the Great Bay Watershed and Moving Towards Sustainability. Invited presentation. Joint EPA and NH DES Sustainability on a Shoestring meeting. Concord, NH. June 2011.

Daley, M.L. and McDowell, W.H. 2011. Non-Point Sources of Nitrogen in the Lamprey and Great Bay watershed. Invited presentation. Newington, NH. July 2011. Invitees included Newington conservation commission, selectmen, planning board, sewer commission, and interested residents.

Daley, M.L. and McDowell, W.H. 2011. Viewing Great Bay from a Nitrogen (and Watershed) Perspective. Invited presentation. Great Bay Stewards Bay Views. Greenland, NH. July 2011.

Daley, M.L. 2011. Urbanization and Suburbanization in NH watersheds. University of New Hampshire Watershed Water Quality Management class. Durham, NH. September 2011.

Daley, M.L. and McDowell, W.H. 2011. Non-Point Sources of Nitrogen in the Lamprey and Great Bay watershed. Invited presentation. Newmarket, NH. September 2011.

Daley, M.L. and McDowell, W.H. 2011. Nitrogen Research in the Lamprey and Great Bay watershed. Great Bay Dialogue. Greenland, NH. December 2011.

McDowell, W.H. and Daley, M.L. 2011. Nitrogen Research in the Lamprey River Watershed and the Great Bay Estuarine Ecosystem. US EPA Region 1 meeting. Boston, MA. May 6, 2011. Meet with EPA staff in Boston to discuss non-point N sources in the Lamprey and other watersheds.

McDowell, W.H. Biogeochemistry of a Suburban Basin. Chinese Research Academy of Environmental Sciences. Beijing, China. September 2011.

McDowell, W.H. Biogeochemistry of a Suburban Basin. Chinese University of Geosciences. Wuhan, China. September 2011.

McDowell, W.H. Biogeochemistry of a Suburban Basin. China Three Gorges University. Yichang, China. September 2011.

Press Releases

Daley, M.L. and McDowell, W.H. 2011. "Sewer Plants in Great Bay Face Tougher Clean Water Standards" by Amy Quinton NH Public Radio. http://www.nhpr.org/sewer-plants-great-bay-face-tougher-clean-water-standards May 20, 2011.

Green Mountain Conservation Group meetings, workshops and presentations March 2011 - February 2012.

March 4th Youth Coalition for Clean Water hosts Bag It film at local high schools
March (after school program on Weds.) Youth Coalition for clean water presents Cool Water Kids to Ossipee Middle School students. They create rain barrels and storm drain stenciling.
March 10th Ossipee Aquifer Steering Committee Meeting debrief from Aquifer ordinance
March 12th Effingham Students present VBAP to Town Meeting
March 29th GET Wet presentation at Ossipee Central School
March 16th Effingham Students present GET WET water information to town

March 30th Youth Coalition partners with Garden Club on BMP project-Rain Garden
April 16th Water Quality Monitoring 2011 Volunteer Training
April 29th Ossipee Aquifer Steering Committee final meeting to debrief after town meeting votes
April Training for GMCG Reps to deliver information to town officials about Water Quality
May 10th Source Water Conference in Concord
May 12th Ossipee Central School water testing program
May 15th Pequawket Foundation WQM presentation
May 20th Ossipee Watershed Coalition meeting with Ossipee BOS
June 1st Ossipee Central School GET WET! & water quality presentation
June 1st Camp Calumet Rain Barrel installation with Youth Coalition
June 3rd Duncan Lake BMP Project with Girl Scouts
June 8th Mustang Academy Madison WQM RIVERS program
June 9th Camp Director Meeting & Presentation/training for 2011 season
June 11th Ossipee Lake Alliance meeting ---economics of milfoil management
June 22th Drive Time Radio Program WQM 2011
June 25th NH Lakes Congress Conference
July 7, 8, 21, 22 Volunteer Lake Assessment Program & WQ Programs with Camps Cody, Huckins, Robin Hood, Marist & Danforth Bay
July 6, 20, Aug. 3 WQ Programs/Ossipee Lake & Tributary testing with Camp Calumet
July (once a week) Madison Library Kids Program on Macroinvertebrates
July 23 Presentation on priorities for water quality protection on Ossipee Lake and prep for possible Watershed Management Plan in 2013
August 6th House Hold Hazardous Waste Day and hand out of GET WET well sampling kits
August 9th State of the Lake forum on Water Quality
August 10 GET WET water sampling day at Huntress House (GMCG office)
August 24 VBAP, Trout in the Classroom & WQM Volunteer Training at Community School with NH Fish and Game
September 7-30th VBAP Programs & WQM daily with Ossipee Central School, Effingham Elementary, The Community School, Freedom Elementary, Sandwich Elementary School
October 4th Rain Garden Training with Garden Club
October 28th Salt workshop for road agents with UNH Storm Center T2
October 29th Regional Road Salt Reduction Workshop with UNH T2 in Chocorua
November 12th Ossipee Aquifer Steering Committee Meeting
December 1st Student WQM Presentation in Tamworth of VBAP & WQ for 2011
December 8th Trout in the Classroom training
December 10th Bald Eagle presentation with NH Audubon
January 14, Ossipee Aquifer Steering Committee Meeting
January 21 Annual meeting and Water Quality presentation
February Training for GET WET program
February 15th 2011 Kingswood Fair for Youth Coalition for Clean Water
February 20th Drive Time Radio Program
February 17th GET WET! & WQM Training Madison