NERRS Science Collaborative Progress Report for the Period 3/1/2013 through 8/31/2013

Project Title: Nitrogen Sources and Transport Pathways: Science and Management Collaboration to Reduce Nitrogen Loads in the Great Bay Estuarine Ecosystem

Principal Investigator(s): William H. McDowell (UNH, NH WRRC; Lead PI), John P. Bucci (UNH, NH WRRC), Erik Hobbie (UNH, Stable Isotope Laboratory), Charlie French (UNH Cooperative Extension), Michelle Daley (UNH, NH WRRC), Jody Potter (UNH, NH WRRC), Steve Miller (Great Bay NERR) and Phil Trowbridge (NH DES, PREP).

Project start date: 09/01/2010

Report compiled by: William H. McDowell, Michelle Daley, Charlie French Steve Miller and Chris Keeley

Contributing team members and their role in the project: William H. McDowell (oversees all project activities), Michelle Daley (manages field work, works collaboratively with stakeholders and is responsible for GIS analysis and data synthesis), Charlie French (science integration co-lead), Steve Miller (science integration co-lead), Chris Keeley (assists with science integration), Jody Potter (manages laboratory analyses and is responsible for caffeine and optical brightener analysis), John P. Bucci (responsible for mitochondrial (mt) DNA analysis) and Erik Hobbie (responsible for isotopic analysis of sediment)

Nitrogen Sources Collaborative-Science Advisory Board members: Members represent a diverse group of stakeholders from the Great Bay watershed including municipal planners and decision-makers, representatives of non-profit organizations, and local and regional businesses. All volunteer their time to meet, engage with the research team, learn about the research being conducted, and discuss how the research results can make a positive impact in the Great Bay watershed.

A. Progress overview: State the overall goal of your project, and briefly summarize in one or two paragraphs, what you planned to accomplish during this period and your progress on tasks for this reporting period. This overview will be made public for all reports, including confidential submissions.

Overall goal of the project: To detect non-point nitrogen sources and transport pathways in the Great Bay watershed while engaging decision makers in the science to ensure results are useful and will ultimately help reduce nitrogen loads in the Great Bay estuarine system.

Revised Project Objectives (based on stakeholder feedback described previously):

1. Integrate scientific investigations with stakeholders to ensure results are useful and accessible to environmental managers and other stakeholders
2. Identify, model and map N concentrations in surface waters throughout the Great Bay Watershed to identify "hot spots"
3. Identify non-point sources of N that reach surface waters and the delivery pathway (e.g. groundwater vs. stormwater) using tracers
4. Quantify N attenuation in large river reaches by modeling N inputs and outputs and inferring N attenuation

During this reporting period our goal was to work on objectives 1, 2 and 3. We planned to host a meeting with our Nitrogen Sources Collaborative Advisory Board (NSCAB), distribute our Great Bay nitrogen sources newsletter: "Nitrogen Sources Newsbytes", collect samples from intensive sties, analyze samples from both extensive and intensive sites, assess watershed characteristics for stream sites in collaboration with the New Hampshire Geological Survey (NHGS) using GIS layers developed or used by NH DES in the Great Bay Nitrogen Pollution Sources Study (GBNPSS), and begin to develop and apply landscape models that predict nitrogen concentrations based on watershed characteristics. We held an NSCAB meeting in August where we gave a project update, discussed the 1 year no cost extension and the NSCAB's involvement over the next year, and started to dig into the types of products that could come out of the project (see discussion of NSCAB meeting in Part B). A "Nitrogen Sources Newsbytes" newsletter was released in April which included an update on the project, a survey, an announcement of the public forum with Carol Shea-Porter on "The Future of Great Bay" and an announcement of the Green Infrastructure RFP for Great Bay communities. The more than 1100 extensive samples have been analyzed to assess the range of nitrogen concentrations in streams throughout the watershed and to look for nitrogen "hot spots". Intensive sites were sampled in June, July and August for isotope analysis and in August a select number of intensive sites were included in a collaborative effort with the town of Durham to detect human waste in waterways using canine detection. In May, NH DES released the draft GBNPSS report which included a detailed description of their methods used to estimate non-point nitrogen sources from human waste, animal waste and chemical fertilizer in the watershed. Spatial datasets on managed turf (e.g. golf courses, parks and ball fields) and the density of septic systems and human population at the Census block level (Census 2010) were included in the draft report. We used the septic and Census 2010 population data released by NH DES to determine the total population density and the population density relying on septic systems for our study watersheds. We also determined the land use for our watersheds using the same land cover data used by NHDES in the

GBNNPPSS (NOAA CCAP 2006 Land Cover). Great Bay landscape models that predict nitrogen concentrations based on watershed characteristics were explored using simple linear regression analysis.

B. Working with Intended Users:

- Describe the progress on tasks related to the integration of intended users into the project for this reporting period.

Our main mechanism for integrating intended users into the research project is the Nitrogen Sources Collaborative Advisory Board (NSCAB) and electronic distribution of the Nitrogen Newsbytes Newsletter. NSCAB members include civic leaders, community decision-makers, business owners, and others who have a stake in the Great Bay nitrogen issues and want to help ensure that good science leads to sound community decision-making. Typically quarterly NSCAB meetings are held to discuss project objectives, progress towards objectives, next steps and final products.

Winter 2013:
The project team communicated via email and phone to the NSCAB to gain input on how to move forward with outreach, and opportunities to participate in workshops and presentations on the nitrogen issue, including the release of the NHDES study and several talks given by Michelle to other groups. Due to the significant increase in water sampling and the time required for analysis, the delay of the release of the GBNNPPSS, and in the interest of effectively utilizing the time of the NSCAB volunteers, the project team felt it was appropriate to postpone the spring meeting with the NSCAB until there were new, more complete results to review.

NSCAB Meeting August 29, 2013:
In June, the integration team worked with the NSCAB to select a date for the NSCAB to meet. The first available date that all interested NSCAB members could meet was August 29, 2013. The NSCAB met on August 29 for a very productive meeting. The agenda included an update and discussion on the following:

- significant progress in the lab with water sample analysis
- newly generated GIS analysis of the watershed characteristics for the study sites
- analysis correlating nitrogen levels to population levels, forest cover and other land use types
- one year no cost extension for the project
- further development of final products for stakeholders from this project
- development of a NSCAB work and meeting timeline for the next year.

In addition to updating the NSCAB on the large amount of progress made by the science team, Michelle presented for the first time how nitrogen levels relate to population density and land use types through the entire Great Bay watershed. This led to a robust discussion about the Nitrogen Sources project, including how it relates to other nitrogen projects and studies recently completed or in the works (e.g. GBNNPPSS). This discussion was central to

a discussion that followed on the products and delivery methods for the results of the Nitrogen Sources Study (see below).

The one-year no-cost extension for the Nitrogen Sources Project was explained and discussed. The NSCAB members in attendance were receptive to the extension and shared the belief that the extension provided an opportunity to research and refine the final products and methods of delivery of the Nitrogen Sources Study. The team gathered feedback from the NSCAB on several options for final products. We have had numerous discussions about an interactive on-line map site. The NSCAB members provide clear and valuable advice on many aspects of producing effective methods to deliver the results, including: a healthy discussion of the difference among our target towns in their internal capabilities and resources, that most towns do not have GIS staff or capabilities, and that any maps produced must be highly accessible to all. An example was given of how the Wildlife Action Plan maps can be downloaded for each town very easily on the WAP website – no need for GIS or highly technical resources, that more often maps are forgotten and not incorporated into normal town procedures and planning processes, that results of the project should be summarized in an easy to digest summary or "4 pager", that each town should be able to simply access all the data from their town as well as other towns, and a discussion of various methods to deliver all of the above including meeting with land use boards in each town. The NSCAB did also discuss the limitation of resources available to this project for final product development and dissemination as well as the need for a review of the project goals as they relate to final products.

Although involvement of the NSCAB was slightly less than first anticipated for the last 6 months while the research team took the time necessary to generate new information for discussion, looking forward, the NSCAB will be fully engaged on a routine bases (quarterly meetings) to produce effective transfer methods for the Nitrogen Sources project. The NSCAB will meet next on Dec. 5, 2013 where the team will present mock-ups of various methods to disseminate the results of the project. Between NSCAB meetings, the research team will continue to keep the NSCAB updated on this project as well as all the other nitrogen efforts in the watershed through email conversations and the newsletter.

Nitrogen Newsbytes Newsletter: The integration team worked with the scientists and local partners to issue the fifth Nitrogen Newsbytes newsletter in April 2013 which included an update on the project, a brief "next steps" survey to gauge the readership's interest and capacity for supporting a variety of homeowner- and community-based actions for reducing total nitrogen in Great Bay, an announcement of Congresswoman Carol Sea-Porter's public forum, "The Future of Great Bay," and an announcement of the related "Green Infrastructure for Sustainable Coastal Communities" Request for Proposals for technical assistance with green infrastructure (a project concurrently funded by the NERRS Science Collaborative). The newsletter continues to be a supplemental method for transferring information to stakeholders as well as collecting their input on questions that drive the activities of the project. The list of subscribers has grown to 130 people representing diverse interests (e.g. sewer districts, conservation and watershed organizations, taxpayers, businesses, national Senator staffers (Shaheen), etc. Looking forward, the project team intends to continue issuing the newsletter on a quarterly basis. The next issue will feature a project update that captures

the results of the recent NSCAB meeting, explains the continuation of the project, and how the project team and NSCAB are now in the stages of developing meaningful products to help bring the project results into use.

Presentations to and discussions with local stakeholders and intended users on nitrogen issues in the Great Bay watershed

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.

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.

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.

- What did you learn? Have there been any unanticipated challenges or opportunities?

  Key lessons learned are:

  - Despite disagreement about the magnitude of the nitrogen problem in Great Bay, and the drivers of the problem, NSCAB members and community stakeholders want to see the science conveyed in a form that is not only understandable to the lay person, but also usable by decision-makers.
  - The NSCAB is fully engaged and deeply interested in this and other nitrogen studies. They have demonstrated through their questions that they understand the issue and that they want to be sure the work being done is trusted and used.
  - The electronic Nitrogen Newsbytes Newsletter is an excellent vehicle for getting out information as well as providing a feedback loop to get input from stakeholders on the work.
  - There is very strong interest in this Nitrogen Sources and Transport study on the part of the public, the Southeast Watershed Alliance (SWA), NH DES, the UNH Stormwater Center, seacoast organizations, and other stakeholders who are not on the NSCAB.
  - Members of the NSCAB voiced a strong interest in the concept of "nitrogen hot spots." They want to know where they were, and expressed that town-level maps identifying such areas would be of great interest to local decision-makers.

- Who has been involved?

The NSCAB, Sewer District representatives, state environmental services staff, Lamprey River Watershed Association, Lamprey River Advisory Committee, Oyster River Watershed Association, Oyster River Local Advisory Committee, Trout Unlimited, Southeast Watershed Association, Newmarket Town Council and Conservation Commission, Marine Docents, US Senator Shaheen's office (via newsletter), state representatives (Spang, Borden, etc.).

- Has interaction with intended users brought about any changes to your methods for integration of intended users, the intended users involved, or your project objectives?

During this reporting period, interaction with intended users was primarily focused on shaping the products that will be developed. Continued support from NSCAB will be critical to informing products, particularly electronic map-based products given the concerns about local capacity for GIS voiced by advisory board members. Now that the sampling and analysis is nearly complete, and since the NSCAB has been engaged throughout that process in learning about the sampling procedures, we will have a much greater opportunity for gaining input on how to disseminate the results in a meaningful way.

- How do you anticipate working with intended users in the next six months?

The NSCAB agreed to continue meeting quarterly over the next year, with the next meeting scheduled for December 5, 2013. The project team will continue to utilize the Nitrogen Newsbytes Newsletter to keep the NSCAB and broader community of stakeholders apprised of project activities. When there are opportunities to present to interested stakeholders, this nitrogen sources and transport project team will welcome the opportunity. The integration team and science team will participate in one or more nitrogen workshops that focus on best management practices, including another presentation at the annual Lamprey River Science Symposium. A timeline for the next six months (Year 4, Q1 and Q2) as well as the remainder of the project can be found in Table 1.

Table 1. Previously revised objectives and activity timeline.

List Project Objectives, Products, Activities	Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Objective 1:Integration of Science with End Users								
Engage stakeholders in framing the research questions	Completed							
Utilize NSCAB to guide the science objectives and desired products	x	x	x	x	x	x	x	x
Great Bay nitrogen sources newsletter: "Nitrogen Sources Newsbytes"	x	x	x	x	x	x	x	x
Adapt science in the field to address stakeholder input/needs	Completed							
Stakeholder analyses and review of findings	x	x	x	x	x	x		
Develop products that are useful for decision-makers		x	x	x	x	x		
Explore publication products with stakeholders				x	x	x		
Objective 2: Identify, model and map N concentrations to identify "hot spots" – Extensive sites								
Site Designation								
Assess catchment characteristics as delineated and described by NH Geological Survey (NHGS)	Completed							
Select ~250 study sites and generate maps necessary for initial sample collection	Completed							
Revise study site locations after site visit, sample collection and analyses	Completed							
Revise maps necessary for field collection	Completed							
Field sampling and Laboratory analyses								
Collect stream samples from extensive sites	Completed							
Process and analyze stream samples from extensive sites	Completed							
Compile data for analyses of N concentrations	Completed							
Create models and maps of N concentrations and "hot spots"								
Delineate watersheds for final extensive sites and characterize attributes (land use, population density, impervious cover etc.)	Completed							
Apply Lamprey DIN vs. population density model to extensive sites	Completed							
Develop Great Bay landscape model that predict N concentrations	x	x	x	x	x			
Identify "hot spots" where N concentrations are higher than expected	x	x	x	x	x			

List Project Objectives, Products, Activities	Year 3				Year 4			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Map N concentrations and "hot spots"	x	x	x	x	x			
Apply N model to NHGS catchments (~3500) and identify those at risk for high N				x	x	x		
Share available data with NHDES for accuracy assessment of nitrogen pollution source study	x	x	x	x	x	x		
Objective 3: Identify N sources in surface waters and the delivery pathway – Intensive sites								
Select ~12 study sites that represent a single N source to test tracers	Completed							
Collect source water samples from tracer testing sites and analyze N fractions	x	x	x	x	x	x		
Isotopic analysis (^{15}N , ^{18}O) of nitrate source water	x	x	x	x	x	x		
Caffeine, optical brightener and mitochondrial DNA analysis of source water	x	x	x	x	x	x		
Sediment collection and ^{15}N analysis of tracer testing sites	Completed							
Select ~8 "hot spots" study sites to apply tracers	x	x	x	x	x	x		
Collect water and sediment samples from tracer application sites during baseflow and storms	x	x	x	x	x	x		
Analyses of tracers and N fractions at tracer application sites	x	x	x	x	x	x		
Data analyses	x	x	x	x	x	x		
Prepare statistical (ongoing and final) analyses	x	x	x	x	x	x		
Objective 4: Estimate N attenuation in large river reaches								
Model N inputs and outputs and infer N attenuation					x	x	x	
Prepare Publications						x	x	x

C. Progress on project objectives for this reporting period:

- Describe progress on tasks related to project objectives for this reporting period.

Progress on **objective 1**: Integrate scientific investigations with stakeholders to ensure results are useful and accessible to environmental managers and other stakeholders

See section B

Progress on **objective 2**: Identify, model and map N concentrations in surface waters throughout the Great Bay Watershed to identify "hot spots".

More than 1100 extensive samples have been analyzed to assess the range of nitrogen concentrations in streams throughout the watershed and to look for nitrogen "hot spots" and "cold spots". We consider "hot spots" sites that have noticeably high N or higher N than we would expect given the watershed's human population density and land use. Similarly, sites that have noticeably lower N than we would expect are considered "cold spots". Data show that several sites exhibit median dissolved inorganic nitrogen (DIN; Figure 1), dissolved organic nitrogen (DON; Figure 2) and total dissolved nitrogen (TDN; Figure 3) concentrations well above the 0.45 mg/L total nitrogen (TN) threshold for assessing impairment of dissolved oxygen in tidal rivers and the Great Bay. Maximum DIN concentrations reached 3.9 mg N/L and maximum DON concentrations reached 1.2 mg N/L among individual samples suggesting that some of these sites are "hot spot" sites.

In May, NH DES released the draft GBNPSS report which included a detailed description of methods used to estimate non-point nitrogen sources from human waste, animal waste and chemical fertilizer in the Great Bay watershed. Spatial datasets on managed turf (e.g. golf courses, parks and ball fields) and the density of septic systems and human population at the Census block level (Census 2010) were released with the draft report. We used the septic data generated by NH DES and the Census 2010 population data to determine the total population density and the population density relying on septic systems for our study watersheds. We also determined the land use for our watersheds using the same land cover data used by NHDES in the GBNNPPSS (NOAA CCAP 2006 Land Cover).

As a first step in developing landscape models that predict N concentrations in the Great Bay watershed, we used simple linear regression analysis to assess the relationship between median nitrogen concentrations and watershed land use/cover (developed, agriculture and wetland) and human population density. Human population density was the best single predictor of median DIN concentrations (r^2=0.17, $p<0.01$; Figure 1) and developed land use (r^2=0.14, $p<0.01$) was also a significant predictor. DIN concentrations were not related to agriculture and had a weak negative correlation with forests and wetlands. Wetland cover was the best single predictor of median DON concentrations (r^2=0.28, $p<0.01$; Figure 1) and DON was weakly related to agriculture (r^2=0.04, $p<0.01$). DON concentrations were not related to human population density or development and had a weak negative correlation with forest cover. Human population density was the best single predictor of median TDN concentrations (r^2=0.18, $p<0.01$; Figure 3) and developed land use (r^2=0.12, $p<0.01$) was also

a significant predictor. TDN concentrations were not related to agriculture or wetland cover, but were negatively correlated with forest cover (r^2=0.17, p<0.01).

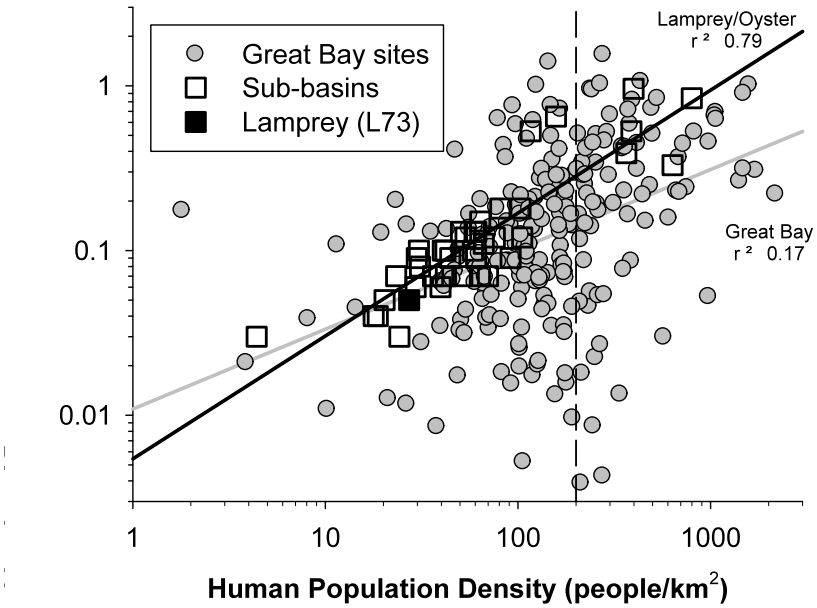

Figure 1. Mean dissolved inorganic nitrogen (DIN) among Lamprey and Oyster sub-basins (open squares), the Lamprey River at Packers Falls (closed square) and median DIN among Great Bay extensive sites (closed circles) vs. human population density.

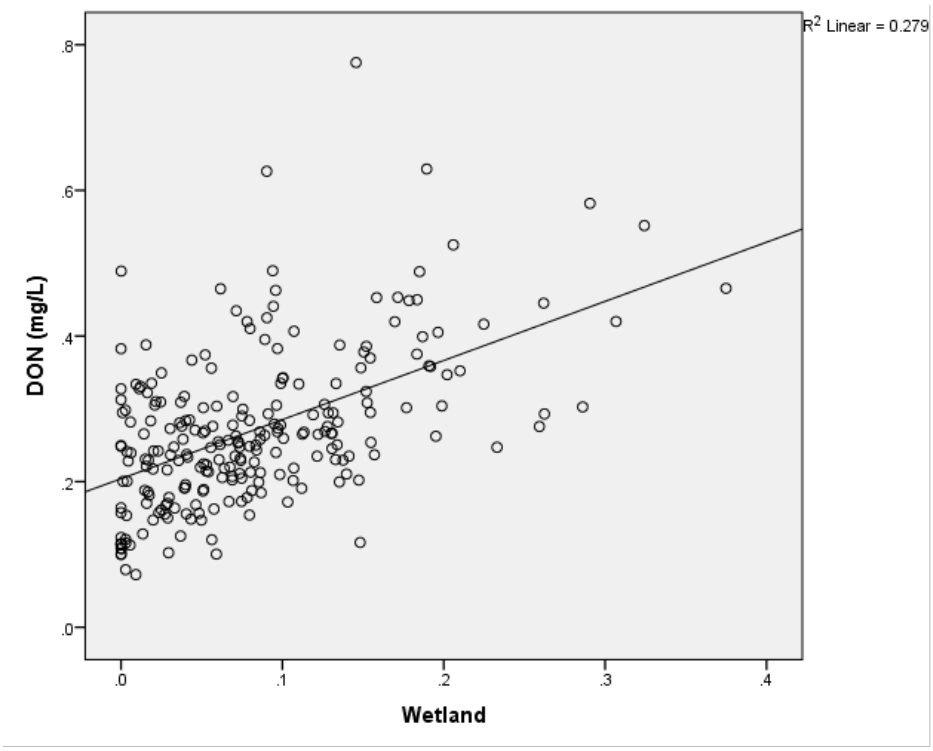

Figure 2. Median dissolved organic nitrogen (DON) concentrations among Great Bay extensive sites vs. the portion of wetlands.

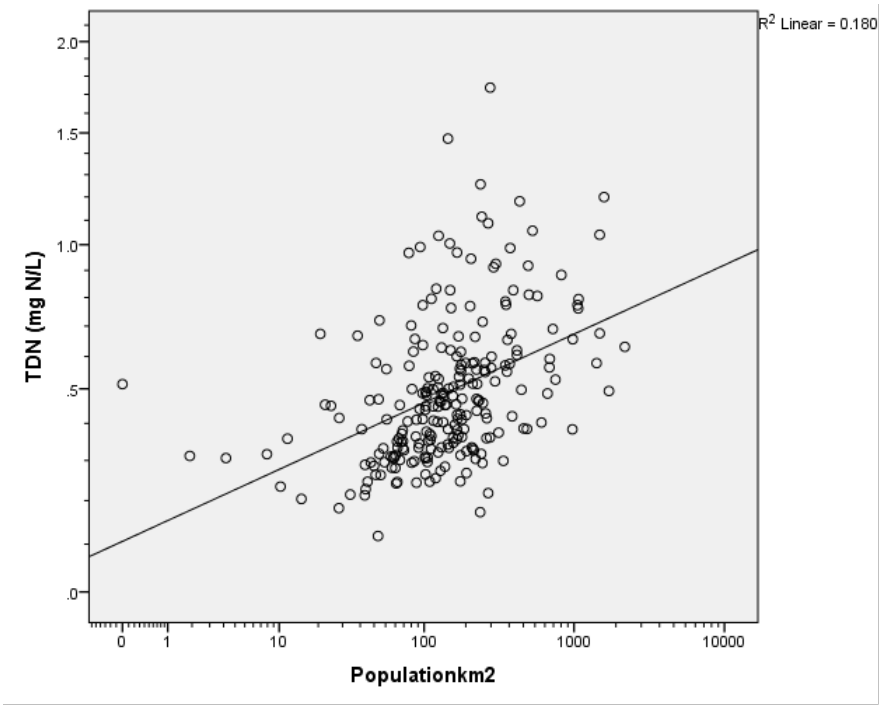

Figure 3. Median total dissolved nitrogen (TDN) concentrations among Great Bay extensive sites vs. human population density.

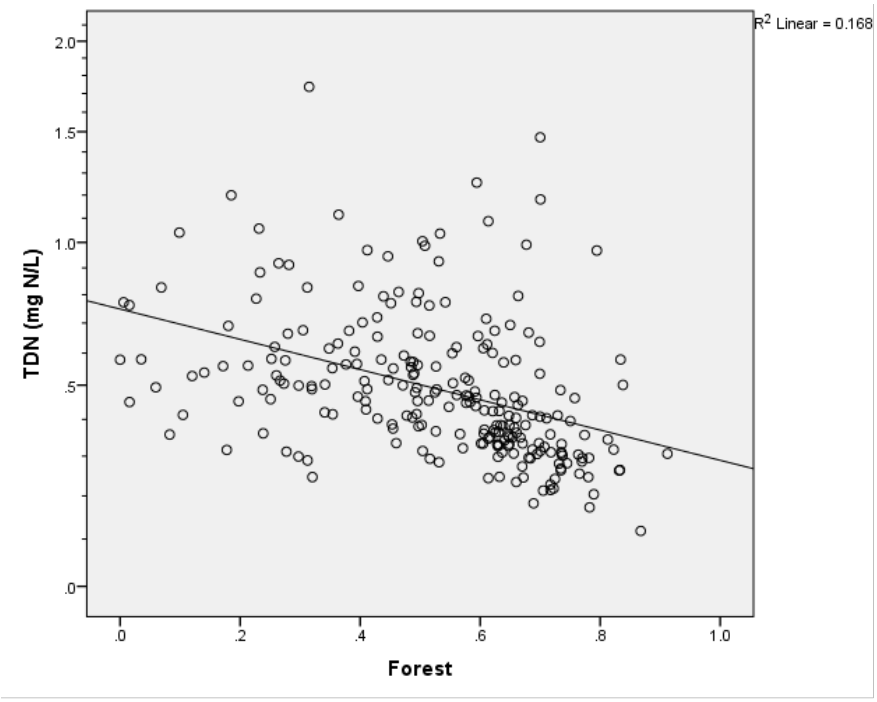

Figure 4. Median total dissolved nitrogen (TDN) concentrations among Great Bay extensive sites vs. the portion of forests.

Human population density was a stronger predictor in the previously developed landscape model for DIN among Lamprey and Oyster sub-basins than it was for our Great Bay study sites. As a next step, we will utilize multiple regression analysis to better describe the spatial variability in DIN, DON and TDN concentrations. We anticipate that this multiple regression analysis will improve our ability to better identify "hot spots" and "cold spots". We will also analyze each sampling campaign individually to minimize the error associated with any temporal variability in N concentrations.

Progress on **objective** 3 Identify non-point sources of N that reach surface waters and the delivery pathway (e.g. groundwater vs. stormwater) using tracers.

Intensive sites were sampled in June, July and August for isotope analysis of nitrate (NO_3) and in August a select number of intensive sites were included in a collaborative effort with the town of Durham to detect human waste in waterways using canine detection. These intensive samples are undergoing laboratory analysis, but the canine detection did confirm that leaky sewer lines or illicit connections were contributing human waste to a few of our intensive sites where we suspected this was occurring.

A graduate student, Marleigh Sullivan, has been conducting experiments on wells in the riparian zone of a few of our intensive sites to quantify N uptake and denitrification. Preliminary results from her work will be available for the next reporting period.

- What data did you collect?

As described previously, we collected feedback from intended users and collected samples and field data from intensive sites. Data collected from the Nitrogen Newsbytes readership revolved around understanding (1) self-identified knowledge levels of nitrogen sources and impacts in Great Bay, (2) local needs for keeping communities engaged in the nitrogen issue, and (3) if there are individuals interested in helping the project team to deliver local presentations.

- Has your progress in this period brought about any changes to your methods, the integration of intended users, the intended users involved or the project objectives?

Members of the NSCAB represent a subset of stakeholders in the watershed who are deeply engaged and concerned about the nitrogen issue. The project team feels that the NSCAB members' knowledge of the science has reached a level to enable them to not only engage in informed dialogue, but to work with constituents in their own communities to address nitrogen-related issues. A good example of this is when a NSCAB member stood up and defended the science at a recent SWA meeting.

Significant changes to our objectives were made based on feedback from intended users and these were reported previously.

- Have there been any unanticipated challenges, opportunities, or lessons learned?

The spatial datasets that were developed for the GBNPSS are a real asset to this project, but the release of these datasets in May 2013 has delayed our ability to characterize the watersheds of our sample sites until this previous reporting period. Nitrogen data from this project will help assess the accuracy of the GBNPSS and this is an important opportunity to build stakeholder trust in the GBNPSS model by providing actual on the ground data in each town. In addition, the concurrent analysis of GBNPSS has placed increased importance on clearly articulating the scope, purpose, and limitations of the Nitrogen Sources study. This sentiment was clearly voiced by NSCAB members at our August meeting.

- What are your plans for meeting project objectives for the next six months?

In the next six months we plan to work on objectives 1, 2, 3 and 4 and perform the activities designated under Q1 and Q2 of year 4 (Table 1). These include continued collaboration with stakeholders through approximately quarterly NSCAB meetings and newsletter distribution. We will work to improve our Great Bay landscape models that predict N concentrations based on watershed characteristics by utilizing multiple regression analysis and analyzing the N concentration data from the 5 extensive sampling campaigns separately. We will also continue to identify "hot spots" and "cold spots" and the sources of nitrogen or watershed characteristics that are associated with these sites. Intensive sites will be sampled monthly regularly for N concentrations and during a couple storms for isotopic analysis of nitrate. All finalized N concentration data will be shared with NHDES as it becomes useful for assessing the accuracy of the GBNPSS.

D. Benefit to NERRS and NOAA: List any project-related products, accomplishments, or discoveries that may be of interest to scientists or managers working on similar issues, your peers in the NERRS, or to NOAA. These may include, but are not limited to, workshops, trainings, or webinars; expert speakers; new publications; and new partnerships or key findings related to collaboration or applied science.

Conference Proceedings & Abstracts:

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.

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.

Related Outreach:

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.

Wollheim, W.W., A. Price, R. Careyu, G. Mulukutla, and W.H. McDowell. 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. Dogs who really know their business: Trained to find human waste in waterways. Foster's. Aug 2, 2013

E. Describe any activities, products, accomplishments, or obstacles not addressed in other sections of this report that you feel are important for the Science Collaborative to know.

Charlie French and Geography colleague, Joel Hartter, taught a land and water resources conflict course in the Masters in Development Policy and Practice program in the summer of 2013. The Nitrogen loading issue facing Great Bay, and the data collected as a result of this NERRS Science collaborative project, served as the focus of the student's final group project. The students' charge was to develop a policy analysis examining the challenges facing Durham and surrounding communities with respect to both point and non-point sources of nitrogen. The project identified a number of challenges to resolving the nutrient issues and restoring the estuarine system to levels that would sustain eelgrass, DO, oysters,

and other important ecosystem functions. The challenges – which were discerned based on intercept survey of residents, focus groups of municipal decision-makers, and interviews with key stakeholders – include: a) lack of awareness of the nitrogen issue and its implications by the majority of residents and many lay officials from Durham and surrounding towns; b) lack of public education and materials that serve to translate the science into relevant, lay terms; c) disconnect between university scientists and decision-makers.

The project group's recommended policies and actions, which seem to resonate with the work of the science and integration team for this project, included: a) bridge research across disciplines so that we can better leverage UNH's resources to address the issue b) provide educational outreach that integrates the work across the University and not just project by project c). help municipalities identify strategies for managing non-point nitrogen and systems for quantifying the impacts so that they can receive 'credit' for their efforts when future nutrient criteria are set for sewage treatment systems.