Interactions between catchment land cover, storm events, and nitrogen export from Connecticut streams

Basic Information

Title:	Interactions between catchment land cover, storm events, and nitrogen export from Connecticut streams
Project Number:	2014CT287B
Start Date:	3/1/2014
End Date:	2/28/2015
Funding Source:	104B
Congressional District:	CT-002
Research Category:	Water Quality
Focus Category:	Non Point Pollution, Nutrients, Solute Transport
Descriptors:	None
Principal Investigators:	Ashley M Helton

Publications

There are no publications.

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<u>Introduction/Research Objective</u>

Humans have more than doubled the natural rate of nitrogen (N) fixation, dramatically increasing N loading to streams and rivers.[1] Streams and rivers transport N to coastal waters, where the environmental consequences of excess N loading, such as hypoxic "dead zones", are well documented.[2] Indeed, according to the EPA, excess nutrients (predominantly nitrogen and phosphorous) are number 3 on the list of the 100 leading causes of water quality impairment in the United States.[3]

Nitrogen loading to the Long Island Sound (LIS) has been identified as the primary cause of seasonal hypoxia.[4] The LIS is an estuary of the Atlantic Ocean, located between Connecticut to the north and Long Island, New York to the south. Its coastal areas are highly developed, and nearly 9 million people live within its 16,820 square mile watershed. In 2002 the Connecticut Department of Energy and Environmental Protection (DEEP) implemented a nitrogen trading program (Nitrogen Credit Exchange - NCE) among 79 sewage treatment plants located throughout the state. The NCE has substantially reduced N loads from point sources within Connecticut, and currently, the NCE is on track to reduce N loads by nearly 65% in 2014.[5]

Although the Connecticut NCE has substantially reduced N loading, the LIS still experiences hypoxia from excessive N loads, particularly via nonpoint catchment sources during storm flows. The NCE does not include nonpoint sources in its N trading program, but does allow for future consideration. However, including nonpoint sources from storm flows in N trading programs is problematic because predicting where and when N loading occurs from landscapes is difficult. Indeed, the Connecticut DEEP Nonpoint Source (NPS) Management Program's annual report states: "Identifying the causes of nonpoint source pollution and the relationship to human activities to the health of Long Island Sound is a priority area of concern for CT DEEP and the Long Island Sound Study estuary partnership."[6]

The Connecticut DEEP NPS Management Program works to abate and prevent water quality impairments from nonpoint source pollution using a mix of statewide programs and geographically targeted watershed projects to meet the required 10% reduction in nonpoint source N loads by 2015.[7] However, increases in surface water runoff and associated issues have already been experienced in our region and are not projected to improve.[8] Thus, current best management practices (BMPs) may alleviate some nonpoint source N loads from storm waters, but future increases in runoff intensity may require development of BMPs that better correspond with the locations and timing of large N fluxes from the landscape. Continued development of efficient BMPs for storm water treatment *<u>requires understanding how the distribution of N flux over the course of a storm event and the overall magnitude of N flux varies among storm events and different catchment land uses.</u>*

Thus, although non-point source N loading from Connecticut streams has been identified as an important contributor to environmental degradation in the LIS, and BMPs are currently implemented in many areas to treat storm water runoff, we understand little about how nonpoint source N loading varies within and among storm events and across catchment land use conditions. In this project we are asking: **How do storm magnitude, intensity, and**

frequency affect the magnitude and distribution of N export? And, how do those relationships change with land use conditions, specifically with urban development? To answer these questions, we are measuring detailed N dynamics across storm pulses for headwater streams to quantify how large scale N transport events vary 1) over time within and among storm events and 2) among catchments that range in their percent and distribution of developed land cover.

Methods/Procedures/Progress

Our overall approach is to collect high resolution measurements of N concentrations (total and dissolved N, nitrate, and ammonium) during storm flows and biweekly grab samples during the remainder of the study period. We are also measuring continuous stream discharge during the study period. Measurements are being collected across a wide range of storm events for five catchments that vary in their land covers (i.e., impervious covers).

Study sites and infrastructure: Our study sites, located in the Farmington River Watershed, include five headwater catchments that vary in their percent development, have similar watershed areas, and have no minimal wetland or agricultural land covers (Table 1). For each of the five sites, we installed flow meters to continuously record stream discharge and ISCO stations for automated water sample collection during storm events in July 2014. Equipment was removed in November 2014 to prevent freezing damage, and re-installed April 2015.

Table 1. Description of study site, including location, percent developed land cover in the watershed, and catchment area

ID	Site Name	Latitude	Longitude	% Developed	Area (sq. km)
1	Hop	41°51'44.10"N	72°48'31.29"W	40.29	3.5
2	Wins	41°55'30.96"N	73° 3'35.53"W	69.08	2.62
3	Tunx	42° 0'57.03"N	72°55'12.79"W	4.15	3.37
4	Bris	41°55'30.97"N	73°3'35.55"W	59.08	3.03
5	Tain	41°46'3.34"N	72°55'23.61"W	18.56	3.61

Stream sampling and analyses: From July to November 2014 and from April 2015 to present (and until November 2015) stream discharge has been continuously recorded at 15 min intervals, ISCOs have collected water samples during storms, and we have collected biweekly surface water samples for all five sites. We have samples for four storms thus far; and biweekly samples since June 2014. For each water sample we have/will measure all forms of N: nitrate, ammonium, total dissolved N, and total particulate N.

Data analysis: For each discrete storm event, we will quantify the total magnitude and the temporal distribution of N flux (for total N and each form of N - ammonium, nitrate, dissolved, particulate) at each of the five sites. We will calculate hydrologic metrics for each storm event, including magnitude (volume), intensity (rate), duration (length), and antecedent conditions (time since previous storm). For each site, we will also calculate the total water volume and N flux summed over the duration of the project.

Within each site, we will analyze the relationship between storm characteristics and N flux patterns. Among sites, we will analyze relationships between N fluxes (total and storm specific) and land use and catchment characteristics. We will also analyze our datasets using common approaches in the literature to evaluate the intensity of the first flux phenomenon in streams with cumulative load curves and event mean concentrations.[9] Cumulative load curves sum the pollutant load and discharge volume cumulatively for each sampling time interval over the course of a storm event, and normalize each time interval for the total pollutant load and discharge volume for the storm event. Event mean concentrations are the flow-weighted average pollutant concentrations for an individual storm defined as the total pollutant load divided by total runoff volume.

Results/Significance

This research addresses a critical scientific management need for expanding our understanding of N export to include storm events in Connecticut streams. Research suggests that the majority of N transport occurs during storm flows[10], and that land use is typically (but variably) related to N exports in streams and rivers[11]. Thus, to predict the magnitude and temporal patterns of N loading to sensitive coastal areas, we must be able to quantify the interactions between catchment land use conditions and N flux during storm events. The overarching question this proposal seeks to answer is: How does the *distribution* and overall *magnitude* of N flux vary among storm events and between land uses?

As part of this research, we will quantify 1) the temporal distribution of N flux (dissolved, particulate, nitrate, and ammonium) and 2) the magnitude of N flux (dissolved, particulate, nitrate, and ammonium) within discrete storm events, and then to compare the temporal distributions and magnitudes of N fluxes 1) across storm events that vary in their magnitude, seasonal timing, and antecedent conditions, and 2) across catchments that vary in their impervious cover intensity. These will provide three important results for understanding N flux during storm events:

1) Distribution of N flux within storm events: Our datasets will provide the distribution of N flux within a storm event and how that distribution changes among a wide range of storm events across land use types. Some research suggests that the majority of pollutant runoff happens within the first 50% of the runoff volume, called the "first flush" phenomenon.[9] However, the "first flush" may vary between watersheds, storm events, and even among different pollutants. Developing the most efficient BMPs for the state of Connecticut, particularly under increasing storm intensity, requires understanding the timing of N flux during storm events, and how that timing changes depending on seasonal and watershed factors.

2) Magnitude of N flux between storm events: Our analyses will also allow us to calculate the total magnitude of N flux during each storm event. These data will be particularly useful for understanding how N export varies seasonally and with antecedent moisture conditions. For example, storms occurring after long periods of drought may flush larger accumulations of N to streams. The seasonal timing of N flux in streams is similarly important for developing storm water treatment strategies as our region experiences seasonal climate shifts in storm dynamics.
3) N flux across catchment land use intensities: Across a range of land use intensities, we will quantify changes in 1) the distribution of N loads (i.e., "first flush" intensity), 2) the total magnitude of N flux during storms, and 3) the cumulative magnitude of N flux across the study period. Even with similar precipitation regimes, land use intensity and distribution has wide ranging impacts on the timing and magnitude of N export. These analyses will allow comparison of N flux dynamics across typical land use conditions in Connecticut.

To date, we have selected sites, installed infrastructure, and begun sampling and water chemistry analysis. We will continue to collect and analyze samples through November 2015, and then will complete our data analysis (described above). As part of this project, we also developed a project for the Natural Resources Conservation Academy (NRCA; http://www.nrca.uconn.edu), a field program that trains Connecticut high school students in natural resource and land use management, during summer 2014. The project explored the connections between the urban University of Connecticut campus and the receiving stream, Eagleville Brook, the country's first total maximum daily load for impervious cover.

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