Evaluating and enhancing communities' willingness to adopt N-Sink as a community based pollution mitigation decision tool

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Publications

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2. Kirchhoff C., J. Barrett, C. Arnold, Q. Kellogg, C. Chadwick, A. Gold. 2015. Can GIS-Based Tools Help Decision Makers Address the Non-point Source Pollution Challenge. [in preparation]

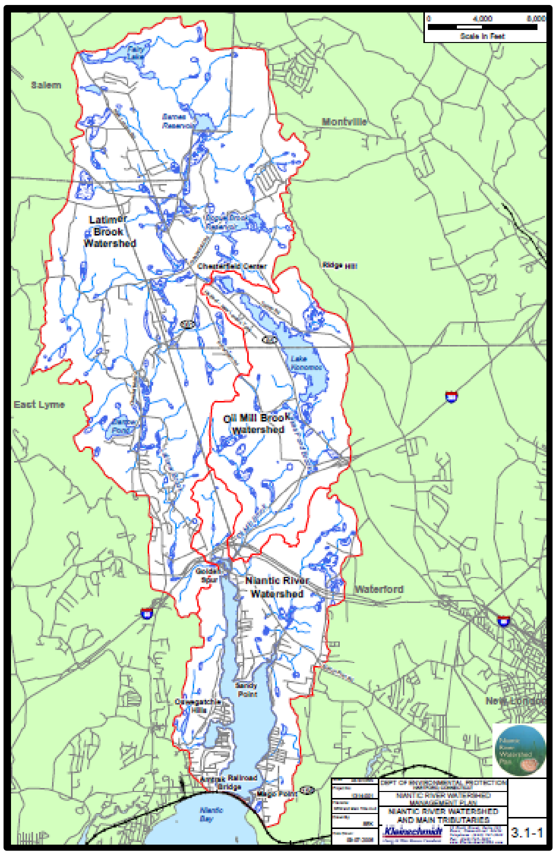

Fig. 1. Niantic River Watershed (DEEP 2006).

2014-2015 FINAL REPORT:

EVALUATING AND ENHANCING COMMUNITIES' WILLINGNESS TO ADOPT N-SINK AS A COMMUNITY BASED POLLUTION MITIGATION DECISION TOOL

By: Christine Kirchhoff, Juliana Barrett, and Caroline Rando

1. Introduction

Nitrogen (N) is increasingly being recognized as a pollutant of concern in both coastal and inland waters. Excess nitrogen triggers algal blooms that in turn cause hypoxia in Long Island Sound. The Clean Water Act (CWA) was established in 1972 to regulate discharges of pollutants and quality standards for surface waters in United States. Connecticut enforces the CWA from point and non-point discharges into receiving waters. Polluted runoff accounts for about 50% of the nitrogen inputs into the Niantic River, a Long Island Sound watershed of concern (see Figure 1 on cover).

In recent years, Connecticut has worked with the EPA to implement a nitrogen pollution reduction plan to improve dissolved oxygen levels and to protect aquatic animals, along with public health. New York, Connecticut, local governments, and the EPA have built and upgraded sewage treatment plants to reduce the nitrogen that goes into Long Island Sound. Despite these improvements, it appears to be inadequate in reducing nitrogen and other pollutants in the Long Island Sound. Figure 2 shows the extent of hypoxia formation in the Sound between 1994 and 2014.

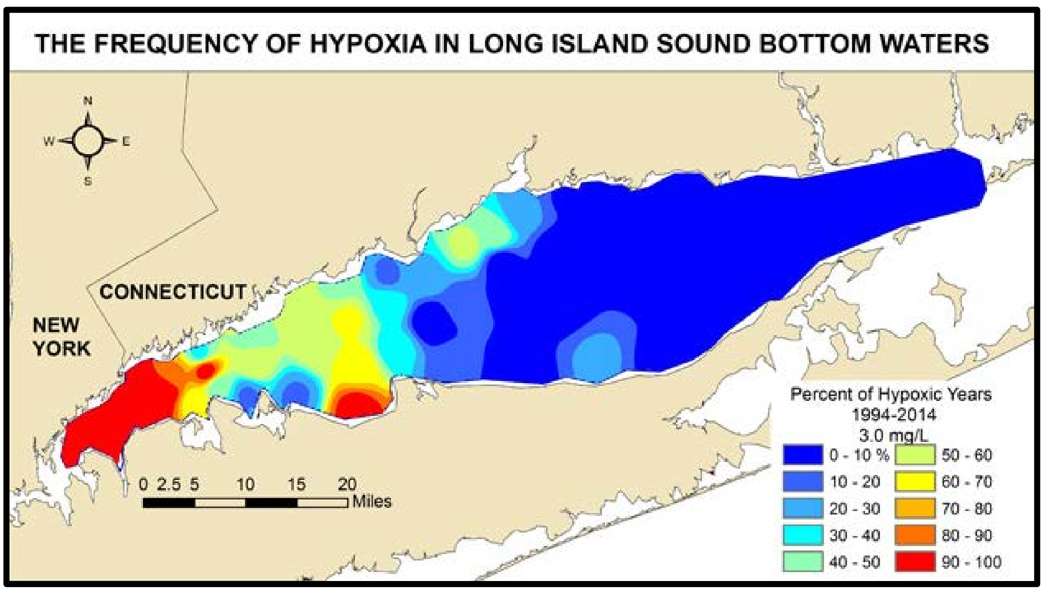

Figure 2. Percent of hypoxic area in Long Island Sound from 1991-2008 (LISS 2015).

Riparian wetlands, reservoirs, small-order streams, and impoundments have the capacity to function as “sinks” for nitrogen. Currently, local decision makers have limited knowledge about N sources and sinks, therefore they are not able to factor N pollution into land policies and decisions. In an effort to help decision makers understand nitrogen sources and sinks, researchers developed a GIS model called N-Sink. N-Sink uses the best available science on landscape-nitrogen interactions along with hydrography, soil, and land cover datasets to reveal major sources and sinks of nitrogen.

Model developers used the Niantic River watershed as a test watershed to develop potentially usable maps and data for identifying nitrogen sources and sinks for local decision makers. The challenge model developers' face is that often there is a gap between what model developers hope is useful and what is actually useful in practice. The purpose of this research was to help bridge the gap by better understanding nitrogen management and policy making in the watershed, decision maker's information needs and opportunities or barriers to integrating new decision support tools for nitrogen management. In addition, this research aimed to help N-Sink model developers test their tool to get feedback on the tool and its usability. The ultimate goal of the research was twofold: first, to understand the context of use of the tool, and second, to make the tool more user-friendly and effective for aiding decision-making. With these goals in place, the N-Sink model could be adopted into management systems including regional, state, and federal levels.

1.1 Research Objectives

This research seeks to help nutrient management decision and policy makers better respond to changing climatic conditions and their impacts on the Long Island Sound. The first goal of the study is to gain background knowledge for the use of the N-Sink tool. A secondary goal is to make the N-Sink tool more effective and user-friendly for assisting decision-making. In order to meet the objectives of this research, feedback was gathered on the N-sink tool. To make an effective and usable tool that can be widely used, it is important to consider criticism from the communities that will be using it.

2. Methods

Data were collected through semi-structured interviews and through observations and surveys of workshop participants. In total, ten semi-structured interviews were conducted in January 2015. Interviewees were selected purposefully to encompass a range of expertise and influence on nitrogen pollution management (see Table 1).

Table 1. Summary of interviewees by organization type or role.

Interviewees	Number
Federal agency	2
State agency	2
Town	3
NGO	1
Scientist	2

Interviewees were asked about the land use or conservation decisions that they make that could potentially have effect on nitrogen sources or sinks, what information they currently use to inform decisions or programs for nitrogen management, and what additional information is necessary to address nitrogen pollution. In addition, interviewees were asked about their perceptions about nitrogen pollution and what actions they or their organization can take to reduce nitrogen pollution. Interviews were transcribed and analyzed to identify patterns and themes around drivers and barriers to nitrogen pollution control, information needs, and strategies to address nitrogen pollution.

In addition to interviews, data were collected through a workshop focused on N-Sink (for more information and access to the tool see http://www.edc.uri.edu/nsinkv2/). Participants were invited to encompass a range of perspectives and potential uses of the tool (Table 2). In total twelve individuals participated in the workshop.

Table 2. Summary of workshop participants by organization type or role.

Workshop Participants	Number
Federal agency	1
State agency	4
Town	2
NGO	2
Scientist	3

The workshop followed an experimental set-up where by participants were first asked to rank a conservation and development scenario without using N-Sink only relying on maps and information distributed in the workshop. Then, workshops were trained on N-Sink and asked to rank conservation and development scenarios using the maps, information, and N-Sink. The decision making process of participants was observed. After each exercise, participants were asked to report how they made their decision and what information or criteria were used in their rankings. In addition to the experiment, participants were asked to provide feedback on the usability and usefulness of N-Sink. Responses were recorded and analyzed along with notes from the ranking experiment.

3. Results

3.1 Interviews

To gain more information on the usability and effectiveness of the N-Sink tool, various employees across different governmental scales and authority over nitrogen were interviewed. While they do not all work at the same level, these interviewees all have ties to the Long Island Sound watershed. Working at a different level means access to different information, responsibilities, and power over regulations. Local or town employees' focus on the area they work for or in and mainly make recommendations pertaining to nitrogen and other contaminants. State level employees look at the bigger picture and make decisions and plans for the whole state or watershed spanning several towns. Out of the ten subjects that were interviewed, eight of them are only able to make recommendations regarding nitrogen pollution. Almost all of these employees work at the town or local level. An Environmental Planner for the town of Waterford, CT said in her interview when talking about the influence of local regulations on nitrogen reduction, there is "nothing directly about nitrogen, nitrogen loading, nitrogen control in either of the regulations, so this is all on a recommendation level." Employees working at the federal or state levels have more power and can make actual decisions and laws when it comes to nitrogen. For example, the EPA has more control over environmental issues with their numerous plans and access to funding. To restore the health of the Sound, the EPA, Connecticut, and New York formed the Long Island Sound Study (LISS). The EPA receives annual funding that contributes mostly to the Comprehensive Conservation Management Plan (CCMP), a plan created by the LISS. The CCMP is aimed at indirectly and directly reducing nutrients through education, public outreach, restoration or protection efforts and more.

A main focus of the interviews was to discover at what scale the subjects view the nitrogen issue, while also considering which level of government they work for. It was important to understand not only how they view the nitrogen issue, but also how they view solutions. In other words, how does their view of the issue shape their view of solutions? All of the subjects interviewed acknowledged that nitrogen pollution was indeed an issue, but at different scales. One interviewee believes it to be a town scale issue, two see it as a watershed scale issue, and one sees it as both a town and watershed scale issue. Most interviewees that work at the local or town level see nitrogen as a local or watershed issue, as that is the scale that they are able to make recommendations for. When asked if anything could be done for nitrogen at her scale, the Environmental Planner for Groton, CT said, "I mean no, I don't think so. I mean we can do it in bits and pieces here, but we're kind of at the bottom of a number of watersheds, so whatever happens to the north, generally it is to the north for us, impacts us." The scale of the problem is relevant when it comes to taking action to fix it.

The main barriers to nitrogen reduction in the LIS that the interviewees discussed were the lack of money, public education, and information regarding nitrogen. Although most local or town level employees that were interviewed are comfortable with the information we currently have on nitrogen, higher-level employees think we need to know more. They are not comfortable with the information we have on the sources and sinks of nitrogen and think more research needs to be done. Two of the ten that were interviewed believe that money constraints are the main problem when it comes to stopping nitrogen pollution. Four of the ten believe that the citizens are preventing them from making strides toward a cleaner environment. One interview stated, "I see that one main barrier is citizen awareness to get individuals that if they don't see the Sound or if they don't directly boat or swim on the sound, understanding that their activities impact water quality of the Sound." A Hydrologist with USGS commented that "it's a tricky situation to get people to do things too because there's a lot of people that don't like to be pushed to do things differently." Aside from these barriers, various interviewees think that storm water management implementations, more regulations, better support tool, green infrastructure, and overall action are required to facilitate change.

When it came to the potential use of the N-Sink tool, there were several different responses from the subjects. Multiple interviewees see the tool being powerful and potentially being very useful for watershed protection, land use planning, and restoration. It could be advantageous to researchers wanting to know where nitrogen is coming from. One interviewee said, "And maybe N-sink is the way, I don't know. It seemed to be it was a pretty cool thing when I seen an earlier version of a demo, it seemed like a very powerful tool, especially since I think a lot of these town officials are moving toward a lot, you know their sophistication is growing over time" (Latimer). There was an overall positive outlook on the tool when it came to the ten subjects that were interviewed.

3.2 Workshops

The experimental design deployed at the workshop enabled a comparison between how workshop participants made decisions about ranking conservation sites (to protect the Niantic Bay) and development sites (to least impact Niantic Bay) with and without the benefit of using NSink. When respondents were asked to rank conservation sites without NSink, using only the maps they were given, respondents proposed one of three combinations (see Table 3).

Table 3. Conservation Scenario – Old School Decision Making.

Priority Ranking	Combination 1	Combination 2	Combination 3
Highest Priority Site	C1	C3	C2
	C2	C1	C3
Lowest Priority Site	C3	C2	C1

The majority of respondents (five out of seven groups) proposed the first combination: C1, C2, C3. When asked to list the factors considered in ranking conservation sites from highest to lowest priority, respondents indicated they considered: presence of hydric soils at or adjacent to the site, proximity of the site to surface water, and the slope of the site as the most important features. Beyond physical features, workshop participants mentioned favoring sites that offer the "most bang for the buck" such as sites that have good public access, link to other open lands, or have the highest potential "developability." When respondents were given the same task for ranking conservation sites but with the option of using NSink, respondents chose four different rank order patterns (see Table 4).

Table 4. Conservation Scenario - N-Sink Test Drive.

Priority Ranking	Combination 1	Combination 2	Combination 3	Combination 4
Highest Priority Site	C1	C1	C3	C2
	C2	C3	C2	C1
Lowest Priority Site	C3	C2	C1	C3

Four out of seven respondents chose the same rank order as before: C1, C2, C3. When asked about the factors considered in ranking the conservation scenarios the second time, respondents indicated that the percent nitrogen removal was the most important overall. Although two groups did not record their factors, the other five groups listed nitrogen removal as their most important factor in ranking the conservation sites. One group stated that they, "looked at N removal and decided areas with greatest removal should be protected." Three of the seven groups made note of two different possibilities of nitrogen removal for C2 and C3. One of the four who ranked the sites as C1, C2, C3 wrote that the N-removal of C3 "depends on the location of the discharge point" which could account for the order variations across the groups.

When the respondents were asked to rank development scenarios without N-Sink, using only the maps they were given, respondents recommended six different development site priority rankings (see Table 5).

Table 5. Development Scenario – Old School Decision Making.

Priority Ranking	Combo 1	Combo 2	Combo 3	Combo 4	Combo 5	Combo 6
Highest Priority Site	D3	D3	D4	D4	D2	D4
	D4	D4	D1	D3	D3	D3
	D2	D1	D2	D1	D1	D2
Lowest Priority Site	D1	D2	D3	D2		D1

Most respondents (three out of seven) selected D4 as having worst impact followed by D3 followed by D1 and D2. The three respondents that chose D4 as the highest priority site all listed hydric soils, proximity to water or discharge, and existing development as factors. The two groups that chose D3 as the highest priority site specified the distance to the Niantic River as the most important factor. For the development scenario, distance from the Niantic River, topography, hydric soils, land cover, slope, land use, and existing development were the main factors considered in ranking site impact to Niantic Bay. When respondents were given the same task for ranking development sites but with the option of using N-Sink, respondents proposed fewer different rank order combinations—four compared with six in the first exercise (see Table 6).

Table 6. Development Scenario – N-Sink Test Drive.

Priority Ranking	Combo 1	Combo 2	Combo 3	Combo 4
Highest Priority Site	D3	D3	D3	D3
	D2	D1	D4	D4
	D4	D4	D1	D2
Lowest Priority Site	D1	D2	D2	D1

Differently from the morning session, once N-Sink was available to use in the afternoon session, participants relied almost exclusively on the tool for evaluating the development scenarios. With the N-Sink tool used to compute the nitrogen removal values for each site, rather than D4, every group chose site D3 as the highest priority development site. One of the seven groups noted that the higher the nitrogen value reported by N-Sink for a particular development site, the greater the potential impact of nitrogen pollution from that site. Still, the group noted, relying on N-Sink alone was insufficient for determining which development site should ultimately be the most important to site protect from development. While most groups relied completely on the nitrogen removal values computed by N-Sink in their evaluation of development sites, some groups accounted for other factors in their decisions. For example, in addition to using N-sink, one group considered the presence or absence of hydric soils when ranking their sites. The variation in use of information for site ranking helps to explain some of the variation observed in the different rankings and rank combinations.

3.3 N-Sink Feedback

The LIS workshop attendees were given the opportunity to use the N-Sink tool and share their thoughts about potential benefits and constraints to using the tool. Many workshop participants acknowledge the tool as being useful for educating the public and decision makers about nitrogen movement on the landscape as well as for assessing development impacts and site or conservation planning. For example, users thought that by integrating a lot of different information into one program, N-Sink helps users to understand connectedness of the land to Long Island Sound. One participant put it this way: the tool "combines graphics and teaches people about their land." Other suggested that N-Sink allows users to easily consider nitrogen impacts by showing how much nitrogen is removed on the way to the Long Island Sound and by easily identifying sites that are "leaky." Most of the nitrogen in a "leaky" site will get to the sound and not be removed, so these sites will need more protection. Another participant suggested that N-Sink would be "beneficial from a municipal standpoint for watersheds, parcels, and landscapes to track downstream effects." Considering that the N-Sink tool was developed for use by decision-makers, it is also important to consider how it could impact their choices, whether the tool will help them make decisions or help them consider nitrogen in their decisions. From the workshop feedback, the participants feel that N-Sink will effect decisions made on development and conservation, permit processes, nitrogen management efforts, and potentially stormwater policies. There was also discussion about how N-Sink may help inform septic system policies and nitrogen management more generally. Because most programs for non-point source control of nitrogen pollution are voluntary, the tool could help decision makers consider nitrogen along with other factors in watershed management. That said, additional regulatory drivers for nitrogen reduction could increase motivation to use the tool.

The N-Sink workshop revealed many issues with the tool and provided suggestions for improvements. Multiple attendees mentioned difficulties with the actual set up of the program. Some technical issues they encountered were moving, expanding, and fitting different windows within the program. For example, users complained the land cover pie chart does not actually fit into the box (see Figure 3) and that it was difficult to use the heat map and land-use layers simultaneously.

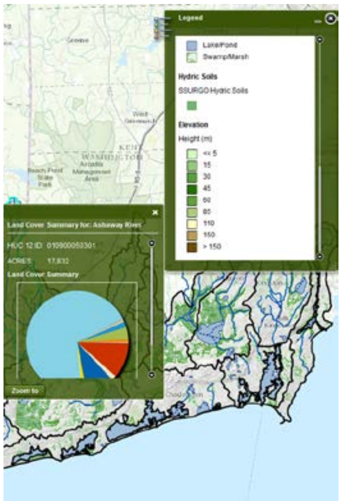

Figure 3. Illustration of mismatched legend and pie chart sizing.

In addition, users noted that the chart colors do not match the map legend, which adds unnecessary obfuscation and decreases ease of use. Several users reported that N-Sink ran very slowly, negatively impacting the speed of assessment. To speed assessment and increase productivity, several users suggested it would be helpful if N-Sink permitted assessment of multiple points (e.g., within a single site or single points across multiple sites) simultaneously (see Figure 4).

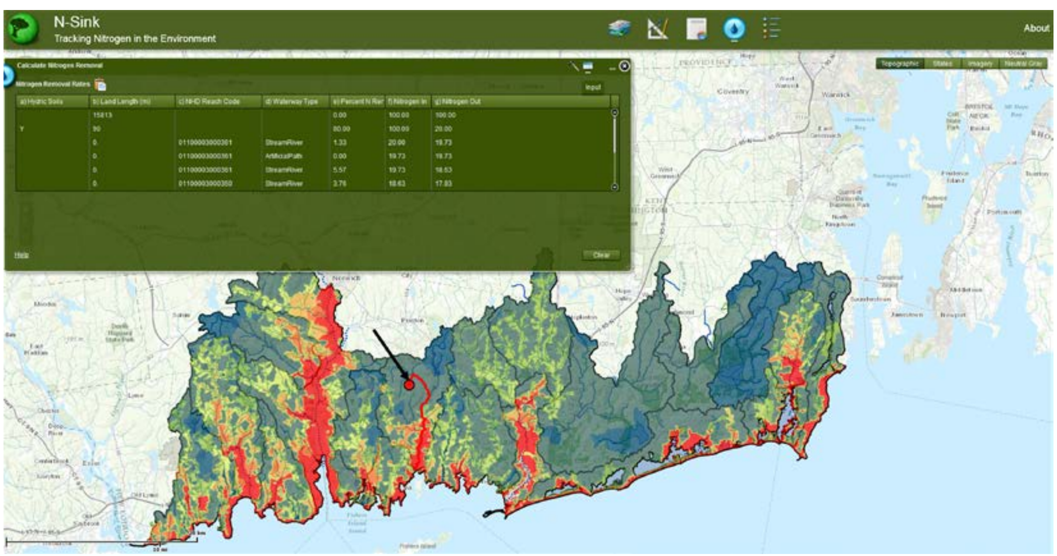

Figure 4. Showing the current single point approach with a black arrow indicating the single point.

If N-Sink had the capability to run multiples points and save the results, it would make it easier to compare different options. One person suggested usability would be increased if tool developers added the option to search by location and a second person suggested adding street names. This additional functionality would make it easier to find unnamed assessment sites that are near specific towns or features including streets. Other users' recommended that tool developers improve icon labeling and define terms to improve usability. For example, users were confused by the hammer icon which indicates "input" when a mouse hovers over it (see Figure 5) and by terms like "local" vs. "cumulative drainage area" making the tool more difficult to use.

Figure 5. Hammer icon shown in red circle.

Additional suggested improvements included adding a pop-up window that would display when users hover over different parts of the watershed to describe layer information, adding more detail on water flow paths and clarification of receiving waters, and adding known sinks not displayed currently. Finally, workshop participants noted that the heat map layer (Figure 6) was a useful part of the tool, but that to improve usability, more work should be done to better explain how to use the heat map to avoid misinterpretation.

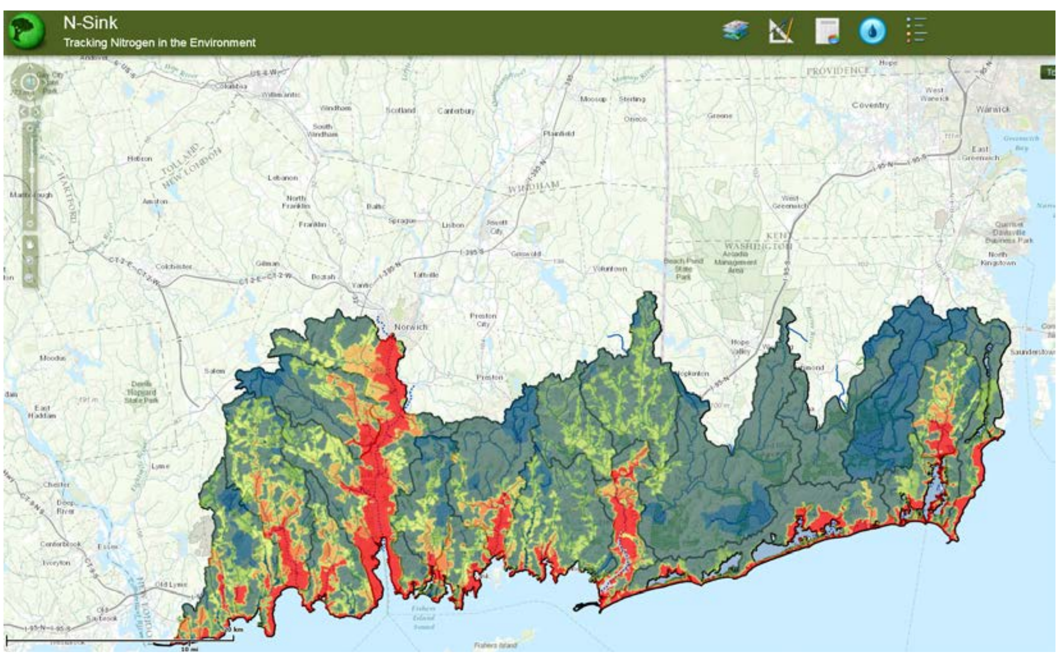

Figure 6. Heat map.

4. Discussion

The voluntary nature of non-point source nitrogen pollution management in the US complicates efforts to reduce nitrogen pollution. Both point (e.g., wastewater treatment plants and municipal separate storm sewer systems (MS4)) and non-point sources contribute to nitrogen pollution. While point sources are regulated, non-point sources are controlled through mostly voluntary programs. When discussing nitrogen pollution, most respondents referred to what is done to comply with the MS4 permits and the many sources of non-point source pollution from agriculture, fertilizer on lawns, atmospheric deposition, septic system leaks, and manure. Respondents who are local and town government employees make recommendations about how to address these diffuse sources of nitrogen pollution, but there is no regulated entity to target which results in little or no change. With little influence they possess, local and town employees seem to be comfortable with the information they currently have on nitrogen. On the other hand, state and federal employees seem to be more aware of the problems caused by non-point sources of nitrogen as they think we need more information on nitrogen. Overall, state and federal employees have a larger scope and more impact on nitrogen decisions and are open to learning more about nitrogen sources and sinks.

The N-Sink tool is based on the premise that local decision makers require environmental data that is highly localized, easily accessible and immediately understandable. Since nitrogen sources and sinks are closely linked to land use, land use decision-makers are a critical audience for a tool like N-Sink that can translate science into information that can be used for management. Respondents at the workshop found the N-Sink tool to be useful for various decisions on development, conservation, permit process, nitrogen management efforts, and stormwater policies. With this broad applicability, N-Sink has potential to aid in implementing decisions to reduce non-point source nitrogen pollution and in so doing help to improve implementation of the voluntary system. A key benefit of the N-Sink tool is that it helps to make it to easier to think about nitrogen and to make changes. For example, comparing the development scenario from exercises 1 and 3 from the workshop, you can see less variation in combinations when the N-Sink tool could be used. While some respondents still considered things such as hydric soils, the tool helped people directly consider nitrogen in their decision. Without the use of the tool it is much harder to think about nitrogen because a concrete number is not given.

There are advantages for decision-makers as well as the public with the creation of the N-Sink tool. The N-Sink tool was originally created "to provide a useful and accessible tool for local land use managers to explore the relationship of land use in their towns and counties to nitrogen pollution of their waters" (Tracking the fate of watershed nitrogen: The "N-Sink" Web Tool and Two Case Studies). Based on suggestions from the pre-workshop interviews, the tool could also be beneficial for public education on nitrogen issues. Whether it is because they live far from the sound or just do not have the background on nitrogen, many interviewees were concerned that the public does not understand why this is an issue and what they can do to help. One respondent included, "I think there's coastal communities where maybe many people are aware of these issues, especially people who use the water a lot and see the effects of what maybe is going and trying to figure out, or you know the fisherman who wants to know why there is no fish left." On the other hand, another respondent said, "I see that one main barrier is citizen awareness to get individuals that if they don't see the Sound or if they don't directly boat or swim on the sound, understanding that their activities impact water quality of the Sound." Whether or not they have direct access to the sound does not necessarily mean they know what to do to lessen the nitrogen impact. One interviewee added, "In the end, you're trying to change behaviors." There is potential for the N-Sink tool to act as a education tool for communities that affect the quality of Long Island Sound. If the public does not know they are hurting the environment with certain practices then they will have no motivation to change.

In order to use N-Sink as a tool for local decision-makers as well as the public, the workshop attendees agreed that modifications were necessary. N-Sink was created to make the process of tracking nitrogen easier and more efficient. If the tool can be updated to become faster and simpler to use, it seems that more decision-makers will consider it in their work. Hopefully the tool will promote more knowledge on nitrogen and how it makes its way to Long Island Sound.

5. Conclusion

The N-Sink interviews and workshop were conducted to gain background on current nitrogen management and decision makers, as well as to test the effectiveness and usability of the N-Sink tool. Based on the feedback collected in the interviews and workshop, there seems to be potential for the tool when it comes to improving the current voluntary nitrogen program, making nitrogen decisions easier and more efficient, and educating the public on nitrogen issues. If technical changes are made to the tool, there will be better usability and the N-Sink tool can be applied to real life nitrogen management scenarios.

6. References

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