EPA/600/F-14/315

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INNOVATIVE RESEARCH FOR A SUSTAINABLE FUTURE

Opportunities and Challenges for Geographically Expanding N-Sink

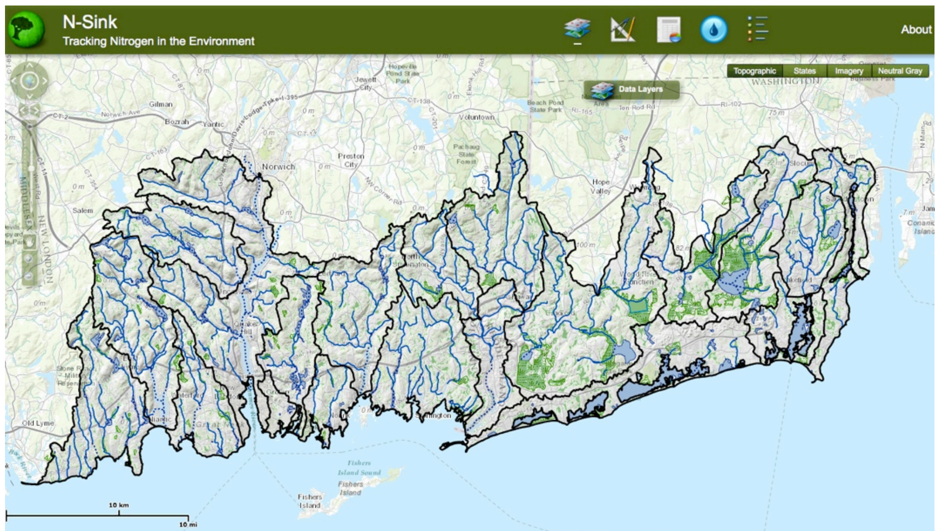

Figure 1. The current geographic extent of N-Sink, from just east of the Connecticut River to just west of Narragansett Bay (figure from the web version).

Introduction

Nitrogen is increasingly being identified as a pollutant of concern in both coastal and inland waters. In some areas, the majority of the nitrogen loading comes from wastewater treatment plants and/or combined sewer overflows. However, in less urbanized catchments nonpoint source runoff and nitrogen from septic systems are the primary vehicles of nitrogen delivery. In these areas, catchment land use has a direct relationship with both sources and sinks of nitrogen.

The N-Sink tool was created to provide a useful and accessible means for local land use managers to explore the relationship of land use in their towns and counties to nitrogen pollution of their waters. N-Sink focuses on three types of landscape N sinks: wetlands, lakes/ponds/reservoirs, and stream reaches. N-Sink uses the best available science on landscape-nitrogen interactions, plus widely available basic datasets for hydrography, soils and land cover, to highlight major sources and sinks of nitrogen within a catchment context.

N-Sink is available as an extension to ArcMap, and as a web-based tool, (www.edc.uri.edu/nsinkv2/). The geographic extent of N-Sink is currently from just west of Narragansett Bay, extending west nearly to the Connecticut River (Figure 1). N-Sink uses HUC12 boundaries as an organizing unit, and as such, currently has analysis capabilities along coastal HUC12s, and those abutting the coastal HUC12s.

The focus of this Science in Action brief is to explore the technical pros and cons of applying N-Sink to other geographic areas.

Considerations for Geographic Expansion of N-Sink

Data Sources:

NHDPlusV2

N-Sink uses the National Hydrography Dataset, NHDPlusV2, (McKay et al., 2012) to acquire hydrologic data necessary for flowpath generation and N removal estimates for stream reaches and lakes/ponds/reservoirs along a specified flowpath. N-Sink flowpath generation makes use of NHDPlusV2 flowlines. N removal estimates use NHDPlusV2 estimates of cumulative drainage areas, and gauge adjusted mean annual flow and velocity. Using this national dataset has capitalized on intensive efforts by USGS to develop and refine NHDPlusV2.

However, there were some technical issues associated with NHDPlusV2 that required manual editing before those data could be used in N-Sink. This is a major consideration for geographic expansion of N-Sink. The manual tasks included: 1) multiple flowlines through lakes/ponds had to be merged, and the associated lengths and drainage areas summed, in order to obtain a single lake/pond feature (see Figure 2); 2) upstream and downstream segment IDs needed to be manually changed to ensure

hydroconnectivity and allow the model to iterate properly through the merged segments, and; 3) some table joins and calculations were needed to deal with stream reaches with multiple line segments, all with the same reach code.
Pros: Nationally available data, so variations in climate are accounted for across regions.
Cons: Apparent need for manual editing (labor intensive).
Prospects/Next Steps: Investigate methods to automate one or all of the manual tasks listed above. This may include converting the vector analysis that estimates N removal along a flowpath to raster. Based on discussions with GIS practitioners, it would be worthwhile to convert one HUC12 from vector to raster to better understand the full range of opportunities and challenges and to compare results from the two methods. Conduct expansion of N-Sink to a regional or larger (HUC-8) watershed to gauge feasibility of manual method. Talk to USGS about future updates to NHDPlusV2 that would ensure that every unique stream reach is composed of only one line segment, and that multiple reaches within water bodies can be merged such that each lake/pond can be treated as a single feature.

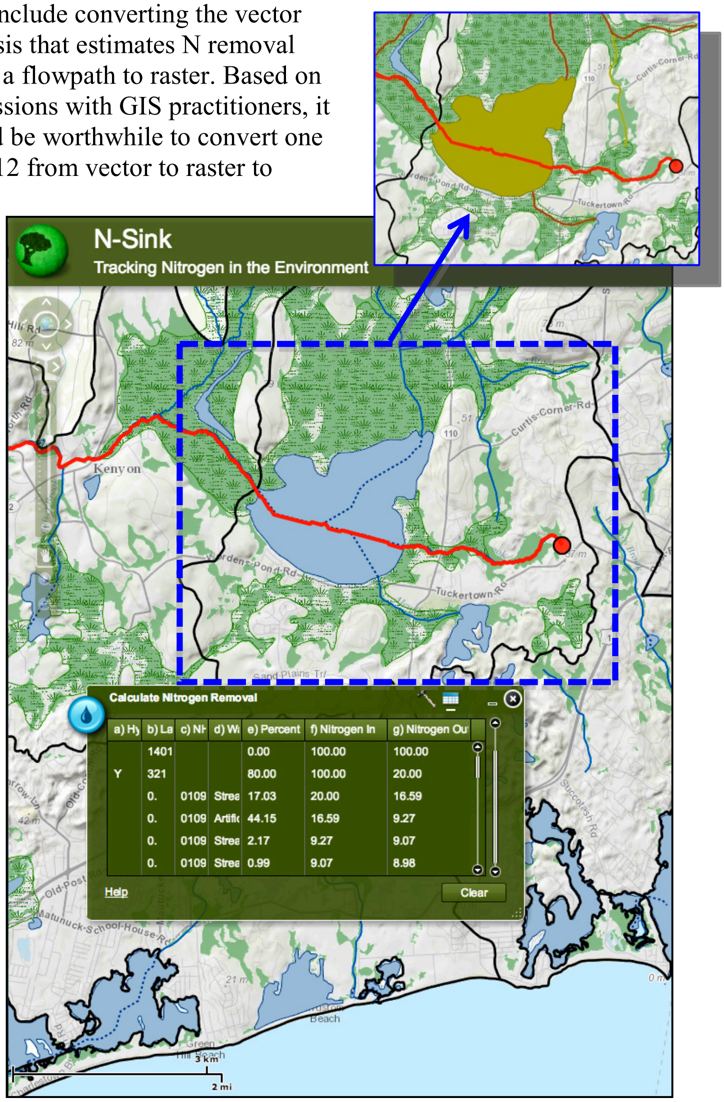

Figure 2. Detail of N-Sink flowpath for the Chipuxet River tributary of the Pawcatuck River in RI. The three NHD flow lines (two in dotted blue and the one chosen by the flow path) shown have to be merged by hand in order for N-Sink to treat the lake as one N sink feature (inset, color coded by N removal potential).

NLCD
The National Land Cover Dataset (http://www.epa.gov/mrlc/nlcd-2006.html) provides land cover raster data at a cell size of 30 m.
Pros: Nationally available data.
Cons: The cell size limits our ability to reliably identify narrow strips of riparian wetlands (discussed below under SSURGO).
Prospects/Next Steps: None necessary. N-Sink seems to produce useful results using 30m data. Eventually, it would be good to build in the ability to allow the user to add higher resolution local data if available, but this is not critical.

SSURGO
N-Sink identifies wetlands by extracting hydric soils (classified as "poorly drained" and "very poorly drained") from the Soil Survey, SSURGO (Soil Survey Staff, 2012) and overlaying NLCD data to include only those hydric soils that are "undeveloped".
Pros: Nationally available data. Resolution ranges from 1:12,000 to 1:63,360. Vector data, with high resolution and accuracy.
Cons: None identified.
Prospects/Next Steps: None needed.

Model Assumptions:

Hydrologic Flowpaths
N-Sink characterizes the flowpath from any given point to a catchment outlet as having a terrestrial component (from source to surface water), followed by a surface water component. Once a flowpath enters surface water, it remains as surface water. This means that even if a stream reach is surrounded by wetlands, removal is based on movement through the stream reach, not on movement through wetland soils. This approach results in a conservative estimate of cumulative N removal.

Each of these components (terrestrial and surface water) is usually made up of a number of "reaches". The terrestrial component assumes that surface flowpaths

represent a close approximation of subsurface flowpaths. A major consideration for geographic expansion of the N-Sink tool is those situations where this assumption will likely be violated. These include dense urban and other areas with engineered drainage, tile drained agricultural areas, areas with karst geology or where significant flow occurs through bedrock fissures.
Pros: It is possible to estimate a complete flowpath from source to outlet.
Cons: This approach cannot be used in areas where surface flowpaths do not approximate subsurface flowpaths.
Prospects/Next Steps: This appears to be a major consideration for the use of N-Sink as decision support for the areas of a watershed with urban drainage. While this does not negate N-Sink's usefulness as a N delivery tool for many areas of a given watershed, it does require more discussion by the team in how to deal with this issue.

N Removal Estimates

Estimated rates of removal from landscape sinks are based on data from a wide geographic range (see Arnold et al., 2013 for methods and citations). In order to evaluate the validity of these N removal estimates in other regions, it will be necessary to engage biogeochemists who work in these regions and are familiar with the mechanisms of N movement through soils and surface water in their regions. It is quite likely that estimates will translate well to other glaciated landscapes similar to the Northeastern US.
Pros: Current methods estimate N removal based on relationships that depend on retention time as a key factor. Because retention times are characterized using data from NHDPlusV2, regional differences in climate and other hydrologic drivers are fairly well accounted for.
Cons: Some accuracy is likely sacrificed by using this broadbrush approach.
Prospects/Next Steps : We are exploring ways to assess this. Colleagues in other areas of the country need to be consulted.

Summary

There is great interest in expanding the geographic extent of N-Sink in the region, within the Narragansett Bay and Long Island Sound watersheds. N-Sink is designed to use nationally available data sets, which will facilitate expanding the tool to other regions. One large hurdle is the apparent need to modify the data from NHDPlusV2. If we stay with vector-based flowpath calculations, this will be potentially prohibitive unless an automated process can be found. A possible alternative is to migrate to raster-based operations. Another hurdle is to determine how to use N-Sink in watersheds that have extensive urban, tiled agriculture, or karst areas.

Recommended Next Steps:

1) Explore the feasibility of converting N-Sink calculations to raster operations using a pilot HUC12 from the current extent of N-Sink, allowing us to compare vector-based calculations with raster-based calculations.
2) If conversion to raster allows for relatively efficient expansion of the NHDPlusV2 data, then the team would identify regions where surface and subsurface flowpaths are expected to be significantly different and eliminate these areas from consideration.
3) Identify the next region for expansion and work with biogeochemists from that region to adjust N removal calculations, if necessary.

References

Arnold, C., D.Q. Kellogg, K. Forshay, C. Damon, E.H. Wilson, A. Gold, E.A. Wentz, and M.M. Shimizu. 2013. The "N-Sink" Web Tool and Two Case Studies. EPA Technical Report EPA/600/R-13/230.

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