# Evaluation of changes in landscape loading of total nitrogen to U.S. waters using monitoring results from the National Aquatic Resource Surveys

EPA United States Environmental Protection Agency

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## Landscape N input and stream N concentration

Uncertainty about how land use practices changes will quantitatively affect water quality and how long it will take to see improvements from management actions hinder efforts to reduce nitrogen (N) in streams. It is important to couple data about changes in inputs to understand changes in water quality over time. We used two existing USEPA datasets to understand the changes in stream water quality over time and how land management can affect stream total N concentration (TN) in the contiguous US:

- USEPA's national inventories of N inputs (2002-2012, fine-scaled) for the contiguous US
- Stream TN concentration from the EPA National Rivers and Streams Assessment (NRSA, yrs. 2000-2004, 2008-2009, and 2013-2014). All samples were collected during summer.

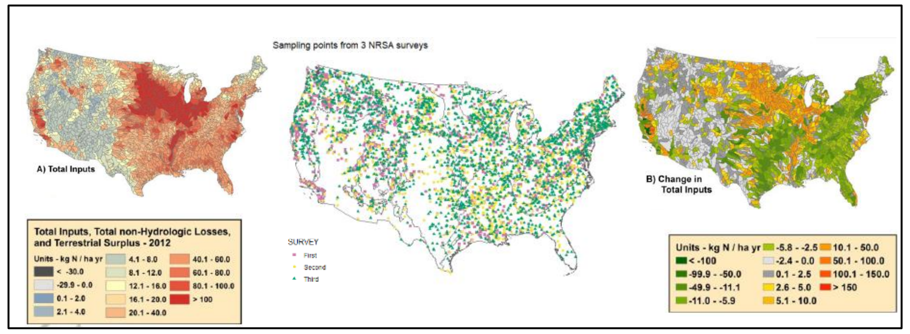



Figure 1. Left: Total N inputs in 2012 for HUC-8 subbasins of the CONUS; Middle: Sampling locations of three EPA National Rivers and Streams Assessment (NRSA); Right: Changes in total terrestrial N inputs between 2002 and 2012 (Sabo et al., 2019).

## Does stream concentration reflect input change?

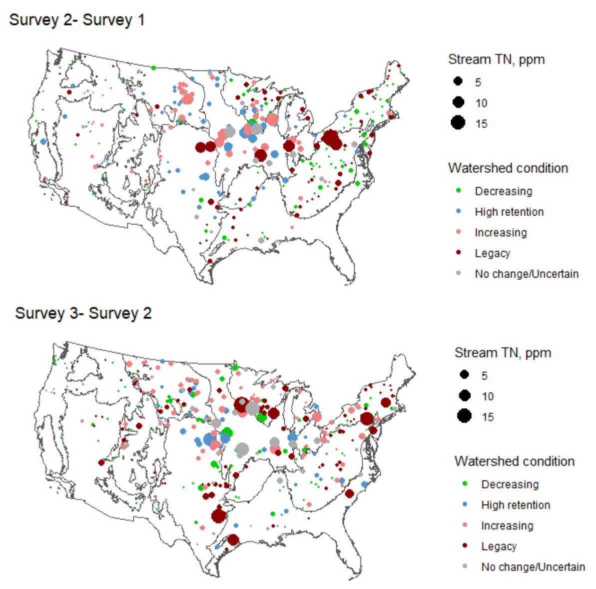
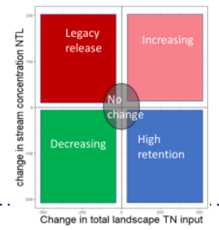



Figure 4. Results show that changes in total landscape input are not always reflected in changes in stream TN concentrations (point size) over time based on results of **samples resampled between two consecutive surveys.**

Response categories




1) Increasing: both TN input and stream [TN] increased;
2) Decreasing: both TN input and stream [TN] decreased;
3) High retention: TN input increased but stream [TN] decreased; potentially caused by conservation efforts or high buffering capacity of watersheds;
4) Legacy release: TN input decreased but stream [TN] increased;
5) No change: changes in stream [TN] < ± 5% and/or changes in TN input < ± 1%.

## Changes in landscape input vs. changes in stream concentration

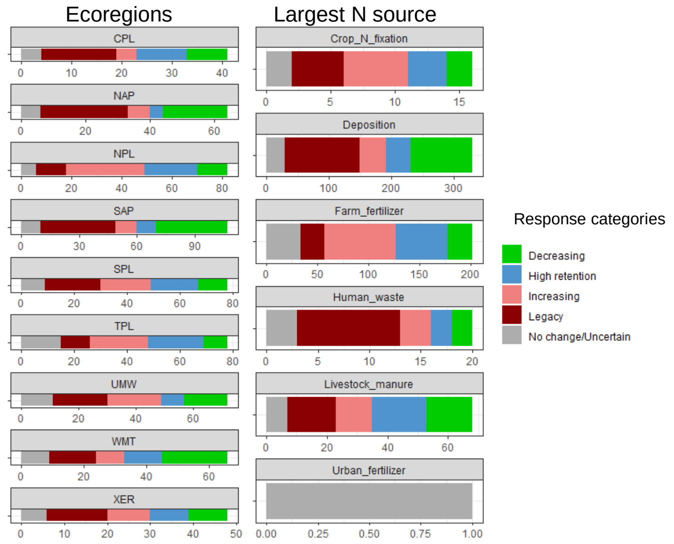



Figure 5. Watershed responses shown by ecoregions (left) and largest N source (right). The x axis represents the number of watersheds falling within certain response categories. **Results are based on resampled sites.** Legacy response is observed across all ecoregions and all land uses. Watersheds with fertilizer input as the largest source (mainly in TPL, UMW, SPL, and NPL) have mostly 'increasing' or 'high retention' conditions (positive TN input changes), while watersheds with deposition as the largest source (mainly in NAP and SAP) have mostly 'decreasing' or 'legacy' conditions (negative TN input changes).

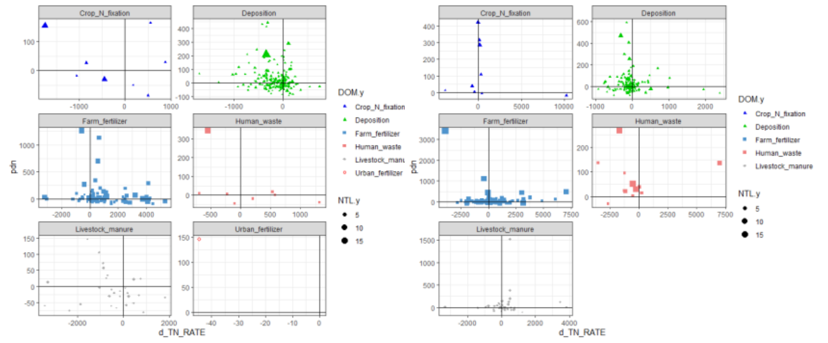


Figure 6. Percent changes in stream concentration (pdn, %) vs. changes in total landscape input (kg/km2) at NRSA sites resampled between two consecutive surveys (total n = 543): **survey 2 vs survey 1 (left)** and **survey 3 vs survey 2 (right).** Data points are colored by the largest N source in the watershed, and scaled by stream TN concentration. Horizontal line and vertical line represent the division between increase and decrease of stream concentration and TN input, respectively.

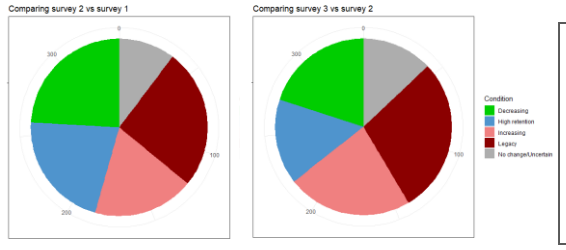
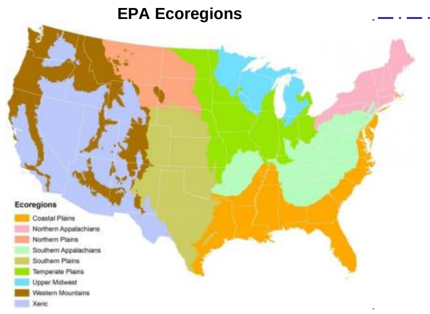



Figure 7. Watershed conditions during three surveys. About 43% of watersheds demonstrate changes in stream TN consistent with changes in landscape input (both decreasing or both increasing). Watersheds with 'legacy' condition are very common, about 26% and 29% during two periods, respectively.

## Relation between landscape TN input and stream concentration




Streams in the Central Plains had significantly greater TN concentrations than streams in the West and Appalachians, reflecting the pattern in N inputs for those areas (agricultural vs. deposition).

Stream TN concentrations did not change consistently across the US from 2000-2014, consistent with a lack of a national trend in N inputs.

Nitrogen inputs alone explained nearly 50% of the variation in stream N concentrations across the US.

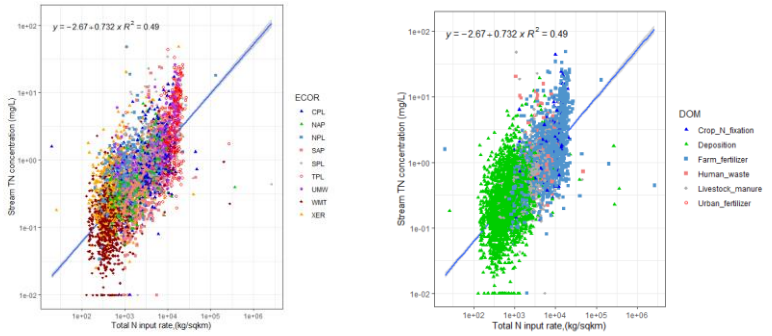



Figure 2. Relationship between stream total nitrogen (TN) concentration and terrestrial TN input rate over the three survey periods. Left: Ecoregional differences can be observed across surveys; right: variations caused by the largest watershed N source across three surveys. Total n = 5092.

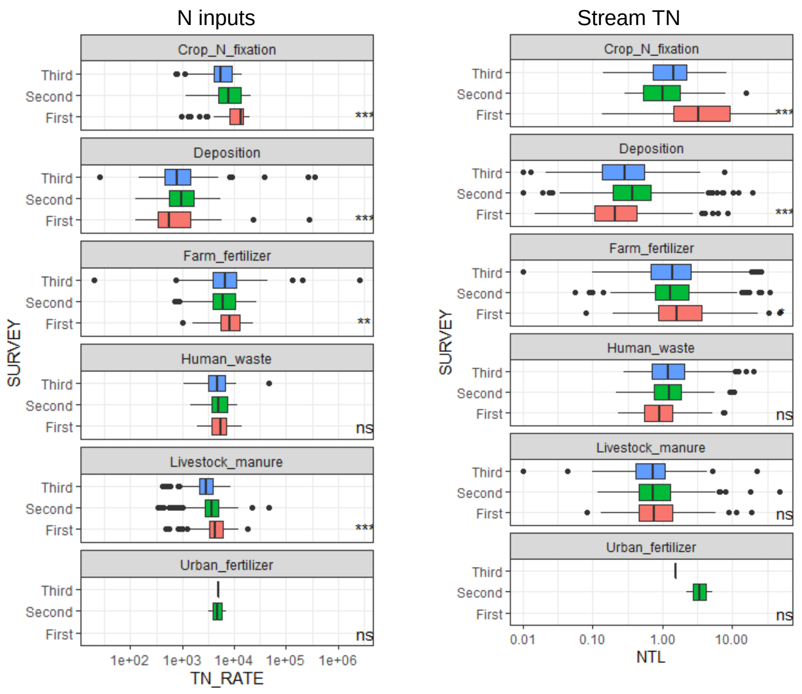



Figure 3. Changes in total landscape input rate (left) and stream TN concentration (right) in the three survey periods, shown by different largest N input sources, as indicated by each grid name.

## Factors impacting changes in TN concentration in agricultural sites

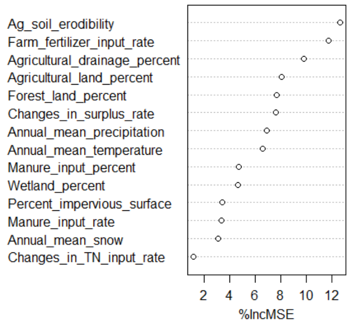



Figure 8. Random Forest results: key variables controlling changes in stream TN concentration. In addition to input sources, input rates and land uses, watershed agricultural soil erodibility and agricultural tile drainage coverage are also key variables.

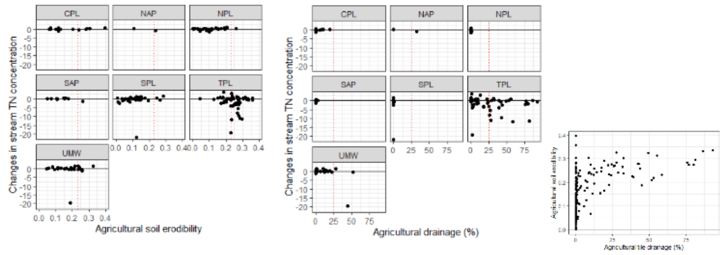



Figure 9. Changes in stream TN concentration between surveys vs. agricultural soil erodibility (left) and percent agricultural drainage coverage (right). Erodibility > 0.22 is associated with a decrease in stream TN, which is mainly found at watersheds with >20-25% tile drainage coverage and low specific discharge (not shown). **These factors are indicative of intensity of human management and potentially conservation efforts, mainly in TPL.** Denitrification in drainage tiles is also potentially associated with reducing stream TN concentrations during summer when agricultural input is low.

## Summary

- Regional/spatial variations in terrestrial N inputs and stream concentration are consistent across surveys
- Largest source has impact on stream TN concentrations across all surveys, as seen by Bellmore et al. (2018) for Survey 2
- Changes in stream concentration were consistent with changes in terrestrial inputs in only 43% of NRSA resample watersheds
- Legacy effect is observed across all regions and land uses, especially in watersheds with deposition as the largest source.
- Higher tile drainage and soil erodibility are found associated with reducing summer stream TN concentration in agricultural watersheds. These sites potentially have greater conservation efforts and management activities.

**References:**

Bellmore, R.A., Compton, J.E., Brooks, J.R., Fox, E.W., Hill, R.A., Sobota, D.J., Thornbrugh, D.J. and Weber, M.H., 2018. Nitrogen inputs drive nitrogen concentrations in US streams and rivers during summer low flow conditions. Science of the Total Environment, 639, pp.1349-1359.

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