# Nutrient monitoring in surface waters of agriculturally-intensive regions of the U.S.: Current status and needs for expansion

ccoates2@ncsu.edu
go.ncsu.edu/oates

**Christopher C. Oates**[1,2], **Hector Fajardo**[1,2], **Khara Grieger**[2,3], **Daniel Obenour**[4,5], **Rebecca L. Muenich**[6], **Natalie G. Nelson**[1,2,5]

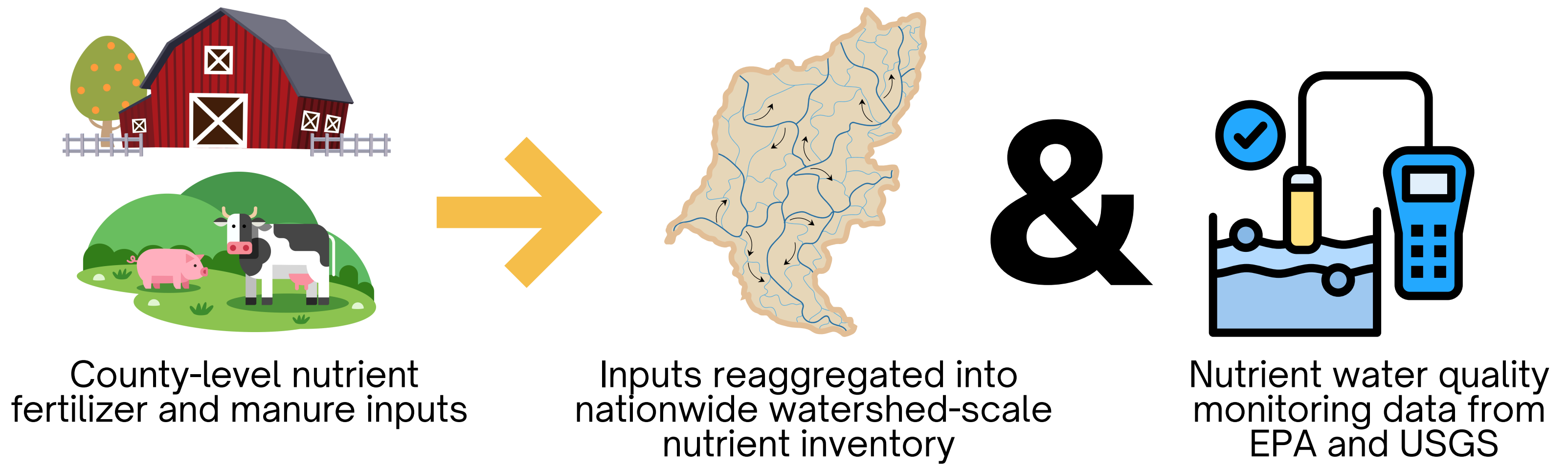
[1]Biological and Agricultural Engineering, North Carolina State University (NCSU); [2]N.C. Plant Sciences Initiative; [3]Applied Ecology, NCSU;
[4]Civil, Construction, and Environmental Engineering, NCSU; [5]Center for Geospatial Analytics, NCSU; [6]Biological and Agricultural Engineering, University of Arkansas

## Motivations

- Nutrient pollution from agriculture is a dominant cause of water quality impairment in U.S. surface waters, yet the extent of monitoring coverage in these regions remains understudied
- Sparse monitoring in rural and agricultural areas limits identification of critical nutrient sources and evaluation of management effectiveness
- **Objective:** Assess the effectiveness of nutrient monitoring in capturing agricultural nutrient inputs and quantify water quality trends in watersheds with sufficient data availability

## Data and Methods

- To assess current monitoring efforts, sites with ⩾40 samples between 2012 and 2021 (i.e., at least seasonal sampling) were selected and compared to HUC8-scale nutrient inventories to evaluate monitoring coverage, capacity, and network strain relative to agricultural inputs

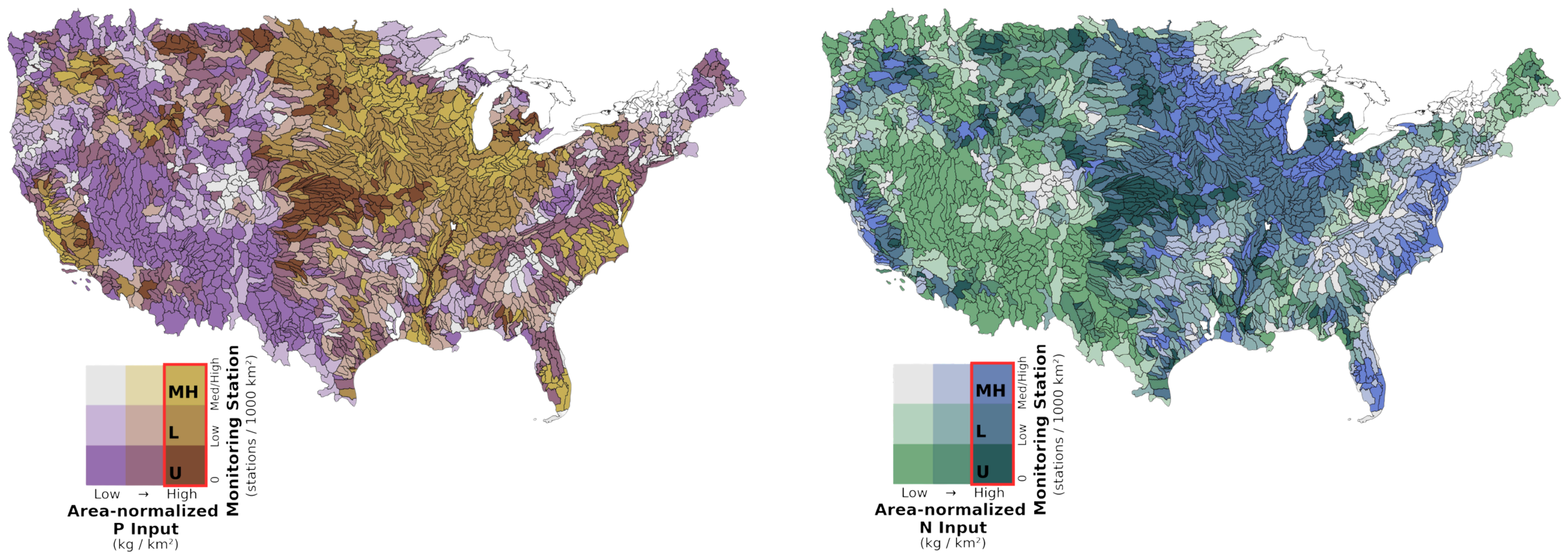


- To assess long term conditions (e.g., improving, worsening, or stable), the time window was expanded to include two decades of sampling history. Sites meeting a ⩾200 sample threshold were delineated by drainage basin and analyzed using Weighted Regressions on Time, Discharge, and Season (WRTDS) to characterize flow normalized trends

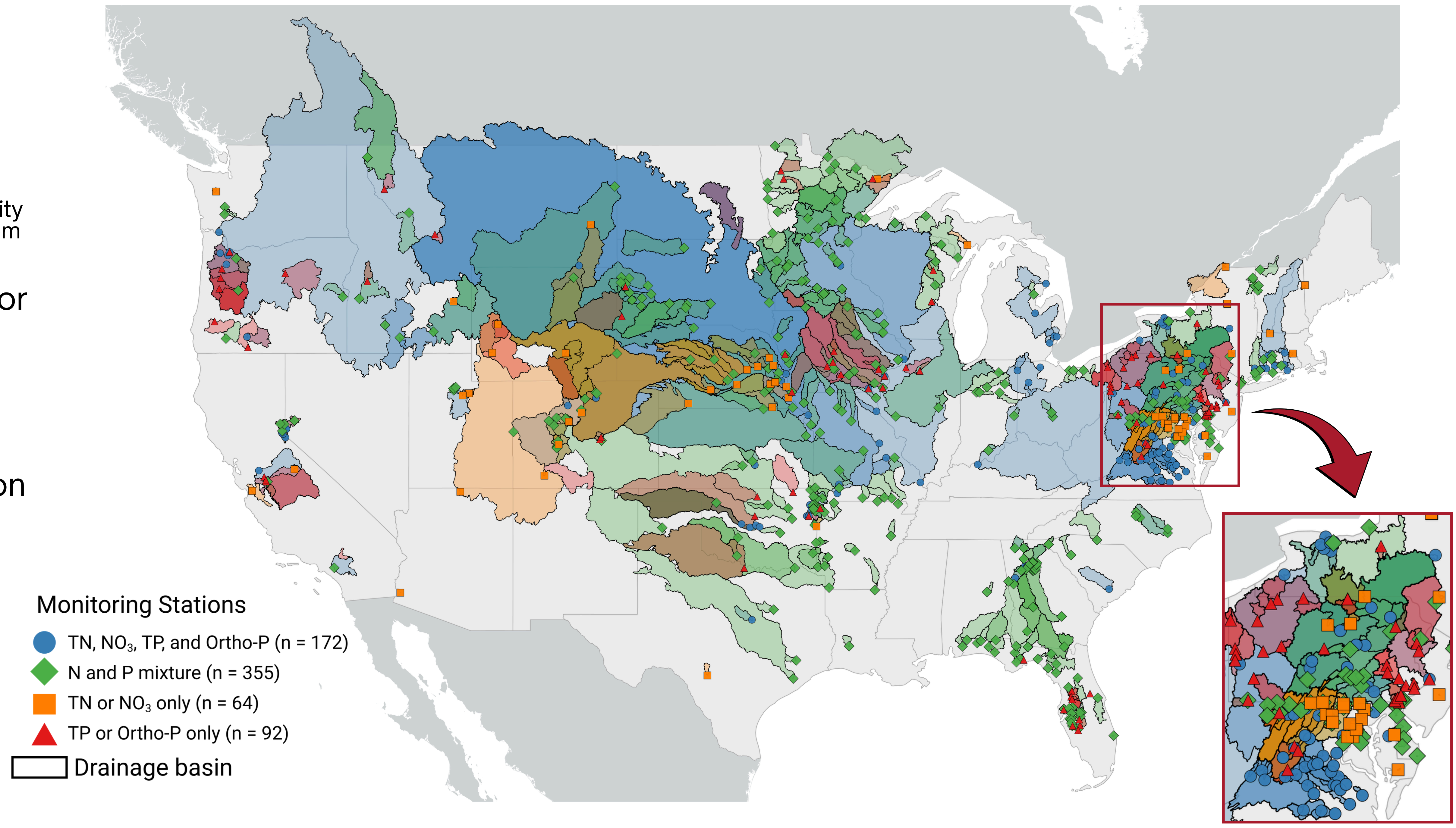
**WRTDS regression equation:**

$$\ln(C) = \beta_0 + \beta_1 t + \beta_2 \ln(Q) + \beta_3 \sin(2\pi t) + \beta_4 \cos(2\pi t) + \varepsilon$$

**7% of U.S. watersheds have high nutrient inputs and zero monitoring stations**



Gaps in monitoring coverage directly limit where long term trends can be estimated, as sparsely monitored regions lack sufficient spatial and temporal data for WRTDS analyses



## Results

- **Monitoring Coverage:** 34.5% of watersheds had no qualifying monitoring stations, and 81.8% had fewer than 10
- **Regional Trends:** Agriculturally-intensive regions were under-monitored relative to nutrient inputs, while areas with established Total Maximum Daily Loads were well-monitored
- **WRTDS Trend Results:** Decreasing trends dominate across nutrients, particularly for phosphorus species, while total nitrogen and nitrate show more mixed responses

| Nutrient | n | Watersheds decreasing in concentration | Watersheds with stable concentrations | Watersheds increasing in concentration |
|---|---|---|---|---|
| TN | 226 | 51.3% | 26.5% | 22.2% |
| NO3 | 585 | 45.5% | 21.7% | 32.8% |
| TP | 317 | 57.7% | 17.7% | 24.6% |
| Ortho-phosphate | 529 | 64.1% | 9.8% | 26.1% |

## Discussion and Next Steps

- Current monitoring networks are misaligned with agricultural nutrient pressures, limiting the ability to target and evaluate effective management strategies. However, nutrient concentrations are generally decreasing
- Integrate WRTDS concentration trends with reference conditions to contextualize basin health and quantify impairment status
- Combine nutrient input data with WRTDS-modeled water quality outputs to evaluate how historical and contemporary nutrient loading relate to decadal water quality trends and outcomes

### Acknowledgements

This material is based upon work supported by the National Science Foundation (NSF) Graduate Research Fellowship Program under Grant No. DGE-2137100. This work was also supported by the STEPS Center, funded by the NSF (grant no. CBET-2019435), U.S. Department of Agriculture (USDA) NIFA Hatch projects (accession number 7003378, multistate project S1089), and U.S. Geological Survey (USGS) Southeast Climate Adaptation Science Center (award G23AC00548). Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the NSF, USDA, USGS, or U.S. Government determination or policy.