# Evaluating Water-Quality Trends in Agricultural Watersheds Prioritized for Management

**Jimmy Webber***, Jeff Chanat, John Clune, Olivia Devereux, Natalie Hall, Robert Sabo, Qian Zhang

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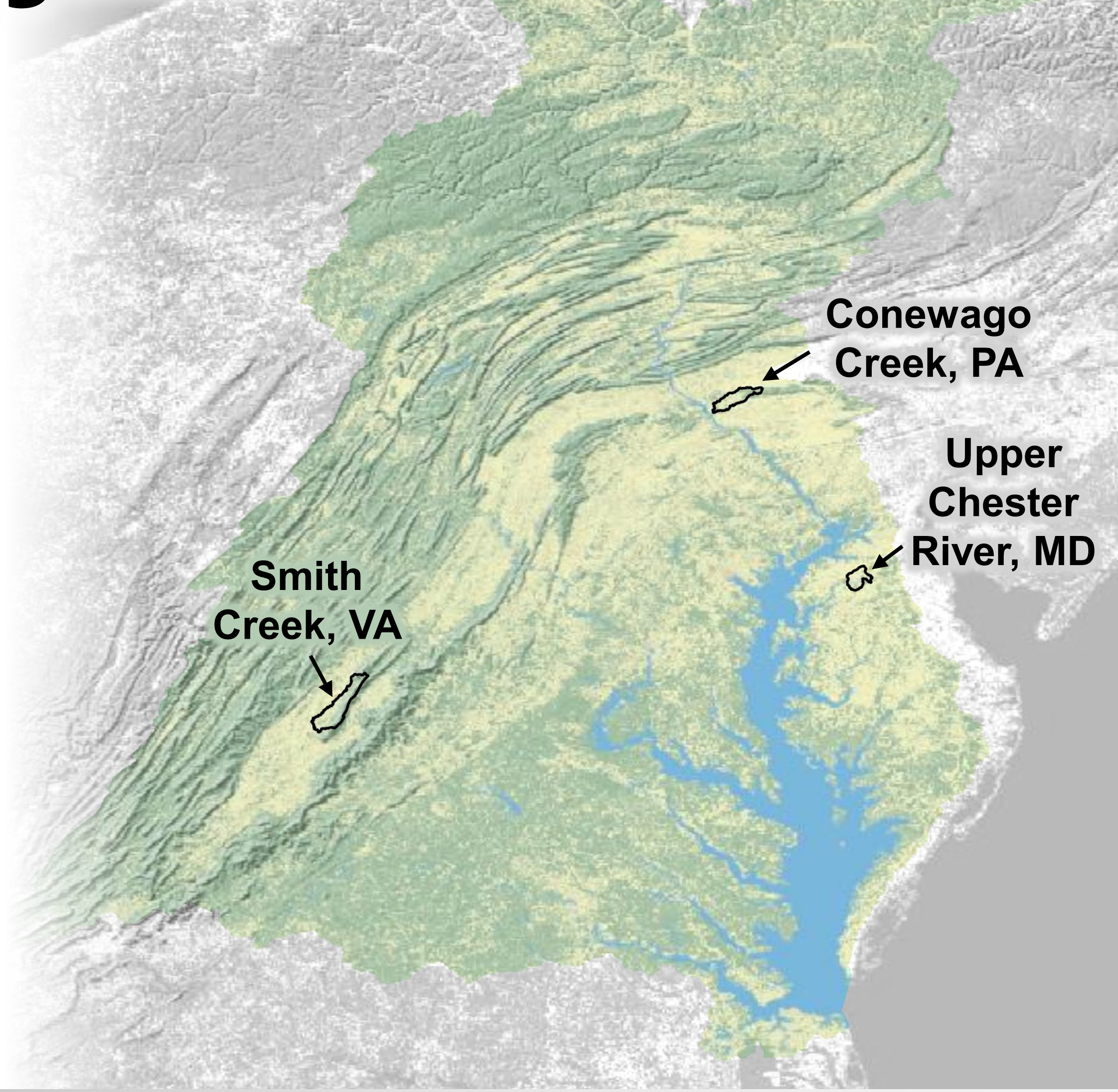
This presentation summarizes the results of a recently published journal article that describes how and why nutrient and sediment loads changed over time in three agricultural Chesapeake Bay showcase watersheds.

This presentation will also discuss a new monitoring effort that has been collaboratively developed by the USGS, EPA, and NRCS to further evaluate the water-quality effects of agricultural management practices.






https://onlinelibrary.wiley.com/doi/10.1111/1752-1688.13197

# Study Background

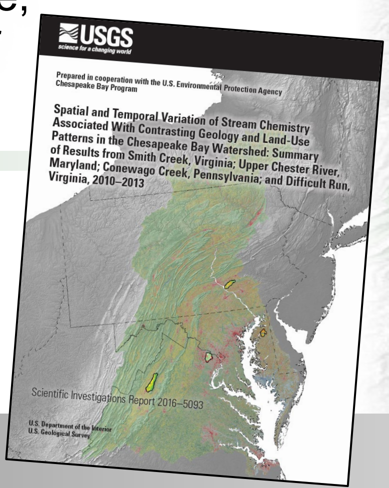
In 2010, the USGS partnered with the USDA and the EPA to

> "*…establish showcase projects in small watersheds to test and monitor the benefits of a focused, highly partnered, voluntary approach to conservation.*"

Three agricultural "showcase" watersheds received enhanced levels of management-practice investment and water-quality monitoring.

Since 2010, the USGS has monitored water-quality conditions in these watersheds to (1) characterize current conditions, (2) evaluate how conditions are changing over time, and (3) understand the drivers of changing conditions.

The recently published journal article builds upon a 2016 USGS report about water-quality in these watersheds.



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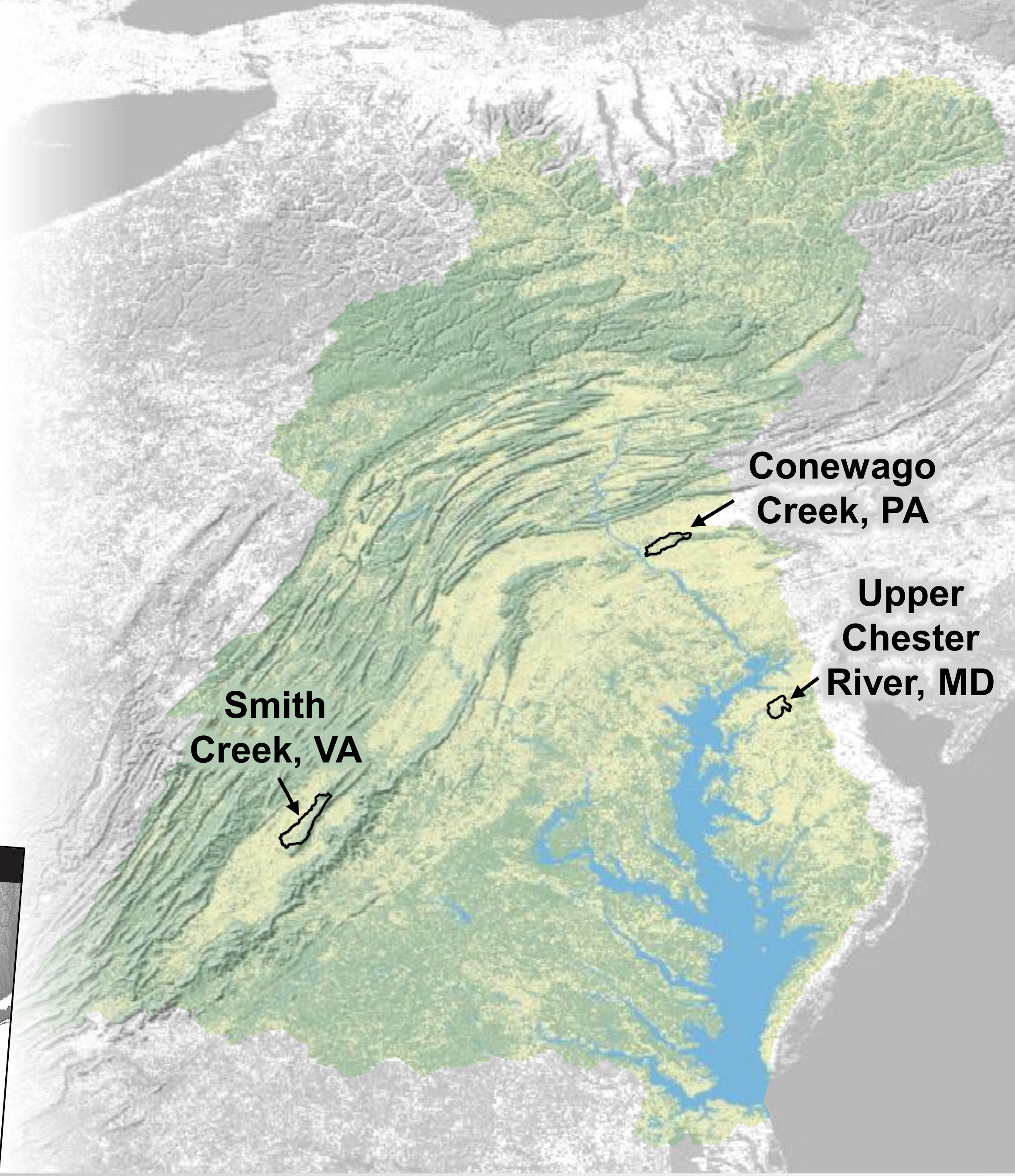
Prepared in cooperation with the U.S. Environmental Protection Agency
Chesapeake Bay Program

Spatial and Temporal Variation of Stream Chemistry Associated With Contrasting Geology and Land-Use Patterns in the Chesapeake Bay Watershed: Summary of Results from Smith Creek, Virginia; Upper Chester River, Maryland; Conewago Creek, Pennsylvania; and Difficult Run, Virginia, 2010–2013

Scientific Investigations Report 2016–5093

U.S. Department of the Interior
U.S. Geological Survey



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**Some important messages from this research:**

1. Increasing amounts of management practices did not consistently result in decreasing nutrient and sediment loads.

2. In some watersheds, the ability of management practices to reduce nutrient loads was likely overshadowed by increased nutrient inputs and suspended-sediment loads.

3. Management practices that reduce nutrient inputs and control the delivery of nutrients and sediment to streams during periods of high streamflow may help reduce loads.

4. Sustained water-quality monitoring, advancements in statistical tools, and collaborative partnerships would help to better understand how agricultural nutrient and sediment loads respond to management practices.


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**The findings of this study support the major messages of the STAC CESR report.**

Selected excerpts from the CESR Executive Summary:

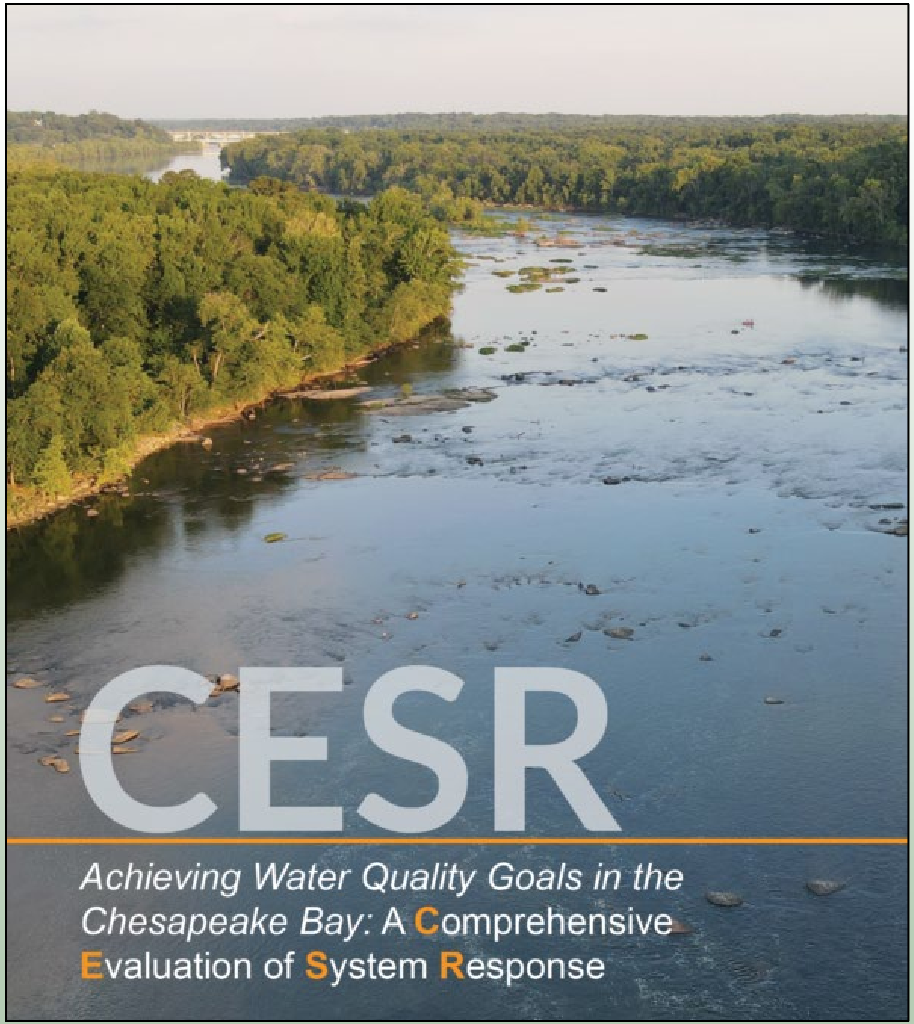
*"The CBP acknowledges the challenges of generating enough nonpoint source BMP adoption to meet nutrient reduction goals…"*

*"…nutrient load reduction gains that have come from BMP implementation efforts are being partially offset by regional increases in imported nutrients."*

*"Achieving large-scale reductions in nonpoint sources of nutrients depends on adequately addressing regional nutrient mass imbalances."*

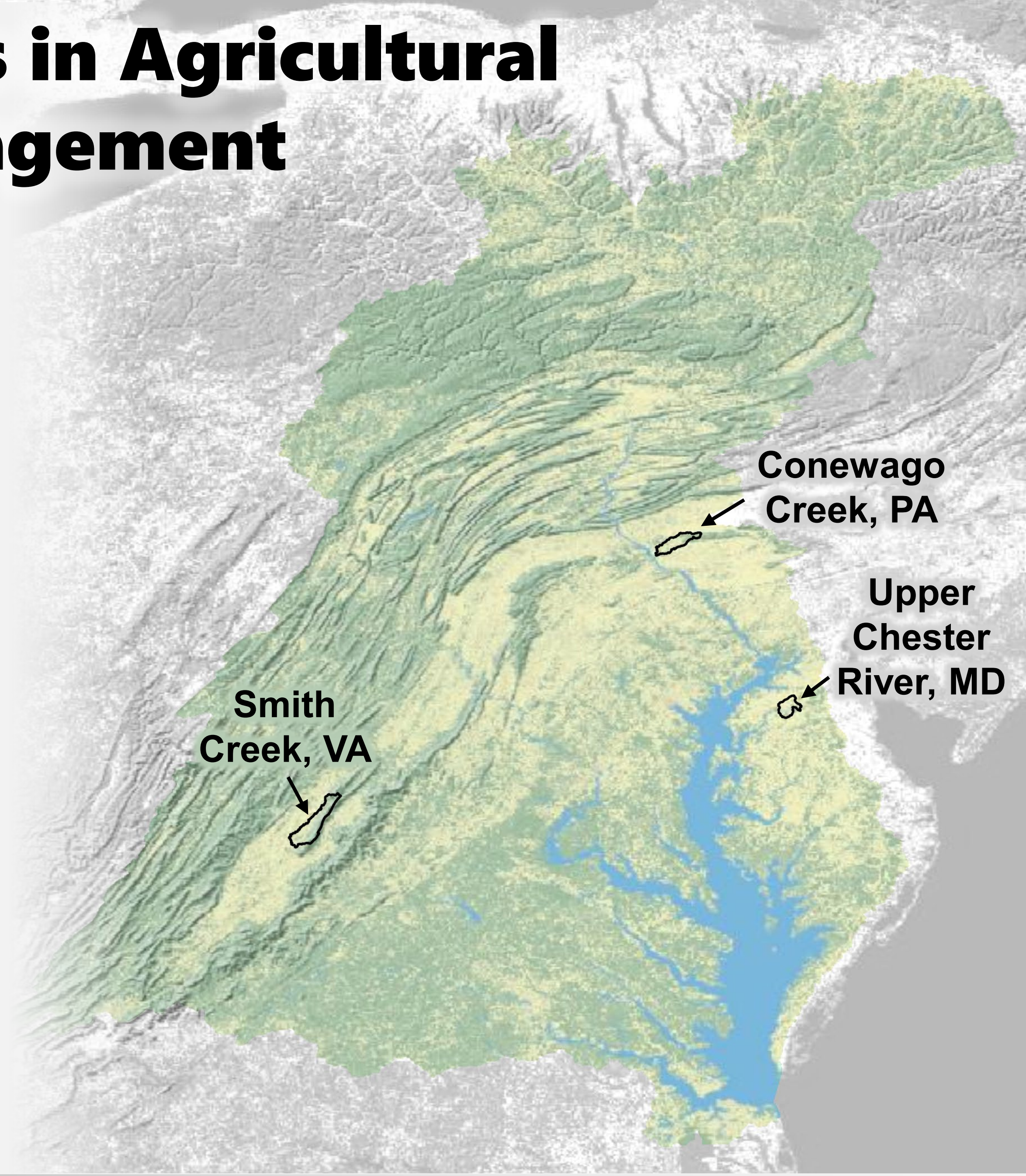
*"…nonpoint source pollutant control efforts may not be as effective at producing nutrient reductions as expected by the CBP…"*

*"While CBP modeling suggests that P reductions targeted by the TMDL are nearly achieved, analysis of water quality at riverine monitoring stations finds limited evidence of observable reductions in P concentrations."*



# Evaluating Water-Quality Trends in Agricultural Watersheds Prioritized for Management

1. Management-Practice Implementation Patterns
2. Water-Quality Responses and Drivers in Recent Years
3. Nitrogen Responses and Drivers in the Smith Creek Watershed



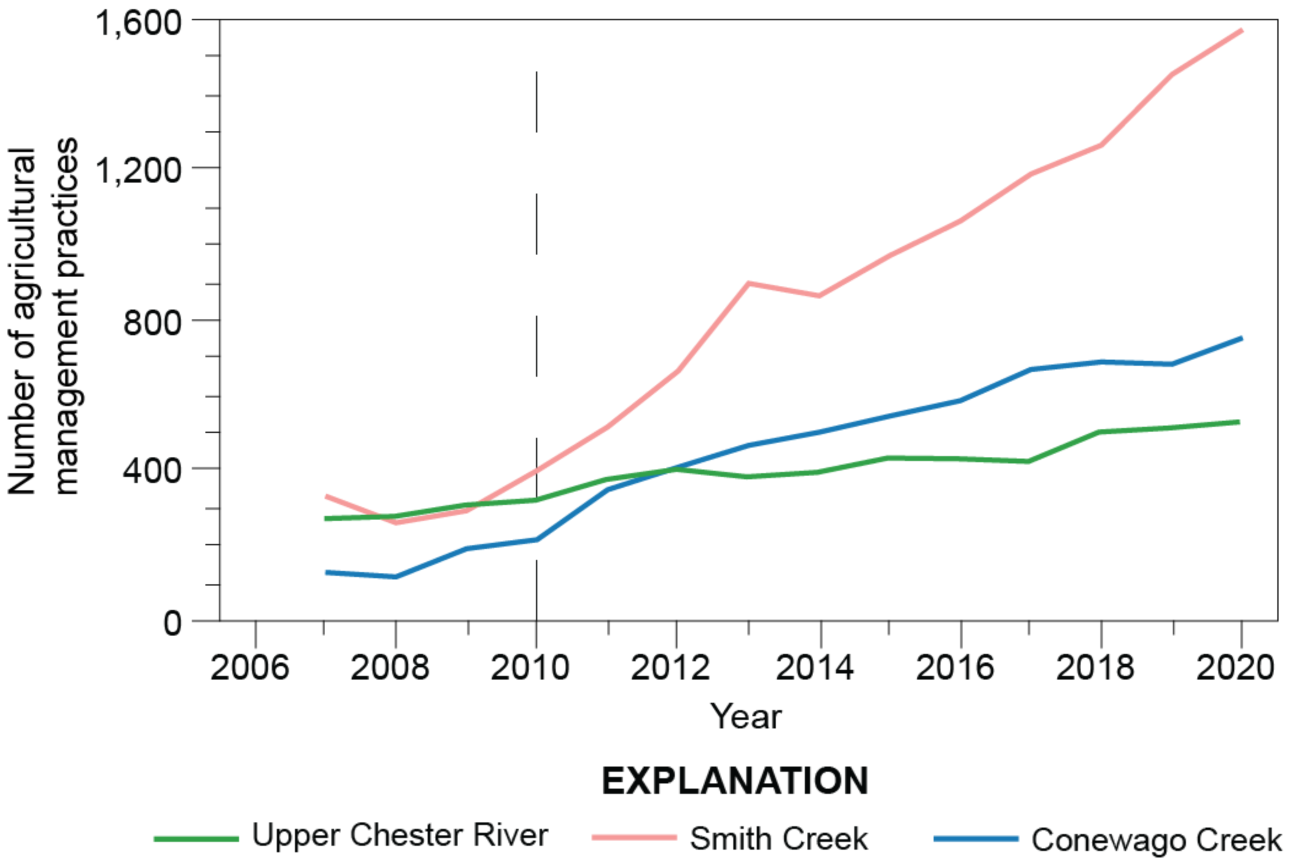
# Agricultural management practices increased over time[1]

The number of management practices was at least two times higher in 2020 than 2007 in all watersheds.

**x2** Upper Chester River

**x4** Smith Creek

**x5** Conewago Creek




A lot or a little? Management-practice area can be compared against agricultural land area.

***Average management-practice area, as a percentage of agricultural land area:***

**178%** Upper Chester River

**22%** Smith Creek

**75%** Conewago Creek

Not all practices are designed to reduce nutrient and sediment loads. With input from NRCS, we identified practices with a "high-impact" potential to reduce loads.

***Average percentage of practices with "high-impact" load reduction expectations:***

**66%** Upper Chester River

**27%** Smith Creek

**47%** Conewago Creek

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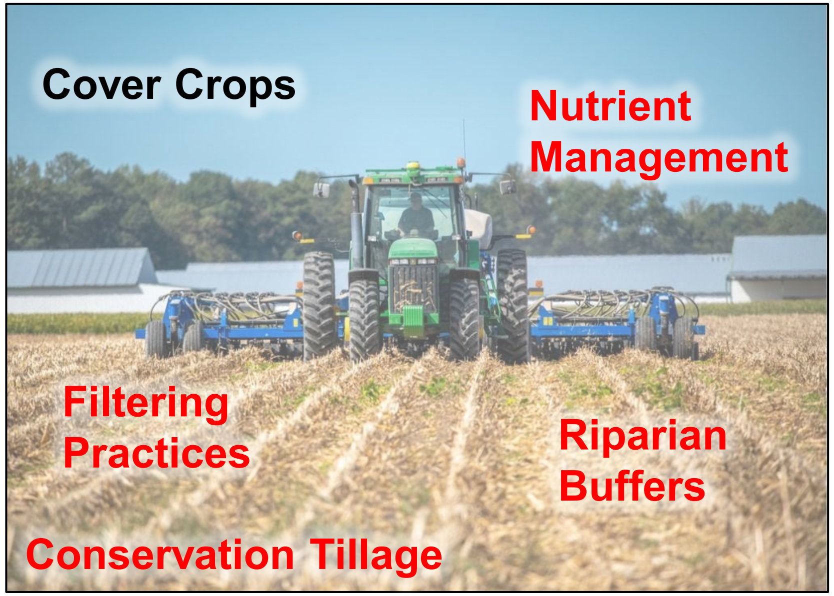
[1]Agricultural management practices that received financial or technical assistance from state or federal agencies were summarized from water years 2007 through 2020.

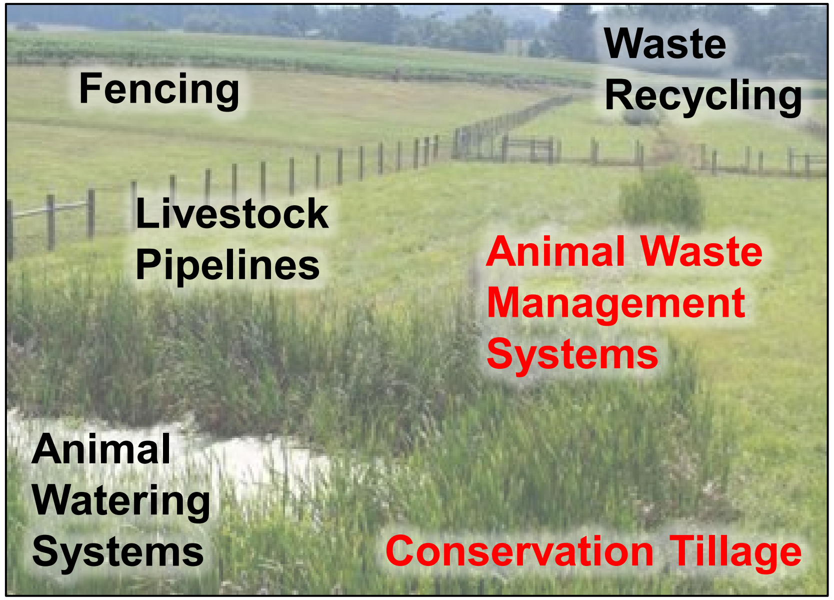
# Each watershed had a unique suite of management practices

## Upper Chester River, MD

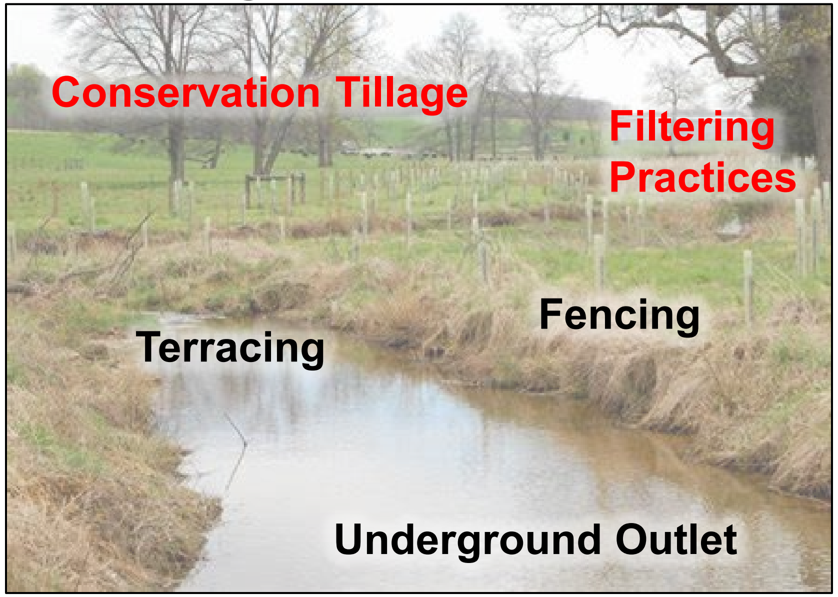



“High impact” nutrient or sediment management practice.

## Smith Creek, VA




## Conewago Creek, PA



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2. **Water-Quality Responses and Drivers in Recent Years**

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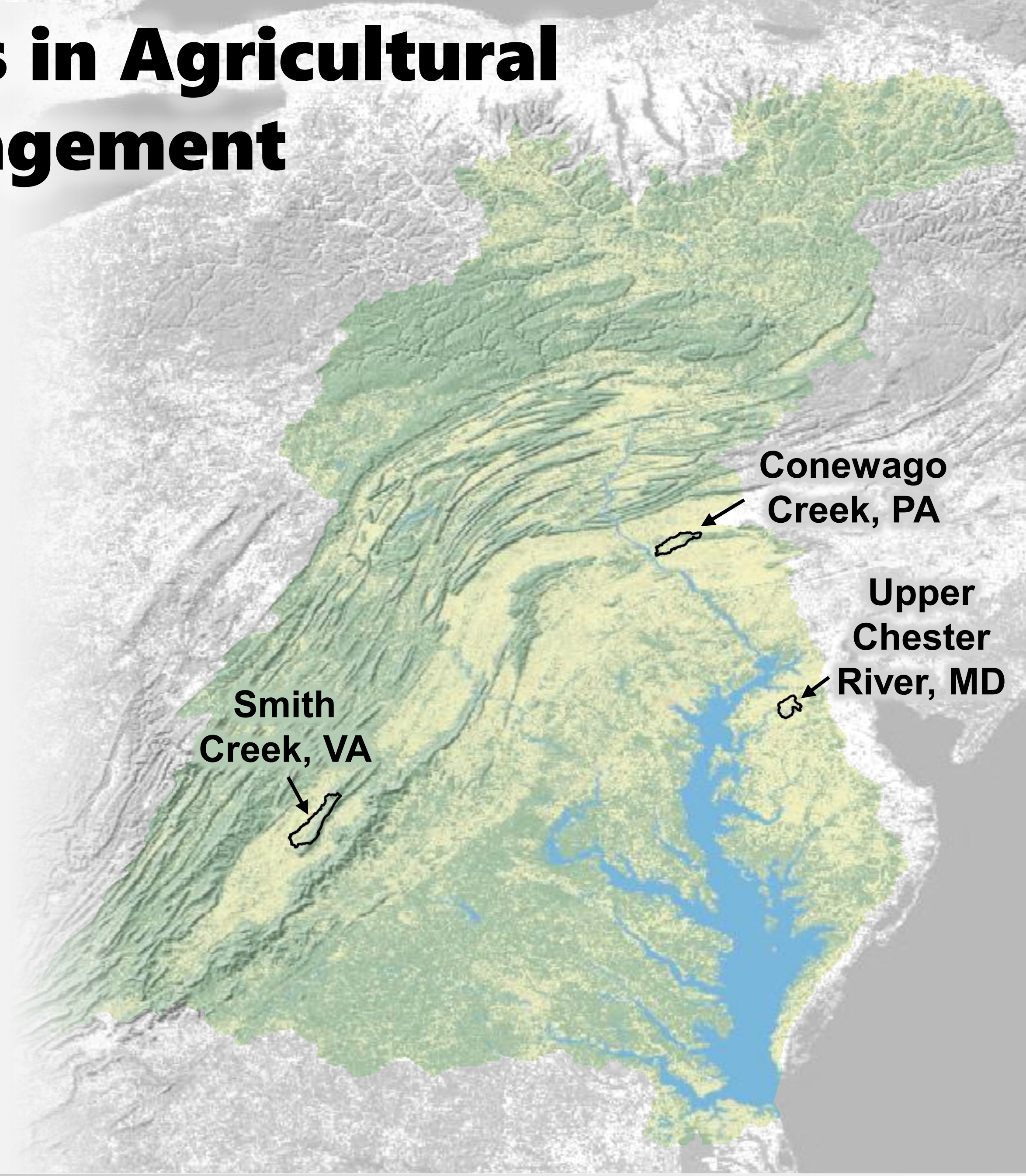
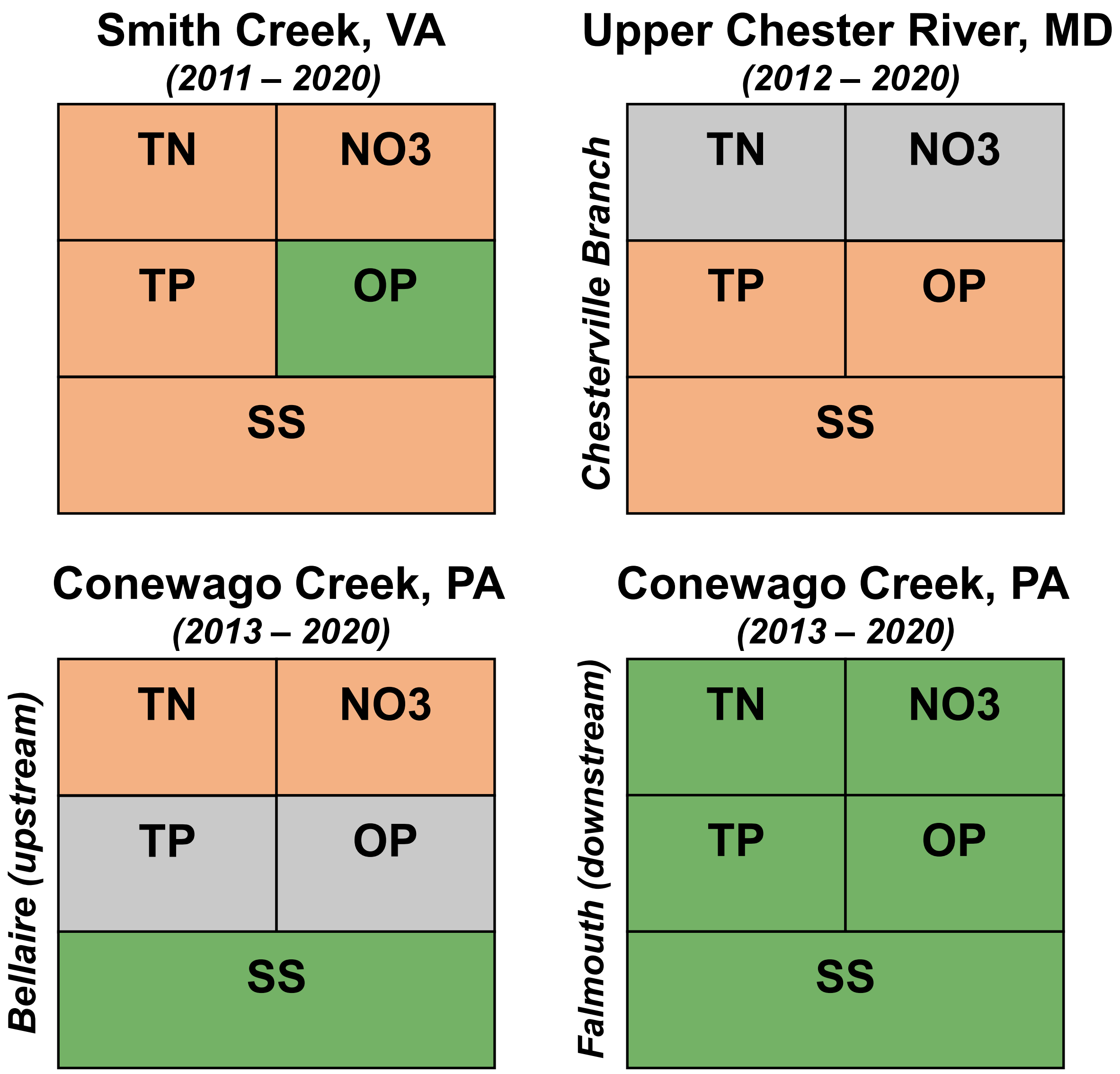


# Since the early 2010's, most FN nutrient and sediment loads did not decrease[1]

9 of 20 FN loads **increased** (45%)

7 of 20 FN loads **decreased** (35%)

***In all watersheds, most nutrient and sediment load changes occurred during days with above average streamflow.***




**TN**, total nitrogen; **NO3**, nitrate; **TP**, total phosphorus; **OP**, orthophosphate; **SS**, suspended sediment.

Increasing trend
Decreasing trend
No trend



[1]Trends in FN load were computed for each showcase watershed streamgage using WRTDS, methods used by the Chesapeake Bay nontidal monitoring network.

# Since the early 2010's, most FN nutrient and sediment loads did not decrease[1]

9 of 20 FN loads **increased** (45%)

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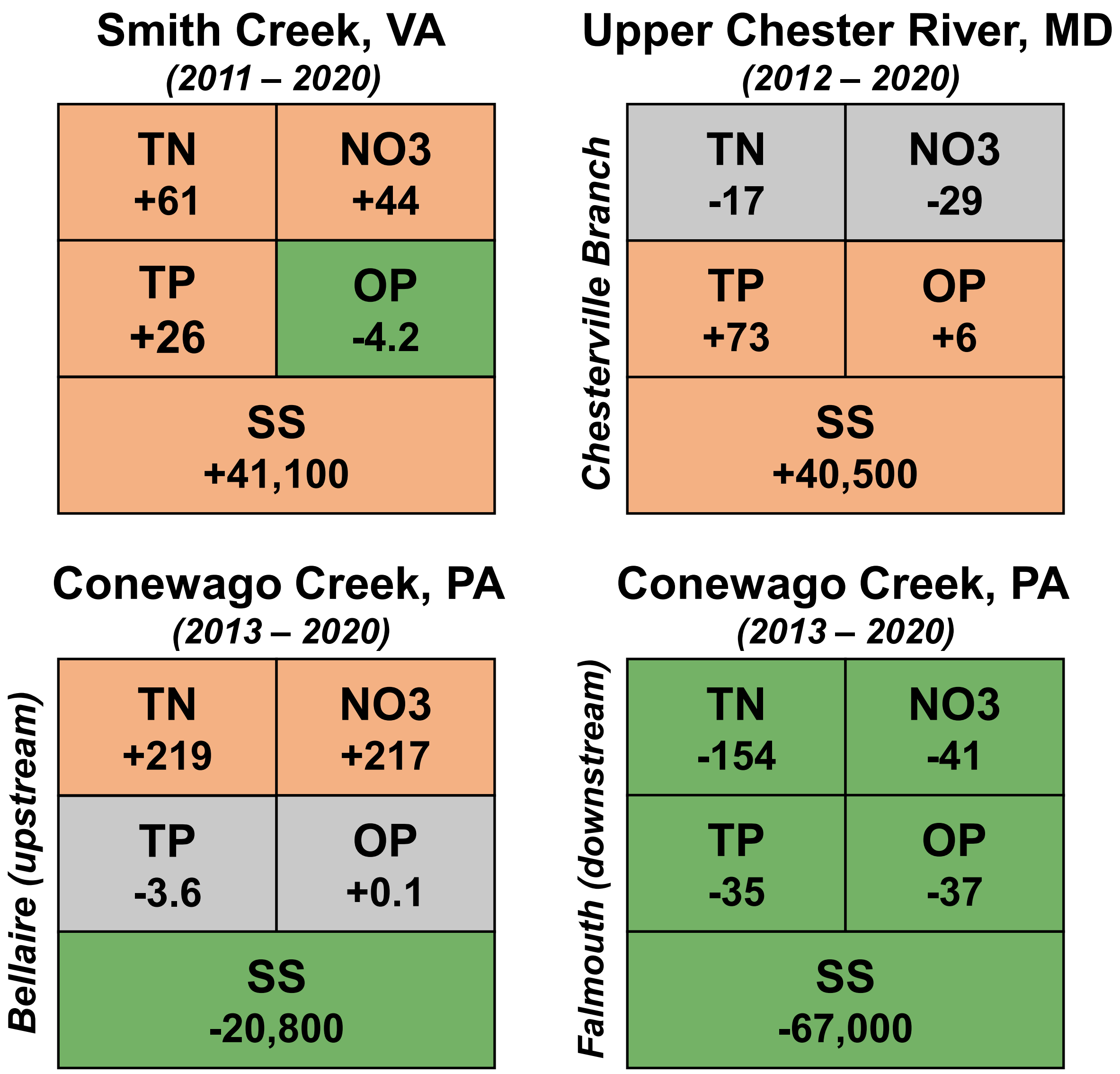
*In all watersheds, most nutrient and sediment load changes occurred during days with above average streamflow.*

Trends in TN were mostly caused by changes in NO3.

Trends in TP were not fully explained by changes in OP.

Trends in TP were likely affected by changes in SS.

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Increasing trend
Decreasing trend
No trend

**+61** Trend in kg/km$^2$

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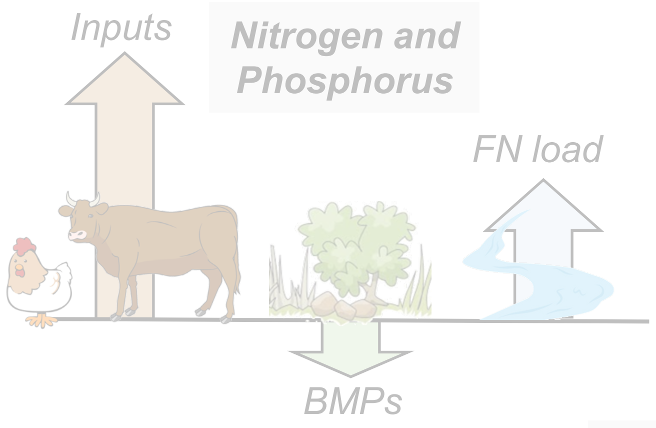
[1]Trends in FN load were computed for each showcase watershed streamgage following methods used by the Chesapeake Bay nontidal monitoring network.

# Some Highlights…

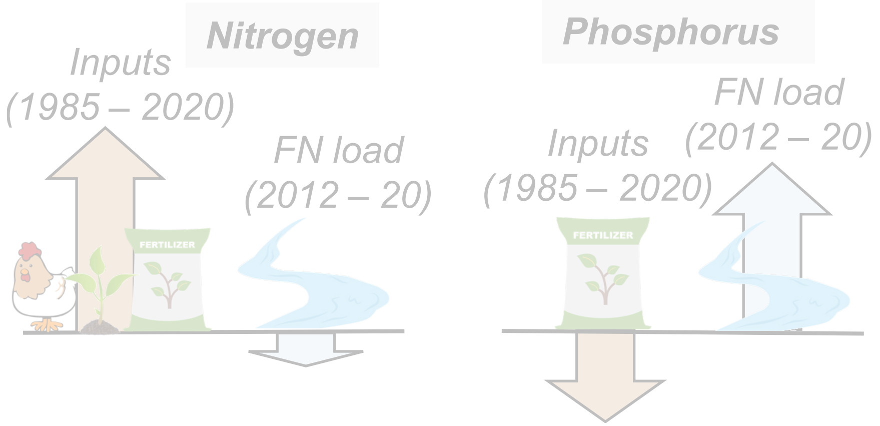
## Smith Creek, VA

- Nutrient loads and inputs increased since 2011. Input increases were larger than management-practice reductions.
- Nutrient inputs exceed crop removal rates. Surplus nutrient inputs increased over time.



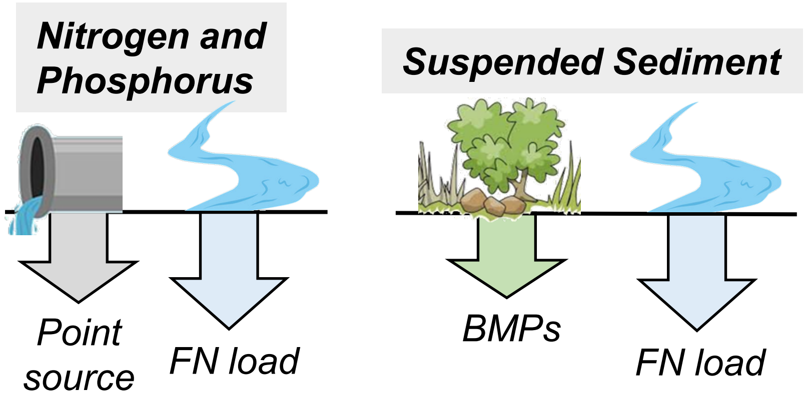

## Upper Chester River, MD[1]

- Nitrogen inputs nearly doubled since 1985, but nitrogen loads did not increase since 2012. It may take decades for nitrogen to pass through groundwater.
- Phosphorus inputs decreased since 1985. Increasing phosphorus loads were likely caused by (1) suspended sediment and (2) soil phosphorus losses.




## Conewago Creek, PA

- Wastewater point source inputs may explain some of the nutrient trend differences between the upstream and downstream streamgages since 2013.
- Suspended sediment loads decreased at both streamgages since 2013. Conewago Creek had more sediment-reducing management practices than other study watersheds.




[1]Represented by patterns at the Chesterville Branch streamgage. The Chesterville Branch streamgage includes a plant nursery in the upstream drainage area, a landscape feature that is unique to the surrounding region.

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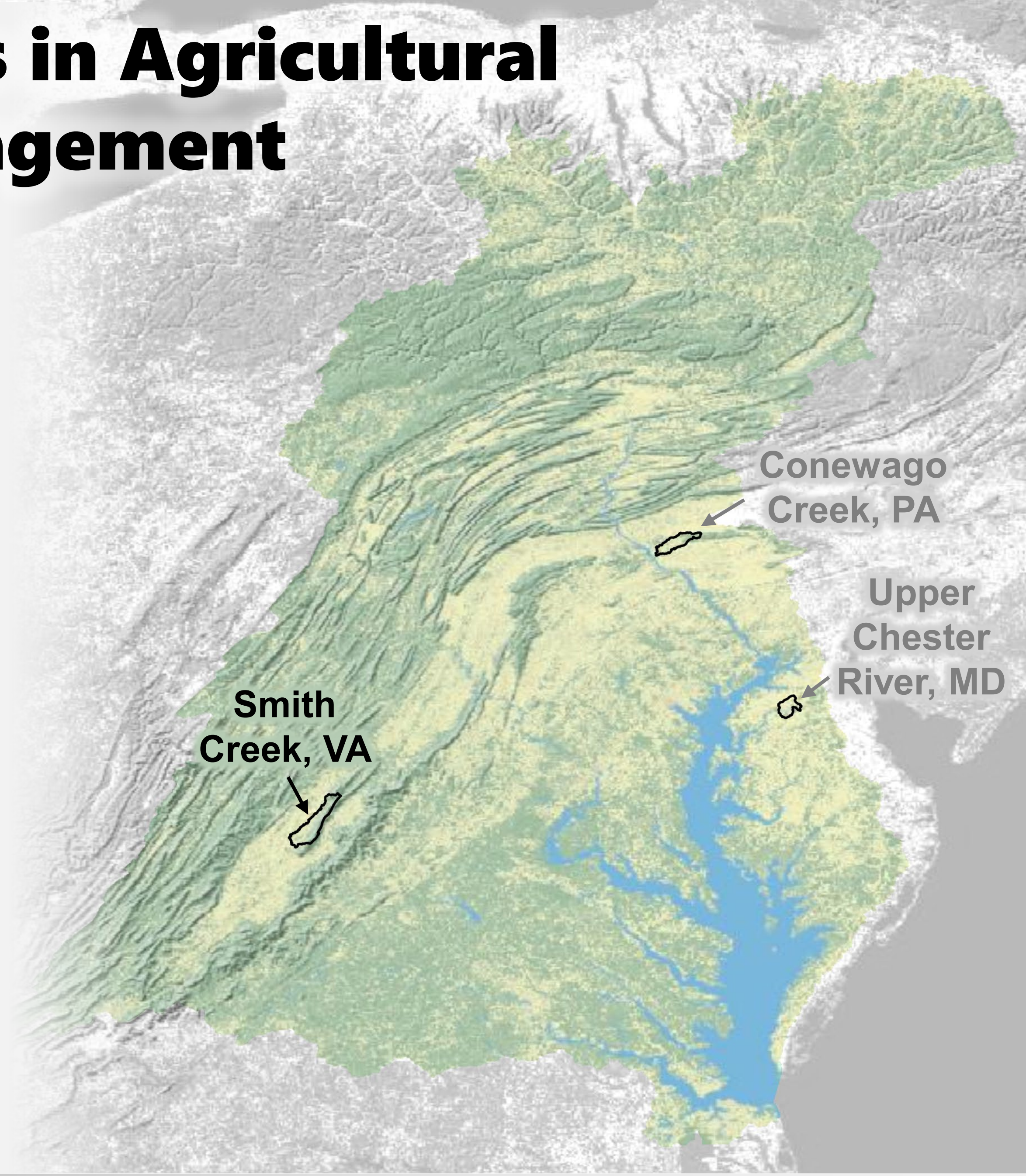
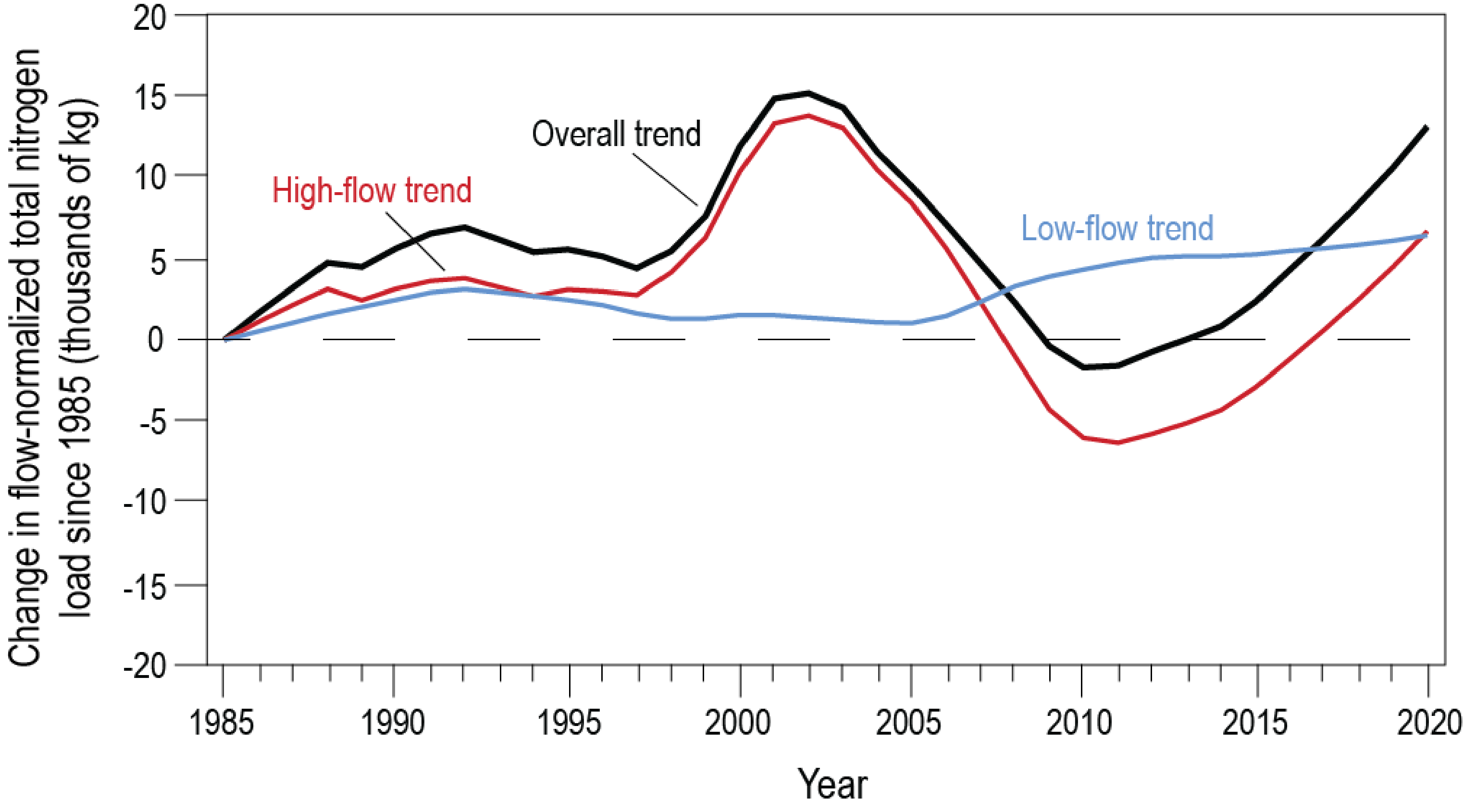


# Smith Creek[1]: flow-normalized (FN) total nitrogen (TN) loads increased[2] from 1985 through 2020

FN TN loads were 7% higher (13,000 kg) in 2020 than 1985.

Changes in load during days with above-average streamflow (**"high-flow"**) caused most of the **overall change** in TN load.

**"Low-flow"** TN loads have increased since the mid 2000's, possibly highlighting increasing amounts of groundwater nitrogen.




***What caused the increase in FN TN load?***

*Climatic effects?*

*Streamflow?*

*Management practices?*

*Nutrient inputs?*



[1]Representing loads and trends at the Smith Creek streamgage (USGS station ID 01632900) from water years 1985 through 2020.

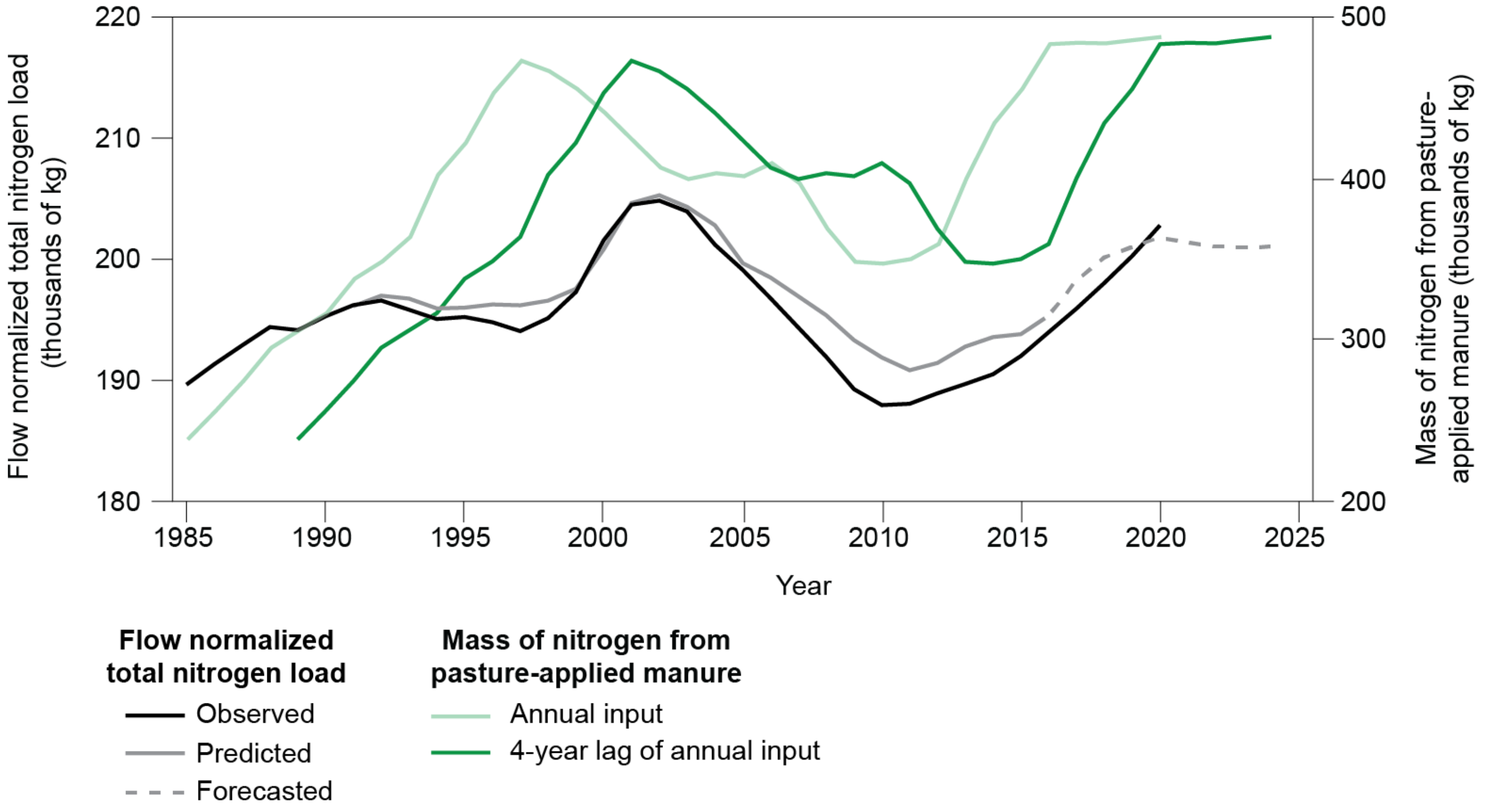
[2]As reported by Mason and others, 2023: https://doi.org/10.5066/P96H2BDO

# Smith Creek: the input of nitrogen from manure[1] explained changes in FN TN load[2]

+100 kg of nitrogen from pasture-applied manure

4 years

+4 kg of FN TN at the Smith Creek streamgage




Manure is the largest nitrogen input in Smith Creek; most nitrogen is applied to pastureland.

Manure nitrogen inputs were 78% higher in 2020 than 1985 in Smith Creek, patterns that reflect increased cattle and poultry populations.

Groundwater ages are variable throughout the Shenandoah Valley and include fractions of young and old water. Some springs include a large fraction of young water (ages of less than 10 years).



[1]Annual nutrient inputs were estimated from the CAST (Devereux and others, 2022: https://doi.org/10.5066/P93SVYQG)

[2]Based on a time-series regression model that considered the ability of water-quality predictor variables to explain annual differences in FN TN load from 1991 from 2016 (n=26).

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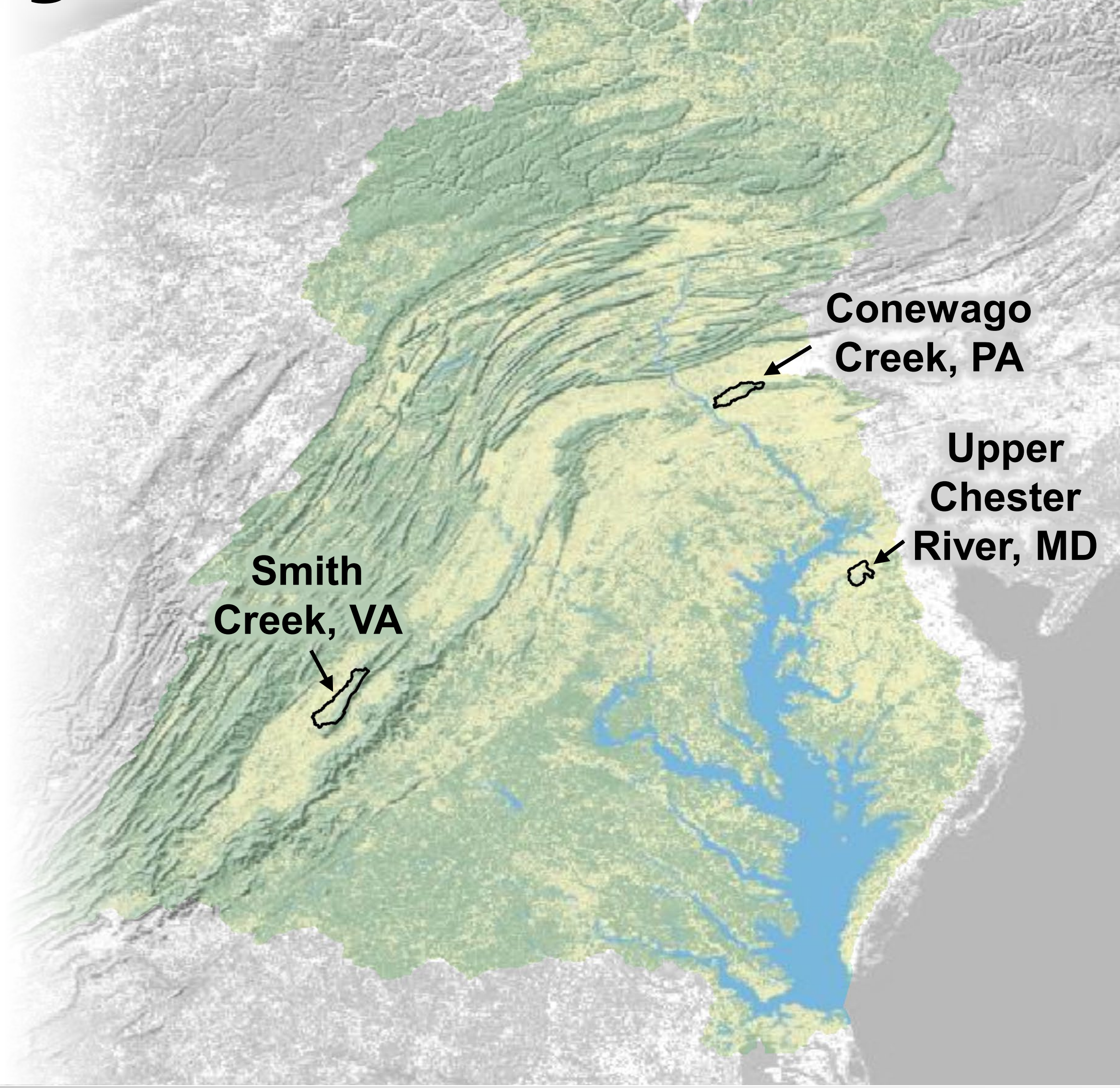




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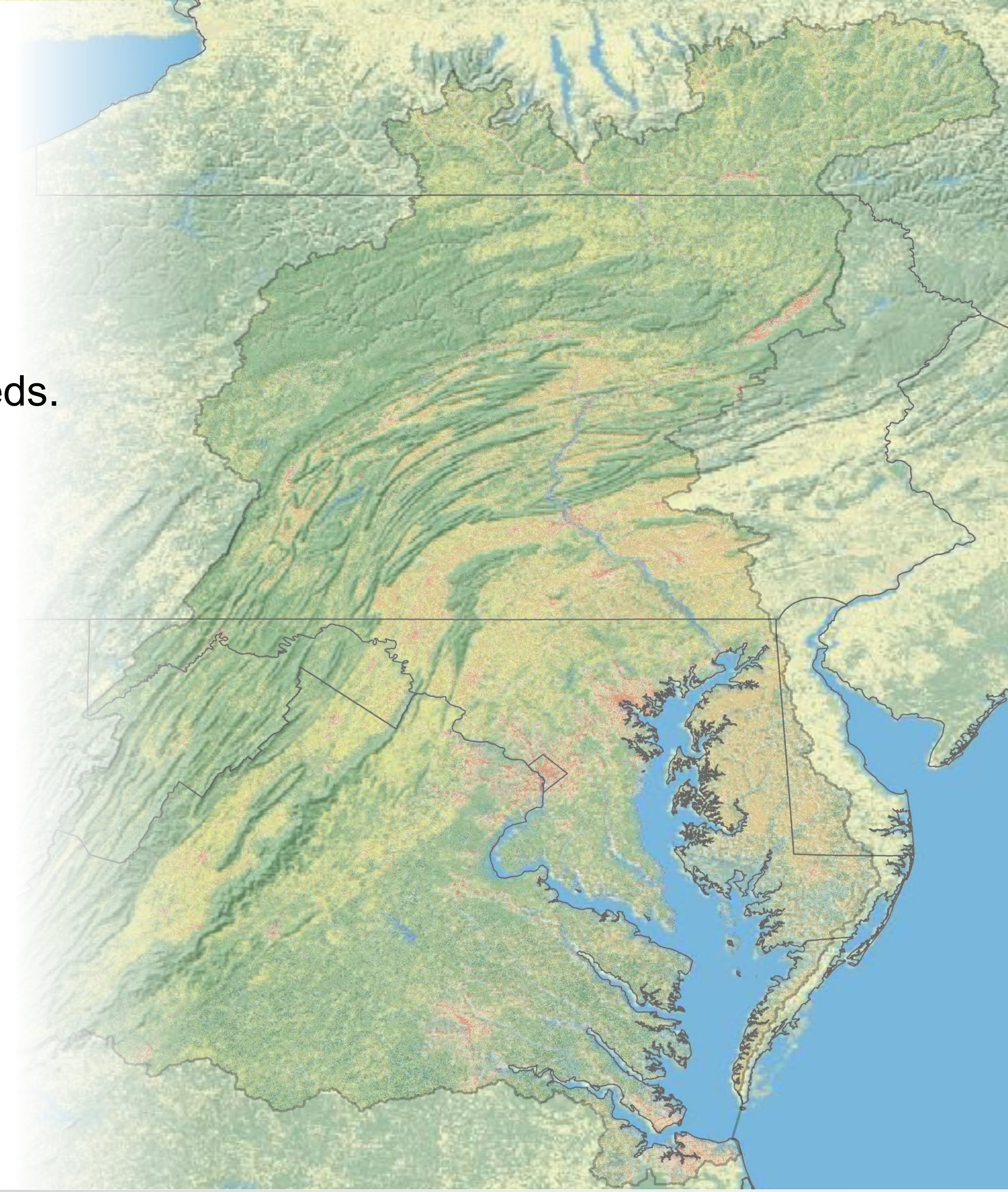
# Small Agricultural Watershed Monitoring Program

The USGS and EPA are planning a new water-quality monitoring effort with Chesapeake Bay partners in small agricultural watersheds.

**The objectives of this new study are to:**

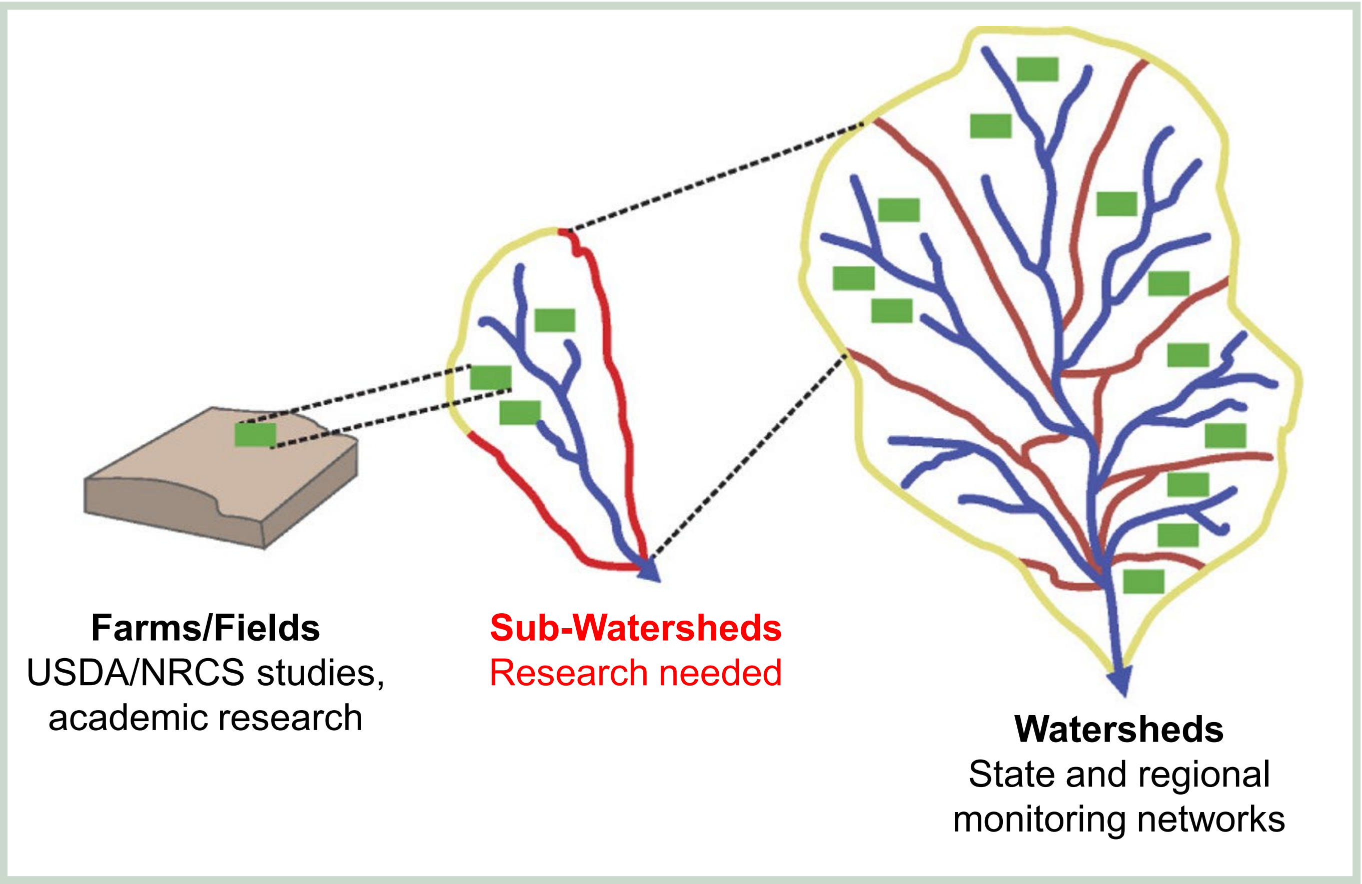
1. Develop new collaborative, outreach, and educational opportunities among agricultural, conservation, scientific, and academic communities.
2. Increase our understanding about nutrient and sediment loads and trends in agricultural watersheds.

***The development of this monitoring effort builds on lessons learned from the showcase watershed study.***



# General Study Design

- Five small agricultural watersheds (between 5 and 13 $mi^2$) will be monitored for multiple years. Small watersheds may:
  - Address a research gap.
  - More clearly demonstrate the water-quality effects of conservation efforts.
  - Better engage local communities.




- Long-term monitoring activities will include:
  1. A streamgage
  2. Continuous water-quality data (15-minute water temperature, specific conductance, pH, dissolved oxygen, turbidity, and nitrate)
  3. Discrete water-quality data (monthly + storm-targeted stream samples analyzed for nutrients, sediment, ions, and metals)

# Current State of the Effort

- The USGS worked with partner agencies (NRCS, state environmental agencies, local watershed groups, etc.) to identify small agricultural watersheds…
  - …with planned conservation efforts.
  - …with collaborative, outreach, and educational opportunities.
  - …that meet our scientific study objectives.

- Two Pennsylvania stations were installed in December. ***Continuous data are available online!***
  1. Hammer Creek, PA (USGS station ID 01576381)
  2. Little Conewago Creek, PA (USGS station ID 01573684)

- Three additional stations will be installed in the spring of 2024 in VA, MD, and DE.

- We're engaged in ongoing conversations with partners about funding to maintain and grow this monitoring network.