

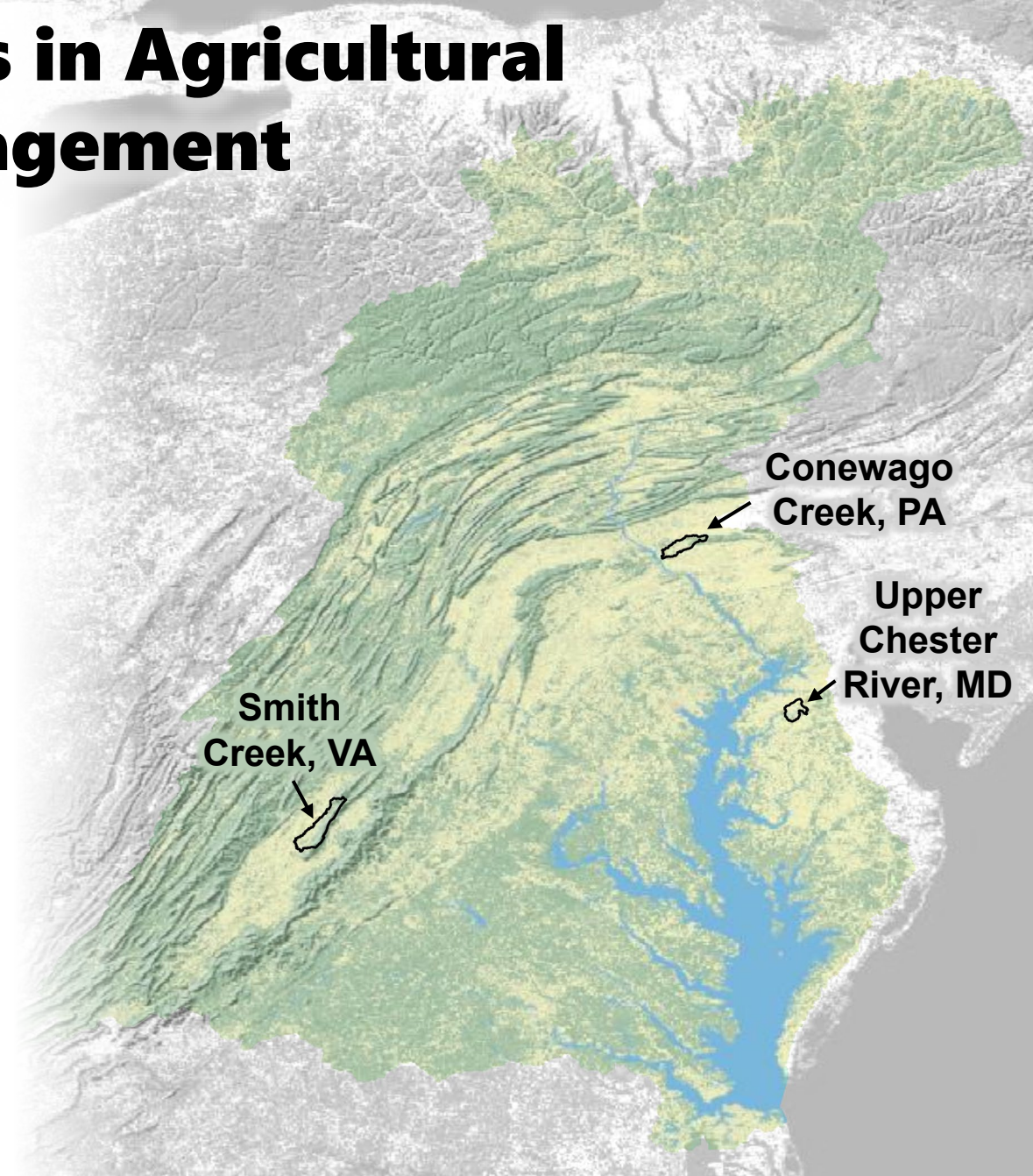
Evaluating Water-Quality Trends in Agricultural Watersheds Prioritized for Management

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This presentation summarizes the results of an upcoming 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.



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.”

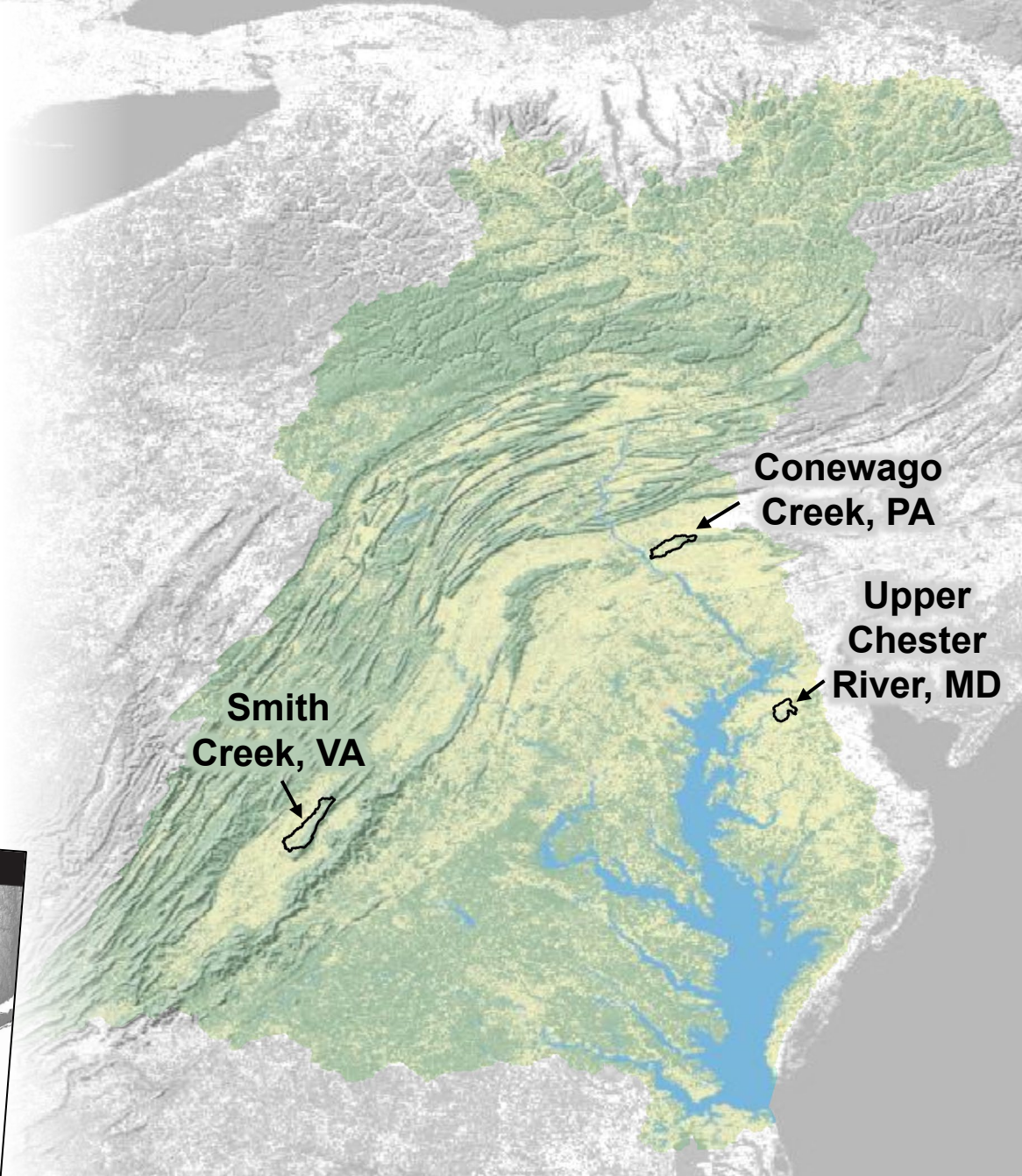
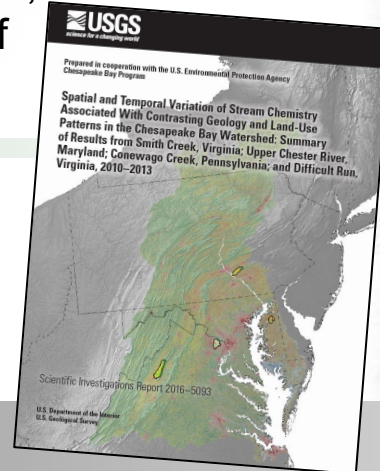


Three agricultural “showcase”
watersheds received enhanced levels
of management-practice investment
and water-quality monitoring.



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



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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:

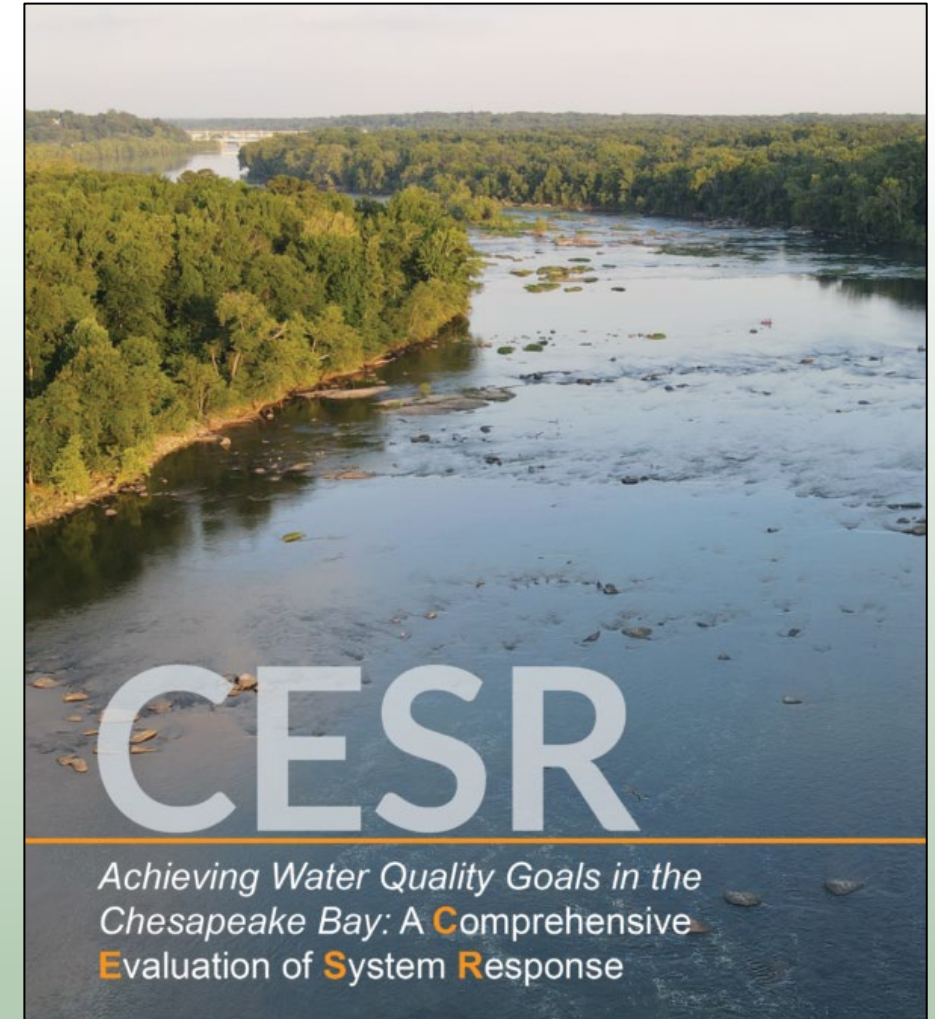
“The CBP acknowledges the challenges of generating enough nonpoint source BMP adoption to meet nutrient reduction goals...”

“...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.”

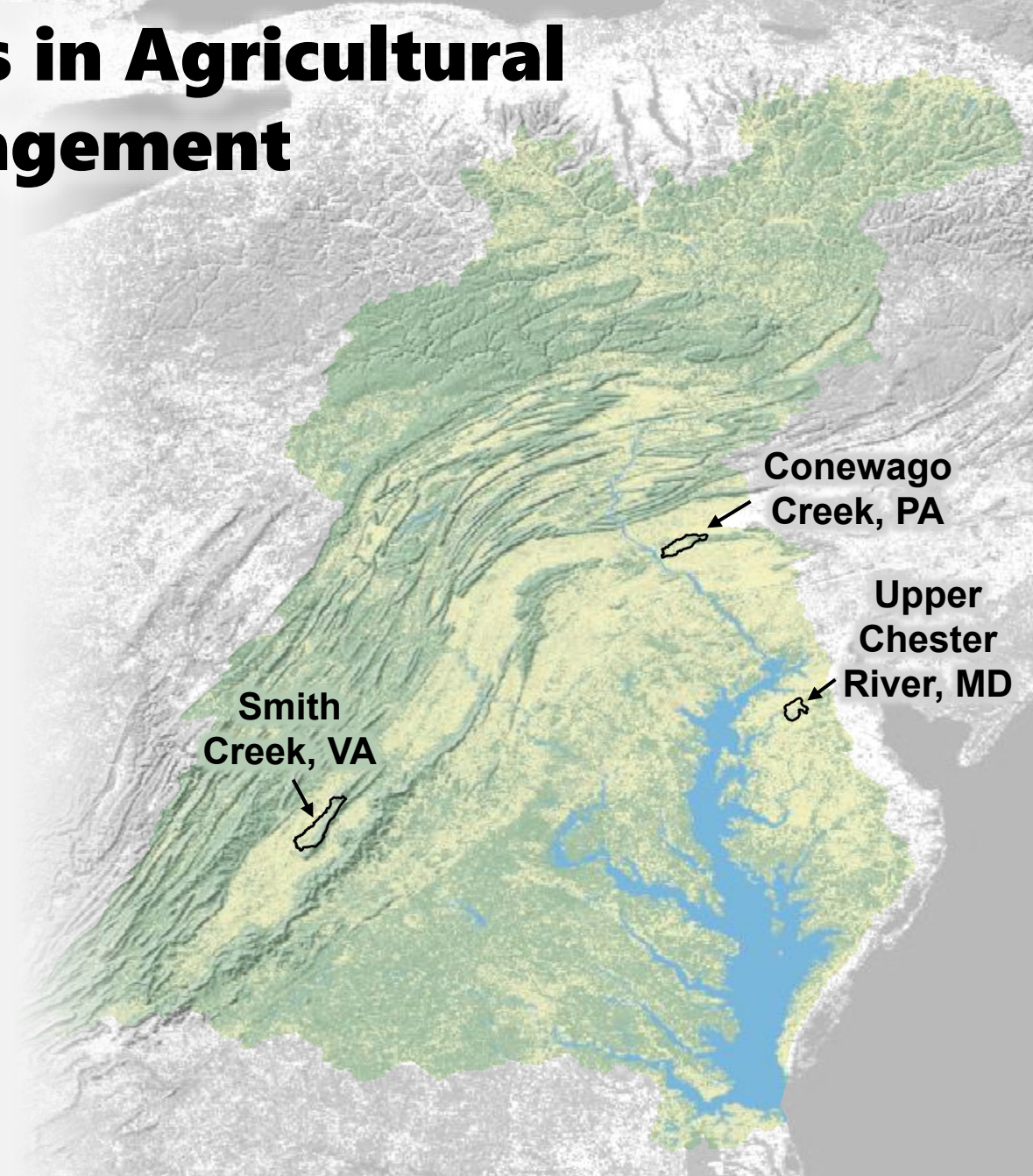


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1. Management-Practice Implementation Patterns

2. Water-Quality Responses and Drivers in Recent Years

3. Nitrogen Responses and Drivers in the Smith Creek Watershed



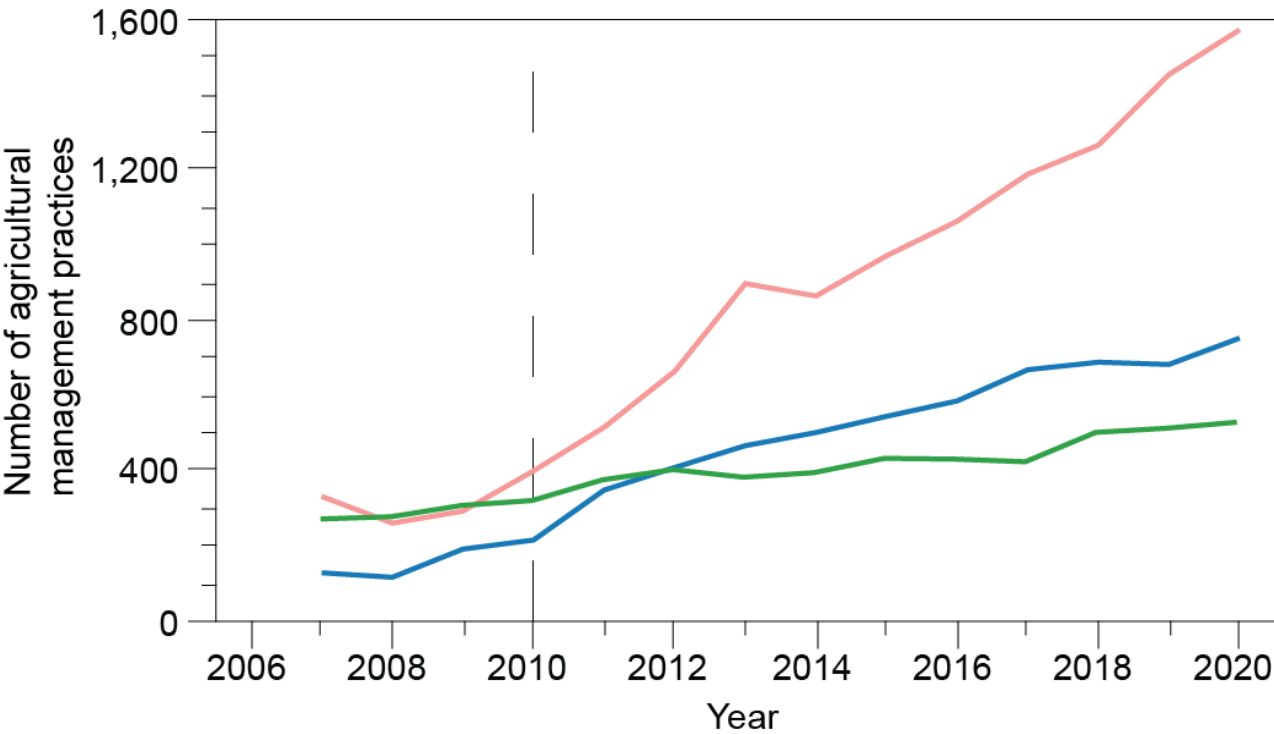
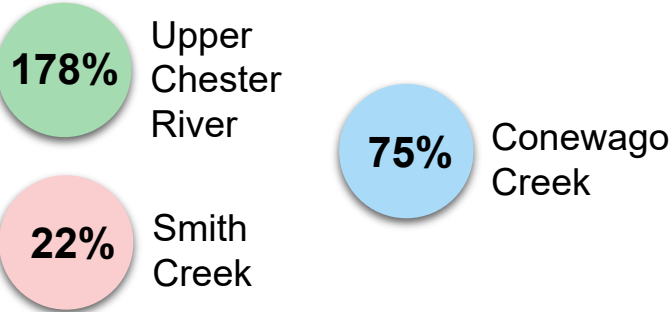
Agricultural management practices increased over time¹

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

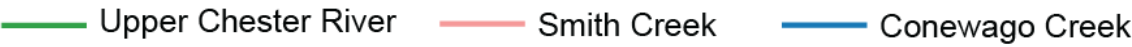


A lot or a little? Management-practice area can be compared against agricultural land area.

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

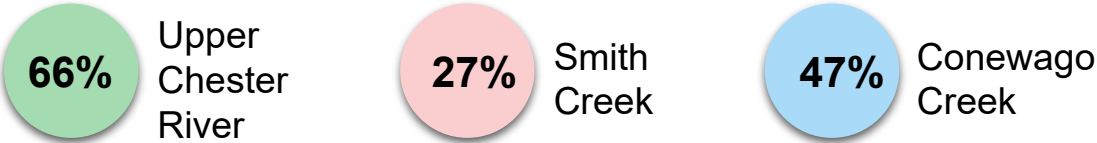


EXPLANATION



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.

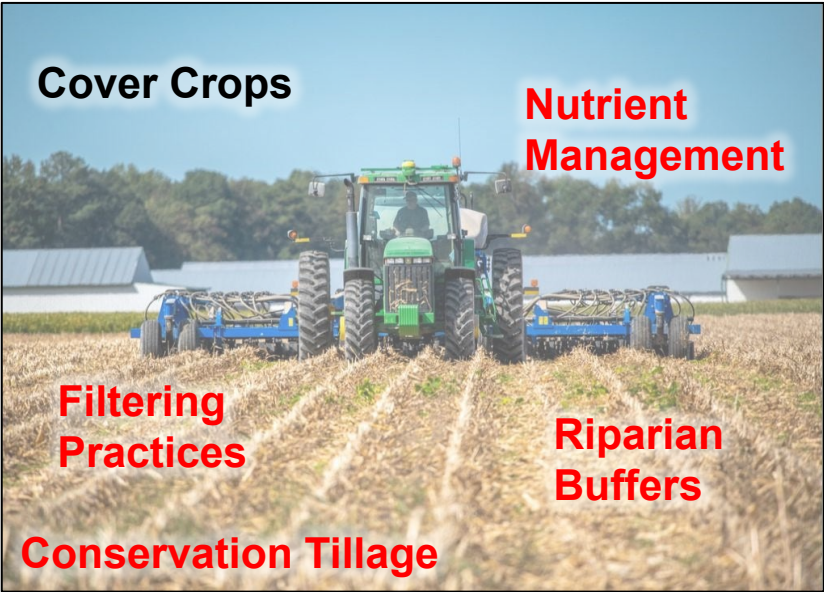
Average percentage of practices with “high-impact” load reduction expectations:



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

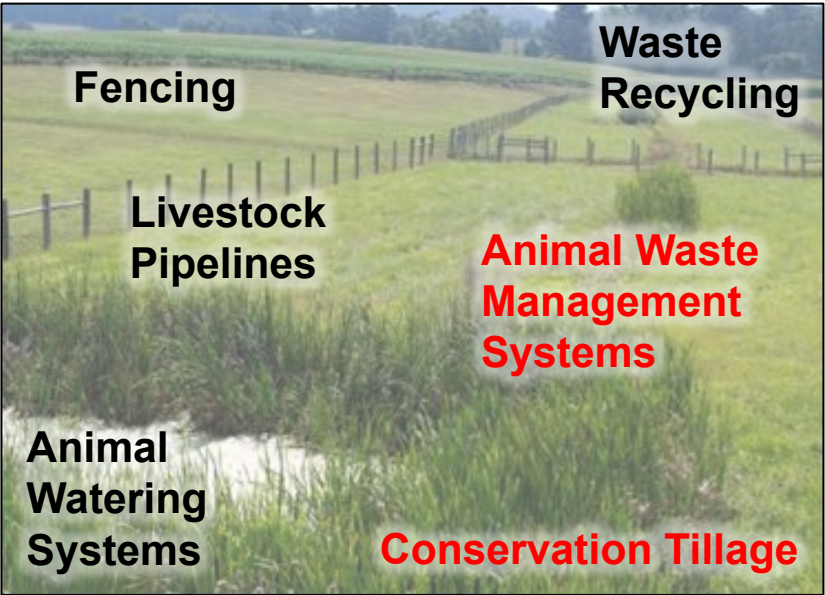
Each watershed had a unique suite of management practices

Upper Chester River, MD



“High impact” nutrient or sediment management practice.

Smith Creek, VA



Conewago Creek, PA

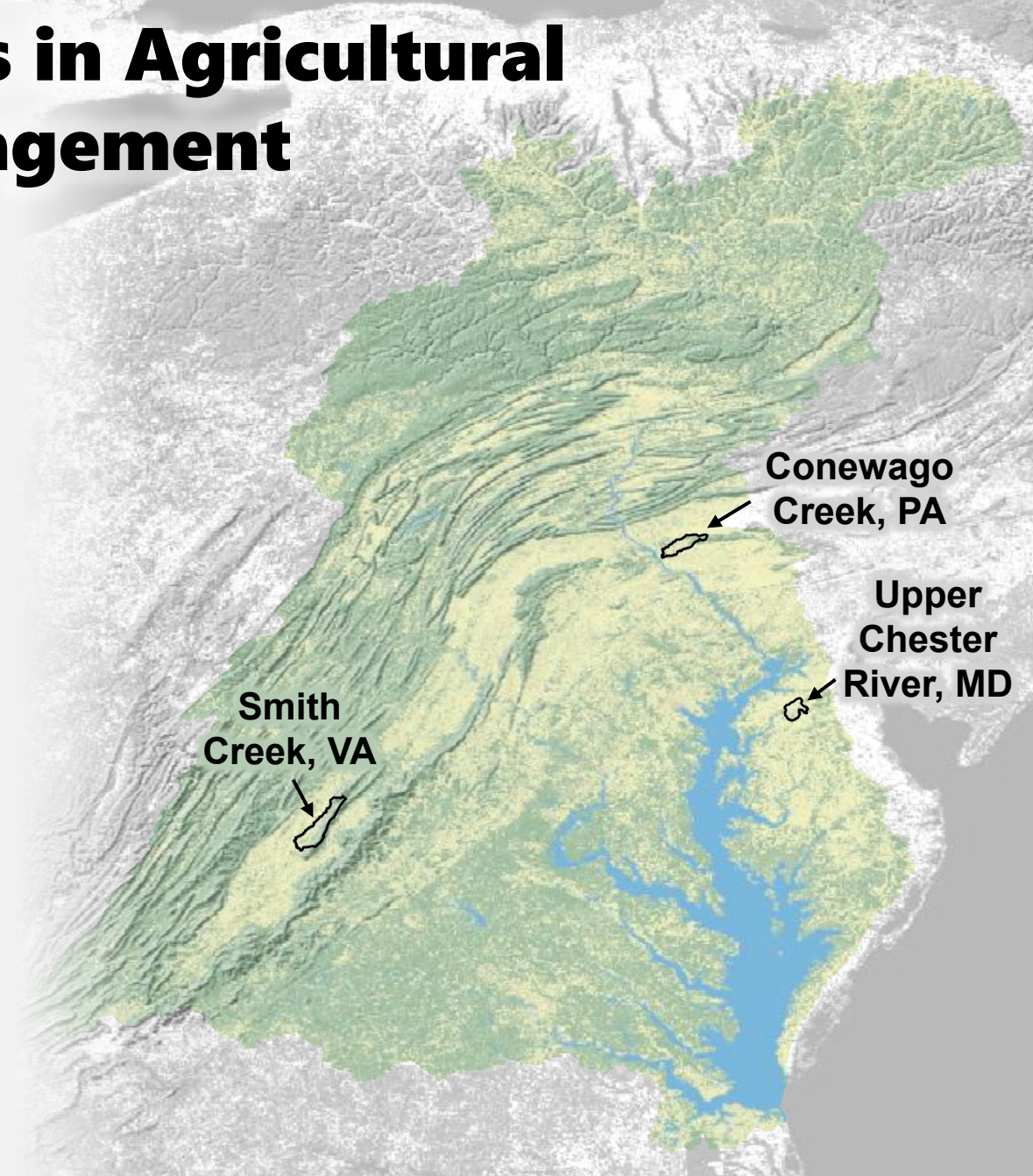


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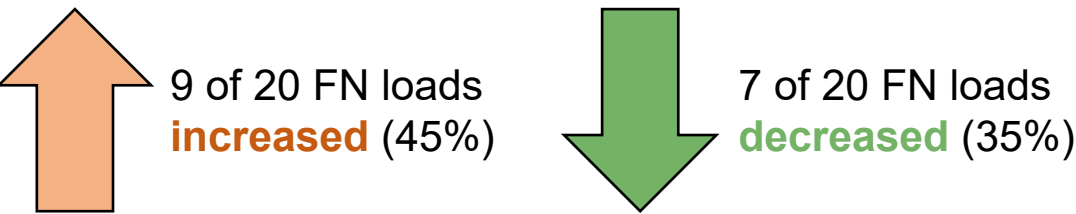
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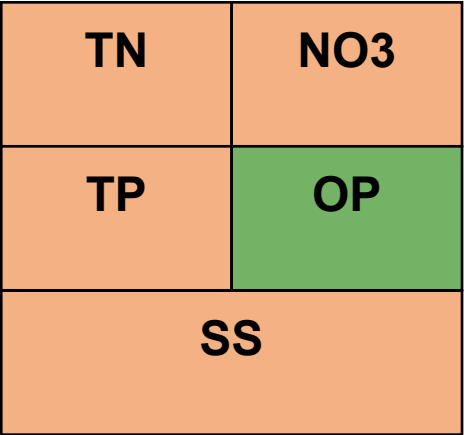


Since the early 2010's, most FN nutrient and sediment loads did not decrease¹

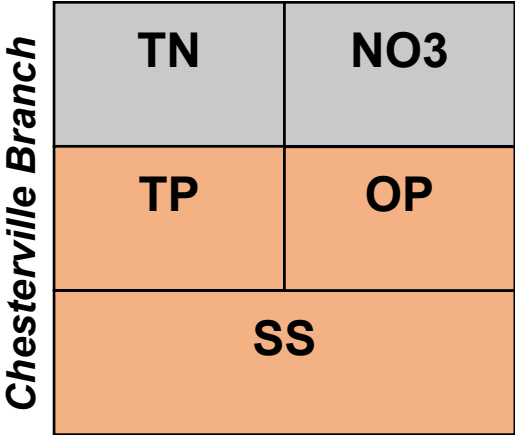


In all watersheds, most nutrient and sediment load changes occurred during days with above average streamflow.

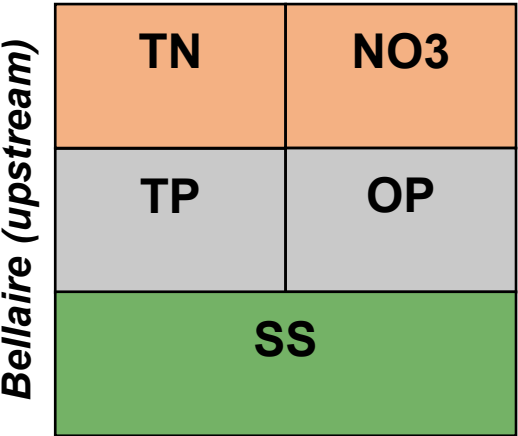
Smith Creek, VA
(2011 – 2020)



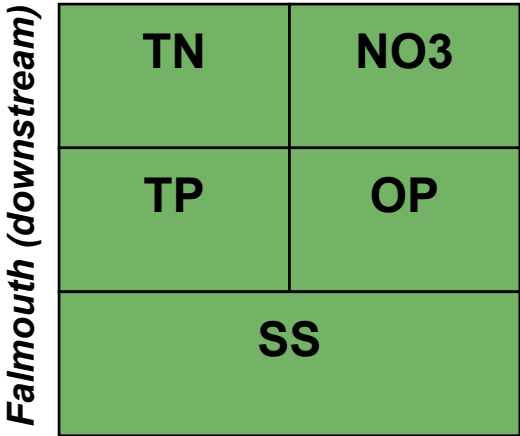
Upper Chester River, MD
(2012 – 2020)



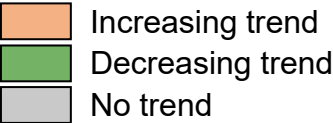
Conewago Creek, PA
(2013 – 2020)



Conewago Creek, PA
(2013 – 2020)

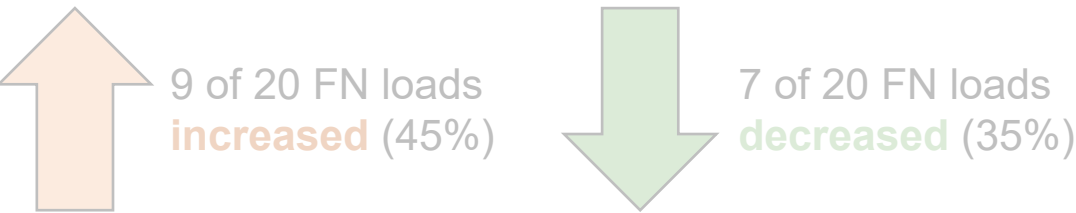


TN, total nitrogen; **NO3**, nitrate; **TP**, total phosphorus; **OP**, orthophosphate; **SS**, suspended sediment.



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

Since the early 2010's, most FN nutrient and sediment loads did not decrease¹



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.

Smith Creek, VA
(2011 – 2020)

TN +61	NO3 +44
TP +26	OP -4.2
SS +41,100	

Upper Chester River, MD
(2012 – 2020)

TN -17	NO3 -29
TP +73	OP +6
SS +40,500	

Conewago Creek, PA
(2013 – 2020)

TN +219	NO3 +217
TP -3.6	OP +0.1
SS -20,800	

Conewago Creek, PA
(2013 – 2020)

TN -154	NO3 -41
TP -35	OP -37
SS -67,000	

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

Increasing trend
Decreasing trend
No trend

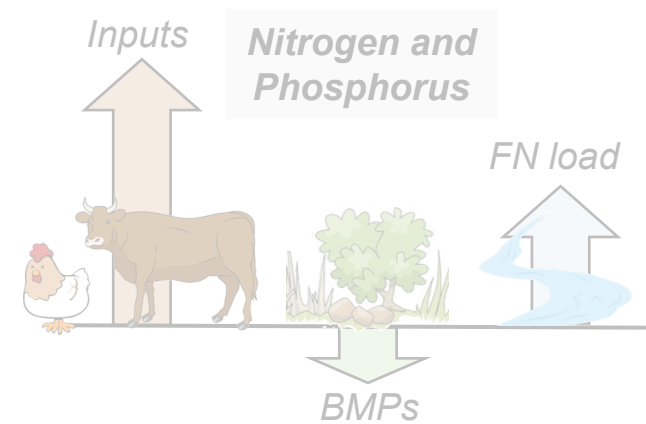
+61 Trend in kg/km²

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

Some Highlights...

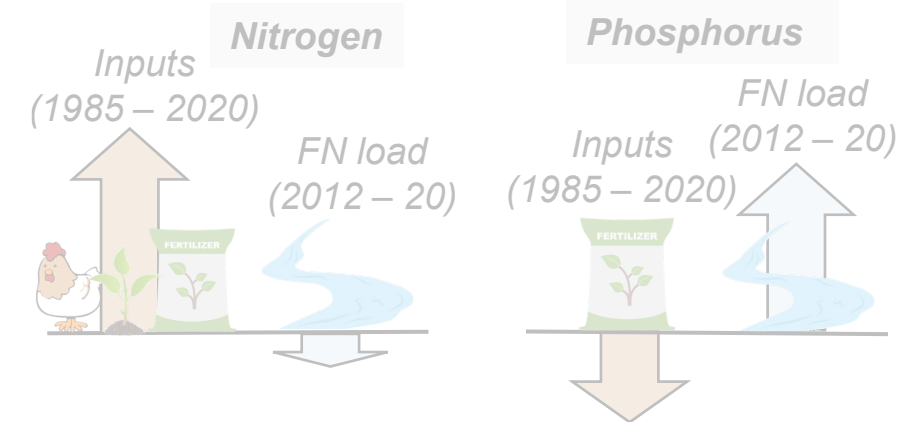
Smith Creek, VA

- 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.



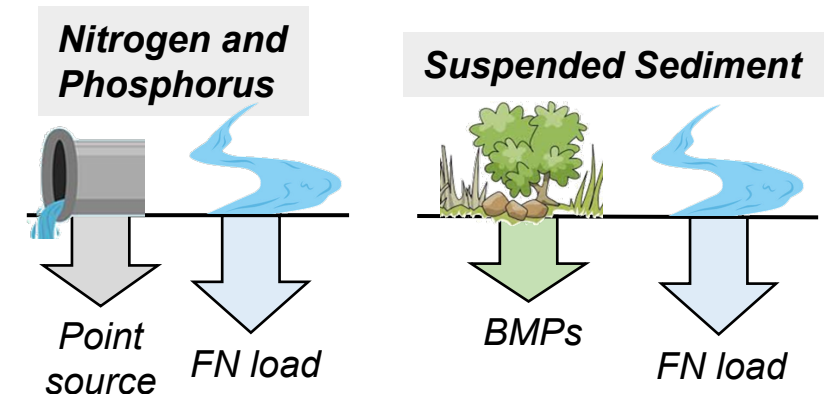
Upper Chester River, MD¹

- 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.

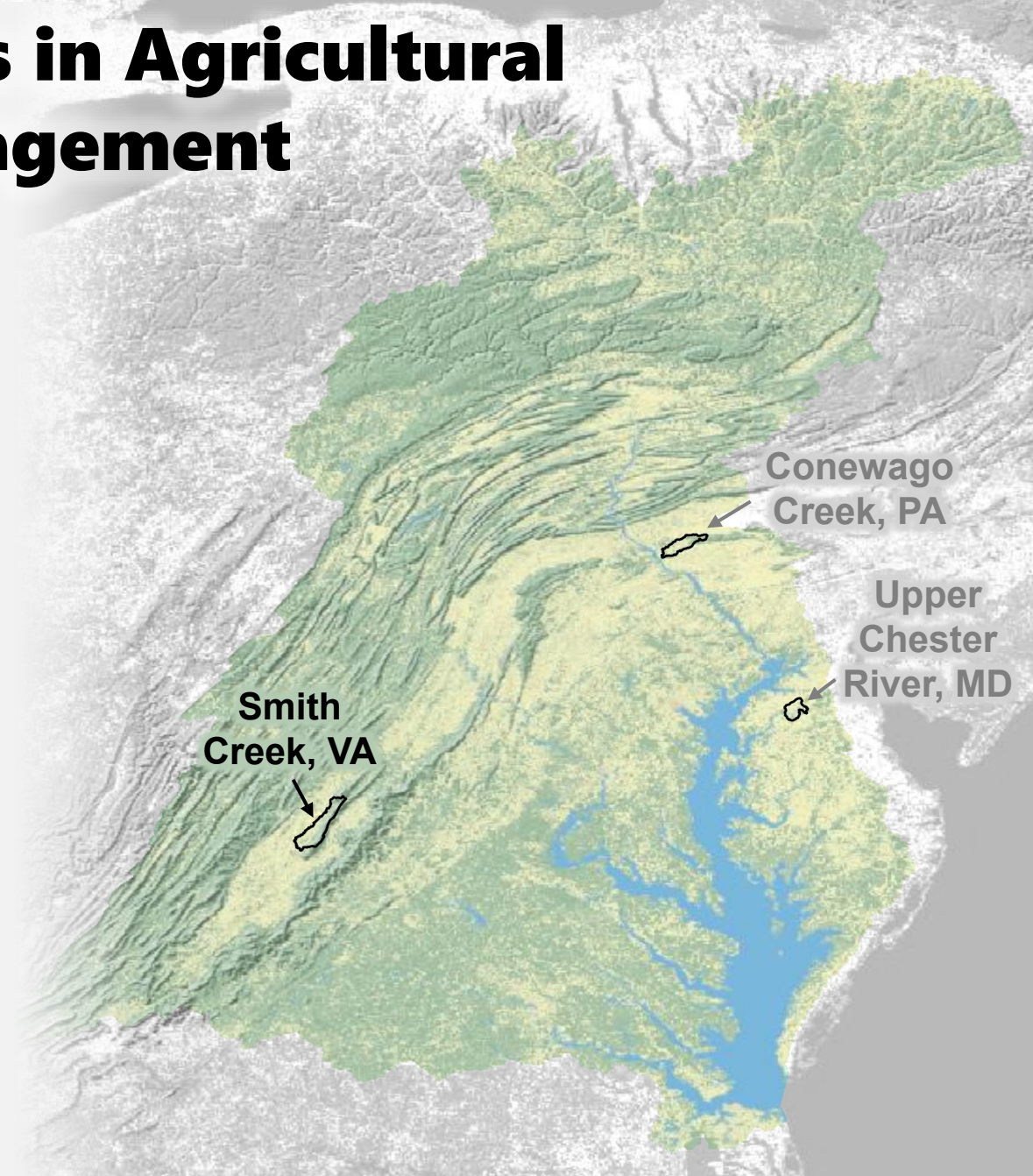


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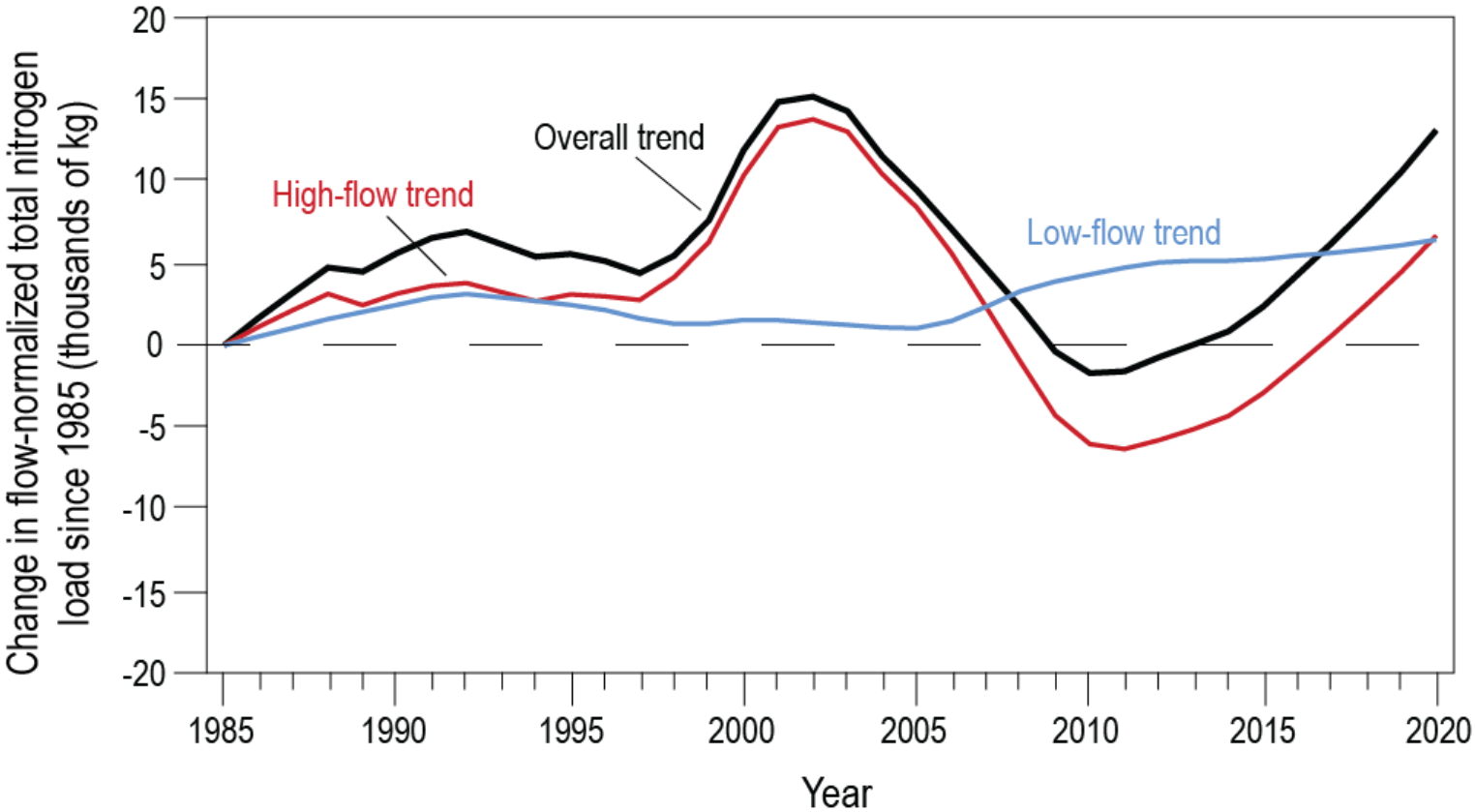


Smith Creek¹: flow-normalized (FN) total nitrogen (TN) loads increased² from 1985 through 2020

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.



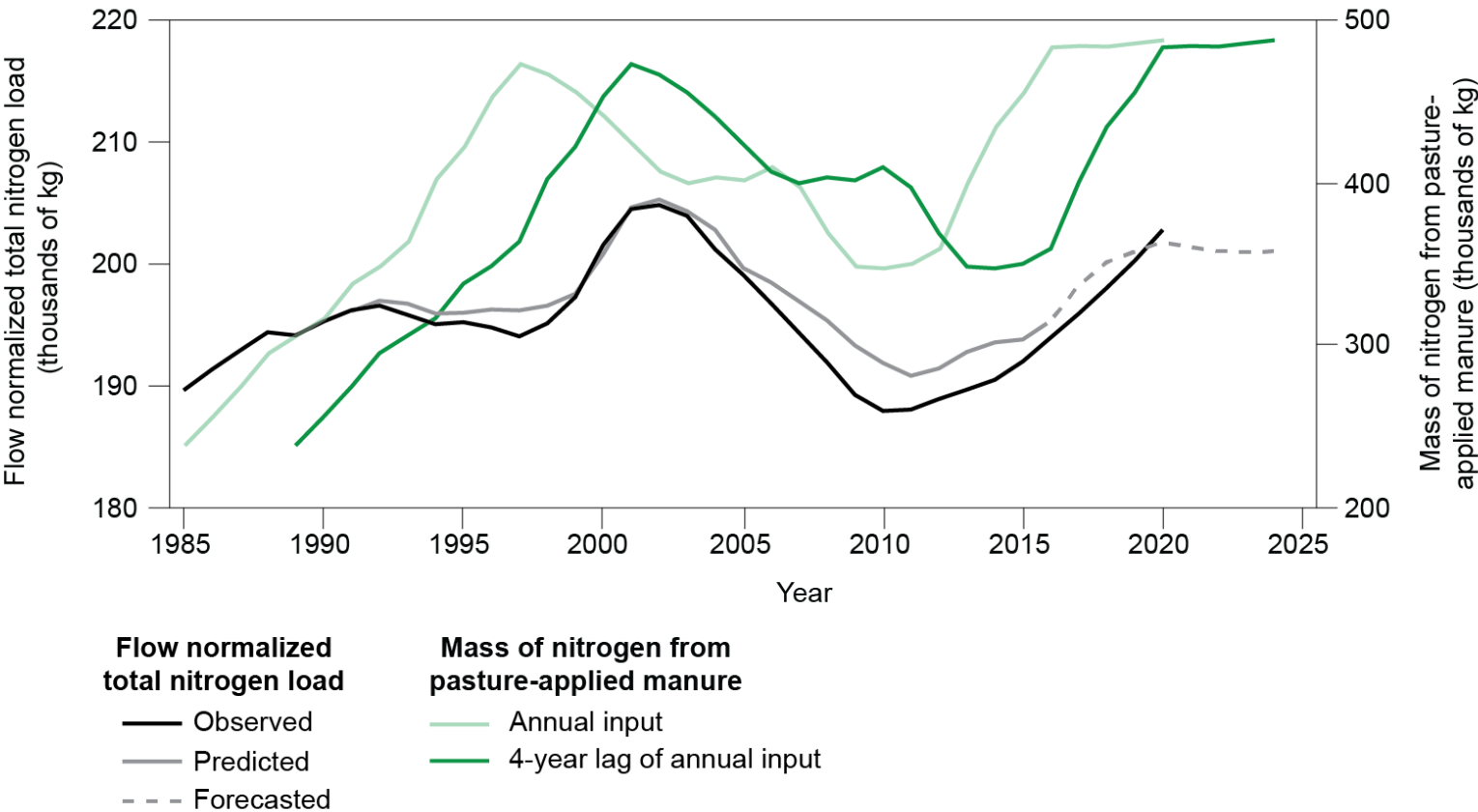
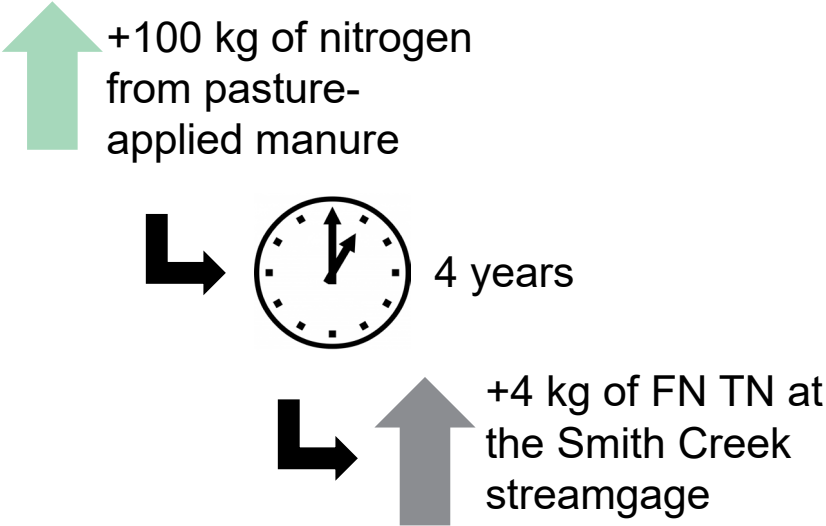
What caused the increase in FN TN load?

- Climatic effects?
- Streamflow?
- Management practices?
- Nutrient inputs?

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

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

Smith Creek: the input of nitrogen from manure¹ explained changes in FN TN load²



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).

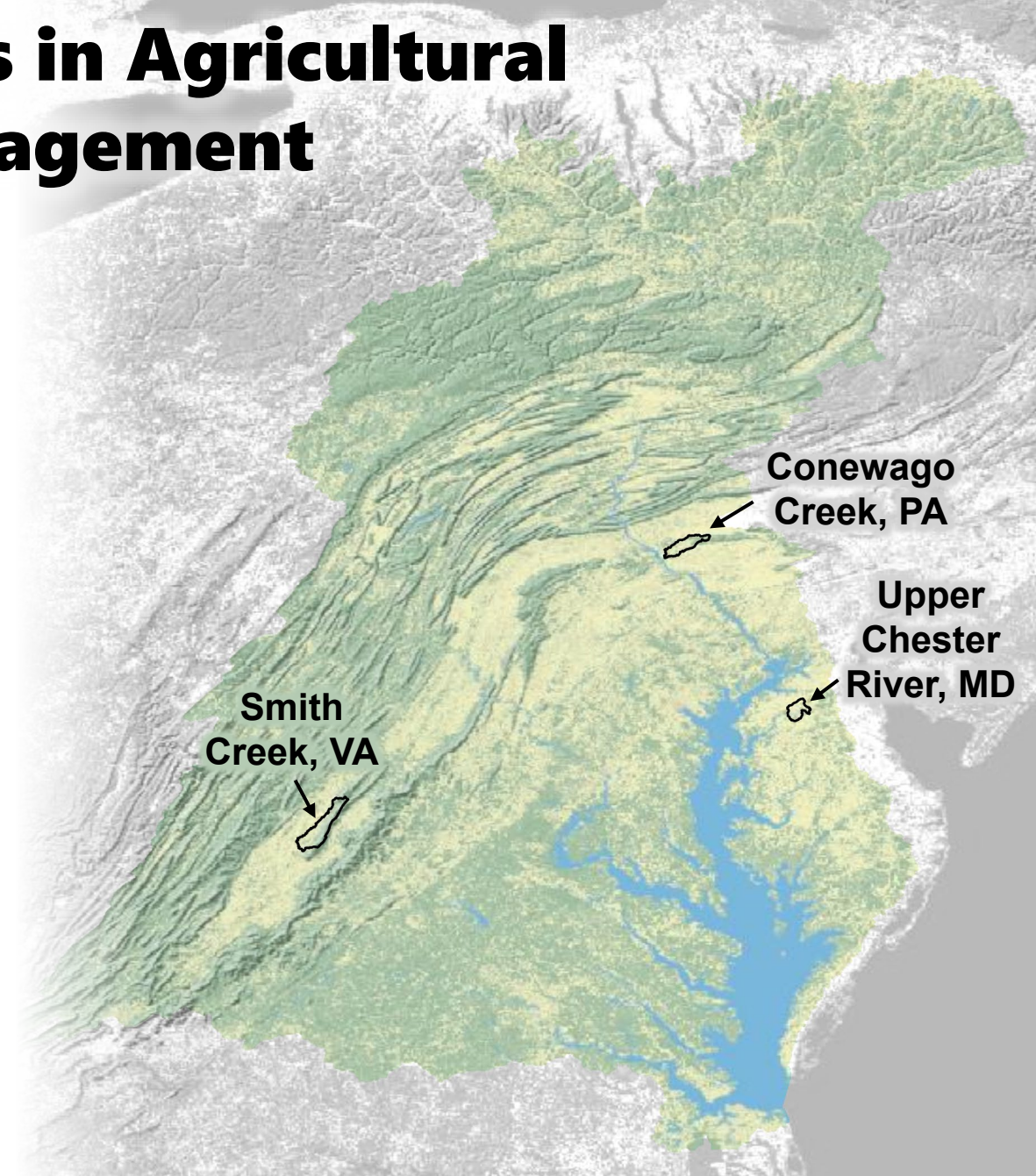
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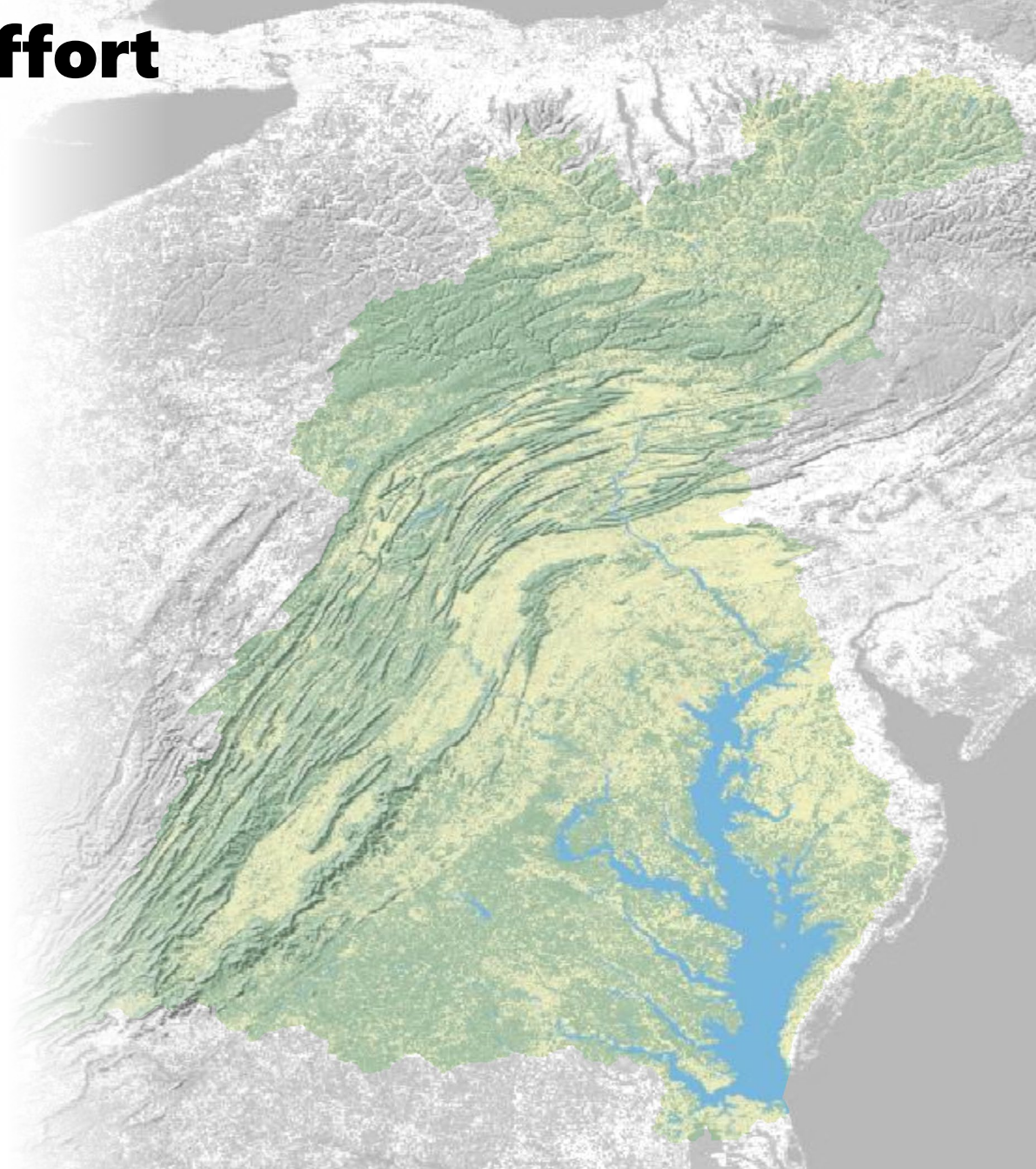
New Water-Quality Monitoring Effort in Small Agricultural Watersheds

The USGS is planning a new water-quality monitoring effort in Chesapeake Bay agricultural watersheds, in collaboration with the EPA, NRCS, and other partners.

The objectives of this effort are to:

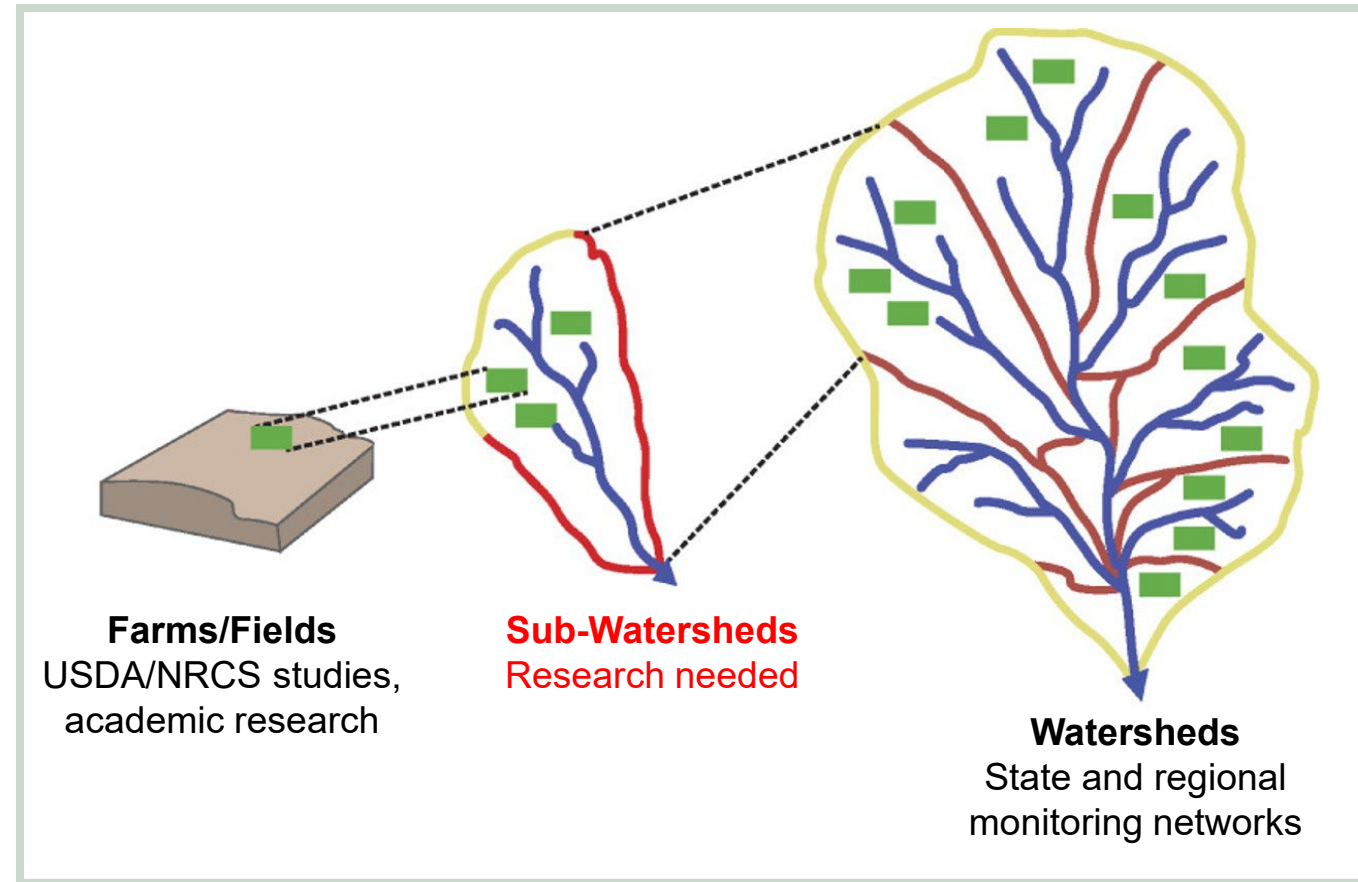
1. Evaluate the water-quality effects of agricultural conservation efforts
2. Develop new outreach and educational opportunities with agricultural, stakeholder, and academic communities.

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



General Study Design

- At least five small agricultural watersheds (between 5 and 20 mi²) will be monitored. 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 streamgauge
 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)
- **These stations may invite additional collaboration.**
Researchers are interested in using these stations to collect additional abiotic and biotic data (agricultural chemicals, benthic, and fish data) and test statistical methods.



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 by the spring of 2024 in VA, MD, and DE. We're selecting stations within the following watersheds:
 1. War Branch, VA
 2. Little Pipe Creek, MD
 3. Nanticoke River, DE
- We're engaged in ongoing conversations with partners about funding to maintain and grow this monitoring network.

