Evaluating Water-Quality Trends in Watersheds Prioritized for Management

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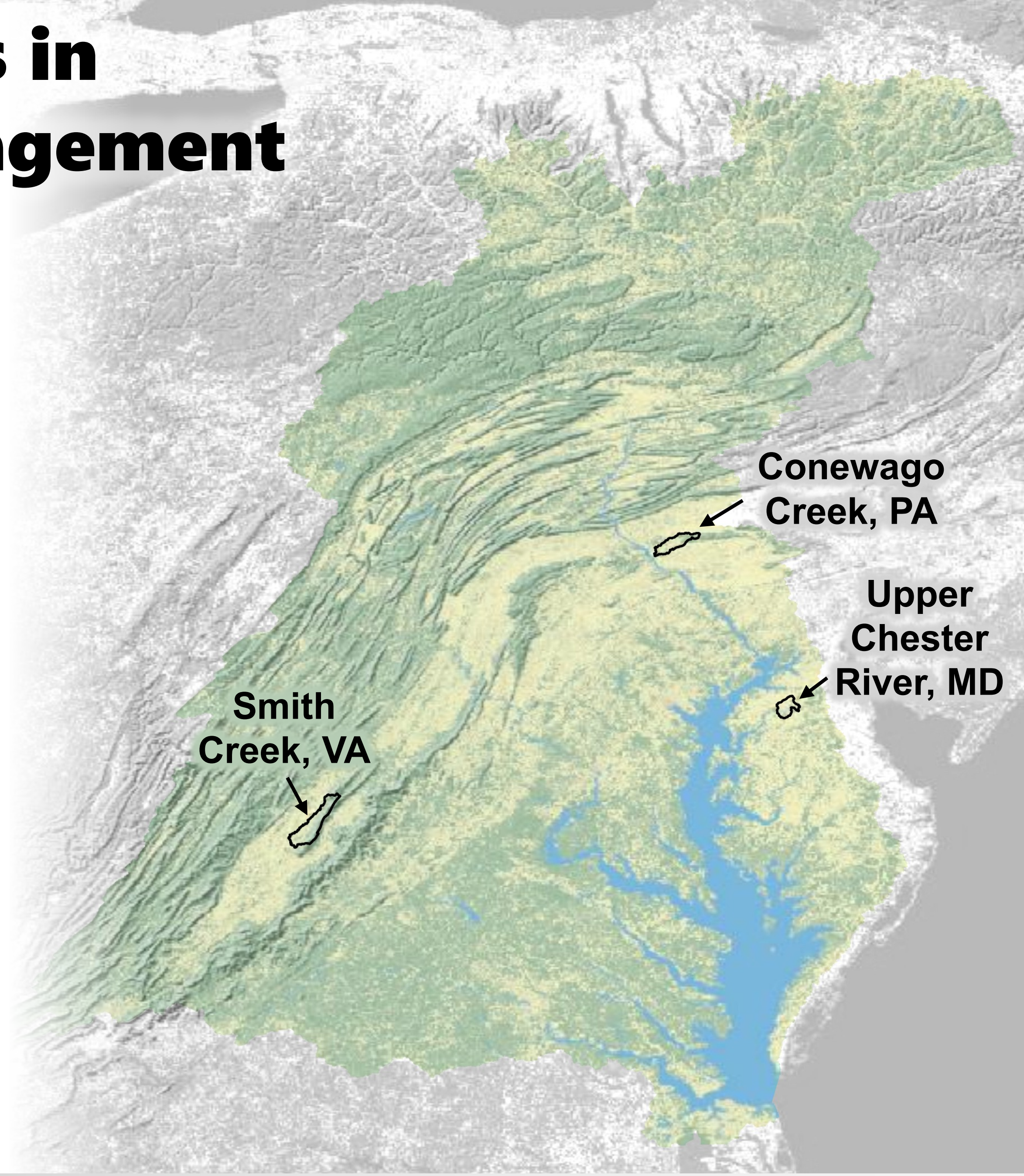
In 2010, the USGS partnered with the U.S Department of Agriculture and the U.S. Environmental Protection Agency to

> "*…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.

This presentation describes how and why water-quality loads changed over time in the showcase watersheds.



Evaluating Water-Quality Trends in Watersheds Prioritized for Management-Practice Implementation

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. Groundwater lag times may not fully explain the lack of water-quality response to management-practices.

4. Monitoring studies can inform (1) watershed management strategies and (2) the Chesapeake Bay Program's watershed model. → Sustained investments in water-quality monitoring, management practices, and statistical approaches are needed to maximize this information.

These messages and related findings will be published in an upcoming journal article.

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[1]Representing loads of total nitrogen, nitrate, total phosphorus, orthophosphate, and suspended sediment computed at four streamgages.

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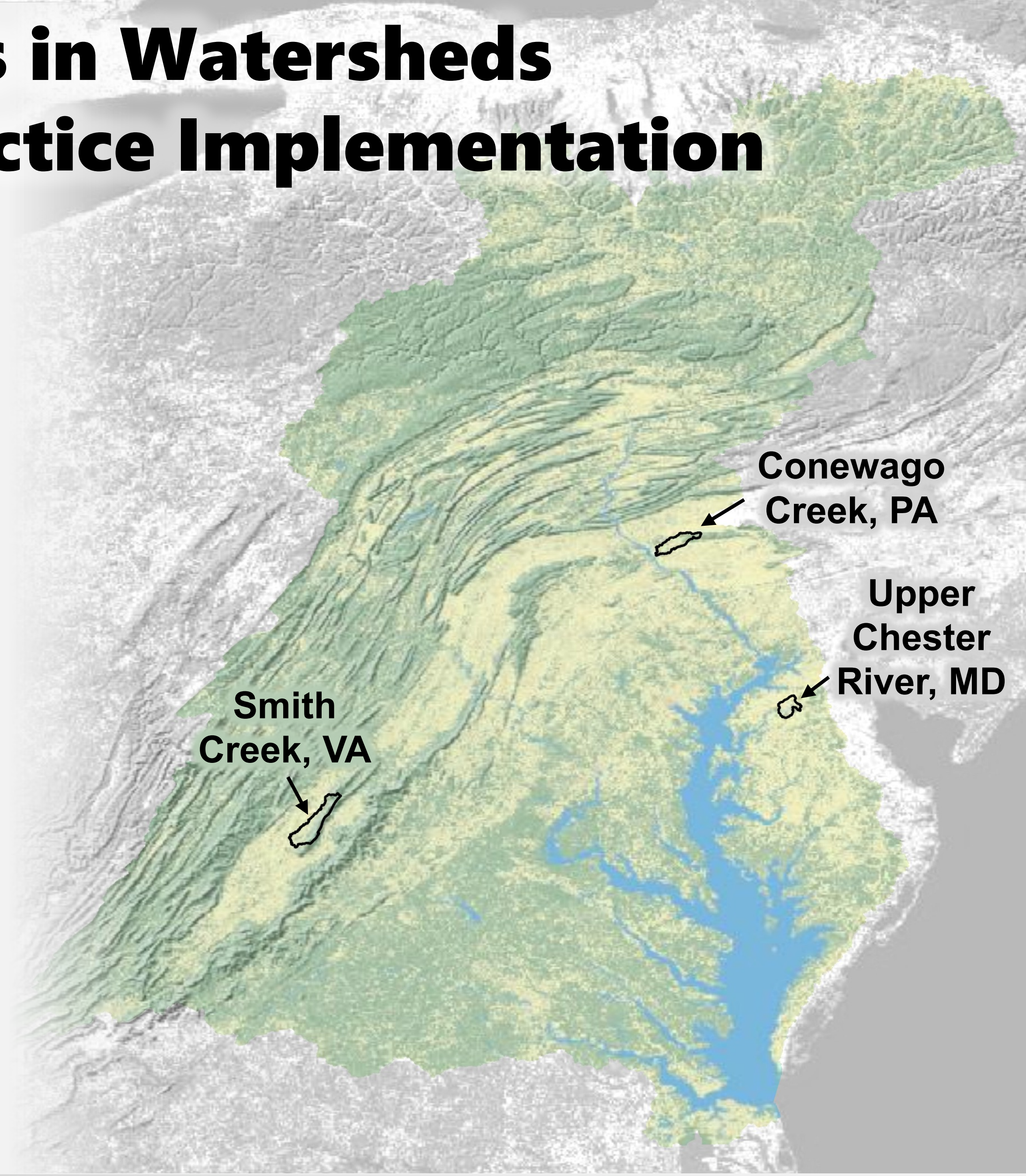
1. Management-Practice Implementation Patterns
2. Water-Quality Responses and Drivers Over Multiple Decades
3. Water-Quality Responses and Drivers in Recent Years



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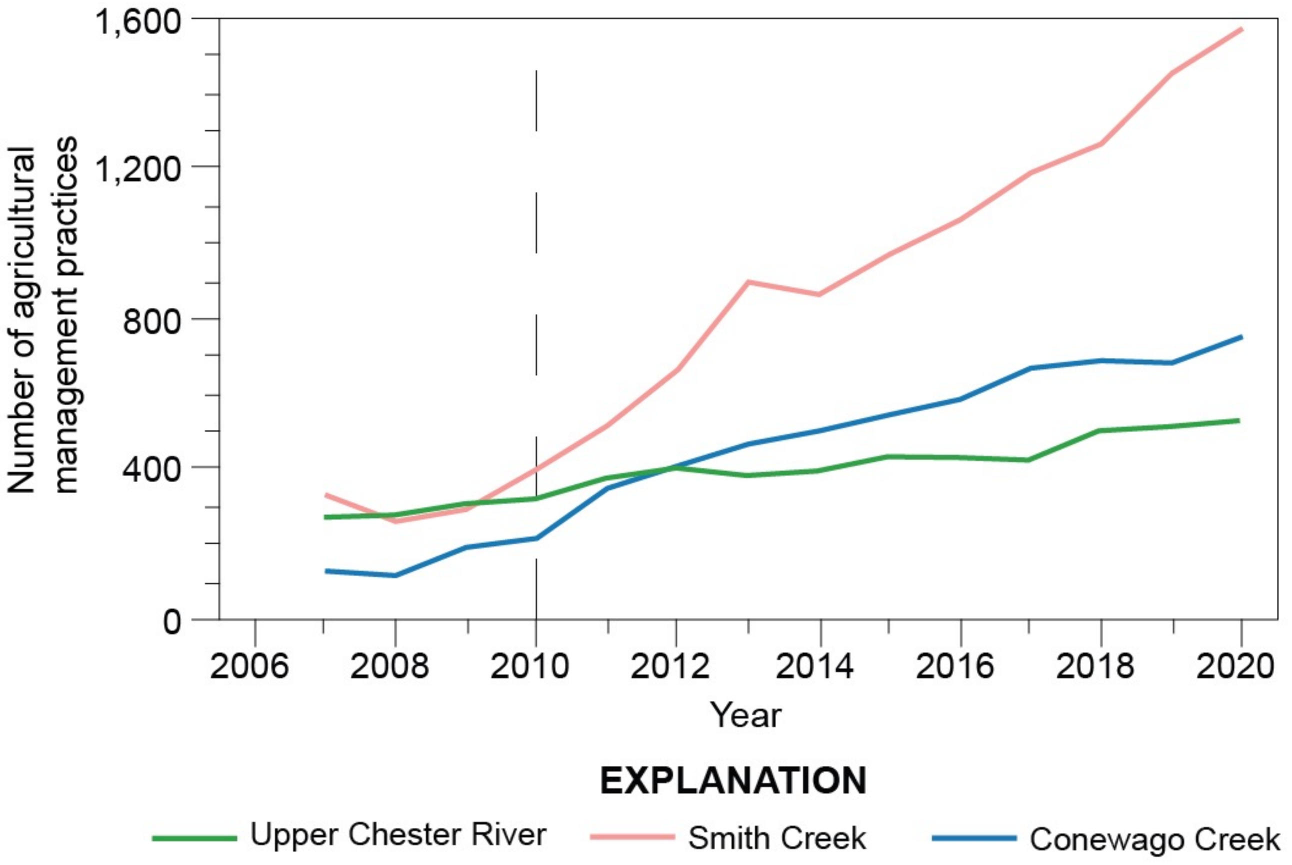
Agricultural management practices increased over time[1]

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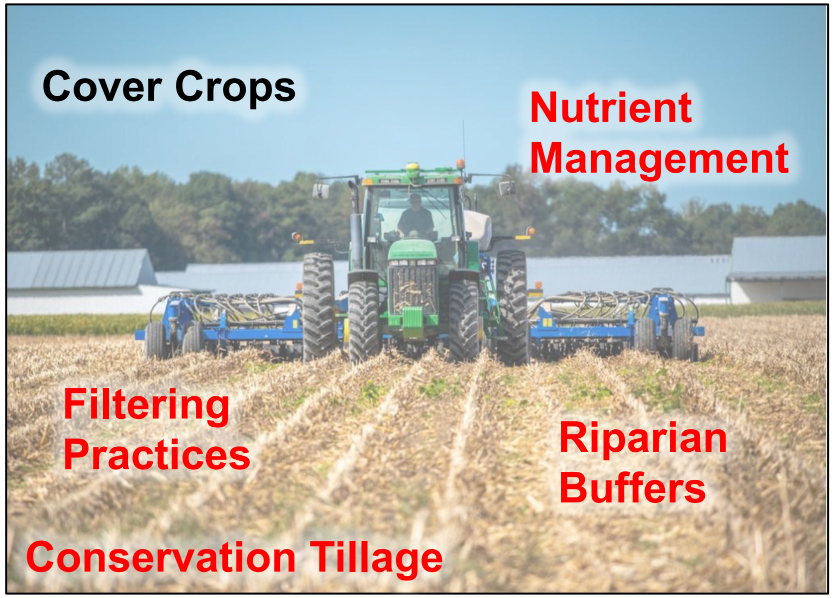
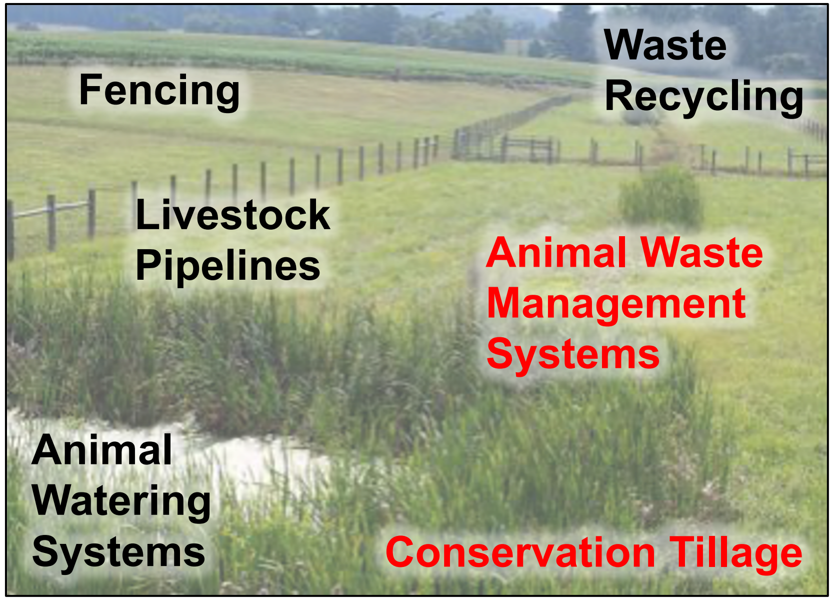
[1]Agricultural management practices that received financial or technical assistance from state or federal agencies were summarized from water years 2007 through 2020.

Each watershed had a unique suite of management practices

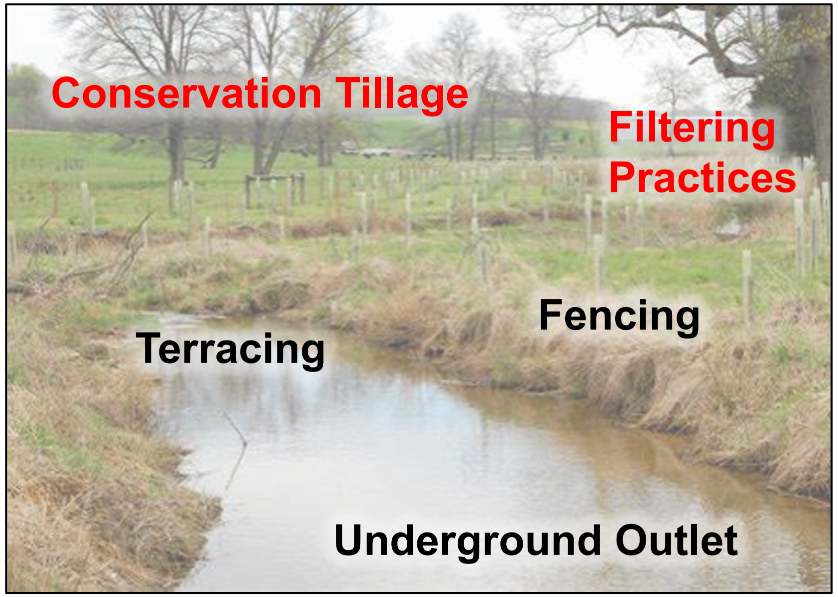
Upper Chester River, MD



Smith Creek, VA



Conewago Creek, PA



"High impact" nutrient or sediment management practice.

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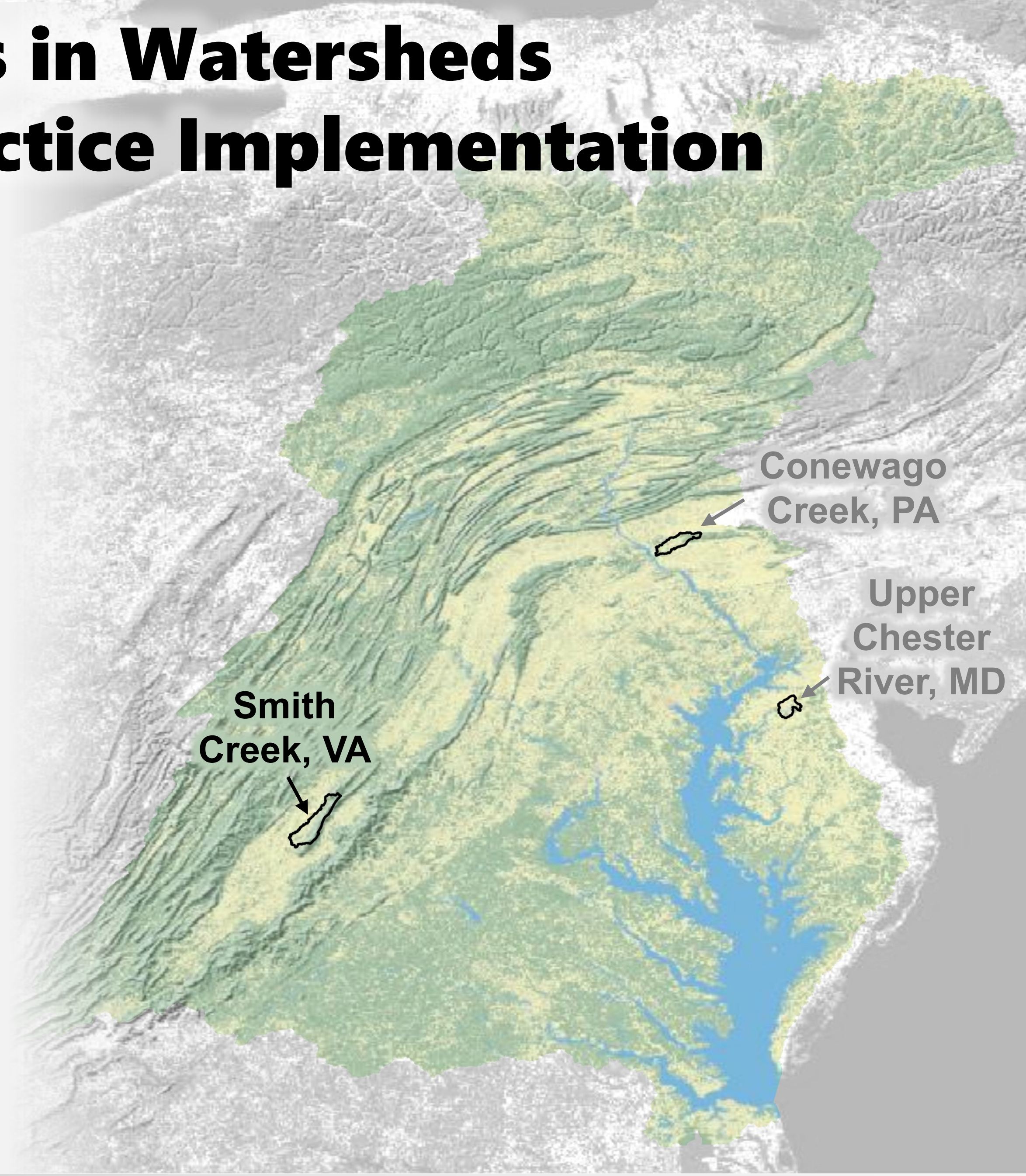
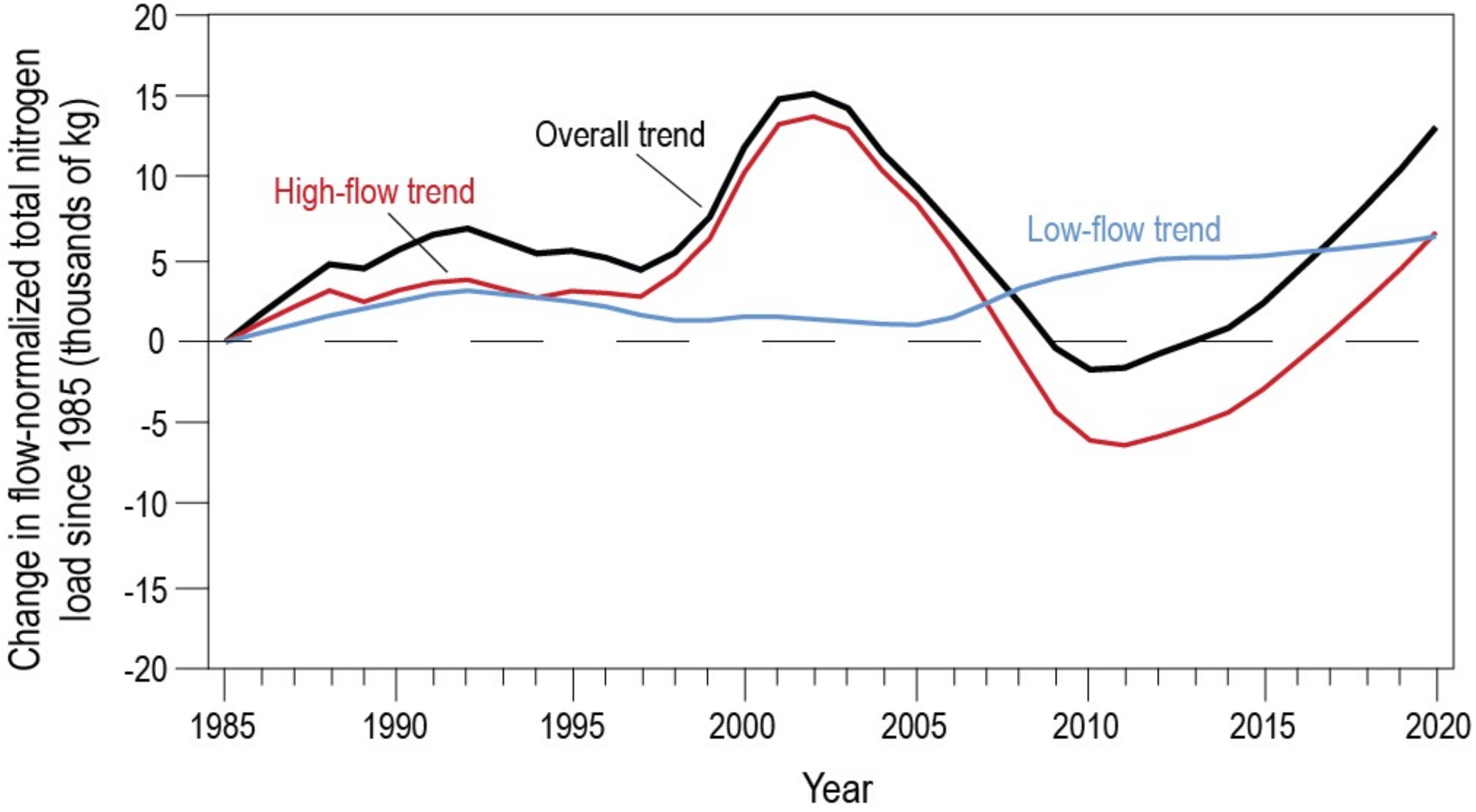


Smith Creek[1]: flow-normalized (FN) total nitrogen (TN) loads increased[2] from 1985 through 2020

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.

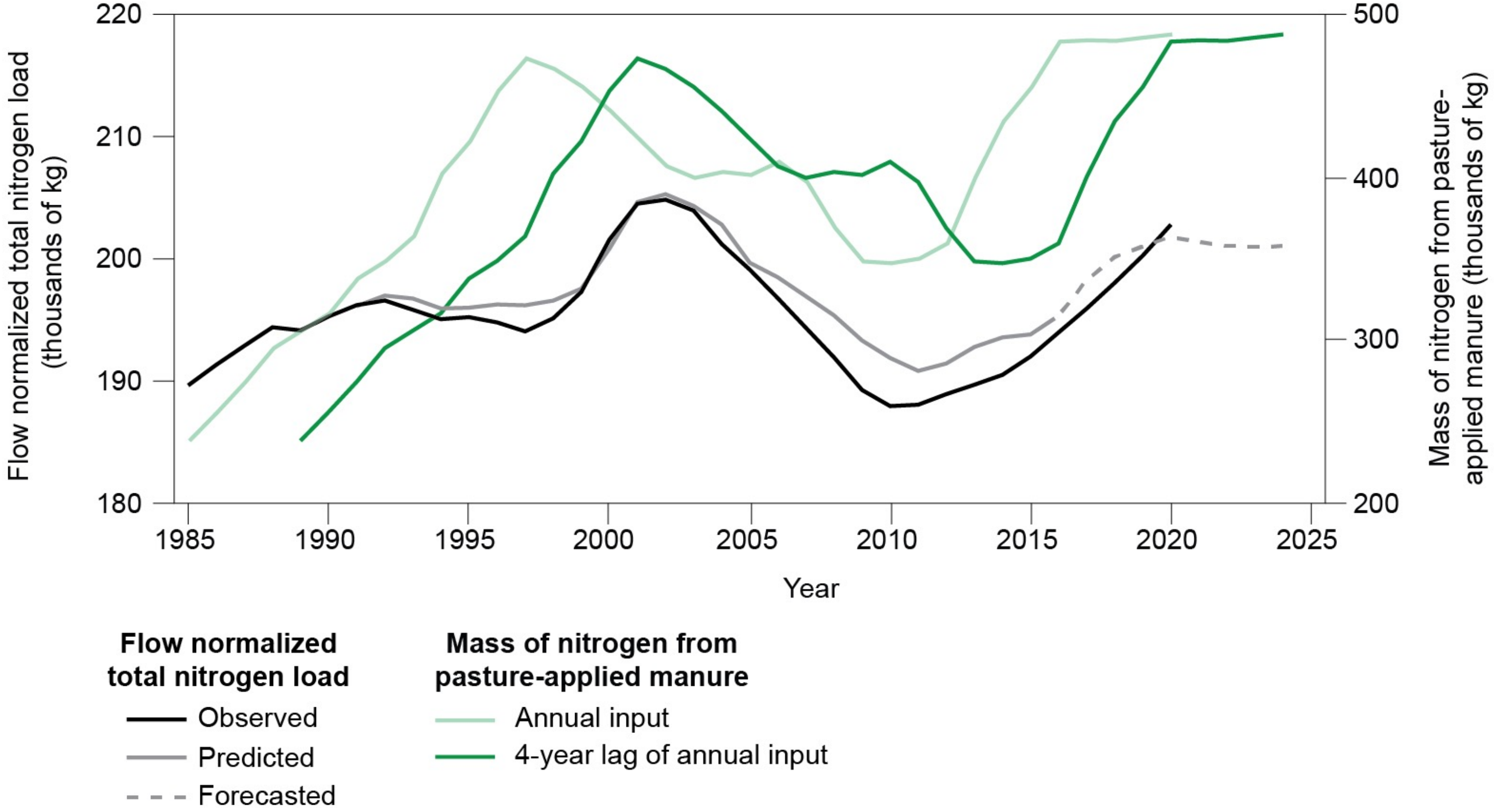
[2]As reported by Mason and others, 2023: https://doi.org/10.5066/P96H2BDO

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).

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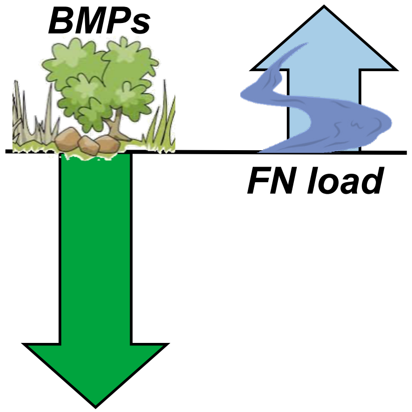
[1]Annual nutrient inputs were estimated from the CAST (Devereux and others, 2022: https://doi.org/10.5066/P93SVYQG)

[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).

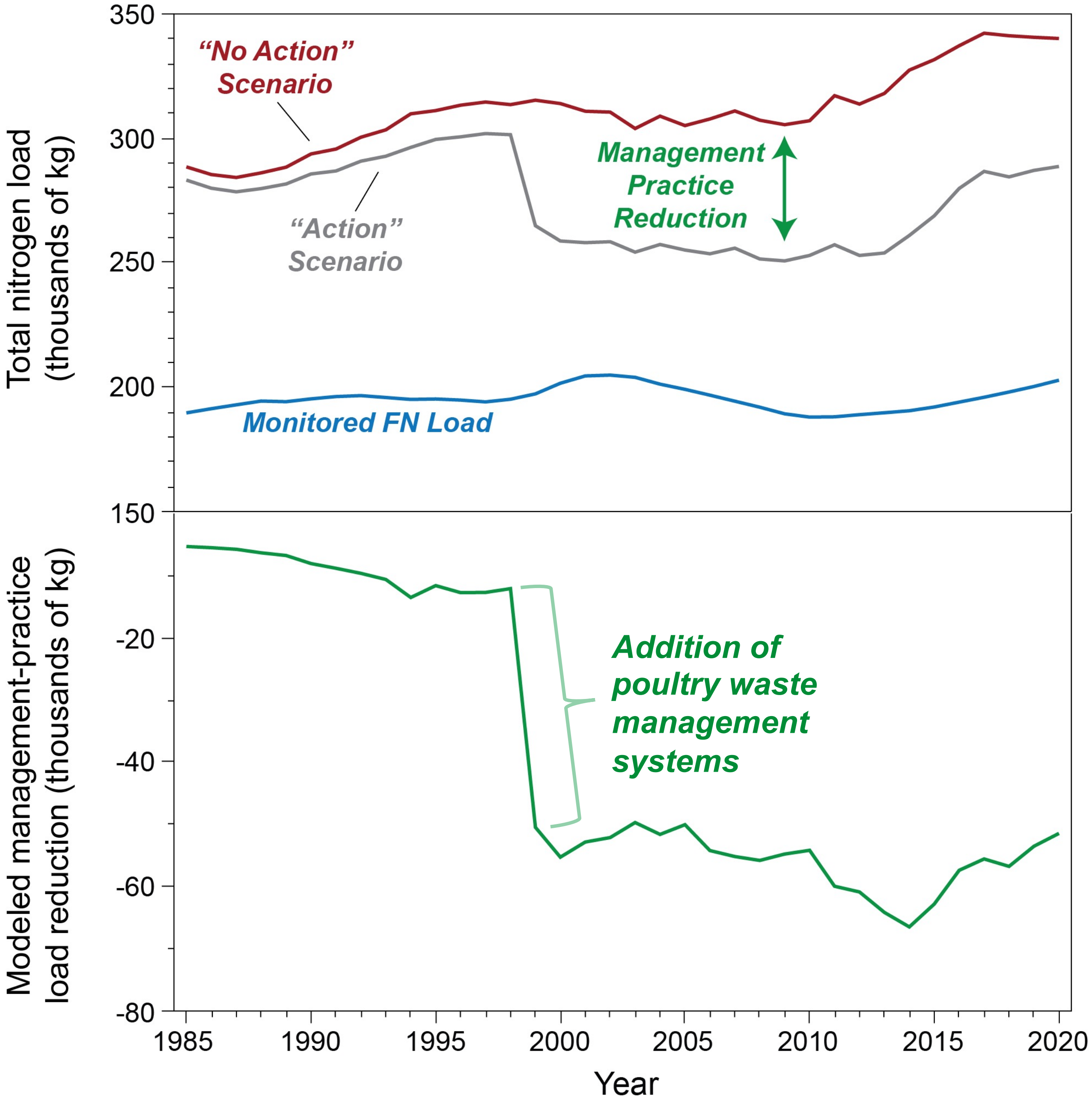
Smith Creek: Did management practices explain changes in load?

Estimated management practice load reductions were about ten times larger in 2020 than 1985 but monitored FN loads increased by 7%.



Estimated management-practice load reductions were modeled by CAST.

= *Modeled load from* ***"Action" scenario*** *with management practices* − *Modeled load from* ***"No-Action" scenario*** *without management practices*



Estimated management-practice load reductions did not help explain changes in FN TN load[1].

[1]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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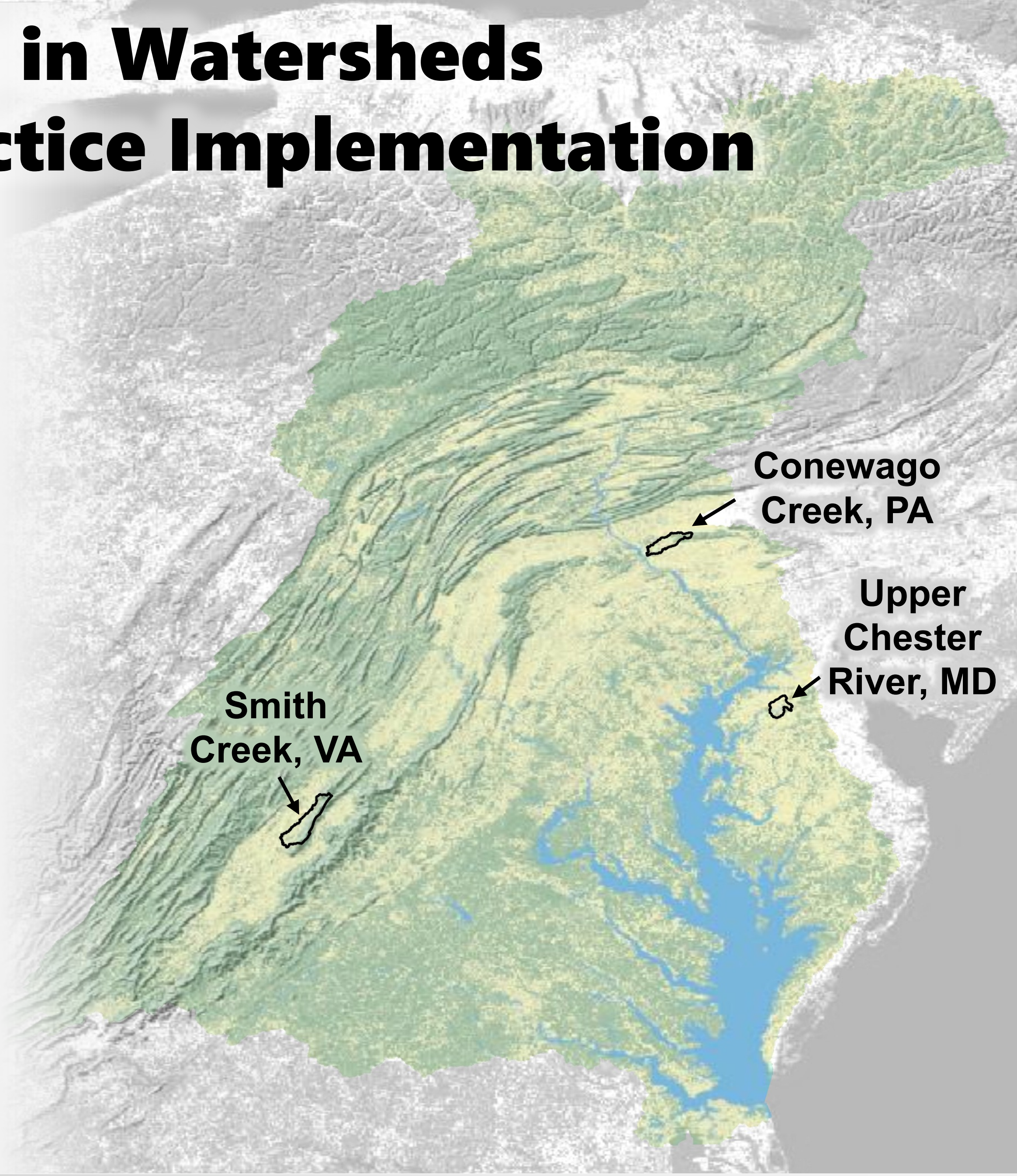
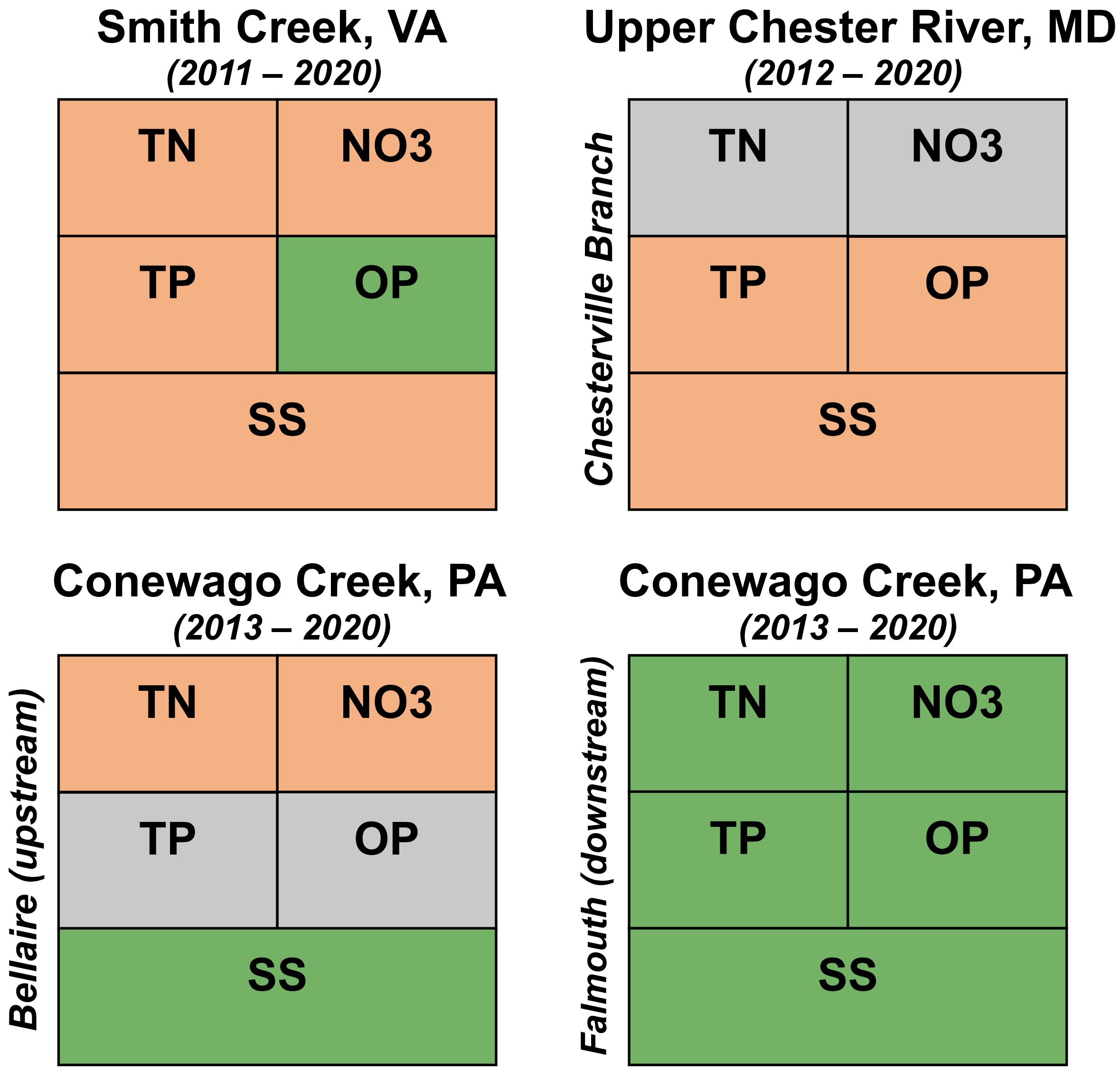


Since the early 2010's, most FN nutrient and sediment loads did not decrease[1]

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

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

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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%)

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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.

Smith Creek, VA
(2011 – 2020)

TN +61 (increasing)	NO3 +44 (increasing)
TP +26 (increasing)	OP -4.2 (decreasing)
SS +41,100 (increasing)	

Upper Chester River, MD
(2012 – 2020)

Chesterville Branch

TN -17 (no trend)	NO3 -29 (no trend)
TP +73 (increasing)	OP +6 (increasing)
SS +40,500 (increasing)	

Conewago Creek, PA
(2013 – 2020)

Bellaire (upstream)

TN +219 (increasing)	NO3 +217 (increasing)
TP -3.6 (no trend)	OP +0.1 (no trend)
SS -20,800 (decreasing)	

Conewago Creek, PA
(2013 – 2020)

Falmouth (downstream)

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

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

Increasing trend
Decreasing trend
No trend

+61 Trend in kg/km^2

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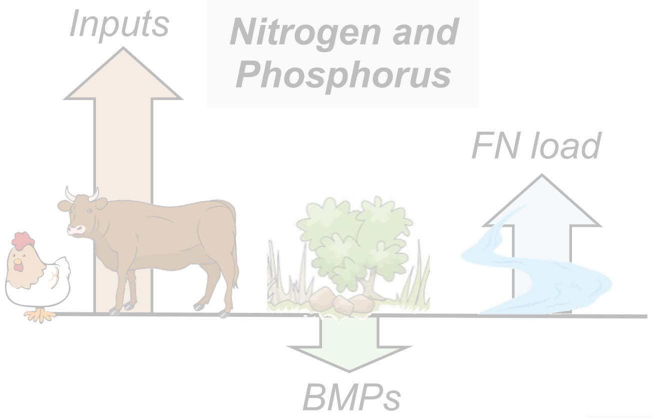
[1]Trends in FN load were computed for each showcase watershed streamgage following methods used by the Chesapeake Bay nontidal monitoring network.

Some Highlights…

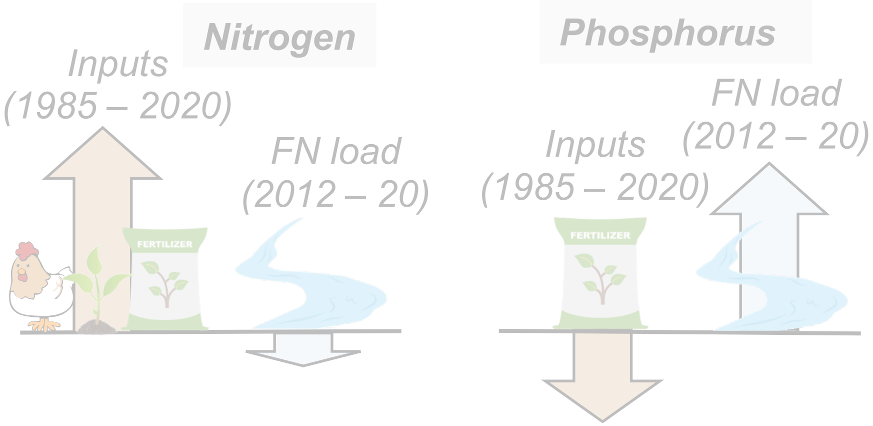
Smith Creek, VA

- 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.



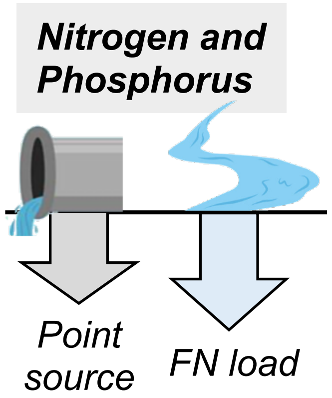
Upper Chester River, MD[1]

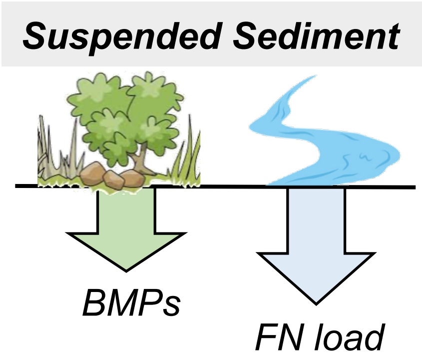
- Nitrogen inputs nearly doubled since 1985, but nitrogen loads did not increase since 2012. It may take decades for nitrogen to pass through groundwater.
- Phosphorus inputs decreased since 1985. Increasing phosphorus loads were likely caused by (1) suspended sediment and (2) soil phosphorus losses.



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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