Nutrient Loads and Trends in Chesapeake Bay Nontidal Network Streams: an update of new results and implications for management

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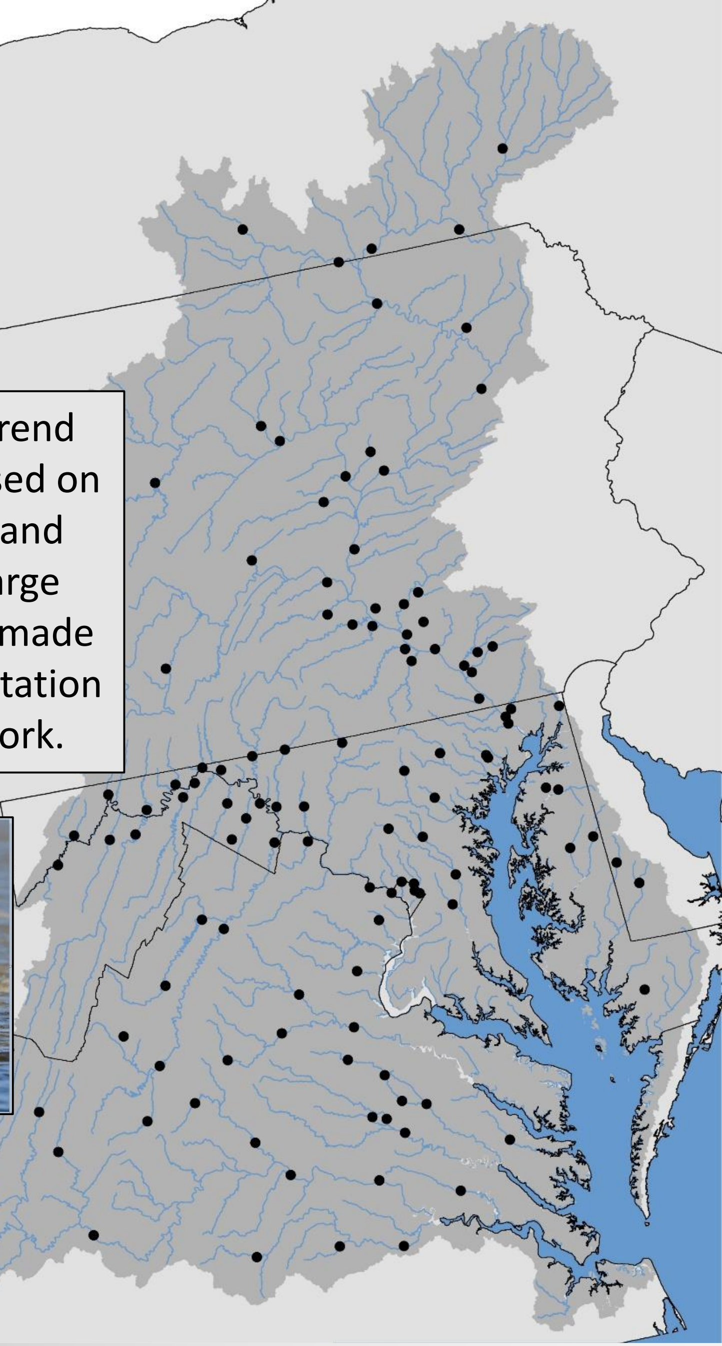
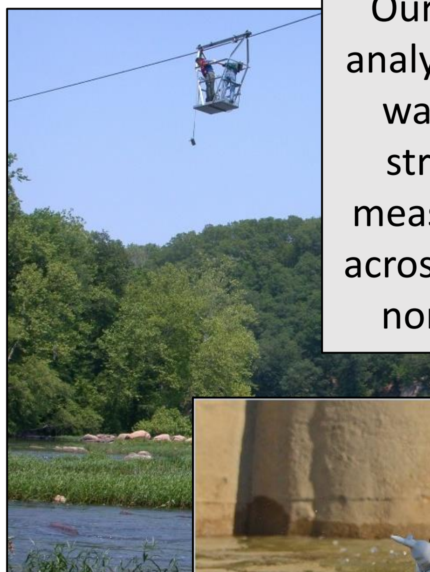
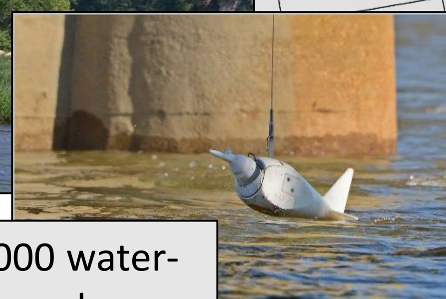
Update for Water-Quality Goal Implementation Team

February 12, 2018



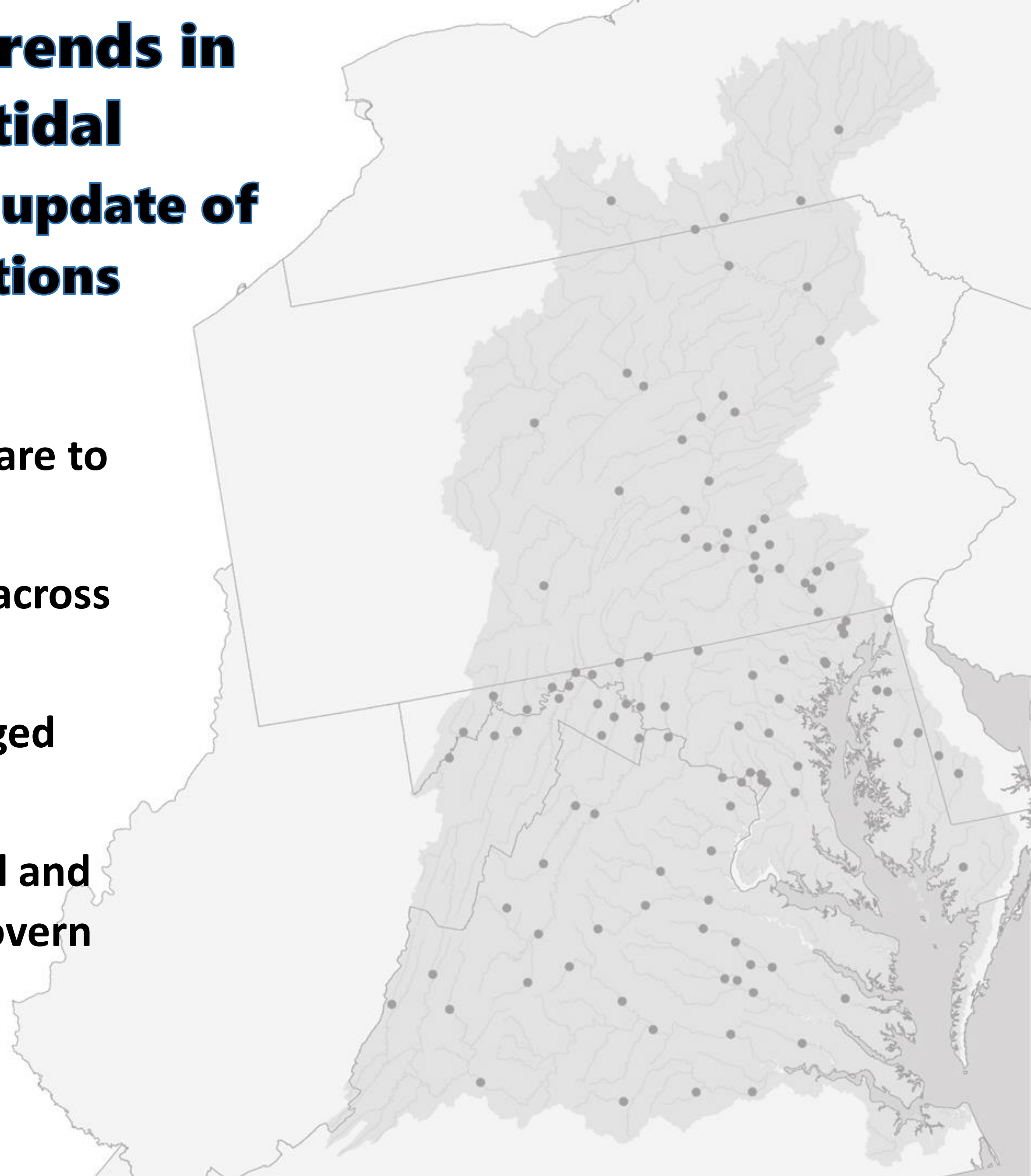




Our load and trend analyses are based on water-quality and stream-discharge measurements made across the 115-station nontidal network.

Over 2,000 water-quality samples are collected each year!

Nutrient Loads and Trends in Chesapeake Bay Nontidal Network Streams: an update of new results and implications for management



Objectives for this presentation are to answer the following questions:

(1) What are the current loads across the Bay watershed?

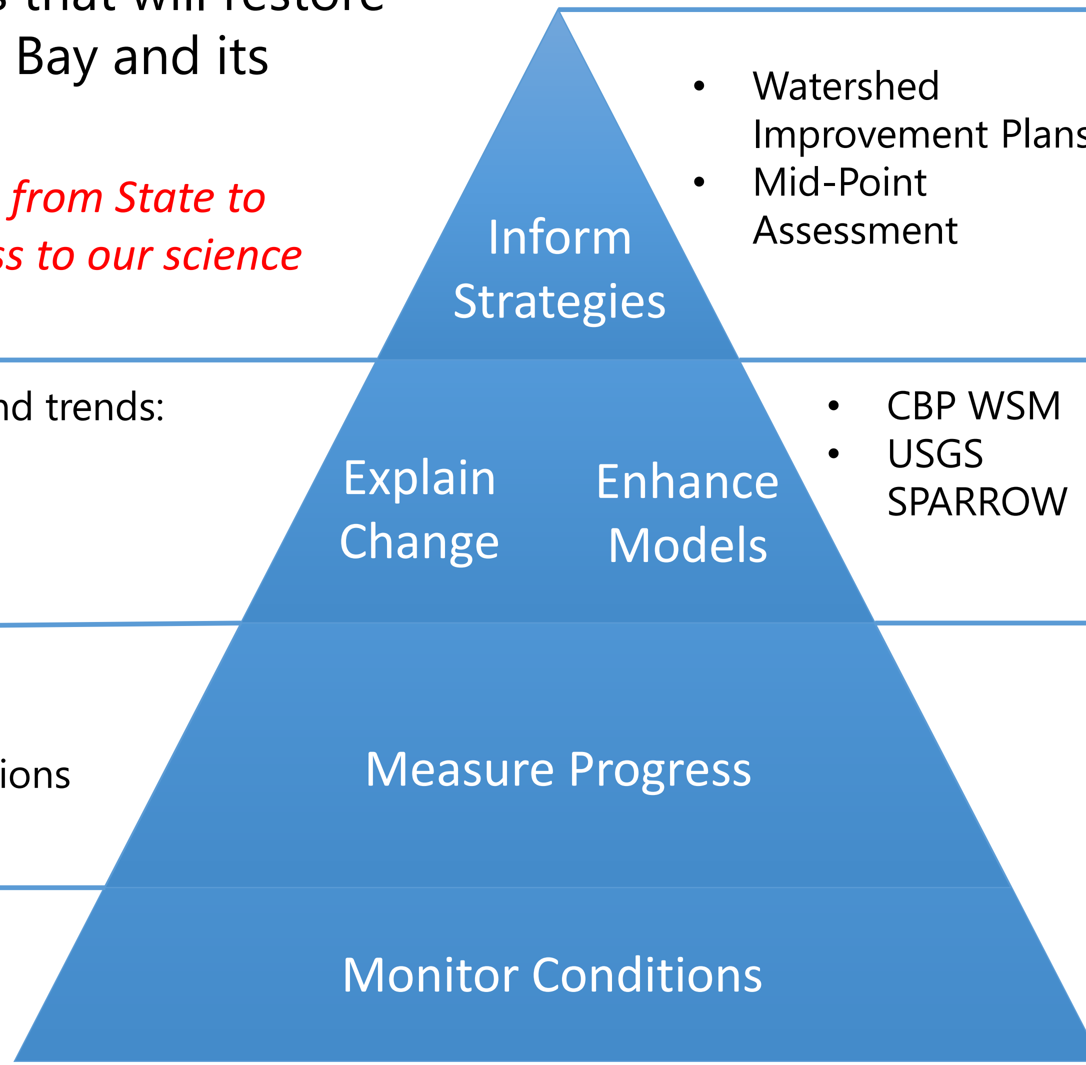
(2) How have these loads changed during 2007-2016?

(3) What are the environmental and management factors that govern loads and trends?

Charge of the WQGIT – "to evaluate, focus and accelerate the implementation of practices, policies and programs that will restore water quality in the Chesapeake Bay and its tributaries …**"**.

Challenge – Ensuring that jurisdictions, from State to local levels, understand and have access to our science to better inform decision making.

- Watershed Improvement Plans
- Mid-Point Assessment



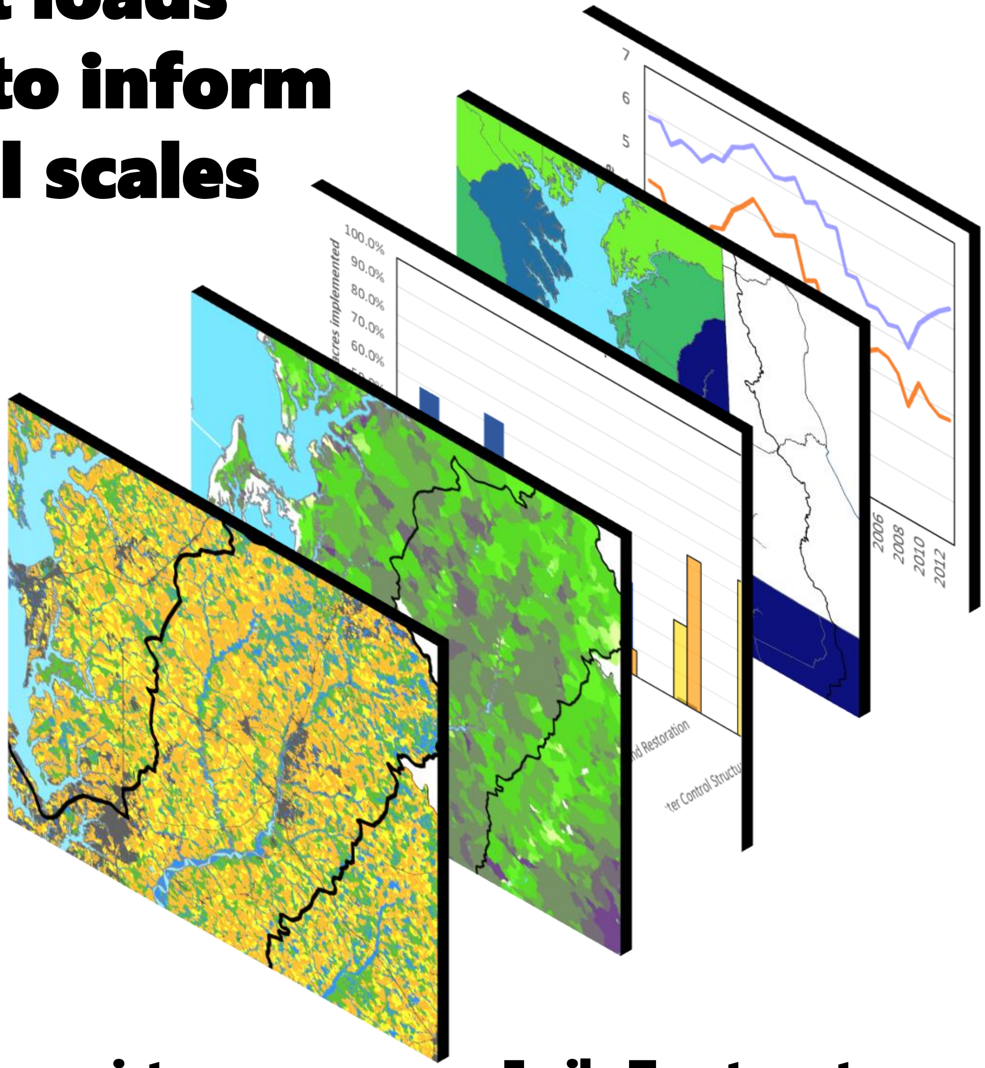
- CBP WSM
- USGS SPARROW

USGS leading efforts to explain conditions and trends:
(1) Across the nontidal bay watershed
(2) Nontidal/Tidal Interface
(3) Sediment
(4) Susquehanna Reservoir

USGS computes nutrient and suspended sediment loads and trends for all NTN stations

Observed water-quality and streamflow collected by 6 Bay States, DC, SRBC, and USGS

Explanations of nutrient loads and trends can be used to inform decision making on local scales



Today's presentation describes patterns of nutrient loads and trends throughout the watershed.

This information can be focused to more specific regional areas to describe the unique conditions and stressors within different states, counties, or watersheds.

We are working through the CBPO to develop strategies to ensure that jurisdictions have access to this information.

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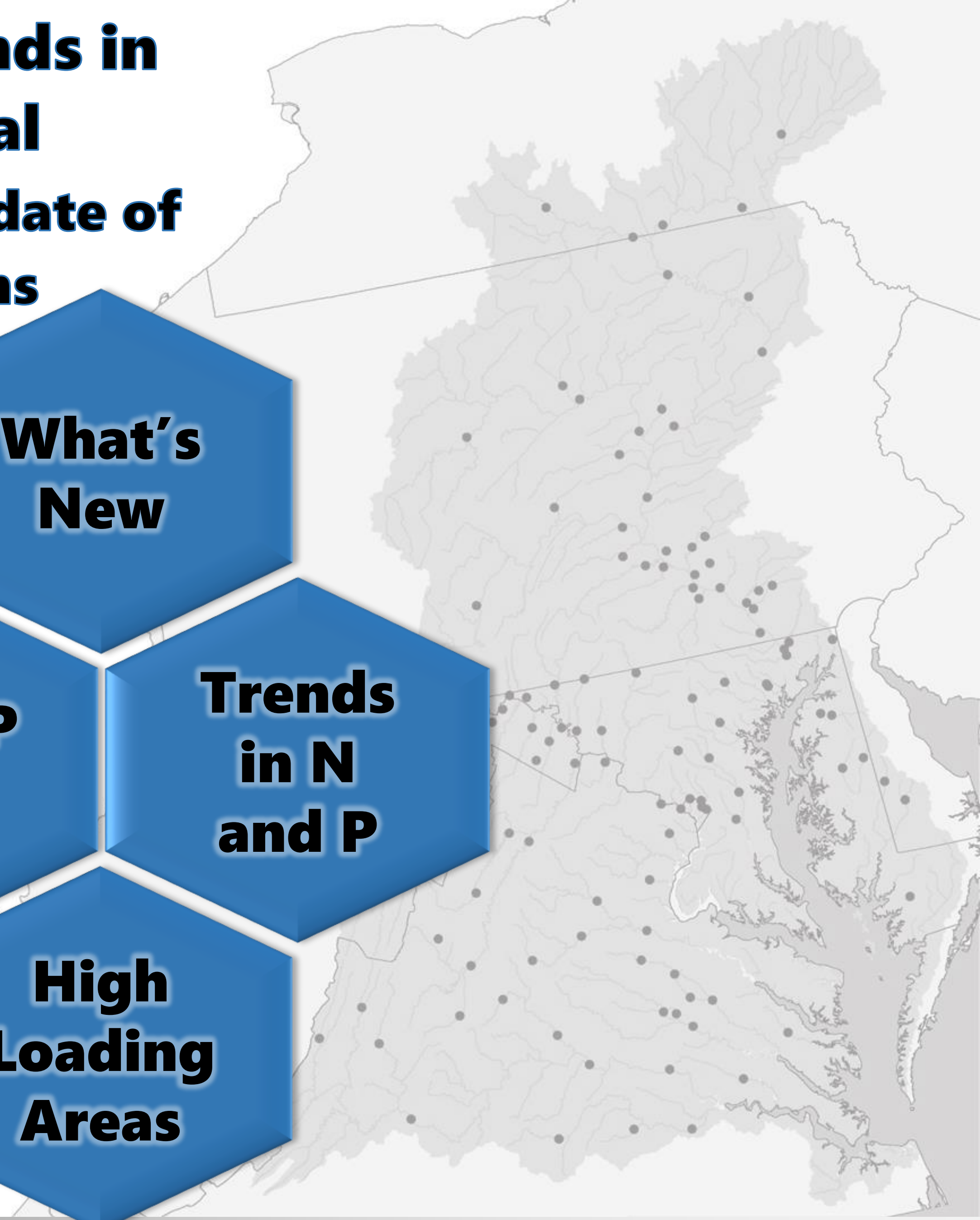
Nutrient Loads and Trends in Chesapeake Bay Nontidal Network Streams: an update of new results and implications for management



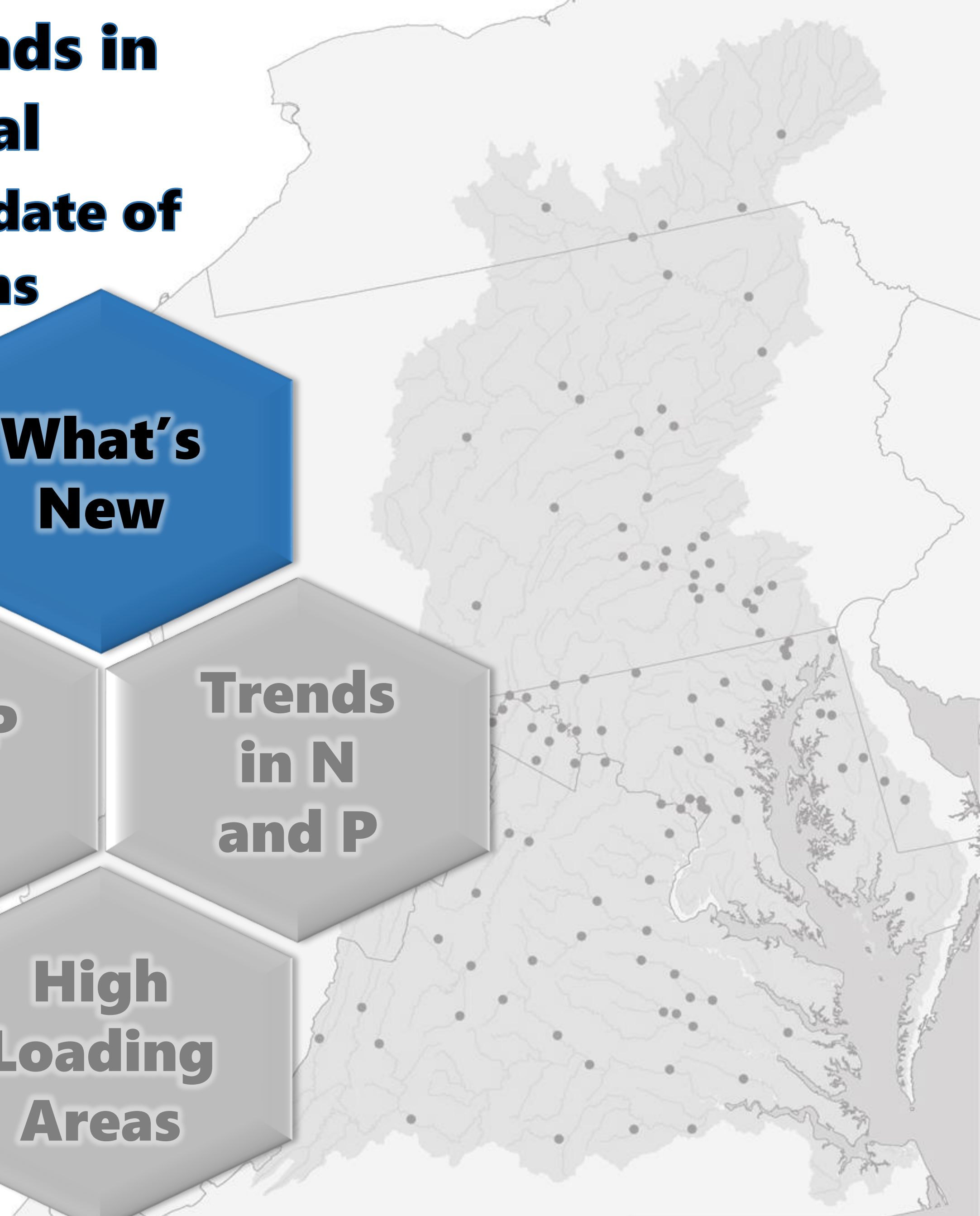
What's New

N and P Loads

Trends in N and P

High Loading Areas

Nutrient Loads and Trends in Chesapeake Bay Nontidal Network Streams: an update of new results and implications for management



What's New

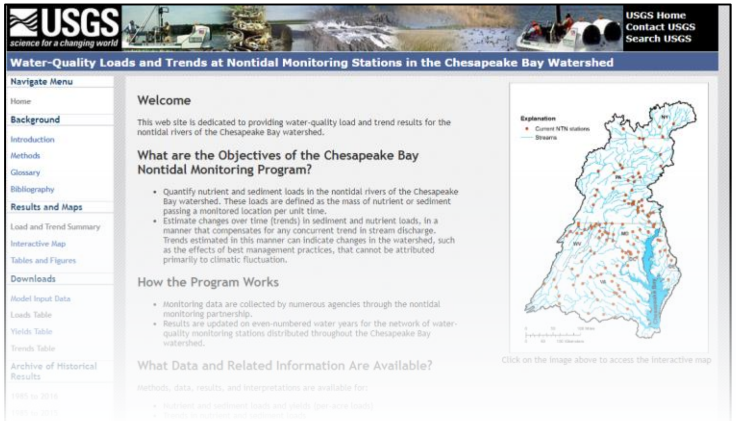
N and P Loads

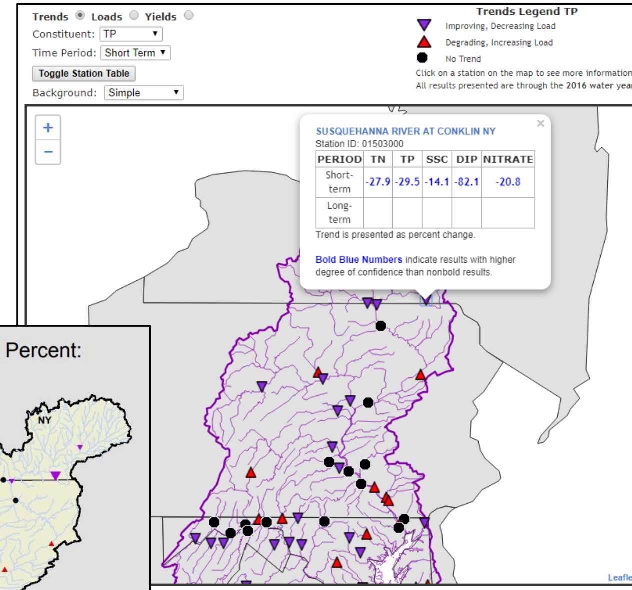
Trends in N and P

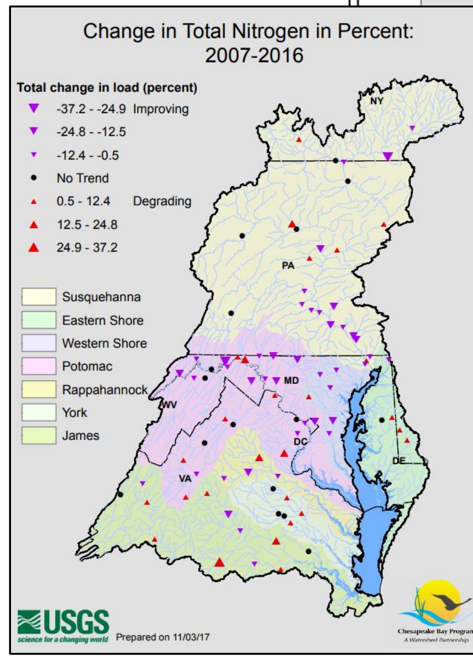
High Loading Areas

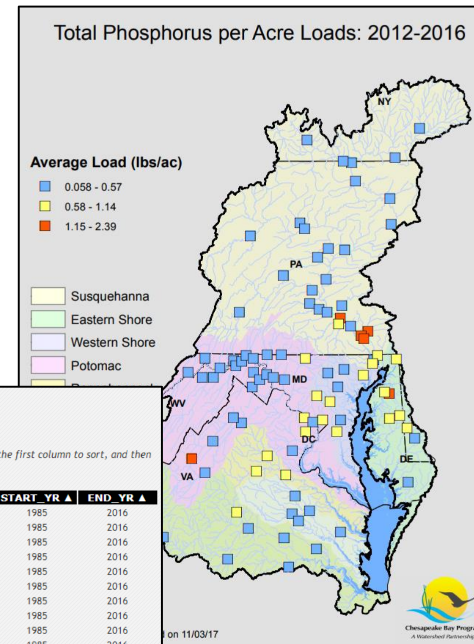
The nontidal monitoring webpage has been updated with 2016 results

https://cbrim.er.usgs.gov/index.html

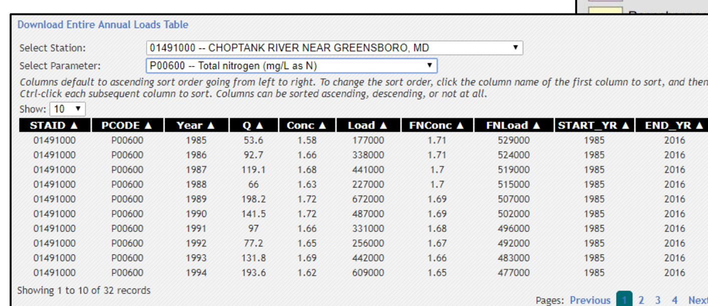








The website contains load and trend results for Total Nitrogen, Nitrate, Total Phosphorus, Orthophosphorus, and Suspended Sediment at individual monitoring stations in graphical or tabular formats.



Download Entire Annual Loads Table

Select Station: 01491000 -- CHOPTANK RIVER NEAR GREENSBORO, MD

Select Parameter: P00600 -- Total nitrogen (mg/L as N)

Columns default to ascending sort order going from left to right. To change the sort order, click the column name of the first column to sort, and then Ctrl-click each subsequent column to sort. Columns can be sorted ascending, descending, or not at all.

Show: 10

STAID ▲	PCODE ▲	Year ▲	Q ▲	Conc ▲	Load ▲	FNConc ▲	FNLoad ▲	START_YR ▲	END_YR ▲
01491000	P00600	1985	53.6	1.58	177000	1.71	529000	1985	2016
01491000	P00600	1986	92.7	1.66	338000	1.71	524000	1985	2016
01491000	P00600	1987	119.1	1.68	441000	1.7	519000	1985	2016
01491000	P00600	1988	66	1.63	227000	1.7	515000	1985	2016
01491000	P00600	1989	198.2	1.72	672000	1.69	507000	1985	2016
01491000	P00600	1990	141.5	1.72	487000	1.69	502000	1985	2016
01491000	P00600	1991	97	1.66	331000	1.68	496000	1985	2016
01491000	P00600	1992	77.2	1.65	256000	1.67	492000	1985	2016
01491000	P00600	1993	131.8	1.69	442000	1.66	483000	1985	2016
01491000	P00600	1994	193.6	1.62	609000	1.65	477000	1985	2016

Showing 1 to 10 of 32 records

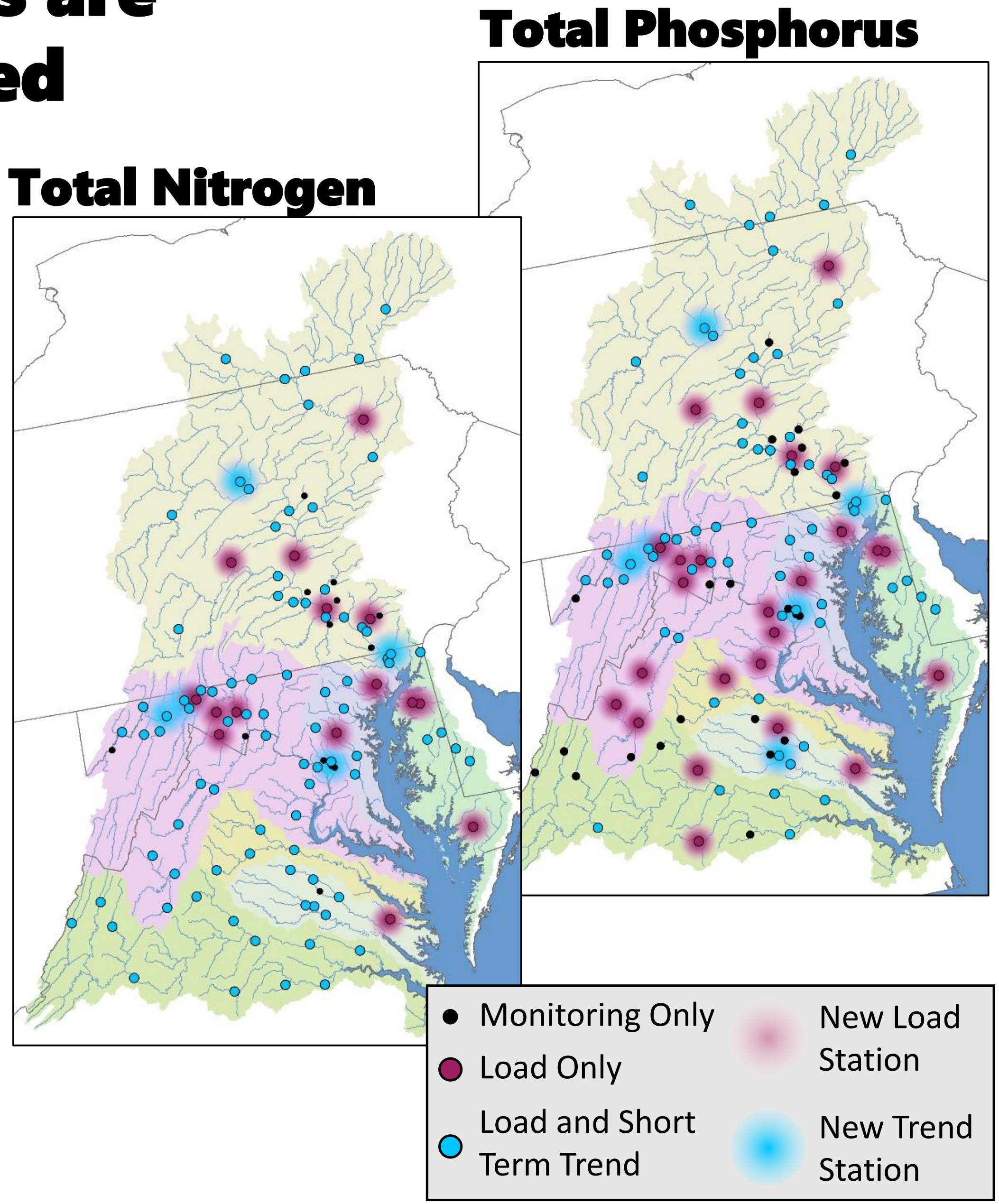
Pages: Previous 1 2 3 4 Next

Loads and trend results are available at an increased number of stations

The computation of loads and trends at these additional stations strengthens our science and is possible because of the continued investment from the Chesapeake Bay partnership.

Juris.	n Stations	TN		TP	
		Load	Trend	Load	Trend
NY	5	5	5	5	5
PA	31	24 (5)	19 (1)	24 (5)	19 (1)
MD	29	28 (5)	23 (4)	28 (5)	23 (4)
DE	2	2	2	2	2
VA	34	33 (1)	32	23 (11)	12 (1)
WV	10	8 (4)	4	8 (4)	4
DC	4	1	1	1	1
TOTAL	115	101 (15)	86 (5)	91 (25)	66 (6)

Values in parenthesis indicate the number of new load or trend stations in 2016.

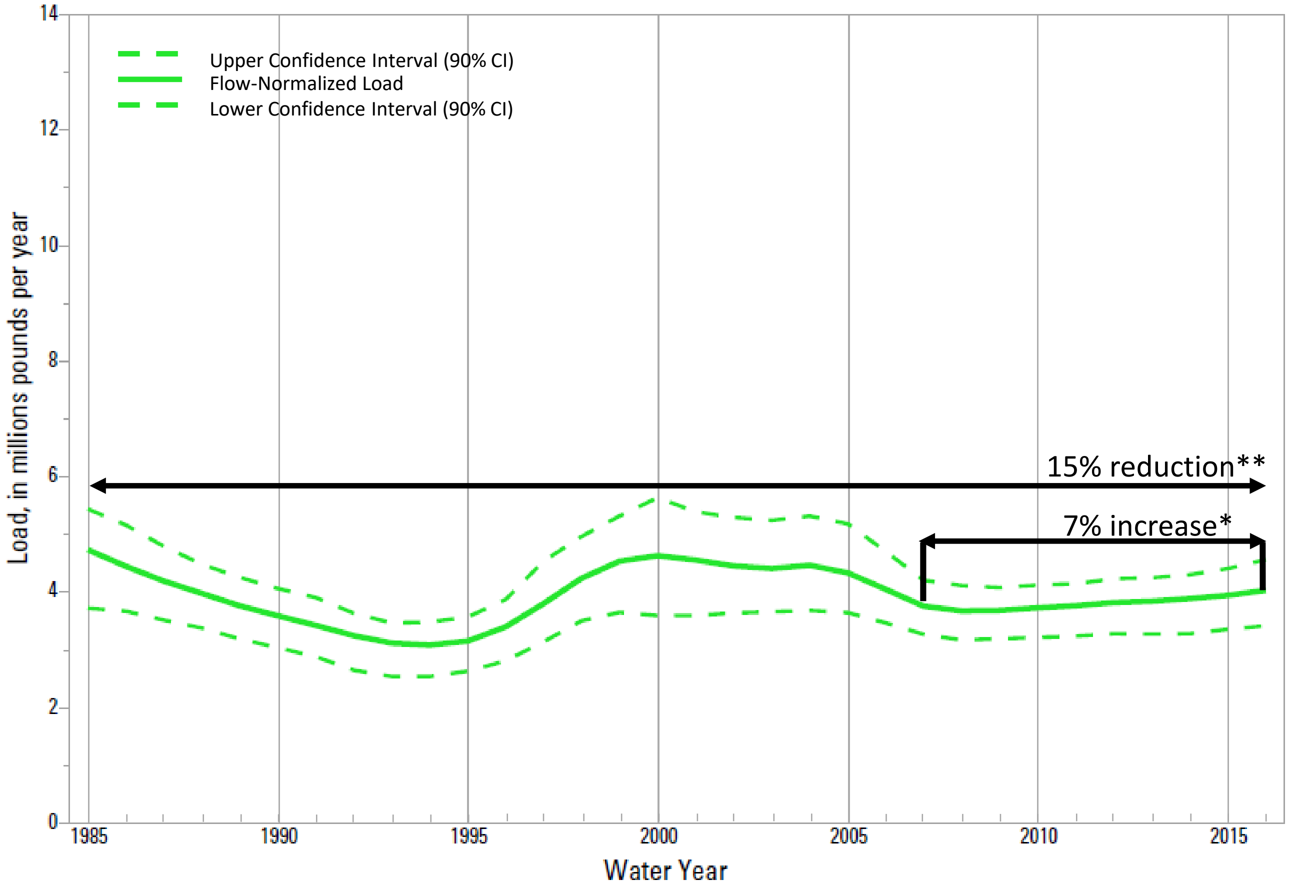


Load and trend results have been computed through 2016

The most recent 10 year ("short-term") trend[1] is computed between 2007 and 2016. Short-term trends were previously computed between 2005 and 2014.

These new results have been thoroughly vetted and this talk will focus on placing the new information in context with our explaining change efforts.

Potomac River at Chainbridge, Washington DC: Total Phosphorus



[1]Moyer and others, 2017

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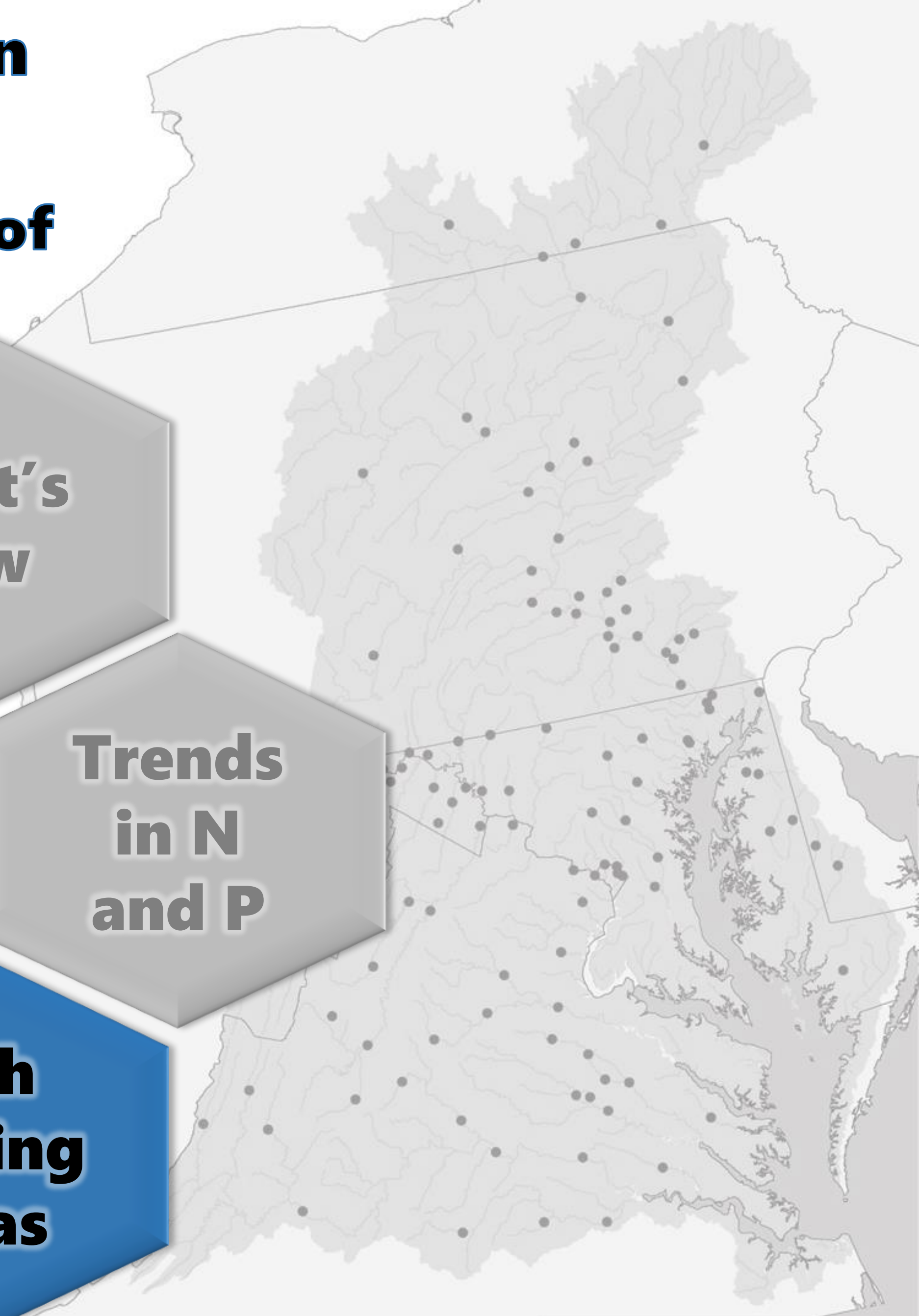


What's New

N and P Loads

Trends in N and P

High Loading Areas

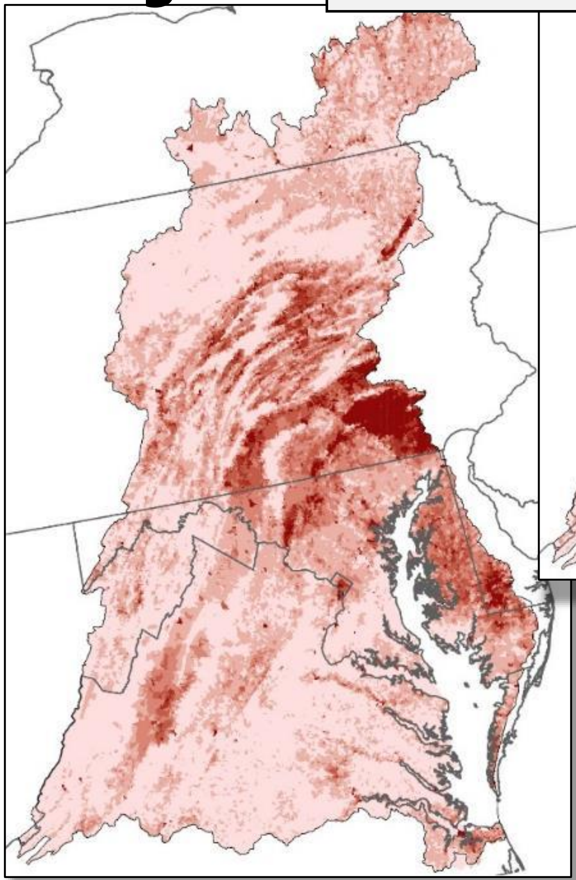
Nitrogen and phosphorus loads vary throughout the watershed based on human activities and environmental settings

Nutrient loads measured in streams throughout the watershed are highly variable as a result of:

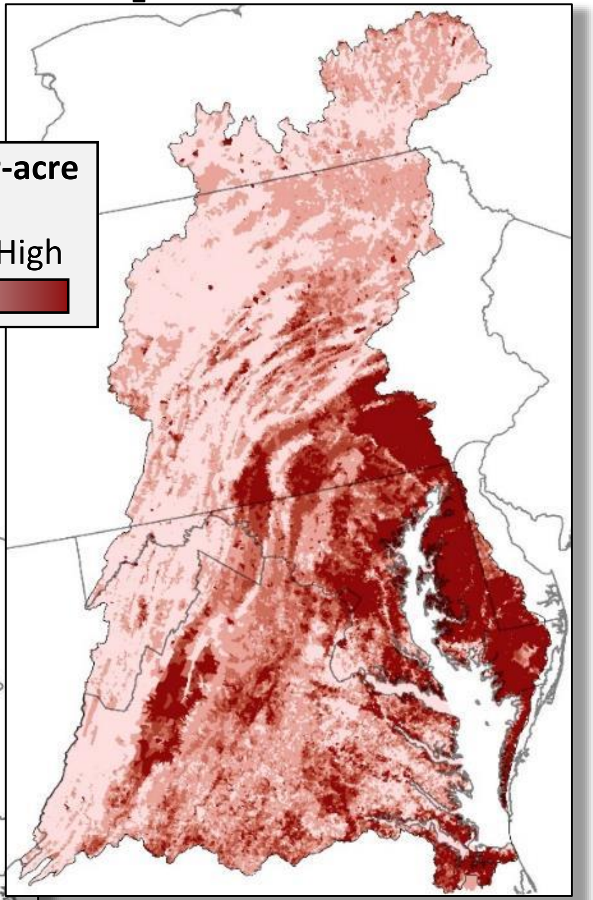
1. The amount of nutrients applied to the landscape or added directly to streams ("*nutrient inputs*"), which reflects the intensity of human activities.

2. The movement of nutrients from the landscape to streams (*"nutrient transport"*), which is primarily a function of geologic setting and climatic conditions.

Nitrogen



Phosphorus



Nutrient per-acre load[2]

Low ⟶ High

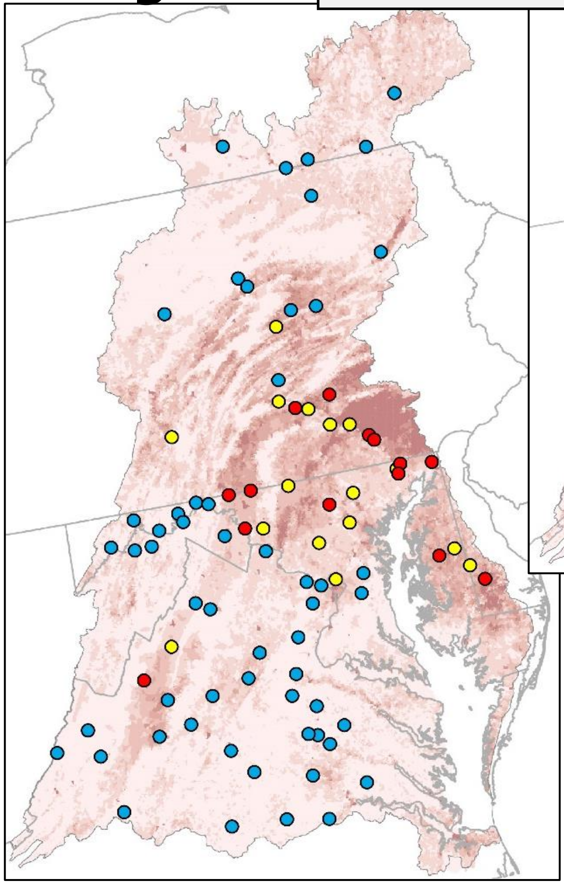
[2]Ator and others, 2011.

The spatial distribution of nutrient per-acre loads has remained relatively similar through time

High per-acre loads exist in these areas because:

1. These areas have received the greatest amount of nutrient inputs in the watershed.
2. There has been a long history of elevated nutrient inputs in these locations.
3. The environmental setting of these areas promote the transport of nutrients to the stream.

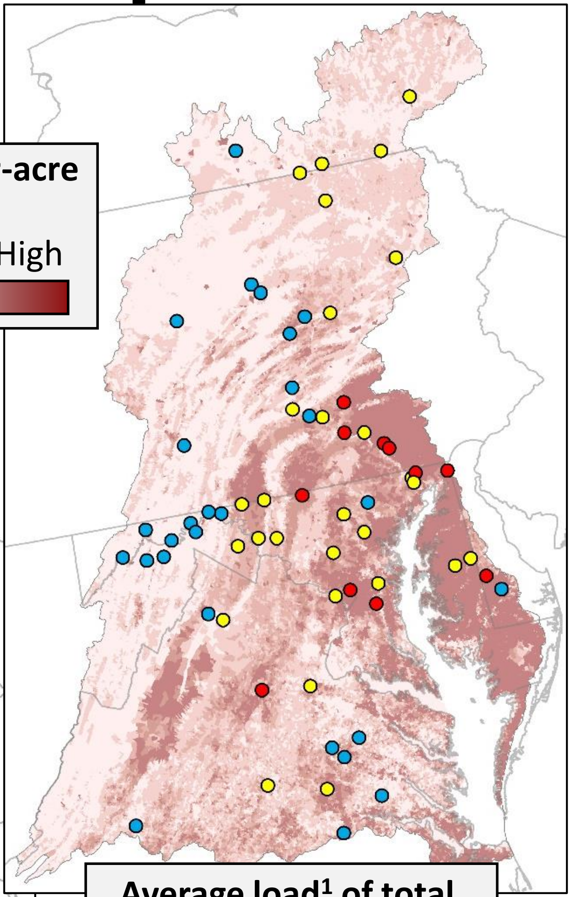
Nitrogen



Average load[1] of total nitrogen between 2007 and 2016, in pounds per acre

- 1.19 to 6.33
- 6.34 to 12.67
- 12.68 to 30.03

Phosphorus



Nutrient per-acre load[2]

Low ⟶ High

Average load[1] of total phosphorus between 2007 and 2016, in pounds per acre

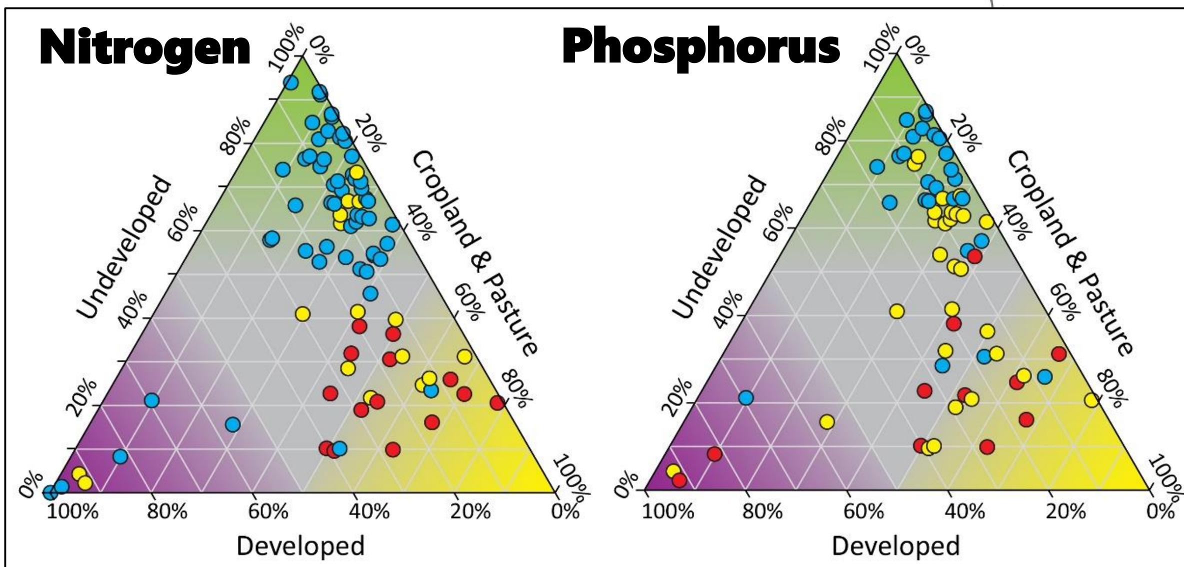
- 0.12 to 0.38
- 0.39 to 0.75
- 0.76 to 2.01

[1]Moyer and others, 2017 [2]Ator and others, 2011

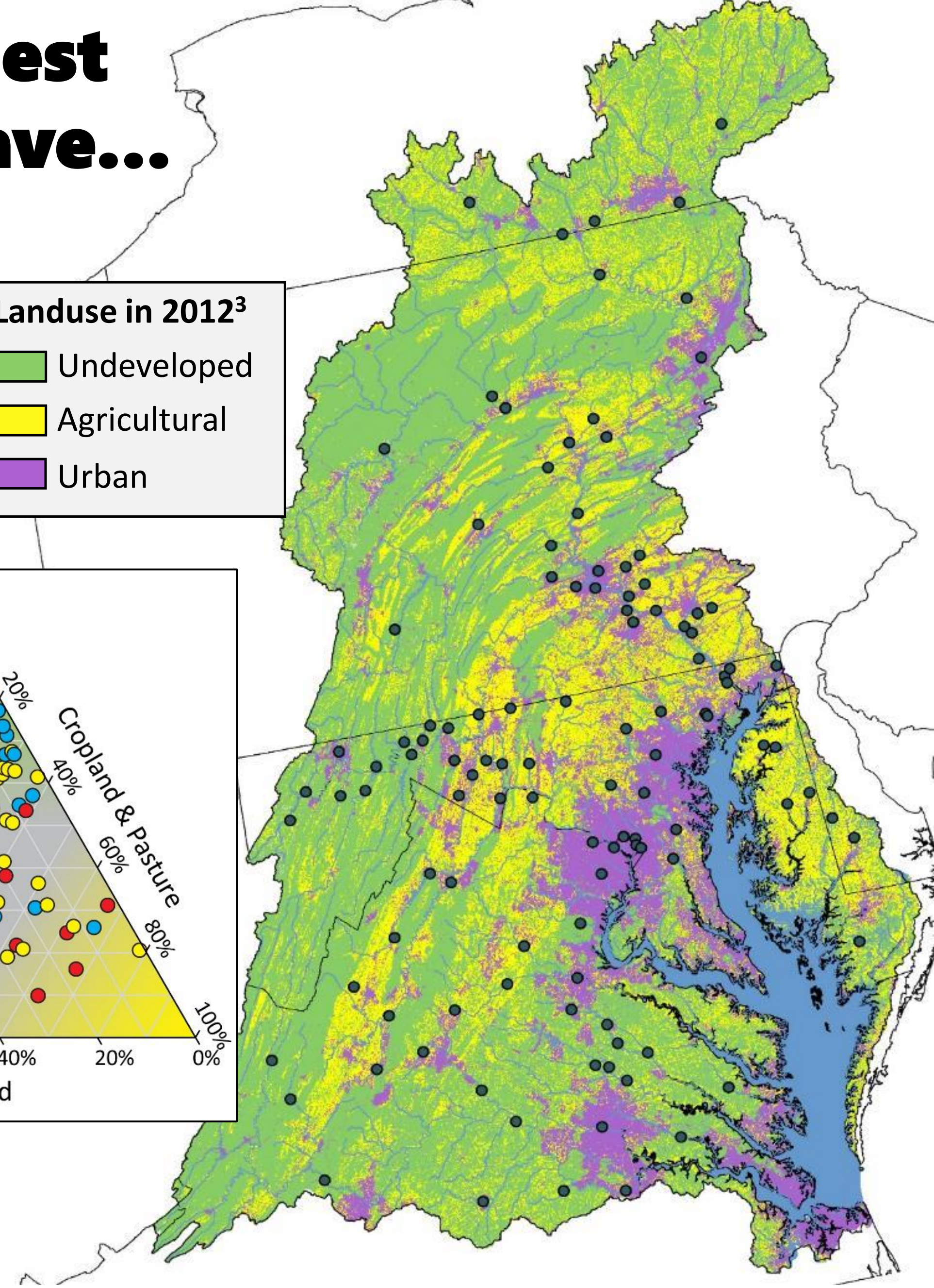
Watersheds with the highest nutrient per-acre loads have…

Large nutrient inputs

The largest nutrient inputs typically occur in agricultural watersheds from fertilizer and/or manure applications, however, urban areas still yield more nitrogen and phosphorus than undeveloped watersheds.



Average nutrient load[1] between 2007 and 2016, in lb/ac
Low   Medium   High



Landuse in 2012[3]
- Undeveloped
- Agricultural
- Urban

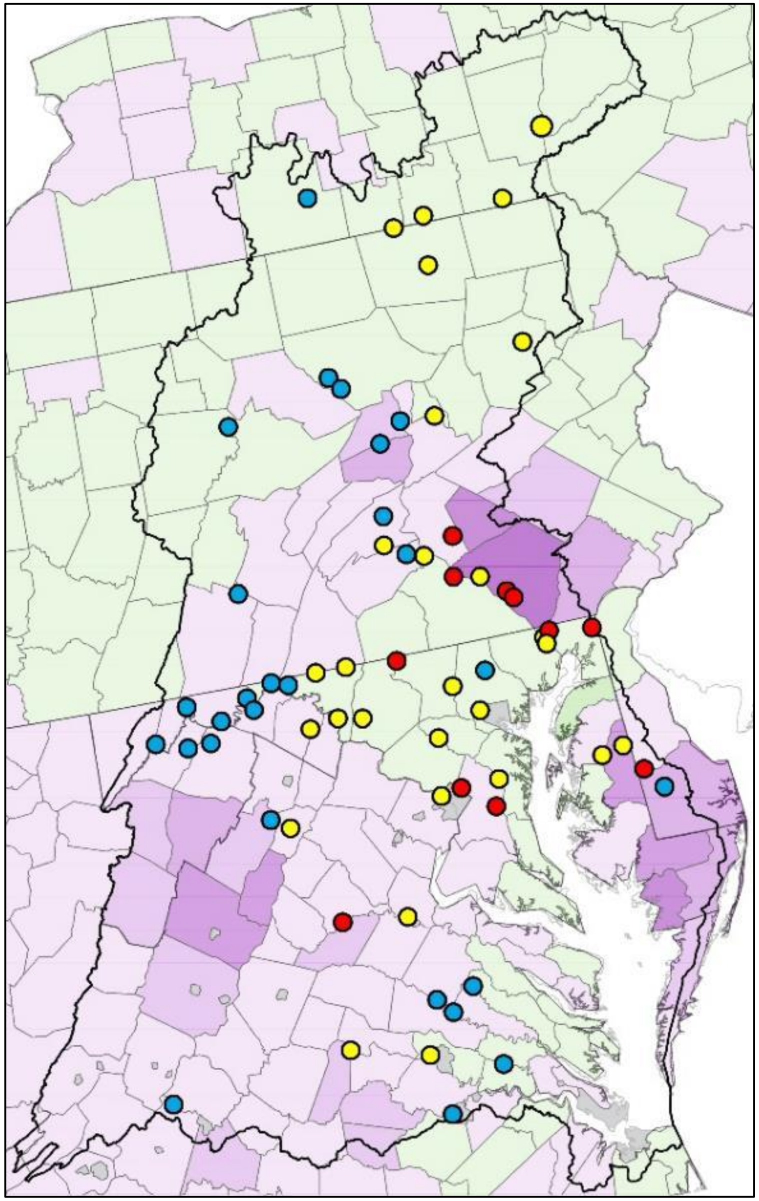
[1]Moyer and others, 2017   [3]Falcone, 2015

Watersheds with the highest nutrient per-acre loads have…

A long history of excess nutrient inputs, which can result in:

Phosphorus saturated soils. Phosphorus can be stored in soils when applications exceed crop removal rates. In areas where this has occurred, up to half of the total phosphorus load is exported in dissolved form[4].

Phosphorus



Average phosphorus balance[5,6] in 2012, in pounds per acre

15 10 5 0 -5

Average nutrient load[1] between 2007 and 2016, in lb/ac

Low Medium High

P balance is computed as the difference between ag. inputs ([5]Sekellick, 2017) and crop uptake. Crop uptake rates are based on methods presented in [6]Ator and Denver, 2015.

[1]Moyer and others, 2017

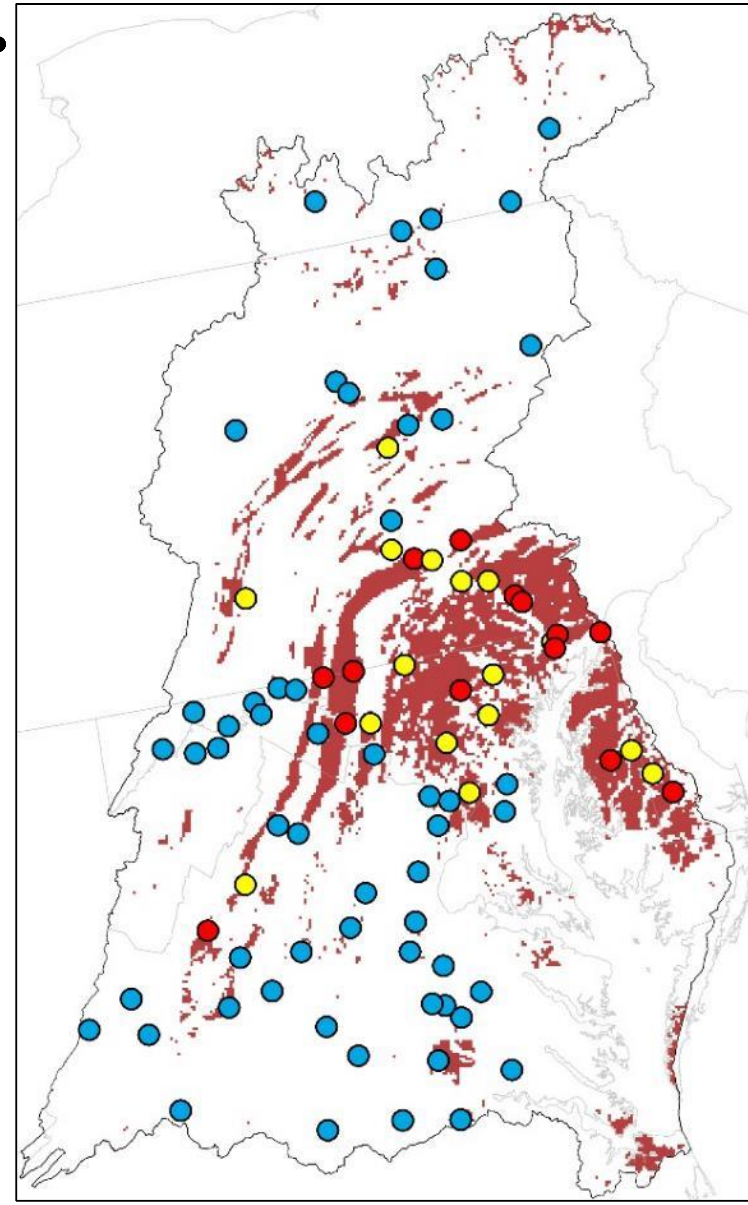
[4]Fanelli and others, 2017

Watersheds with the highest nutrient per-acre loads have…

A long history of excess nutrient inputs, which can result in:

Nitrogen movement to groundwater.
Groundwater is the primary delivery pathway of nitrogen to streams and groundwater nitrogen concentrations (as nitrate) are typically elevated in agricultural watersheds.

Nitrogen



Probability of nitrate concentrations in groundwater exceeding 3 mg/L as N[7]

>50%

Average nutrient load[1] between 2007 and 2016, in lb/ac

Low Medium High

USGS science for a changing world

[1]Moyer and others, 2017

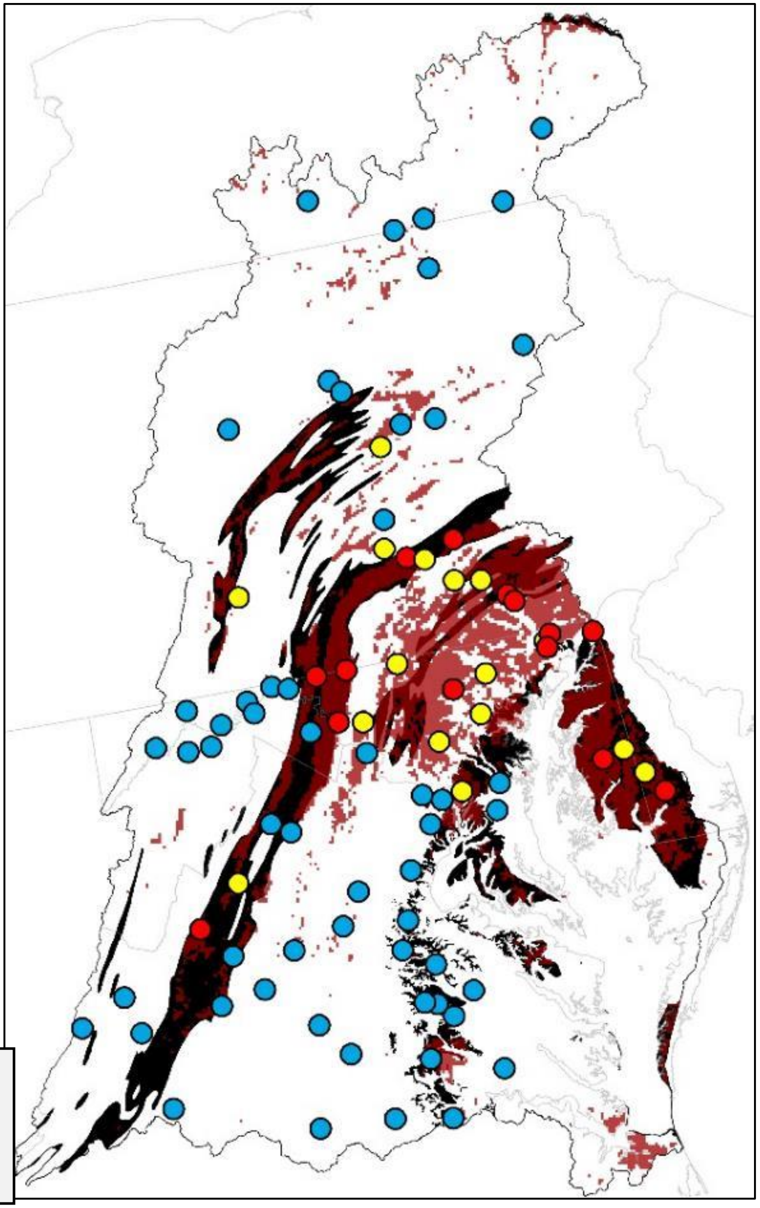
[7]Greene and others, 2005

Watersheds with the highest nutrient per-acre loads have…

Environmental settings that allow nutrients to be efficiently transported to streams

Watersheds with carbonate geology or portions of the coastal plain with coarse-grained sediments have very low denitrification rates, which allows nitrogen inputs to move relatively unaltered into the groundwater.

Nitrogen



Probability of nitrate concentrations in groundwater exceeding 3 mg/L as N[7]

>50%

Generalized Geology[8]

Carbonate and Coarse Coastal Plain

Average nitrogen load[1] between 2007 and 2016, in lb/ac

Low Medium High

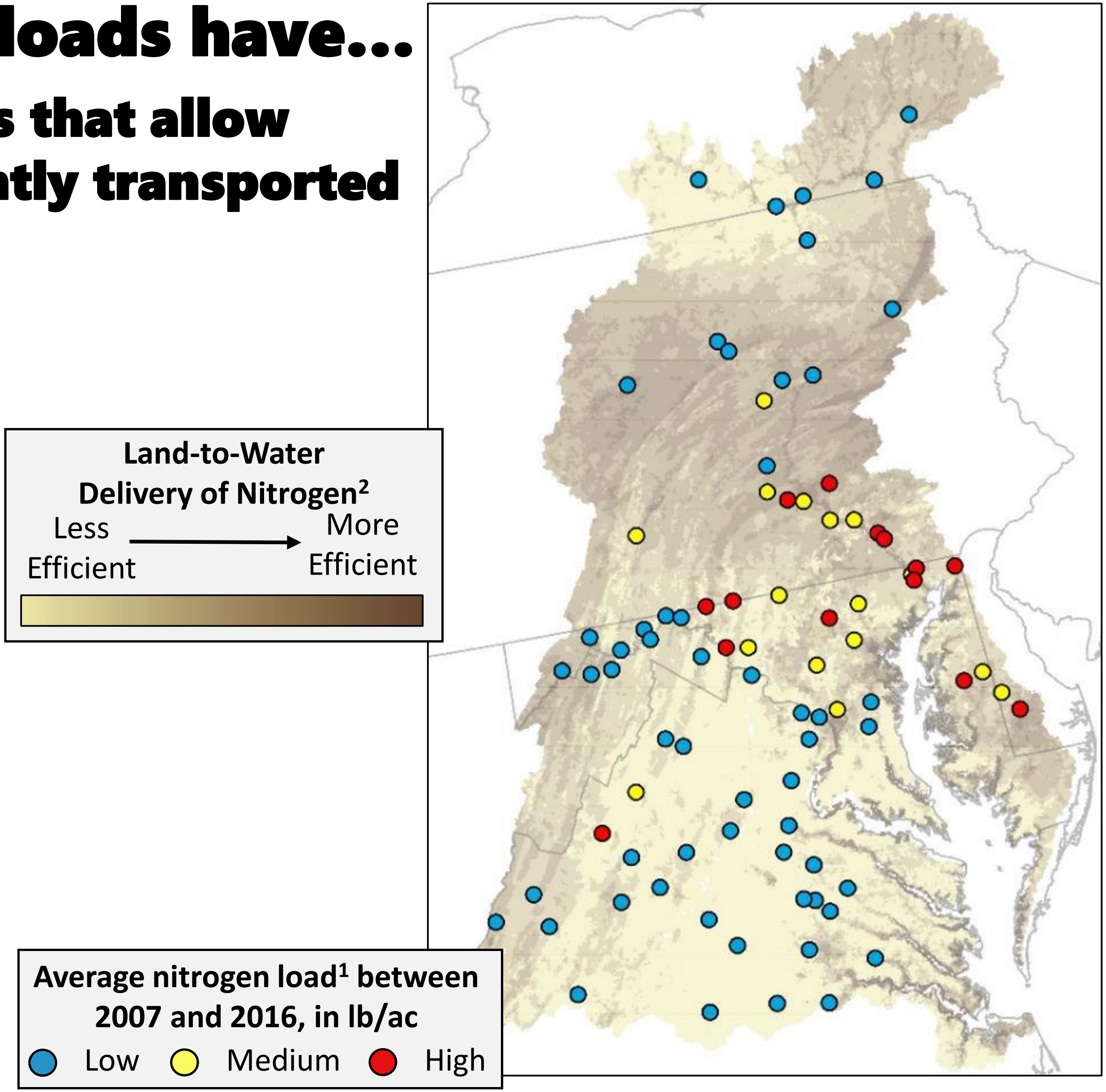
[1]Moyer and others, 2017 [7]Greene and others, 2005 [8]King and Biekman, 1974

Watersheds with the highest nutrient per-acre loads have…

Environmental settings that allow nutrients to be efficiently transported to streams

More nitrogen is removed from warm streams than cool streams by denitrification. Nitrogen is transported more efficiently to streams in northern regions than in southern regions because of this process.

Nitrogen



[1]Moyer and others, 2017

[2]Ator and others, 2011

Watersheds with the highest nutrient per-acre loads have…

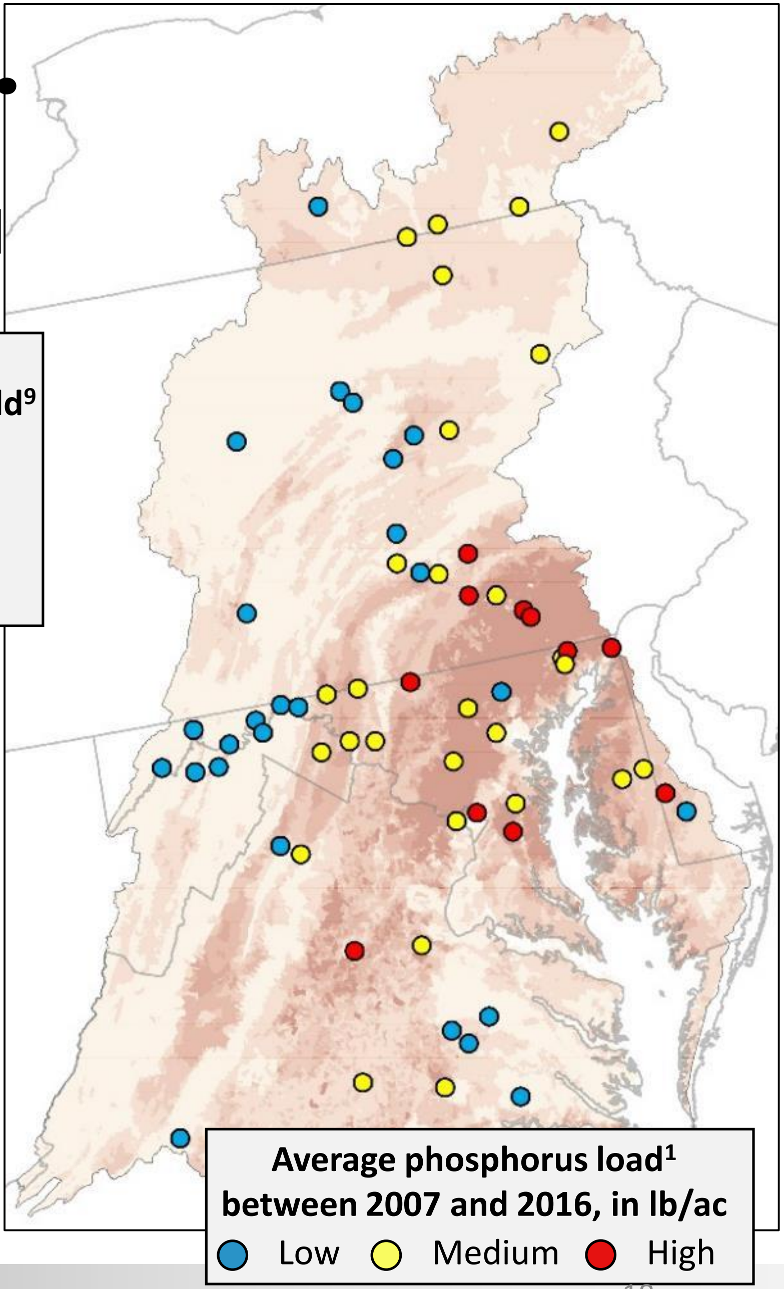
Environmental settings that allow nutrients to be efficiently transported to streams

Runoff of sediment-bound phosphorus is the primary delivery pathway of phosphorus to streams. This process is enhanced in areas with highly erosive soils.

Unlike nitrogen, there are no natural processes that remove phosphorus from the river network (like denitrification). Impoundments and flood plain deposition retard phosphorus movement through the stream corridor.

The movement of N and P from the land to streams differs and therefore requires different management strategies.

Phosphorus



[1]Moyer and others, 2017

[9]Brakebill and others, 2010

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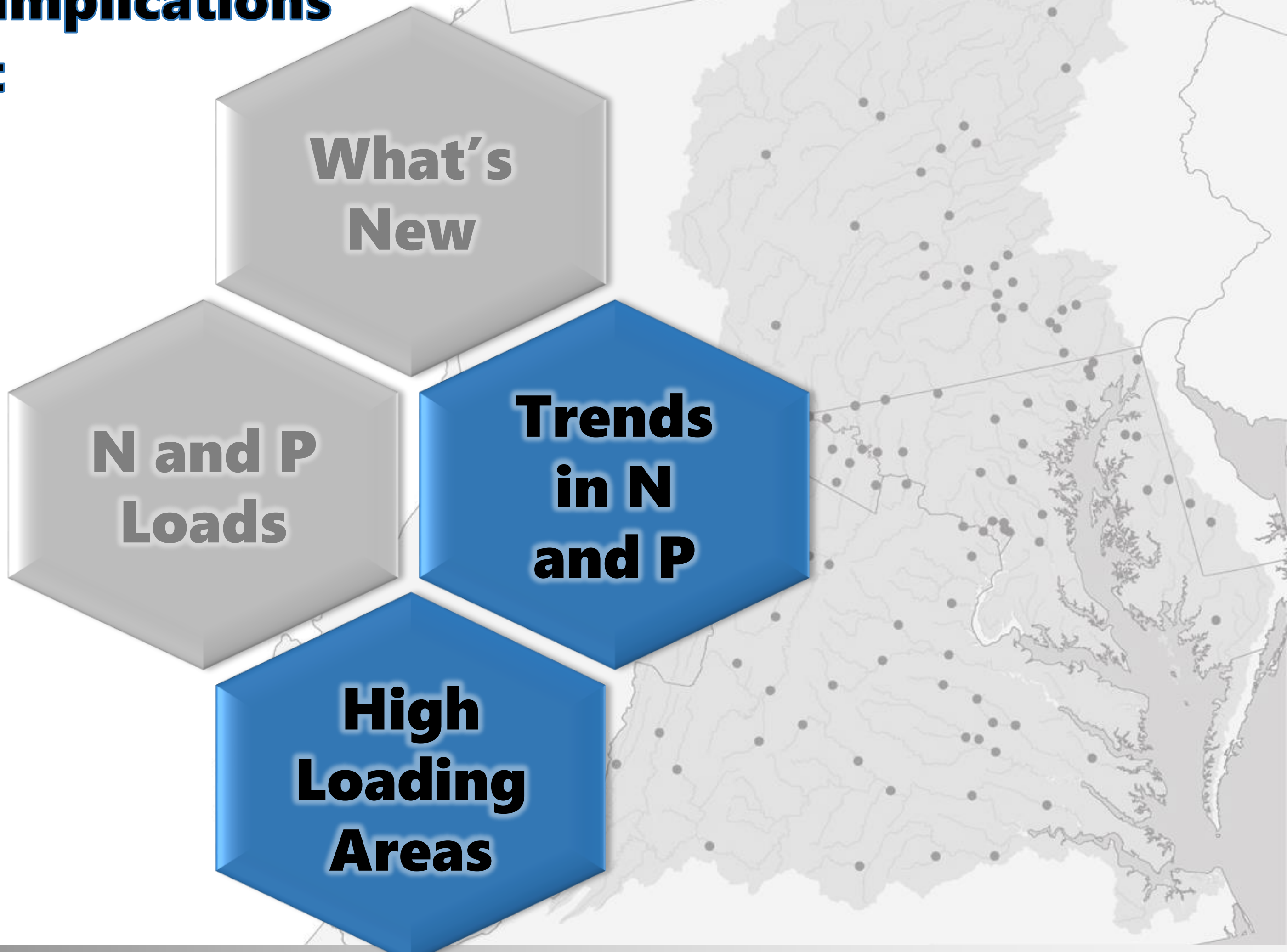

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Trends in nitrogen loads result from changing nitrogen inputs or transport

In the most recent ten year period (2007 – 2016)[2]:

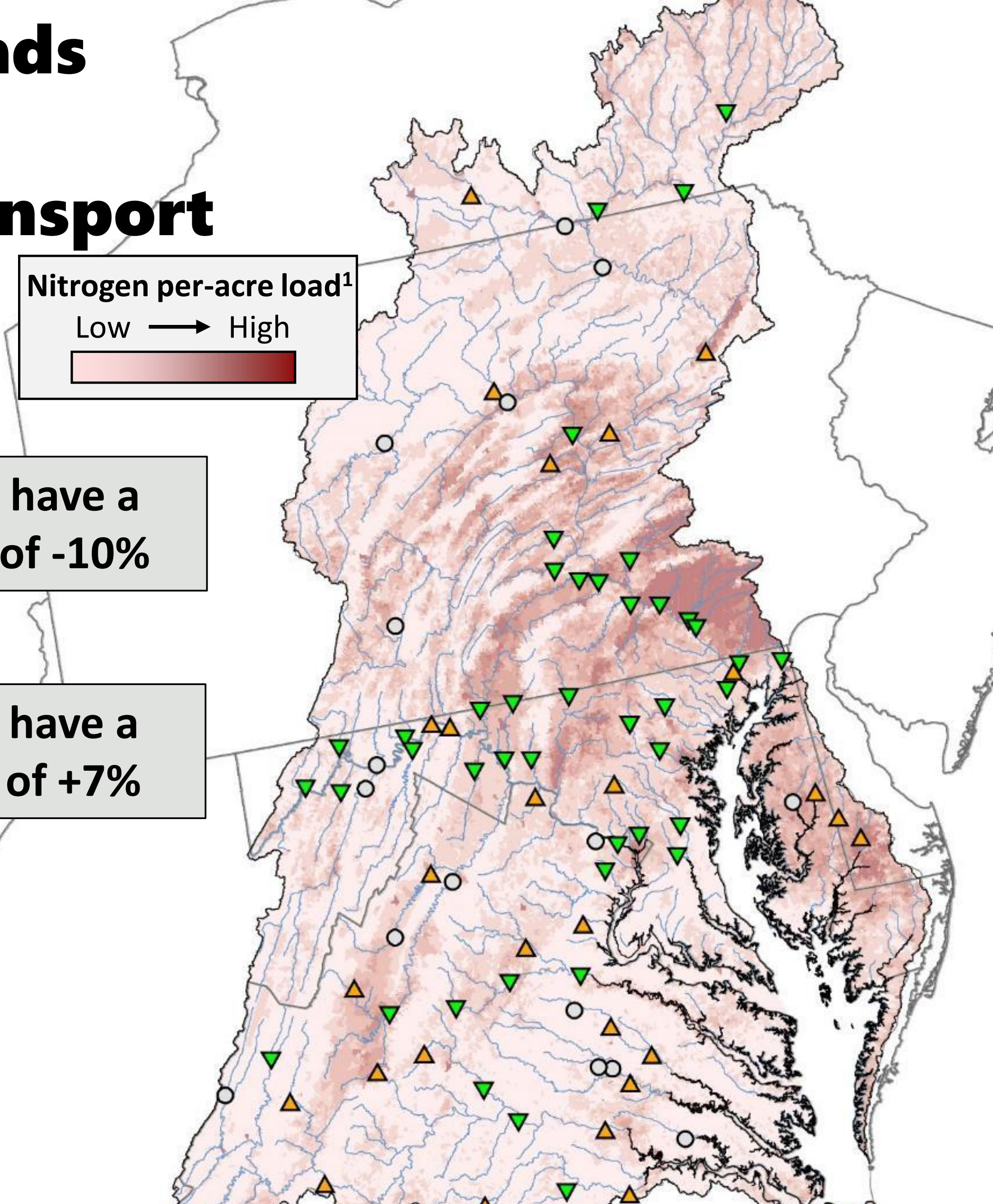
% of sites improving: 50%

Improving sites have a median change of -10%

% of sites Degrading: 31%

Degrading sites have a median change of +7%

% of sites with no trend: 19%



[1]Ator and others, 2011

[2]Moyer and others, 2017

USGS
science for a changing world

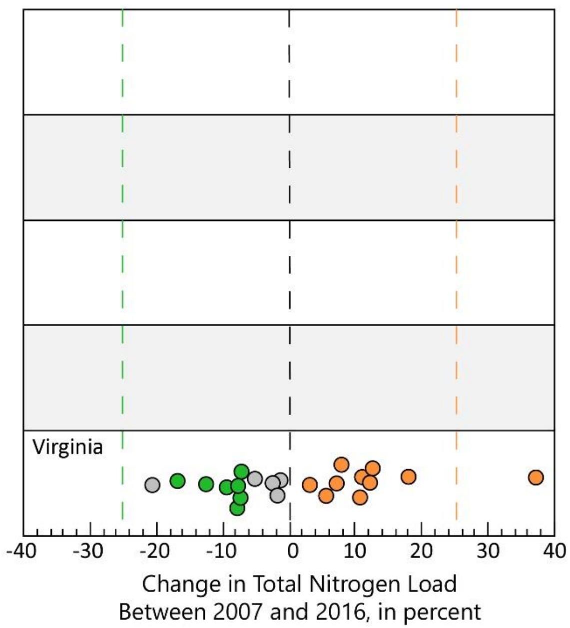
Trends in nitrogen loads result from changing nitrogen inputs or transport

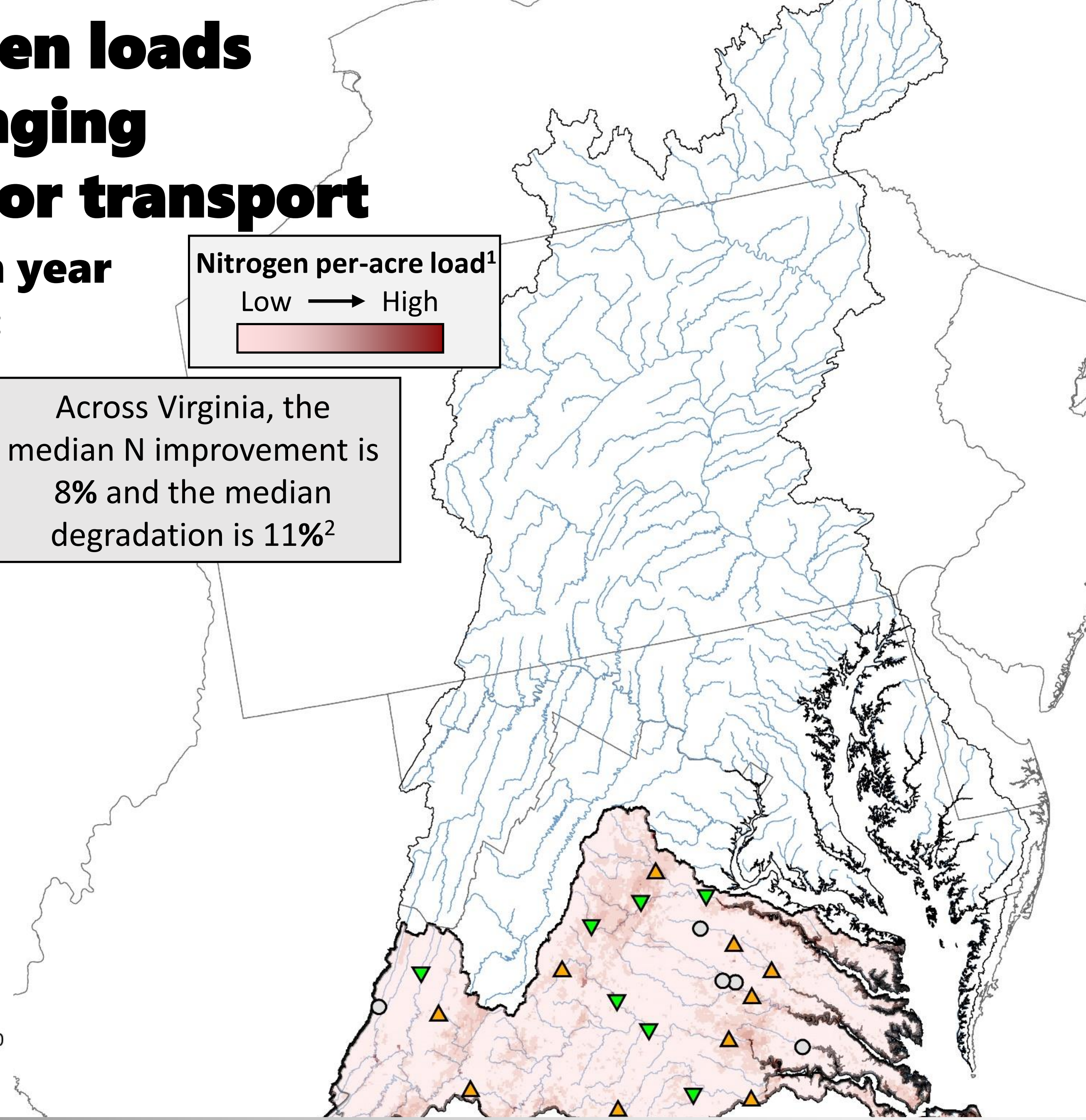
In the most recent ten year period (2007 – 2016)[2]:

Nitrogen per-acre load[1]
Low ⟶ High

Nitrogen loads **(n=22)** have improved at **7**, degraded at **10**, and have no trend at **5** of stations[2].

Across Virginia, the median N improvement is 8**%** and the median degradation is 11**%**[2]





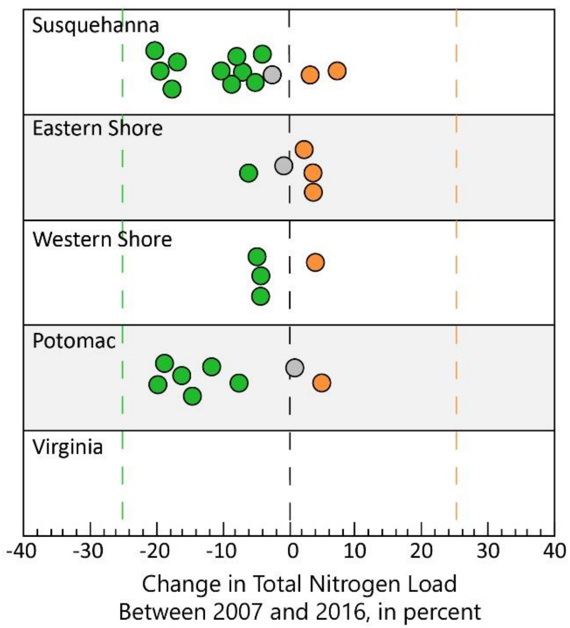
[1]Ator and others, 2011

[2]Moyer and others, 2017

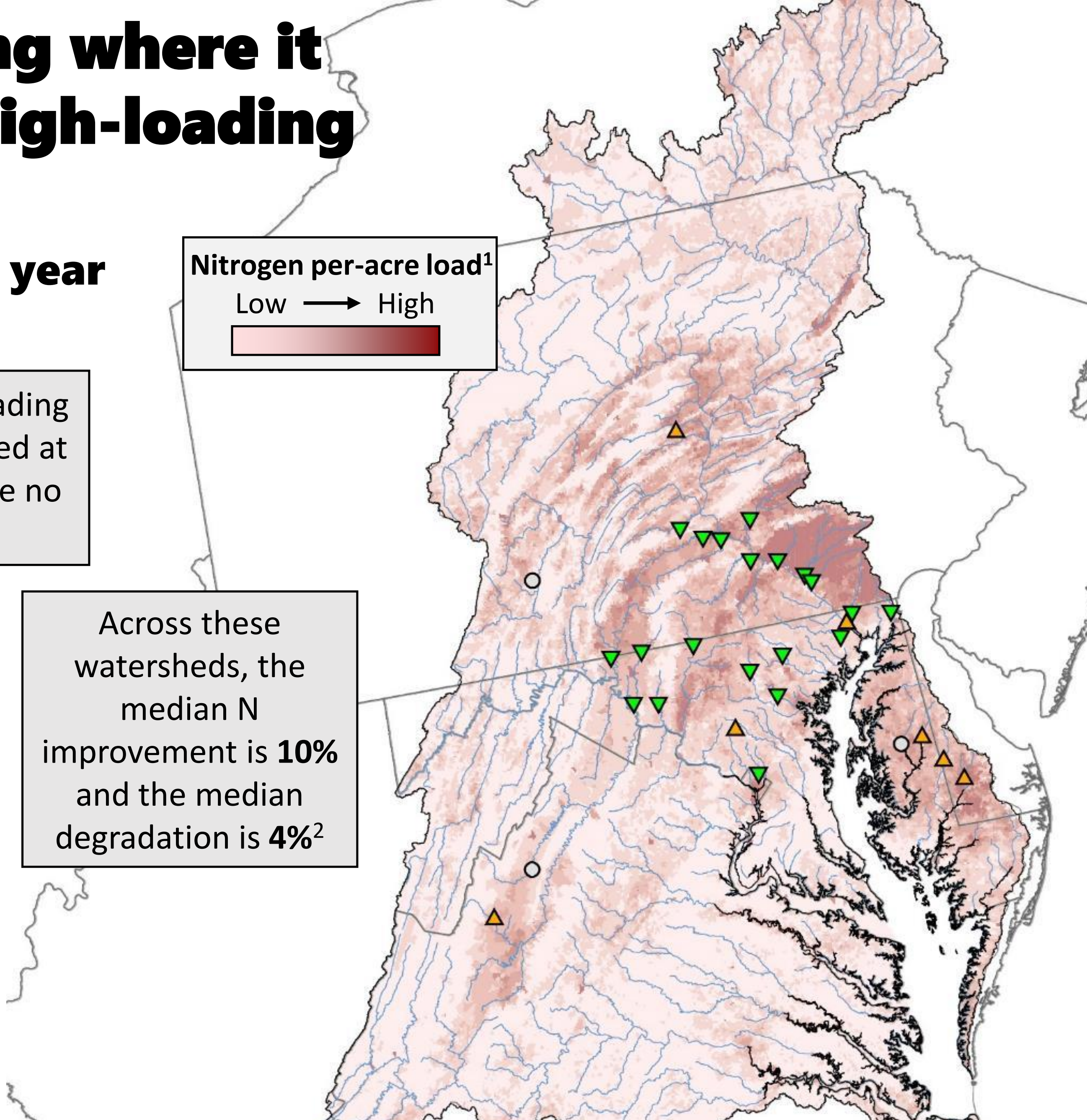
How are we doing where it really matters: high-loading areas?

In the most recent ten year period (2007 – 2016)[2]:

Nitrogen loads in the highest loading watersheds (n=30) have improved at **67%**, degraded at **23%**, and have no trend at **10%** of stations[2].



Across these watersheds, the median N improvement is **10%** and the median degradation is **4%**[2]



[1]Ator and others, 2011

[2]Moyer and others, 2017

Trends in phosphorus loads result from changing phosphorus inputs or transport

In the most recent ten year period (2007 – 2016)[2]:

Phosphorus per-acre load[1]
Low ⟶ High

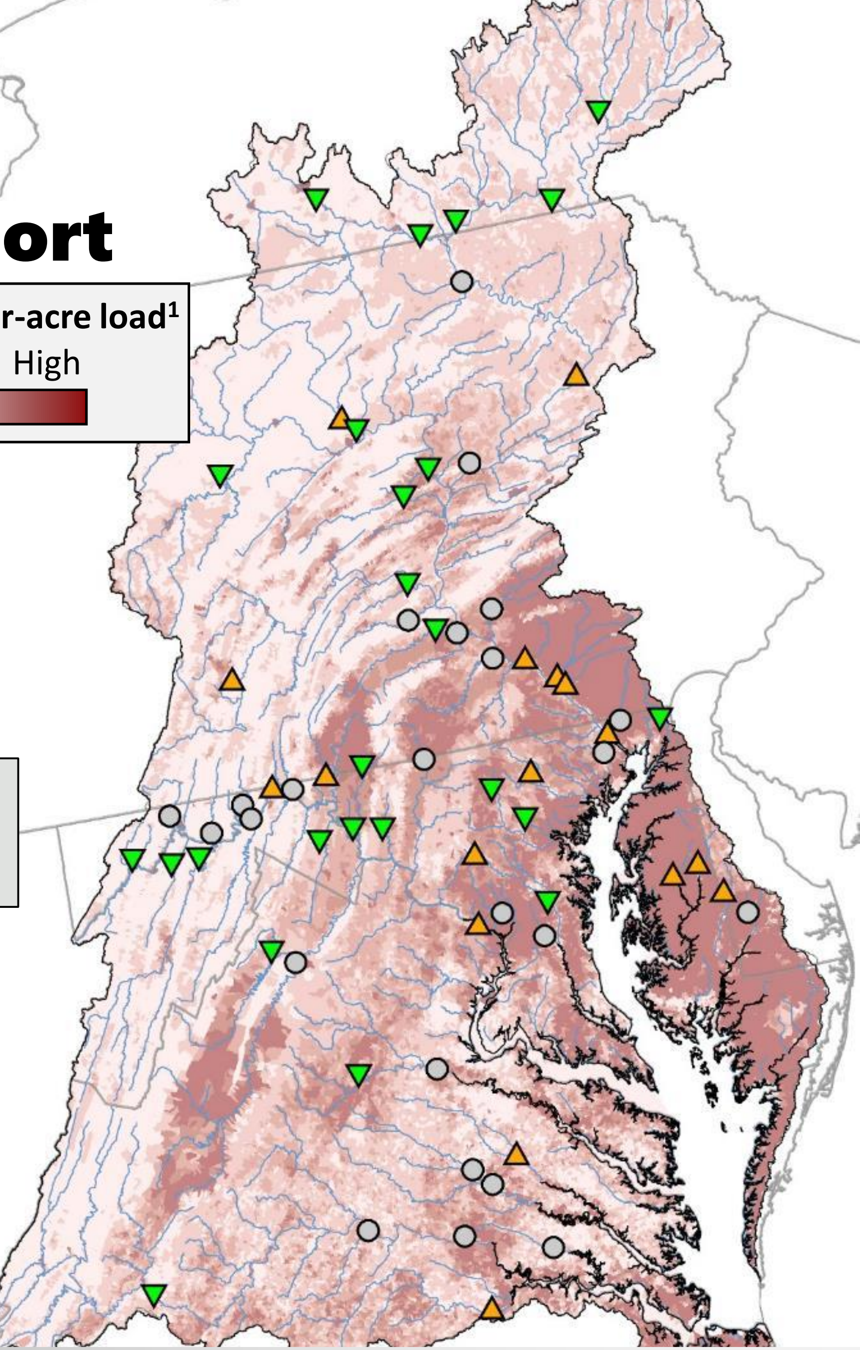
% of sites improving: **38%**

Improving sites have a median change of -23%

% of sites Degrading: **26%**

Degrading sites have a median change of +21%

% of sites with no trend: **36%**



[1]Ator and others, 2011

[2]Moyer and others, 2017

Trends in phosphorus loads result from changing phosphorus inputs or transport

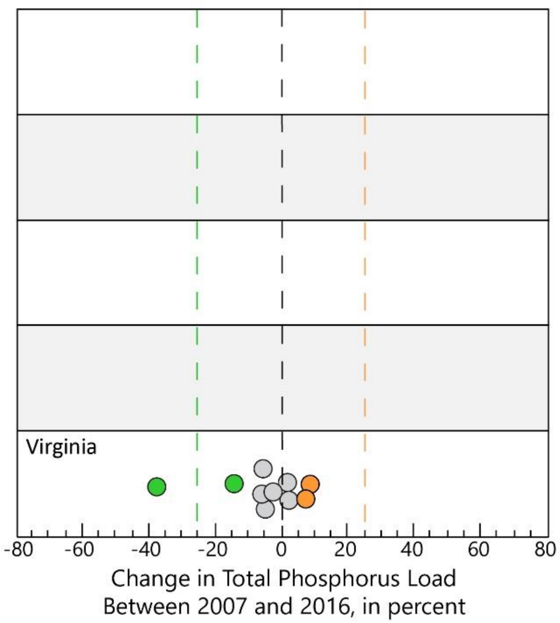
In the most recent ten year period (2007 – 2016)[2]:

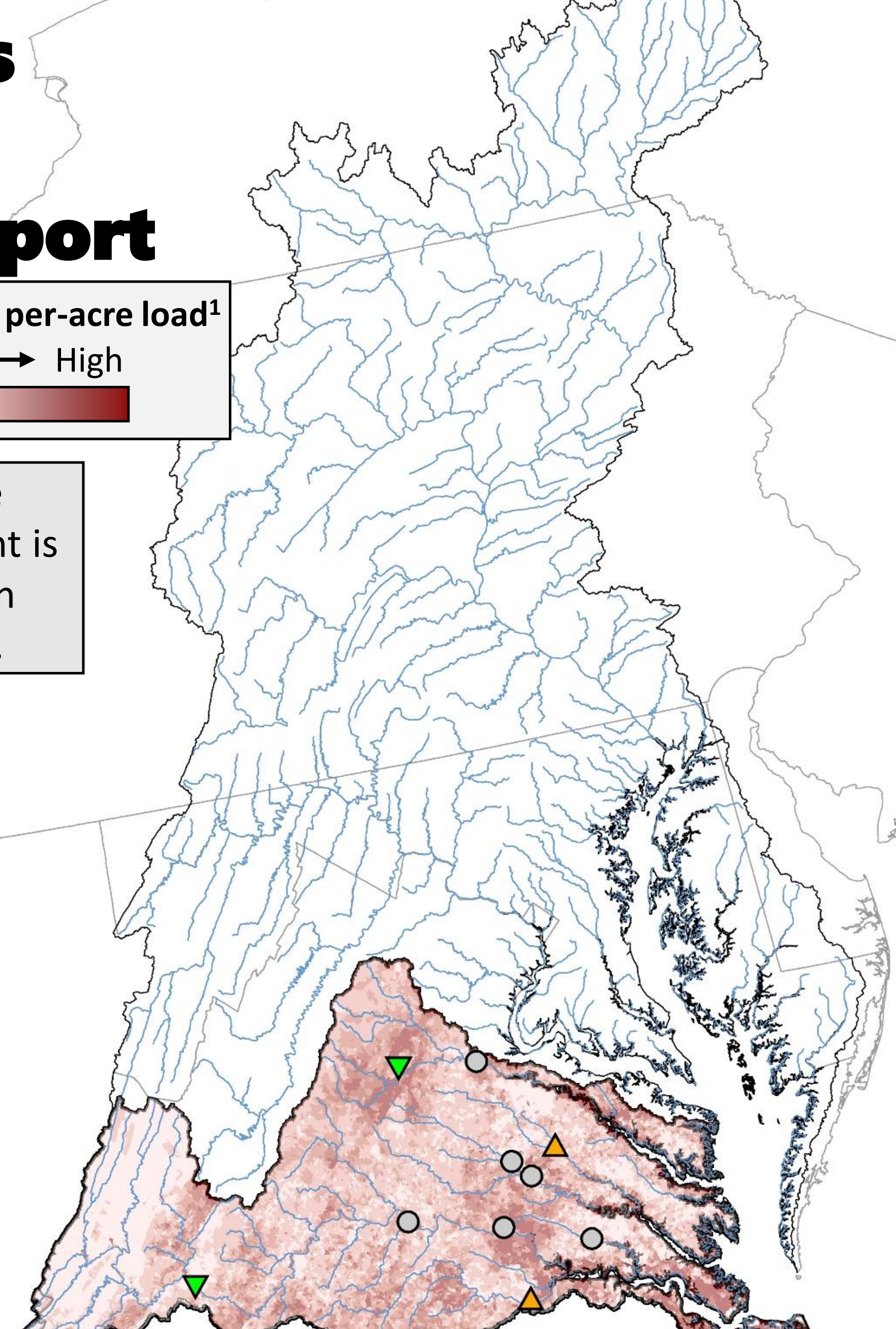
Phosphorus per-acre load[1]

Low ⟶ High

Phosphorus loads **(n=10)** have improved at **2**, degraded at **2**, and have no trend at **6** of stations[2].

Across Virginia, the median P improvement is **26%** and the median degradation is **9%**[2].





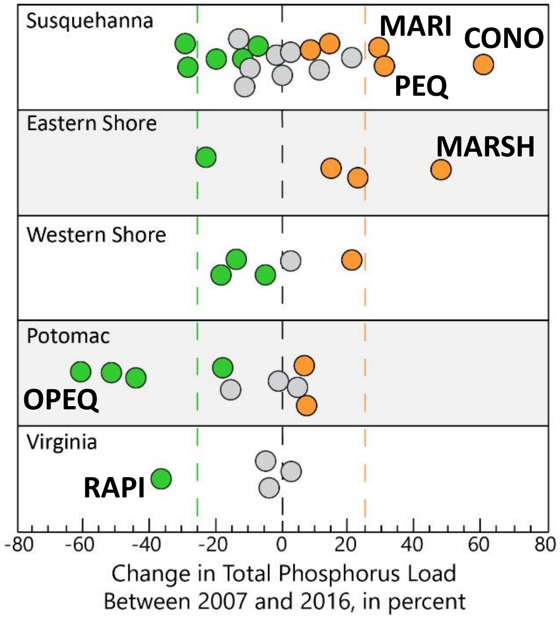
[1]Ator and others, 2011

[2]Moyer and others, 2017

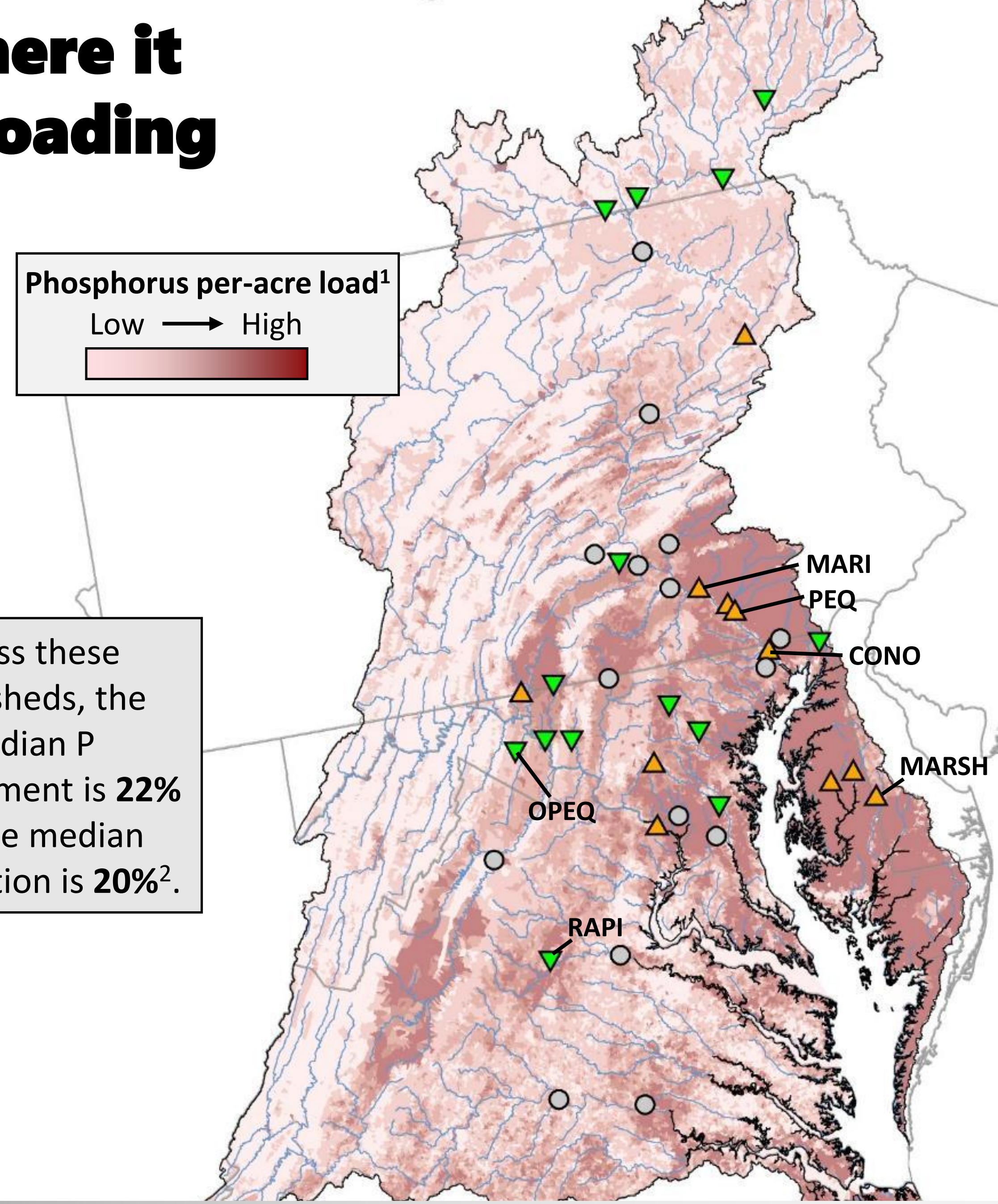
How are we doing where it really matters: high-loading areas?

In the most recent ten year period (2007 – 2016)[2]:

Phosphorus loads in the highest yielding watersheds (n=40) have improved at **35%**, degraded at **28%**, and have no trend at **38%** of stations[2].



Across these watersheds, the median P improvement is **22%** and the median degradation is **20%**[2].



[1]Ator and others, 2011

[2]Moyer and others, 2017

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New Stations
TN – 15 load and 5 trend stations (n=101)
TP – 25 load and 6 trend stations (n=91)

Website Updated
https://cbrim.er.usgs.gov/index.html

Loads
High-loading regions for TN and TP:

- Have remained consistent over time
- Occur in agricultural and urban areas that receive the largest amount of nutrient inputs

Trends in High-Loading Regions
TN – 67% of the stations in high-loading regions are improving with a median improvement of **10%**
TP – 35% of the stations in high-loading regions are improving with a median improvement of **22%**

Environmental Setting
Geologic and climatic properties are highly variable across the watershed and may enhance or retard the transport of nutrients to streams. These properties influence both loads and trends.

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References Cited

(1) Moyer, D.L., Chanat, J.G., Yang, Guoxiang, Blomquist, J.D., and Langland, M.J., 2017, Nitrogen, phosphorus, and suspended-sediment loads and trends measured at the Chesapeake Bay Nontidal Network stations: Water years 1985-2014: U.S. Geological Survey data release, https://doi.org/10.5066/F7XK8D2R.

(2) Ator, S.W., Brakebill, J.W., and Blomquist, J.D., 2011, Sources, fate, and transport of nitrogen and phosphorus in the Chesapeake Bay watershed—An empirical model: U.S. Geological Survey Scientific Investigations Report 2011–5167, 27 p.

(3) Falcone, J.A., 2015, U.S. conterminous wall-to-wall anthropogenic land use trends (NWALT), 1974–2012: U.S. Geological Survey Data Series 948, 33 p. plus appendixes 3–6 as separate files, http://dx.doi.org/10.3133/ds948.

(4) Fanelli, R., Blomquist, J, and R. Hirsch. 2017. Unraveling the drivers of orthophosphate trends in tributaries to the Chesapeake Bay. Coastal and Estuarine Research Federation Annual Meeting. Providence, RI. November 8, 2017. Link to abstract: https://cerf.confex.com/cerf/2017/meetingapp.cgi/Paper/3461

(5) Sekellick, A.J., Devereux, O.H., Keisman, J., Sweeny, J.S., and Blomquist, J.D., 2017, Spatial and Temporal Patterns of Best Management Practice Implementation in the Chesapeake Bay Watershed: U.S. Geological Survey Scientific Investigations Report, in review.

(6) Ator, S.W. and J.M. Denver. 2015. Understanding nutrients in the Chesapeake Bay watershed and implications for management and restoration—the Eastern Shore. U.S. Geological Survey Circular 1406, 72 p.

(7) Greene, E.A., LaMotte, A.E., and Cullinan, K.A., 2005, Ground-water vulnerability to nitrate contamination at multiple thresholds in the Mid-Atlantic Region using spatial probability models: U.S. Geological Survey Scientific Investigations Report 2004–5118, 24 p.

(8) King, P.B., and Biekman, H.M., 1974, Geologic map of the United States: U.S. Geological Survey, 3 sheets, scale 1:2,500,000.

(9) Brakebill, J.W., Ator, S.W., and Schwarz, G.E., 2010, Sources of suspended-sediment flux in streams of the Chesapeake Bay Watershed: a regional application of the SPARROW model: Journal of the American Water Resources Association, v46 no4, 757-776 p.