Nutrient and Sediment Loads and Trends in Chesapeake Bay Nontidal Network Streams:
results and management implications in the COG region

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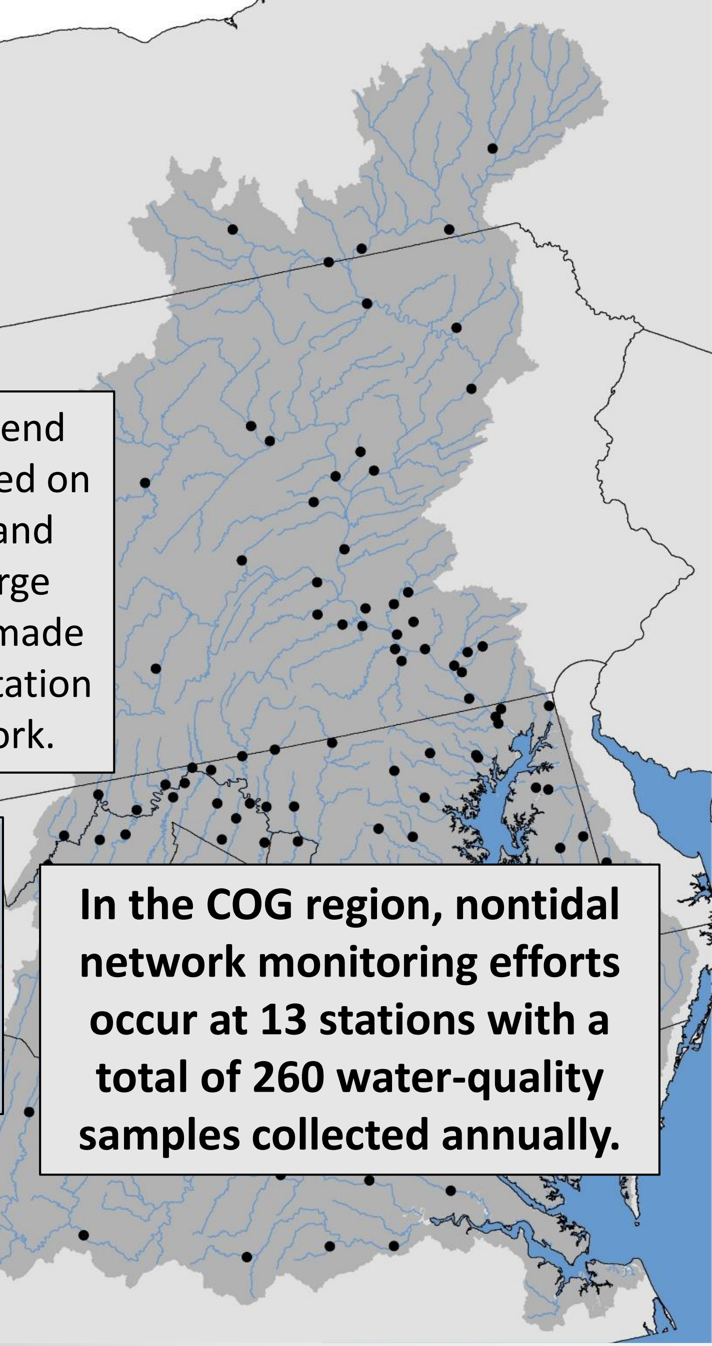
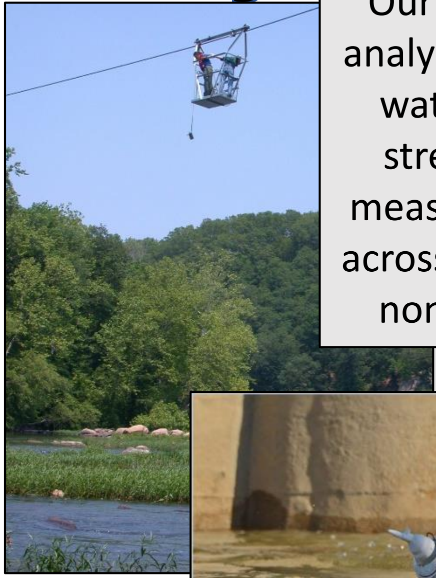
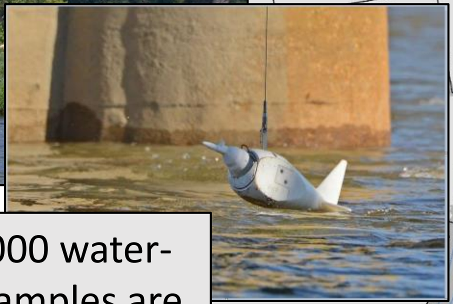


Our load and trend analyses are based on water-quality and stream-discharge measurements made across the 115-station nontidal network.





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

In the COG region, nontidal network monitoring efforts occur at 13 stations with a total of 260 water-quality samples collected annually.

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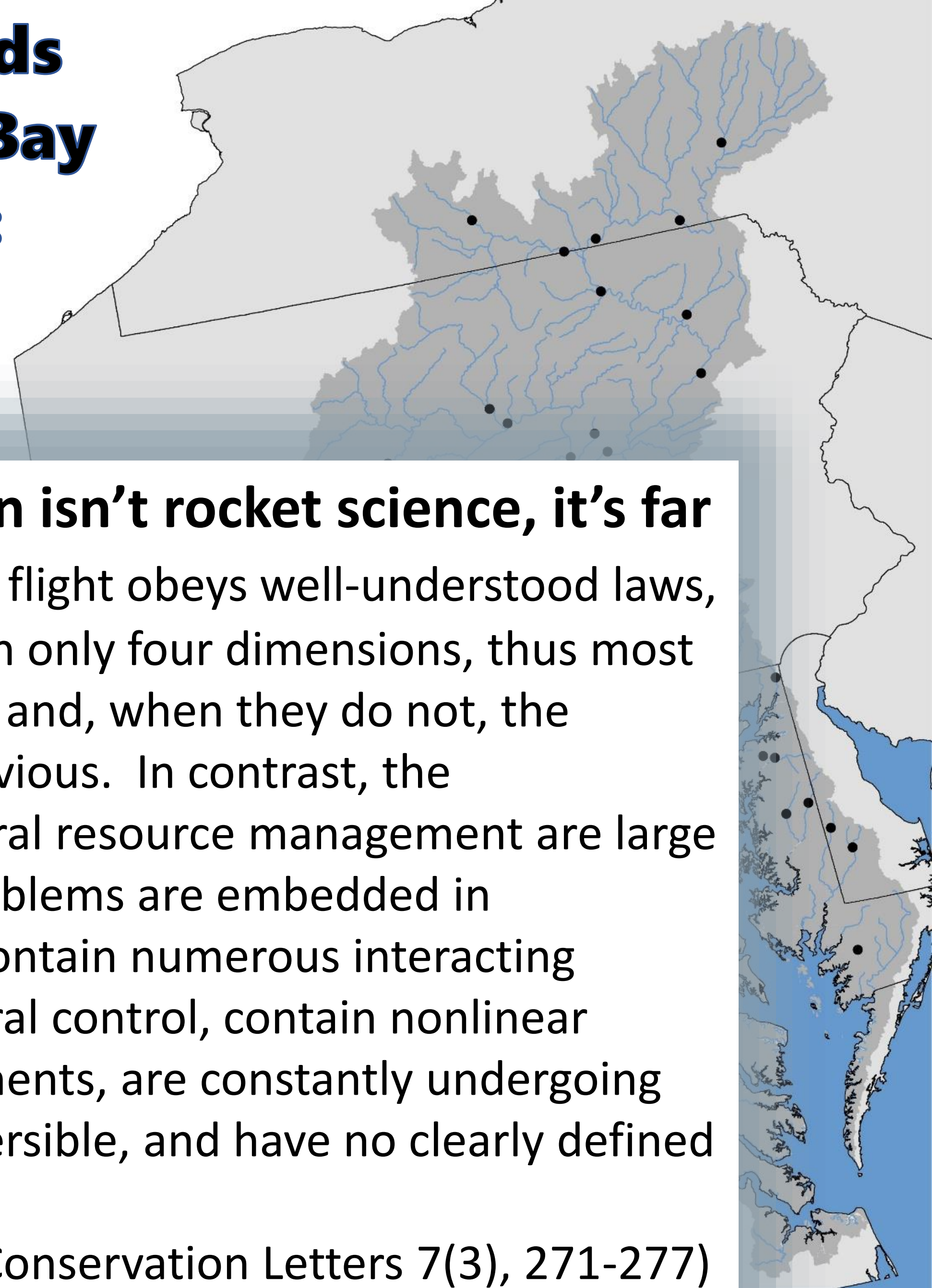


Resource conservation isn't rocket science, it's far more complex. Rocket flight obeys well-understood laws, is predictable, and varies in only four dimensions, thus most rockets reach their targets and, when they do not, the reasons are likely to be obvious. In contrast, the uncertainties around natural resource management are large because most of these problems are embedded in socioecological systems, contain numerous interacting elements lacking any central control, contain nonlinear interactions between elements, are constantly undergoing change that is seldom reversible, and have no clearly defined boundaries

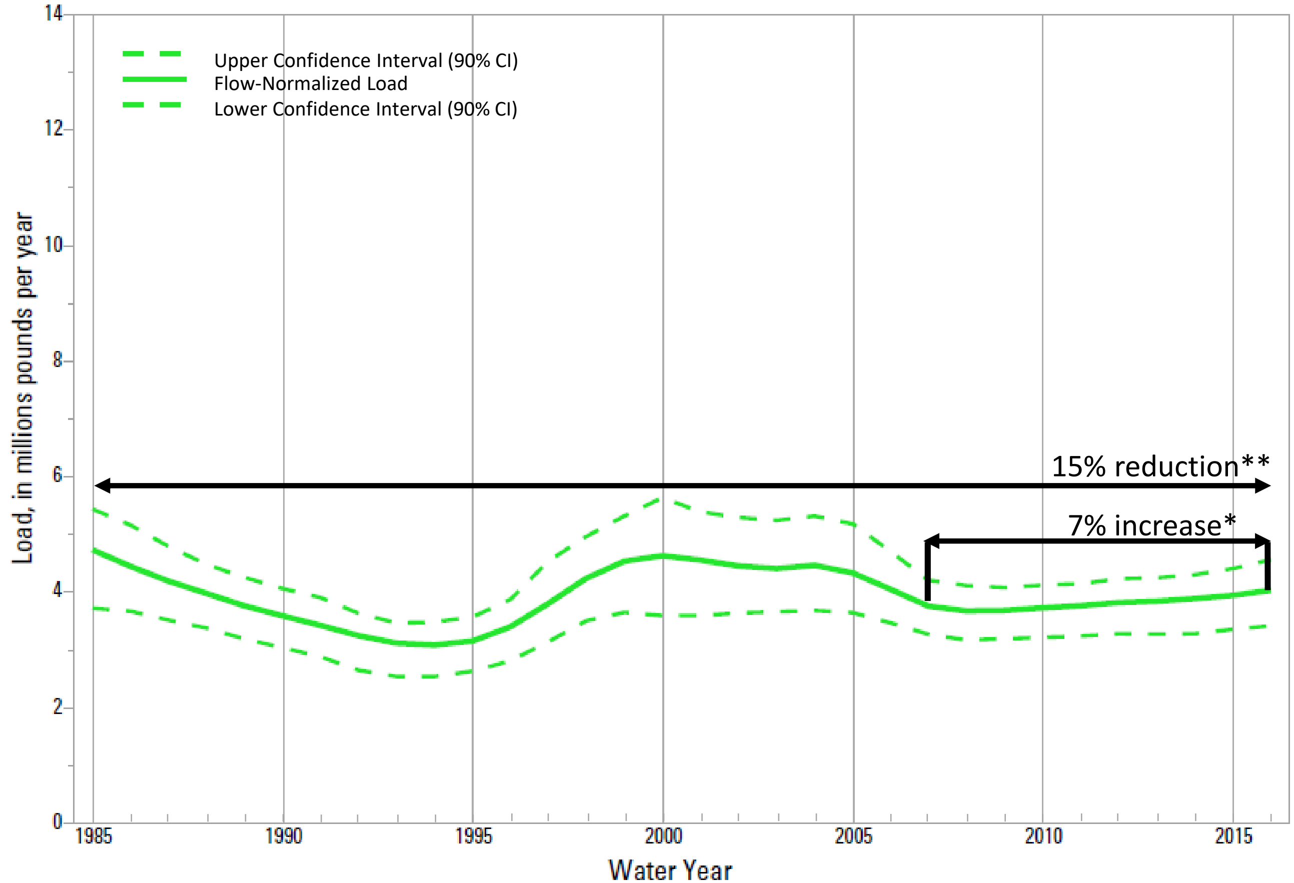
(Game and others, 2013, Conservation Letters 7(3), 271-277)

Load and trend results have been computed through 2016 to provide timely information available for decision making

Flow-normalized loads results by removing most of the hydrologic variability associated with loads. Important for understanding water-quality responses to watershed changes

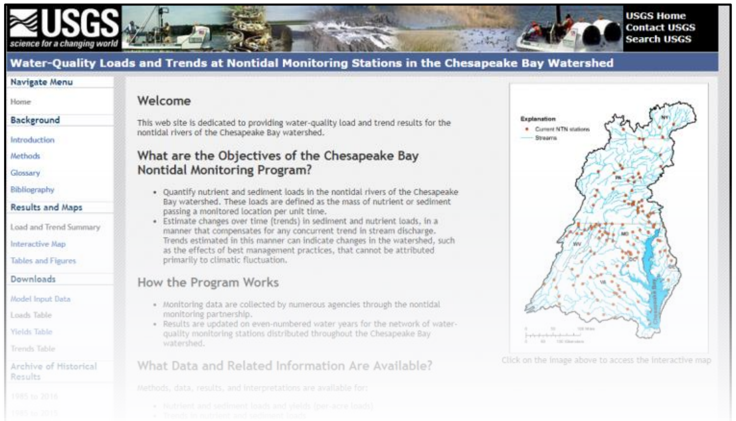
response.

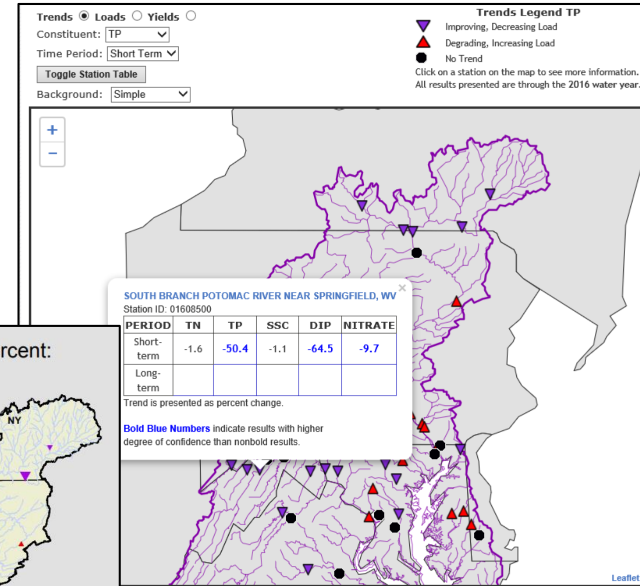
Potomac River at Chainbridge, Washington DC: Total Phosphorus

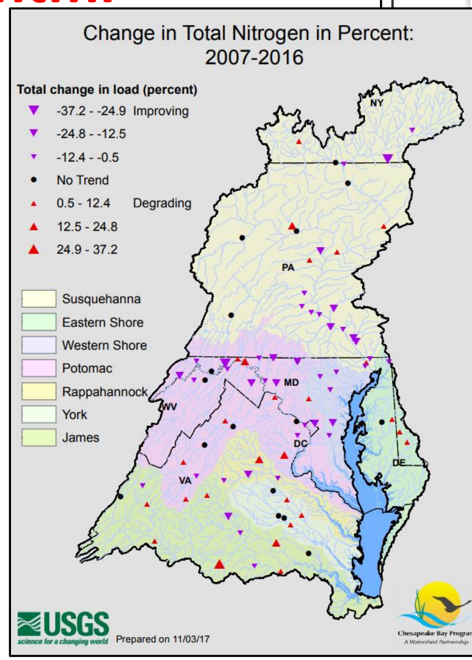


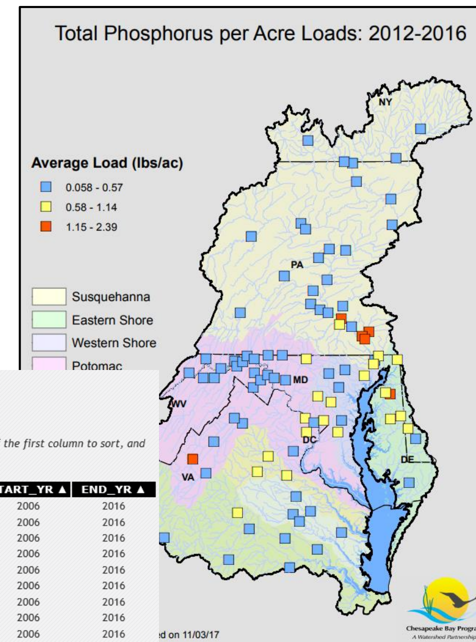
The nontidal monitoring webpage has been updated with 2016 results

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









Download Entire Annual Loads Table

Select Station: 01608500 -- SOUTH BRANCH POTOMAC RIVER NEAR SPRINGFIELD, WV

Select Parameter: P00665 -- Total phosphorus (mg/L as P)

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 ▲
01608500	P00665	2006	975	0.1	172000	0.11	260000	2006	2016
01608500	P00665	2007	1361.1	0.1	284000	0.1	242000	2006	2016
01608500	P00665	2008	1437.6	0.09	225000	0.09	226000	2006	2016
01608500	P00665	2009	1062.4	0.09	155000	0.09	209000	2006	2016
01608500	P00665	2010	1394.6	0.09	244000	0.08	194000	2006	2016
01608500	P00665	2011	1636.9	0.08	283000	0.07	181000	2006	2016
01608500	P00665	2012	1230.7	0.06	157000	0.06	168000	2006	2016
01608500	P00665	2013	1332.9	0.05	149000	0.05	155000	2006	2016
01608500	P00665	2014	1441.8	0.05	162000	0.05	142000	2006	2016
01608500	P00665	2015	1140.1	0.04	86500	0.04	131000	2006	2016

Showing 1 to 10 of 11 records

Pages: Previous 1 2 Next

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.

CB Nontidal Network Monitoring Stations: COG Region

USGS Station Name	Drainage Area (sq mi)	Monitoring Start Date	Years
Catoctin Ck nr Middletown, MD	67	1985	33
Catoctin Ck at Taylorstown, VA	89	1985	33
Difficult Run at Great Falls, VA	58	1985	33
Potomac Riover at Chain Bridge	11,570	1985	33
NW Br Anacostia R nr Hyattsville, MD	49	2007	11
Accotink Ck nr Annandale, VA	24	1991	27
SF Quantico Ck nr Ind Hill, VA	8	1994	24
Patuxent River nr Unity, MD	35	1985	33
Patuxent River nr Bowie, MD	348	1985	33
WB at Upper Marlboro, MD	90	2006	12
Rock Ck at Sherill Dr at Wash, DC	62	2013	5
Hickey Run at NY Ave at Wash, DC	1	2013	5
Watts Br at Wash, DC	3	2013	5

Data Re
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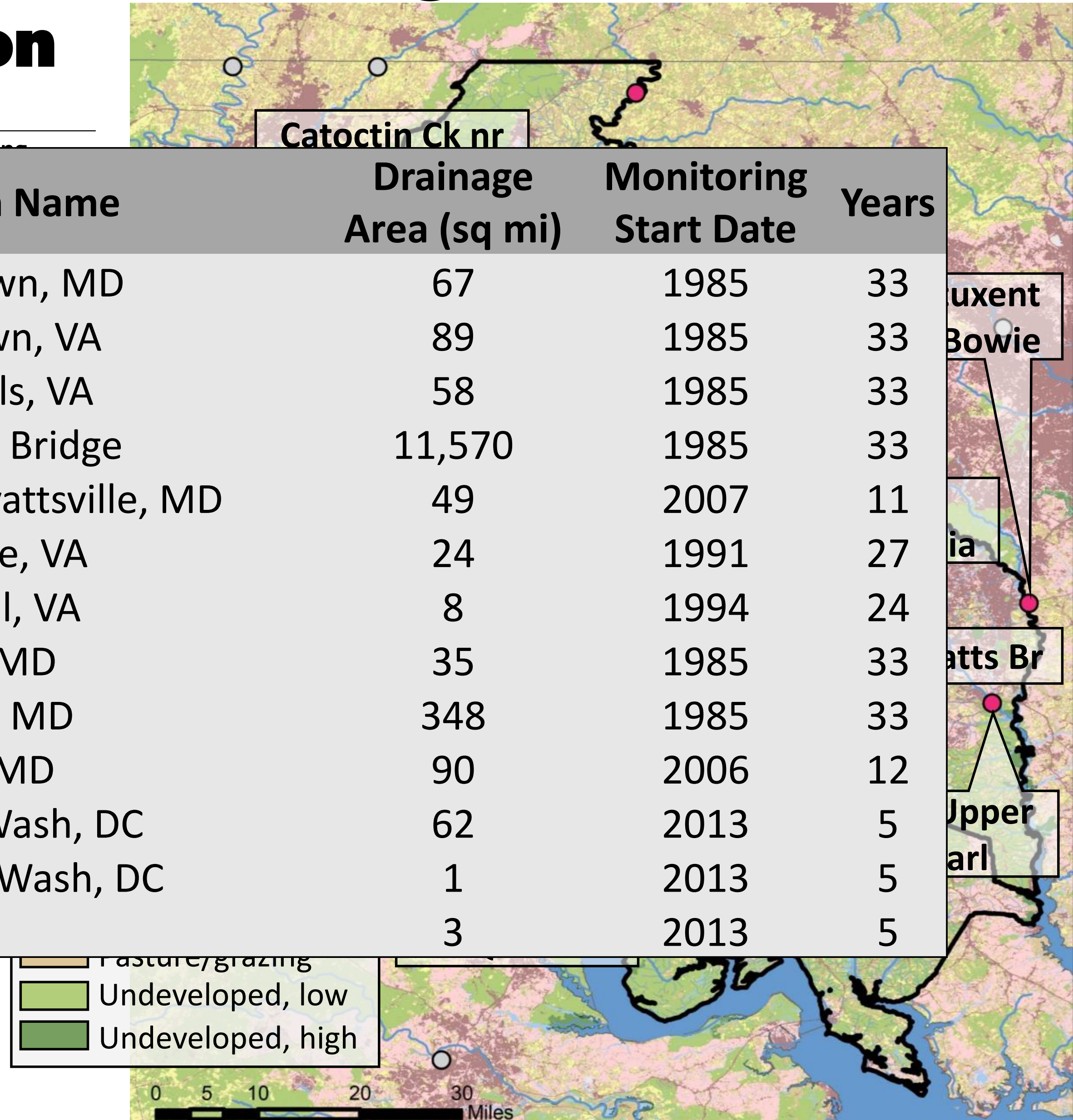
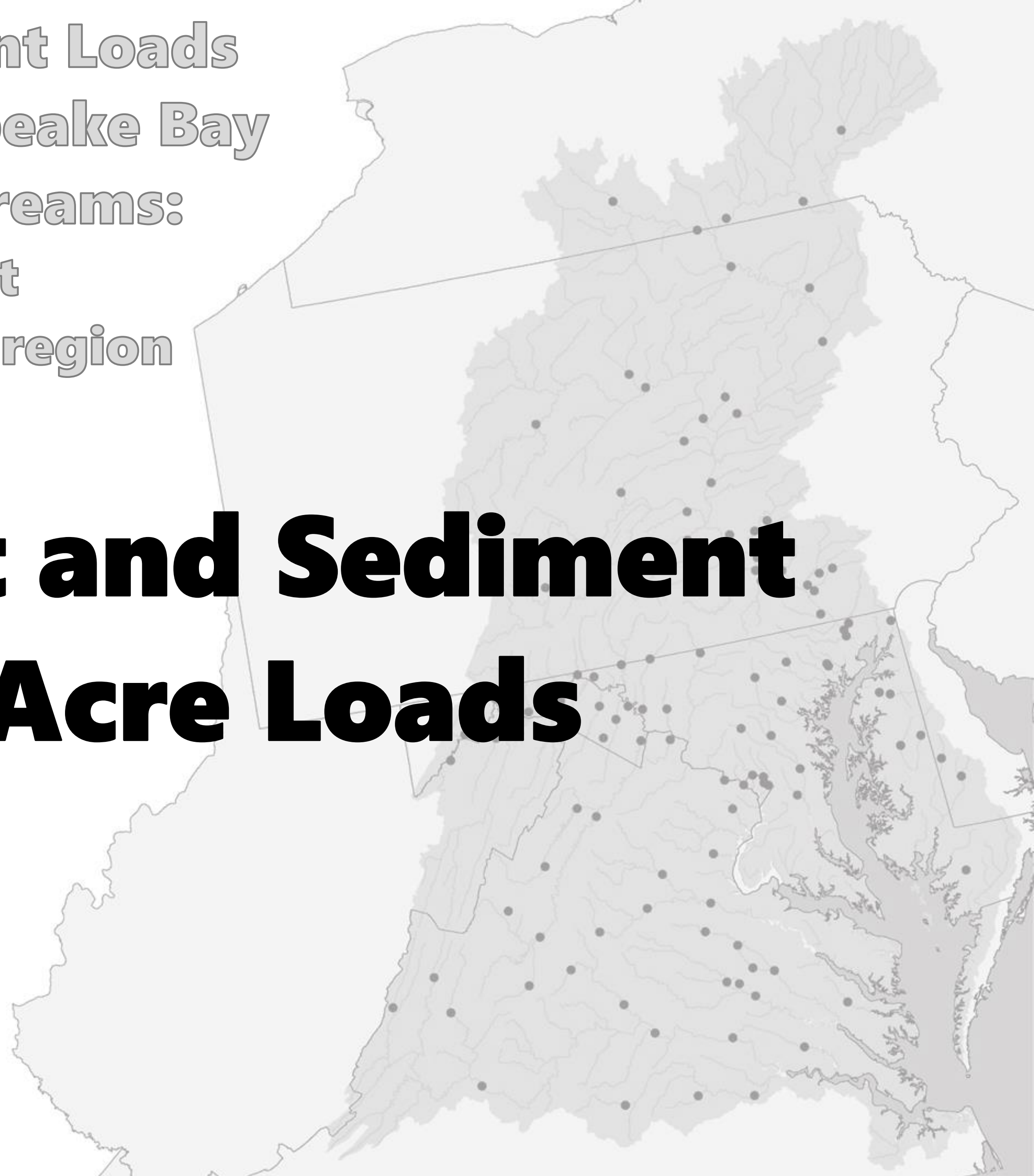
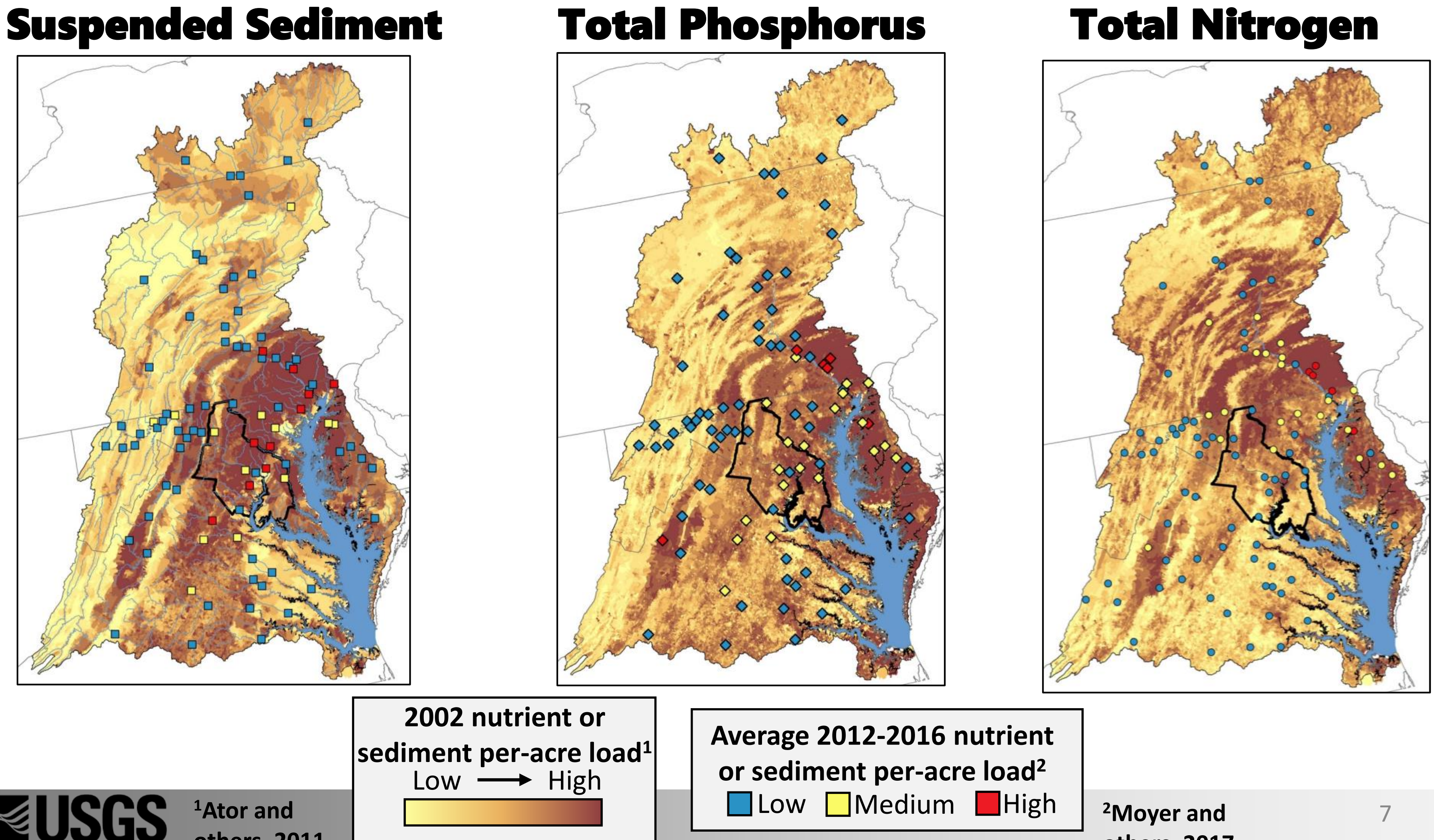
Trends – 10 years





Nutrient and Sediment Per-Acre Loads

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

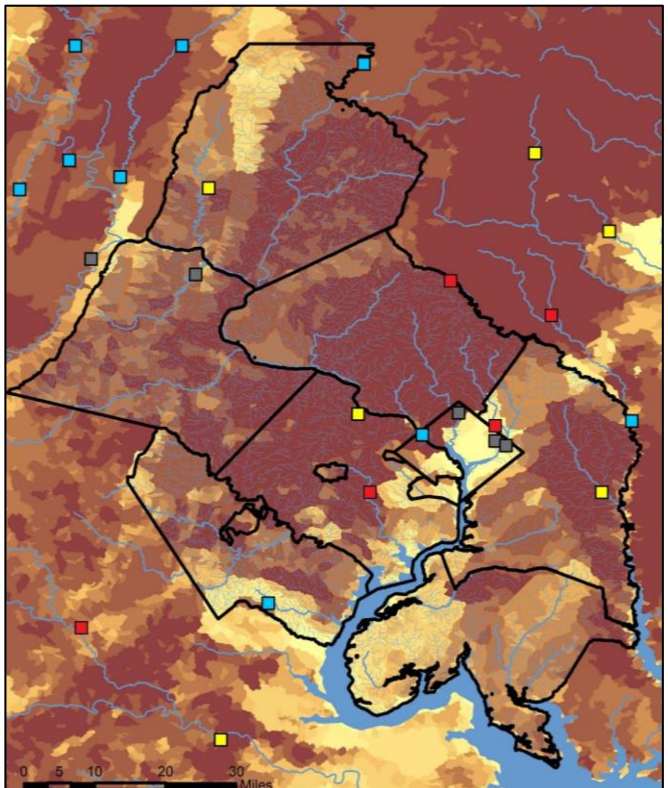


[1]Ator and others, 2011

[2]Moyer and others, 2017

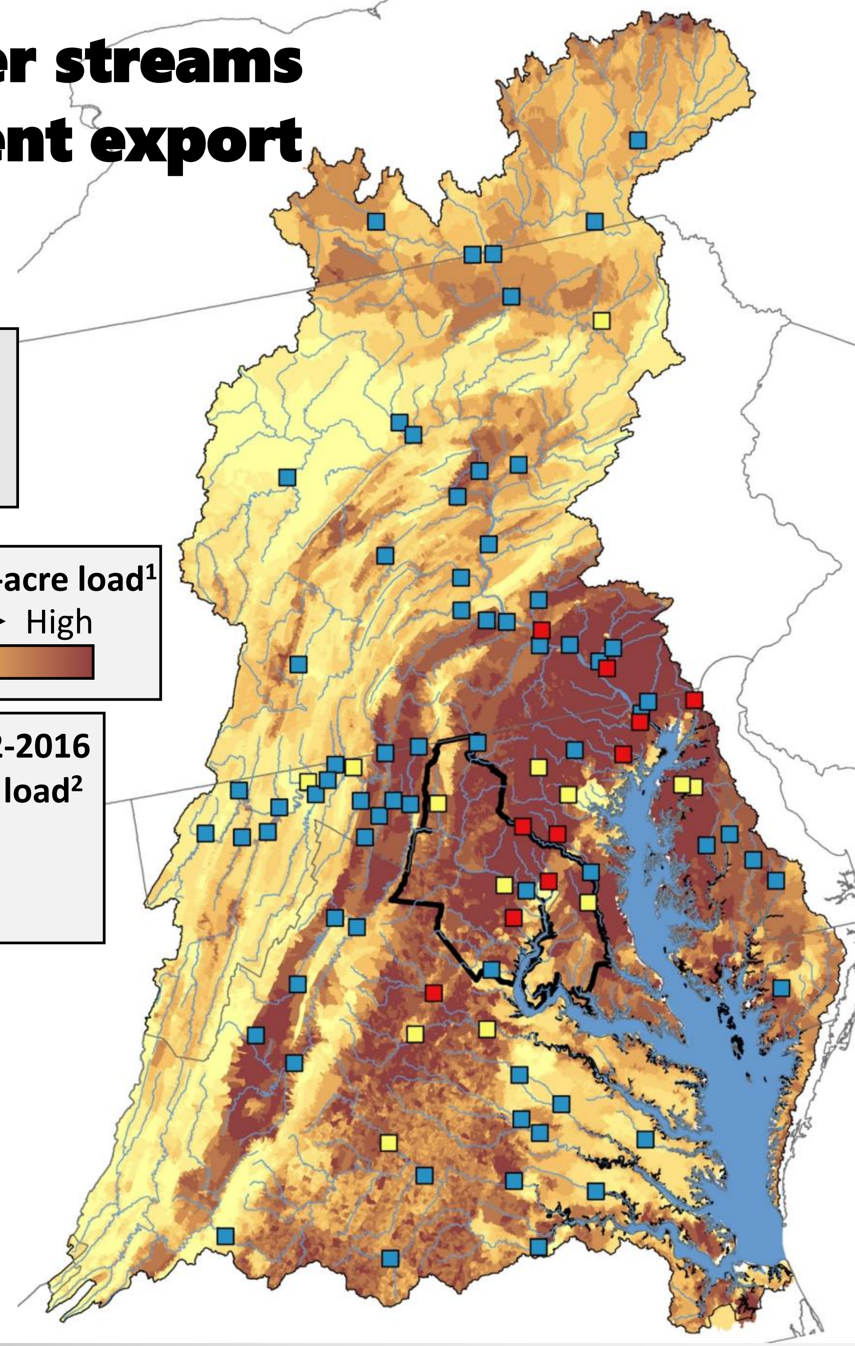
SSC: Urban, Piedmont, headwater streams have the greatest rates of sediment export in the Chesapeake watershed

Sediment export rates are lower in agricultural streams, but agricultural areas are more widespread than urban piedmont watersheds.



2002 SSC per-acre load[1]
Low ⟶ High

Average 2012-2016 SSC per-acre load[2]
Low
Medium
High



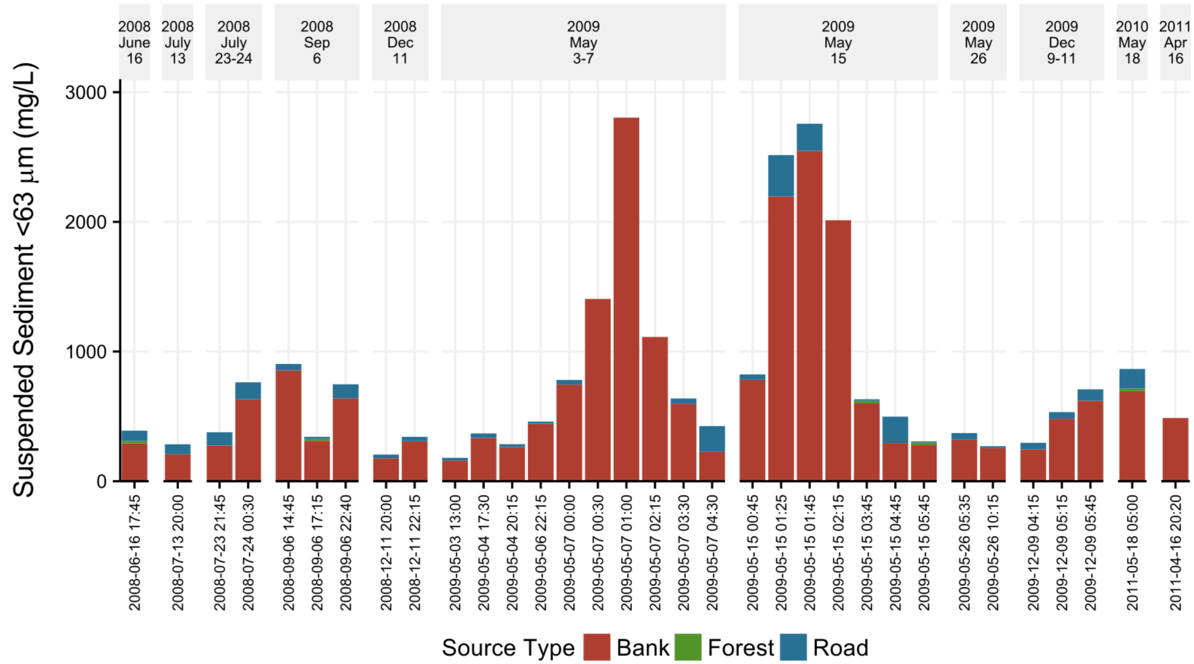
[1]Ator and others, 2011

[2]Moyer and others, 2017

SSC: Major sediment sources vary temporally and spatially in streams throughout the watershed

Major sediment sources include agricultural land, urban areas, and stream banks[1].

Most fine-sediment transported during storm events in Upper Difficult Run is derived from bank material[2].



Practices associated with stream restoration are important in urban areas and headwater streams where **bank erosion** is commonly a dominant source of sediment export.

Practices associated with preventing soil erosion are important in agricultural areas where upland sediment is commonly mobilized to streams.

Practices associated with floodplain protections are important in larger order streams where **floodplains can trap most upstream eroded sediment.**

[1]Noe and others, in Review

[2]Cashman and others, in Review

Sources of nitrogen and phosphorus are relatively similar, but how they move is very different

Nonpoint (N and P) sources are applied to the landscape and may be delivered to streams. Inputs include:

- In **agricultural areas**, fertilizer and manure.
- In **urban areas**, fertilizer, septic effluent, leaking sewer pipes, pet waste, and industrial spills.
- In **forested areas**, atmospheric deposition (for nitrogen) and geologic materials (for phosphorus).

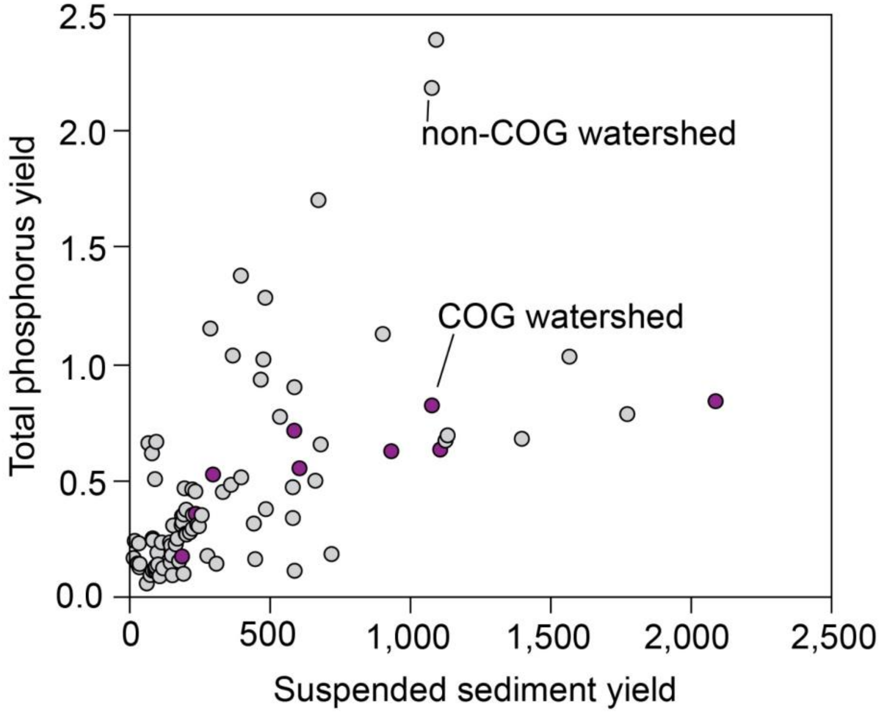
Nitrogen is very mobile.
Nonpoint source applications are easily transported to groundwater aquifers as nitrate. Nitrogen is delivered to most streams as nitrate from the groundwater.

Phosphorus is very immobile.
Nonpoint source applications commonly bind to soil particles. Phosphorus is delivered to most streams as particulate-P from soil erosion.

Nitrogen and phosphorus point sources are discharged directly to streams or tidal waters and can result in relatively large loads. Management of these inputs can result in relatively quick water-quality improvements.

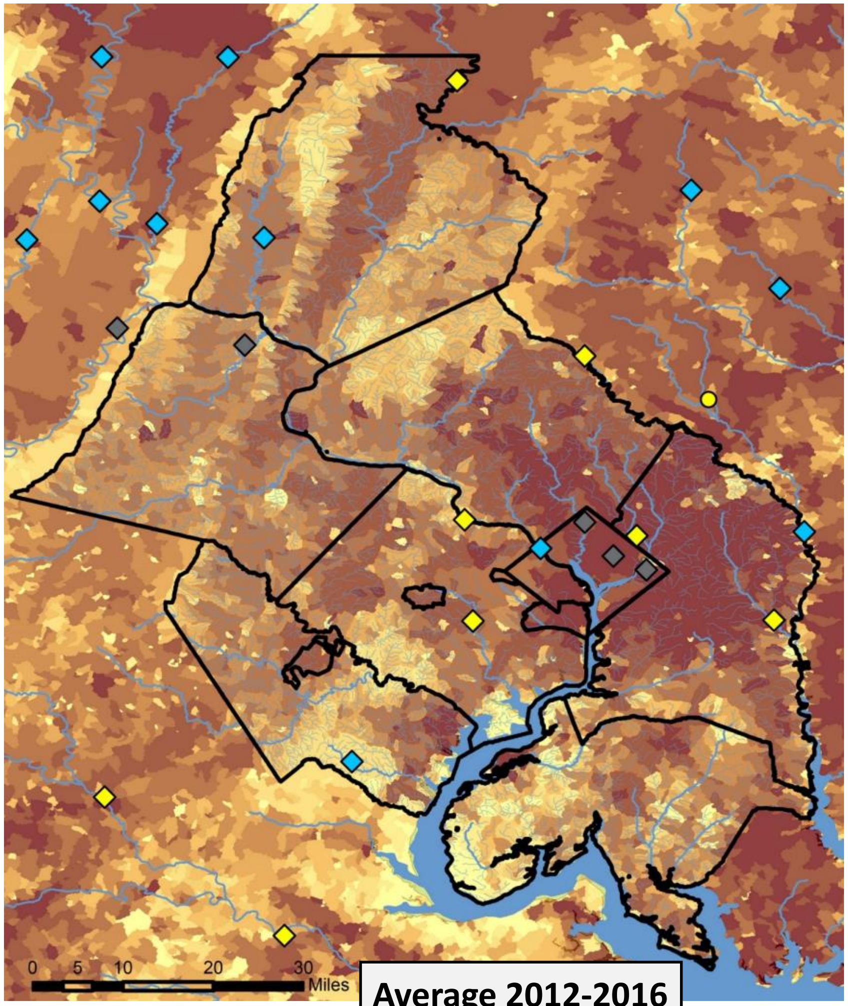
Effective nitrogen and phosphorus management practices will reduce applications. For nitrogen, practices will prevent movement to groundwater. For phosphorus, practices will reduce soil erosion.

TP: Phosphorus is delivered to most streams in a particulate form attached to sediment



Phosphorus is very immobile.
Nonpoint source applications commonly bind to soil particles.

Effective phosphorus management will focus on practices associated with stream restoration or those that prevent soil erosion.



2002 TP per-acre load[1]
Low → High

Average 2012-2016 TP per-acre load[2]
- Low
- Medium
- High

[1]Ator and others, 2011

[2]Moyer and others, 2017

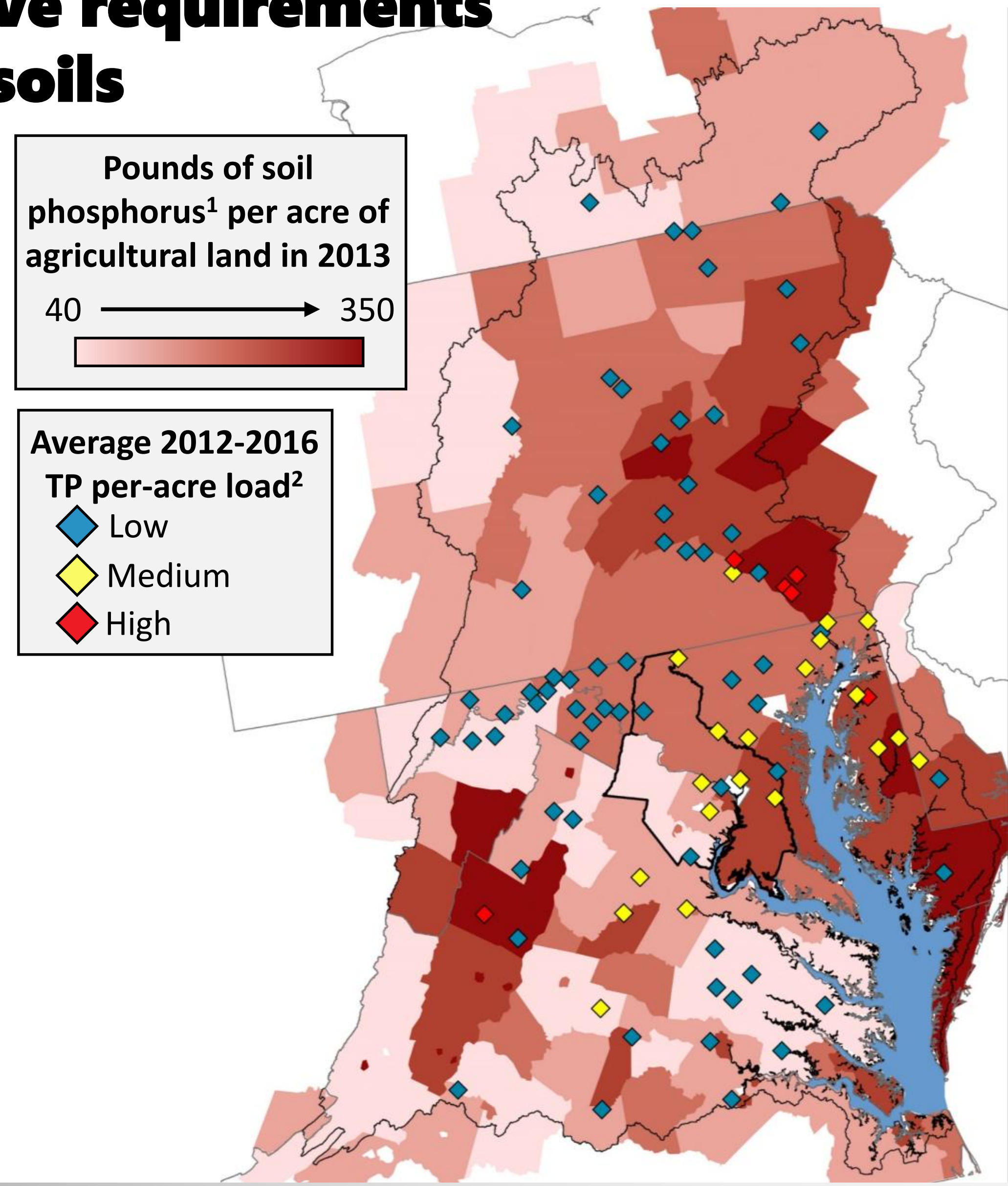
TP: Watersheds that receive large, prolonged inputs that exceed vegetative requirements have phosphorus stored in soils

Other than plant uptake, there are no processes that remove phosphorus from the environment.

New phosphorus applications in watersheds with phosphorus saturated soils can more readily runoff to streams as dissolved phosphorus.

Erosion in these areas can deliver soils particles containing high phosphorus concentrations to streams.

Effective phosphorus management focuses on practices that reduce applications and controls sediment export to streams.



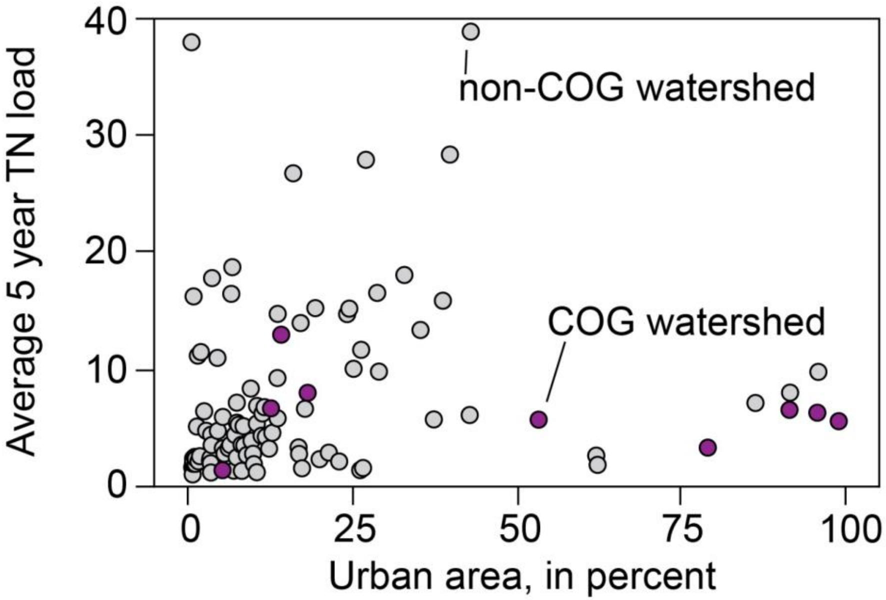
USGS science for a changing world

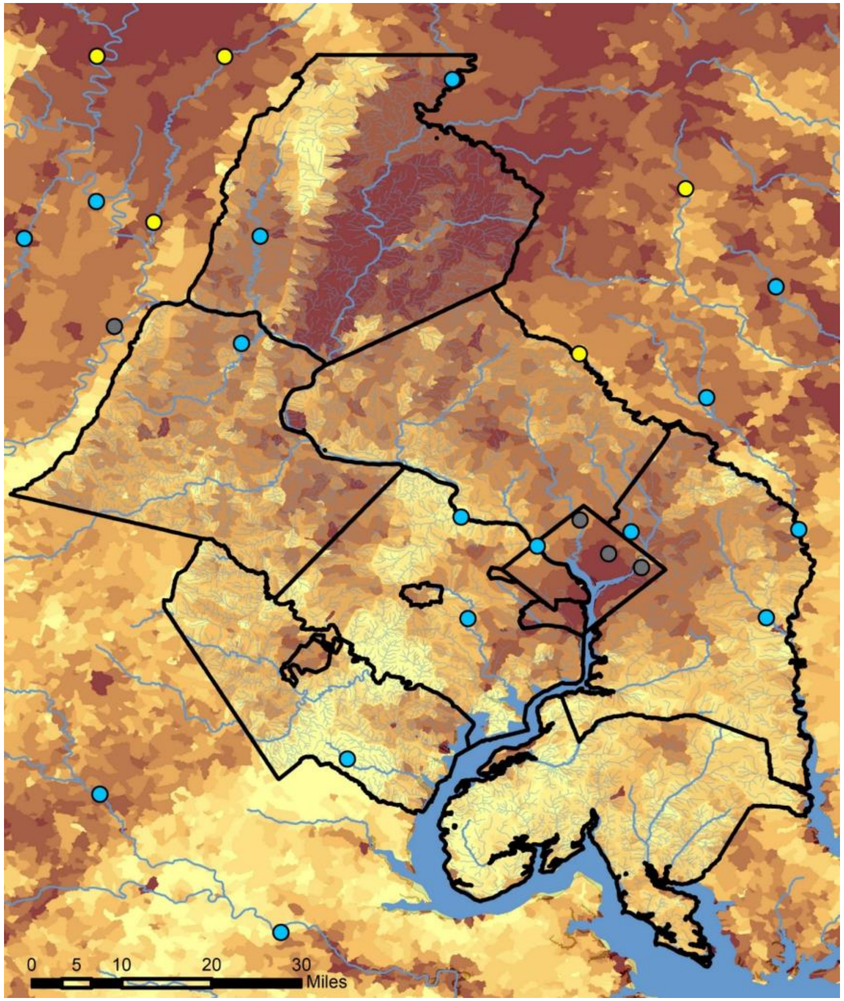
[1]Moyer and others, 2017

[2]Chesapeake Bay Watershed Model version 6 calibration inputs

TN: Watersheds with elevated nitrogen per-acre loads have large nitrogen inputs

The largest nutrient inputs typically occur in agricultural watersheds, however, urban areas still yield more nitrogen and phosphorus than undeveloped watersheds.





2002 TN per-acre load[1]
Low ⟶ High

Average 2012-2016 TN per-acre load[2]
- Low
- Medium
- High

[1]Ator and others, 2011

[2]Moyer and others, 2017

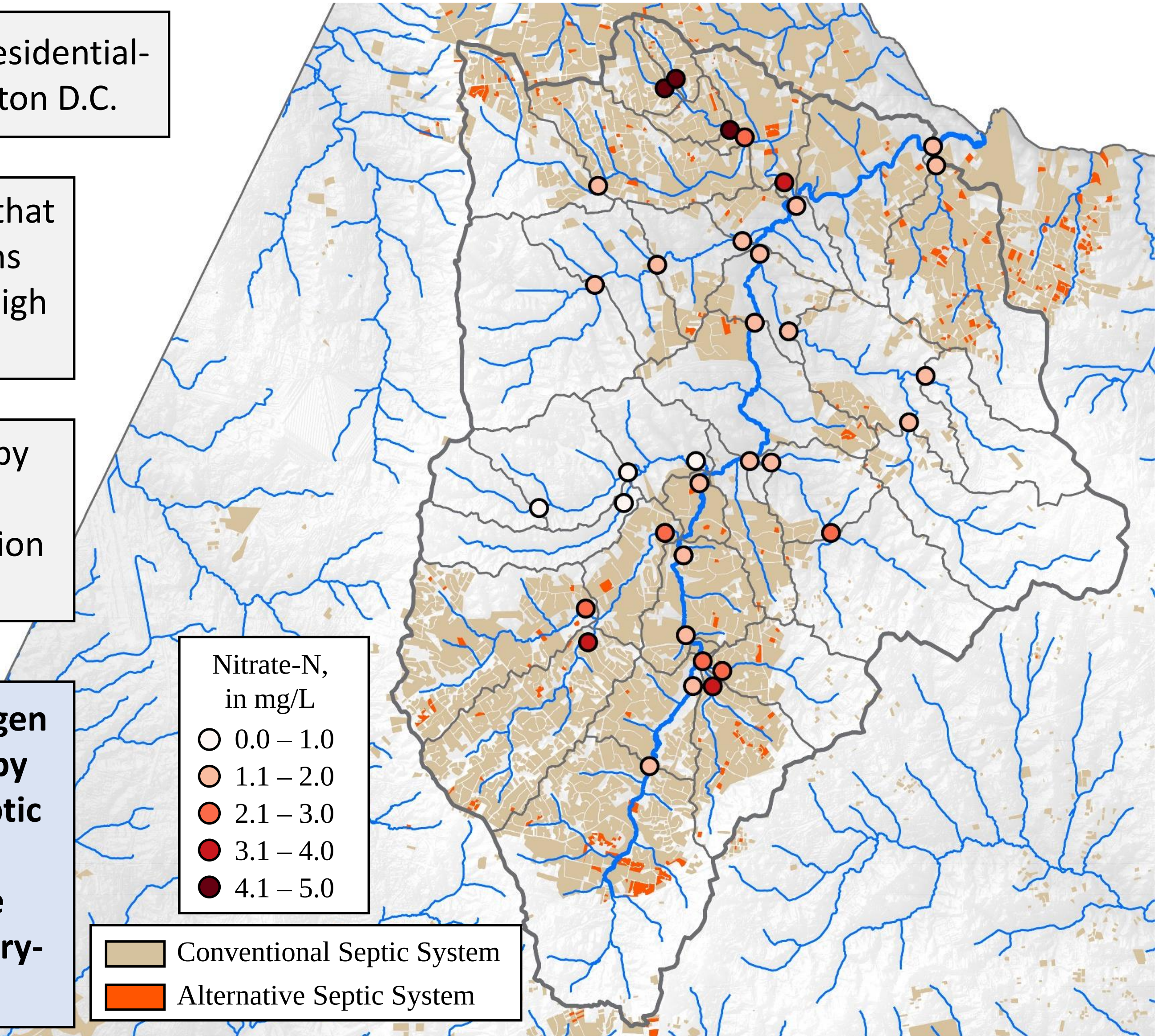
TN: Diffuse wastewater inputs can be important sources of nitrogen delivered to streams from urban watersheds

Difficult Run is a 56 square mile residential-urban watershed near Washington D.C.

Water-quality sampling revealed that the high nitrogen concentrations were derived from areas with a high density of septic systems[1].

Nitrogen loads are contributed by the discharge of septic system effluent to groundwater, in addition to other diffuse urban inputs[1].

Management activities for nitrogen would likely be most effective by the ongoing maintenance of septic systems, the management of fertilizer applications, and the possible expansion of the sanitary-sewer infrastructure.

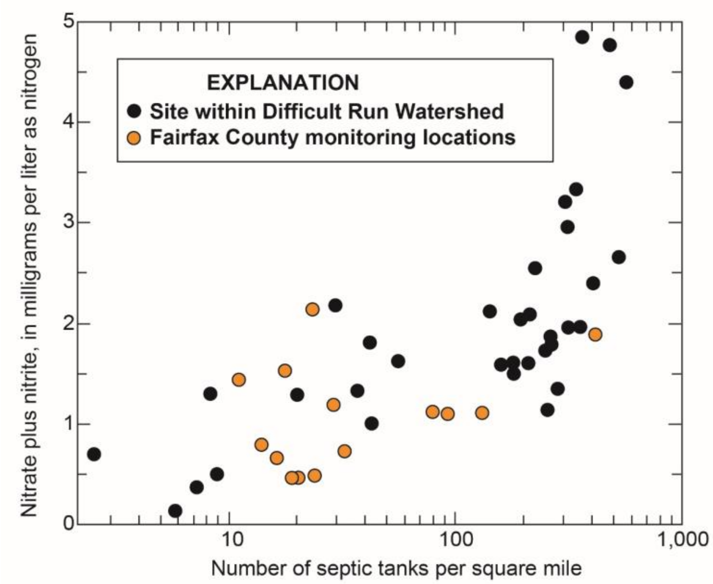


USGS science for a changing world

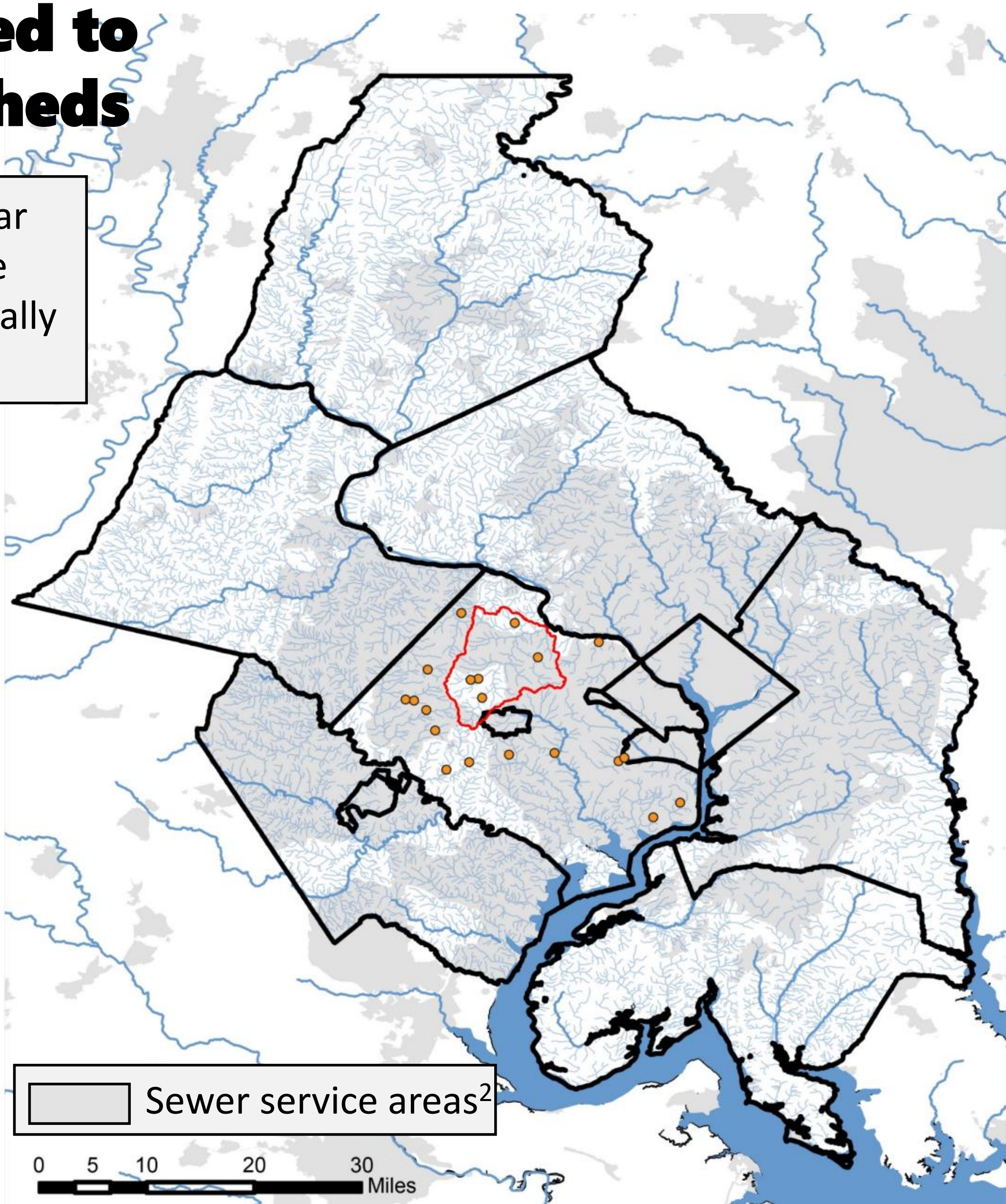
[1]Hyer and others, 2016

TN: Diffuse wastewater inputs can be important sources of nitrogen delivered to streams from urban watersheds

Fairfax county monitoring locations had a similar septic-nitrate relation and suggest that diffuse wastewater from septic systems may be a regionally important source of nitrogen to streams[1].



There are approximately 131,000 septic tanks within the COG region[2].



[1]Hyer and others, 2016

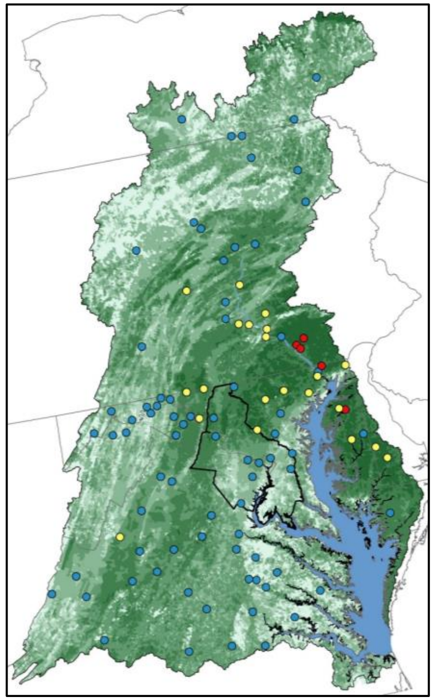
[2]Chesapeake Bay Watershed Model version 6 calibration inputs

TN: Watersheds that receive large, prolonged inputs and have low denitrification rates have high groundwater nitrogen concentrations

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

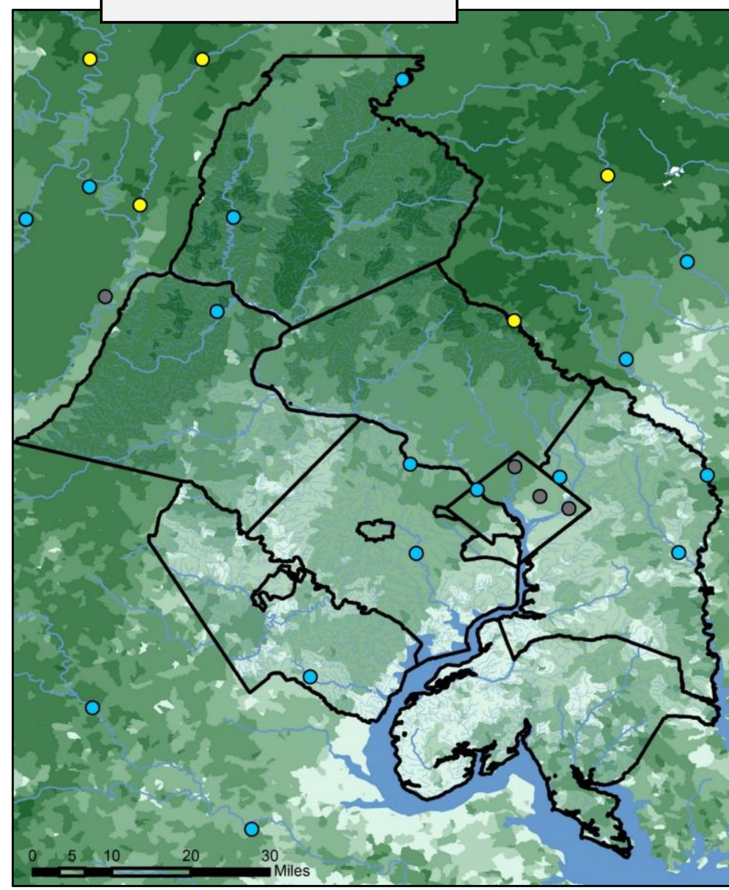
Watersheds with carbonate geology or portions of the coastal plain with coarse-grained sediments have very low denitrification rates, which allows nitrogen inputs to move relatively unaltered into the groundwater.

Effective management practices would reduce applications and control groundwater transport in these areas.



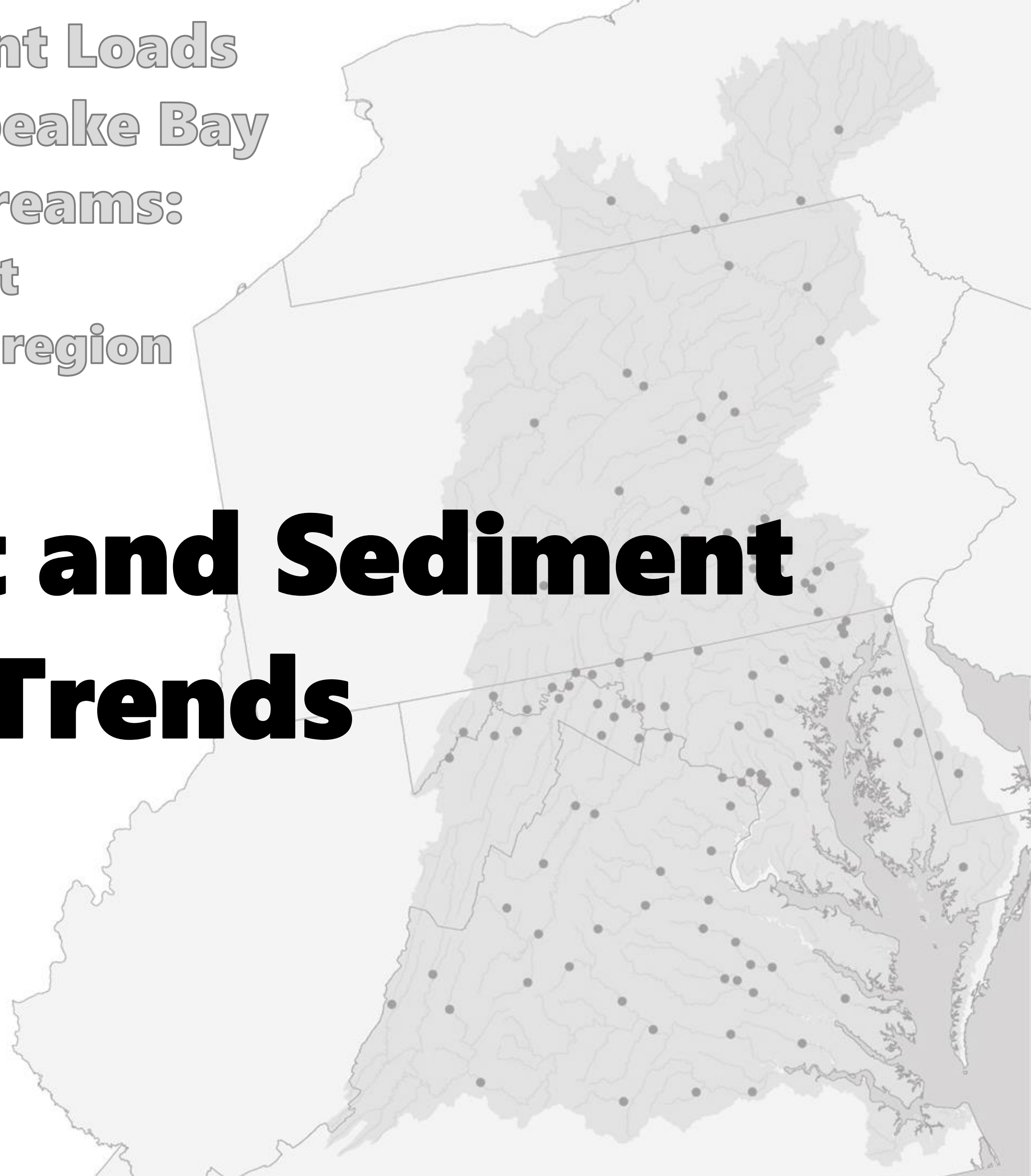
Average 2012-2016 TN per-acre load[2]
- Low
- Medium
- High

Per-acre nitrate load from groundwater delivered to streams[1]
Low → High



[1]Terziotti and others, 2018

[2]Moyer and others, 2017



Nutrient and Sediment Trends

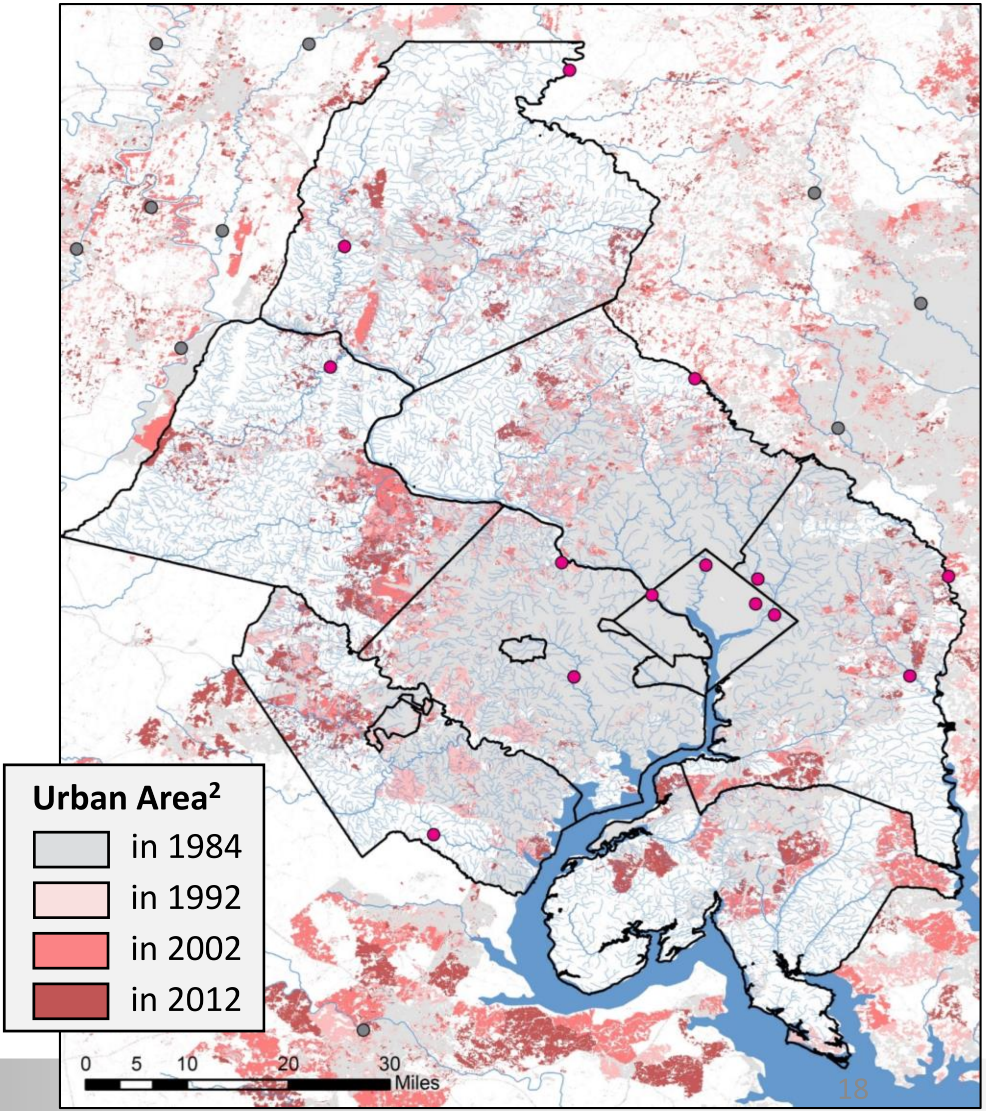
Urbanization typically increases nutrient and sediment export to streams, but effects vary over time and with prior land use

Urban nutrient inputs are typically greater than the limited sources found in forested watersheds, but are generally less than inputs of fertilizer and manure within agricultural watersheds.

Most urbanization has occurred at the expense of forested land, which typically increases nutrient loads in affected streams.

Urbanization typically leads to increased sediment yields, which may remain high for decades after construction has ceased[1]

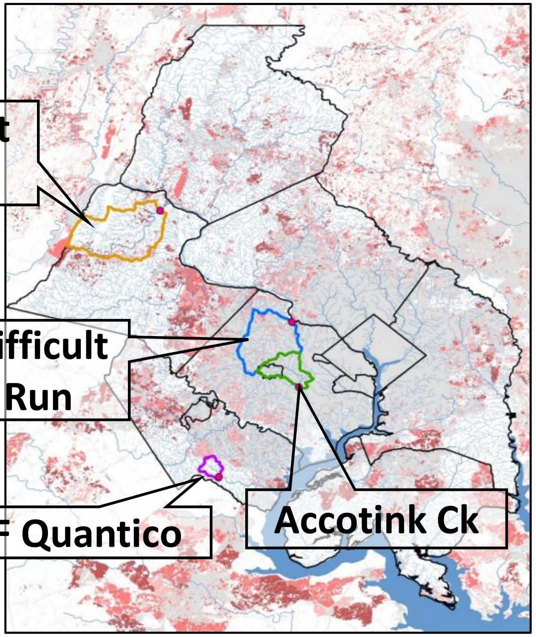
As population continues to grow in the watershed, effective management of urban NPS loads will be needed to achieve mandated load reductions.



USGS science for a changing world

[1]Gellis and others, 2017 [2]Falcone, 2015

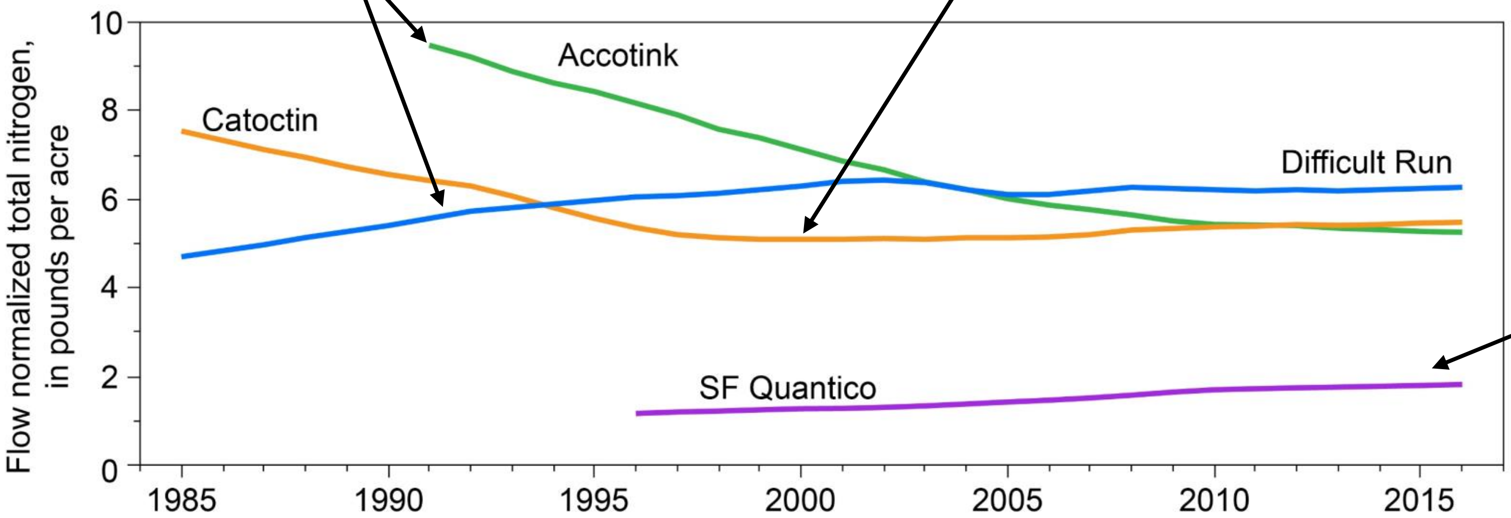
TN Trend: Difficult Run, Accotink Creek, Catoctin Creek, and SF Quantico



TN trends differ between Accotink Ck and Diffcult Run.

- Urban area has increased in Difficult Run by about 10% over the past 30 years, but has remained stable in Accotink Ck[2].
- Accotink Ck is completely sewered, whereas portions of Difficult Run are served by septic systems.

Catoctin Ck is a primarily agricultural where urban area expended by about 7% over the past 30 years[2]. Long-term N trends are decreasing, but short-term N trends are increasing[1].



A forested watershed, TN per-acre loads at **SF Quantico** are relatively low.

[1]Moyer and others, 2017 [2]Falcone, 2015

Trends in nitrogen loads result from changing nitrogen inputs or transport

In the most recent ten year period (2007 – 2016)[1]:

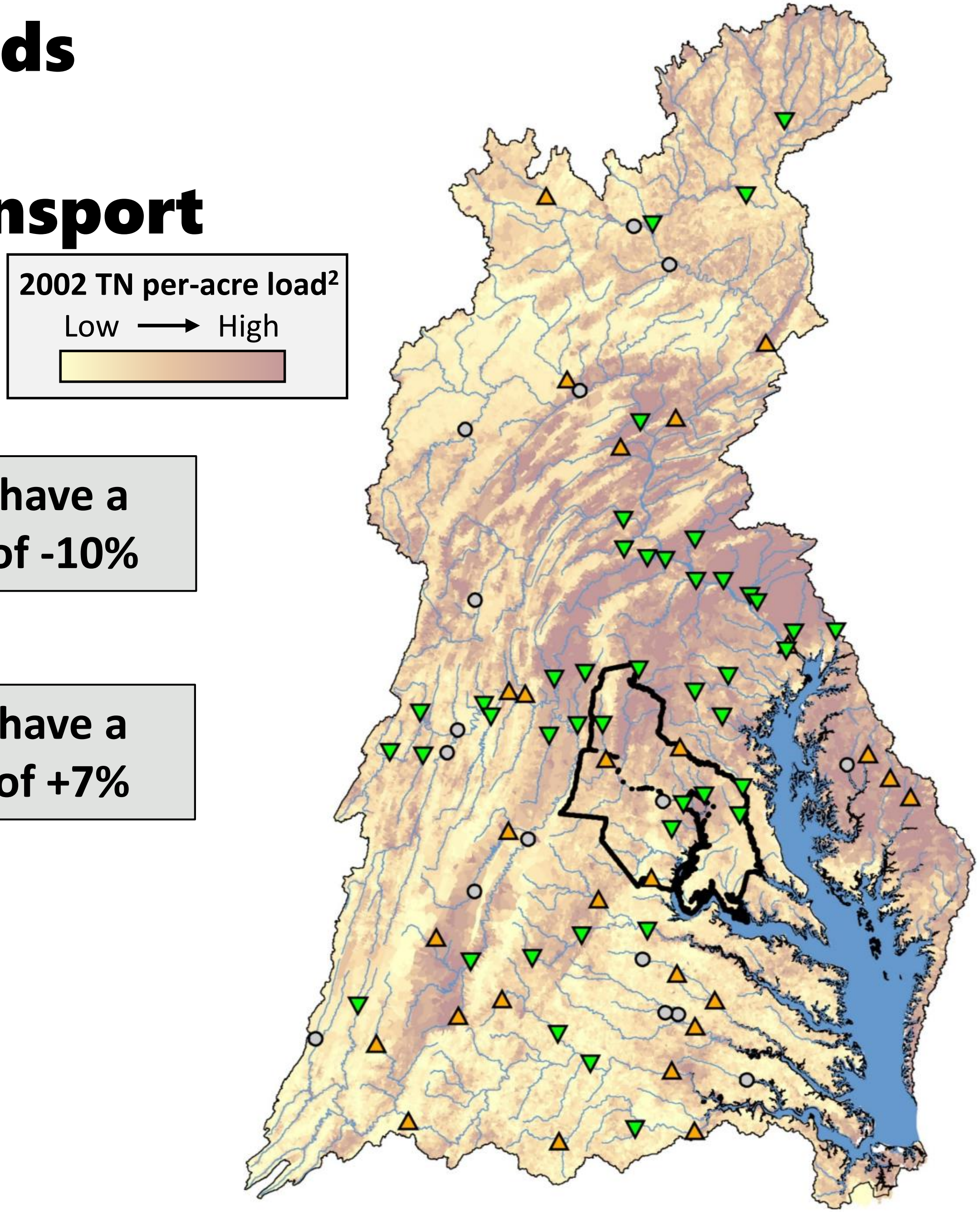
% of sites improving: **50%**

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%**

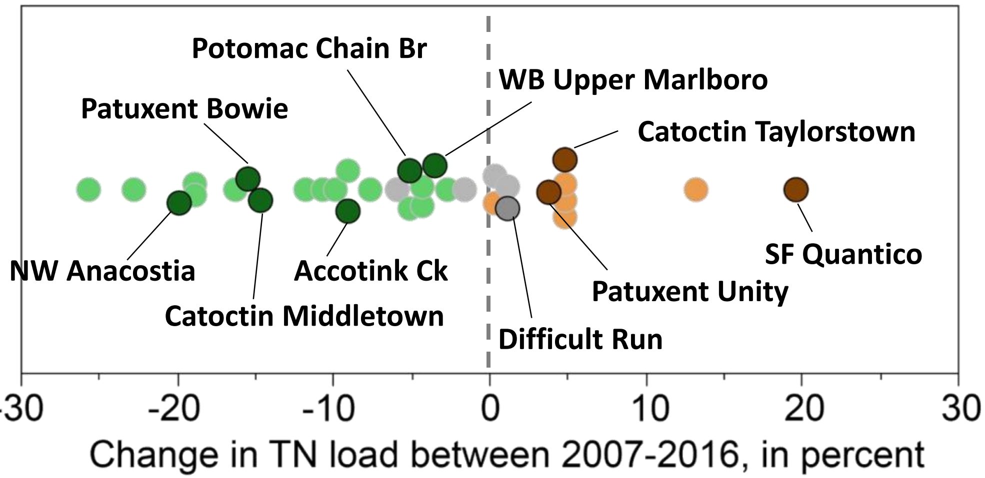


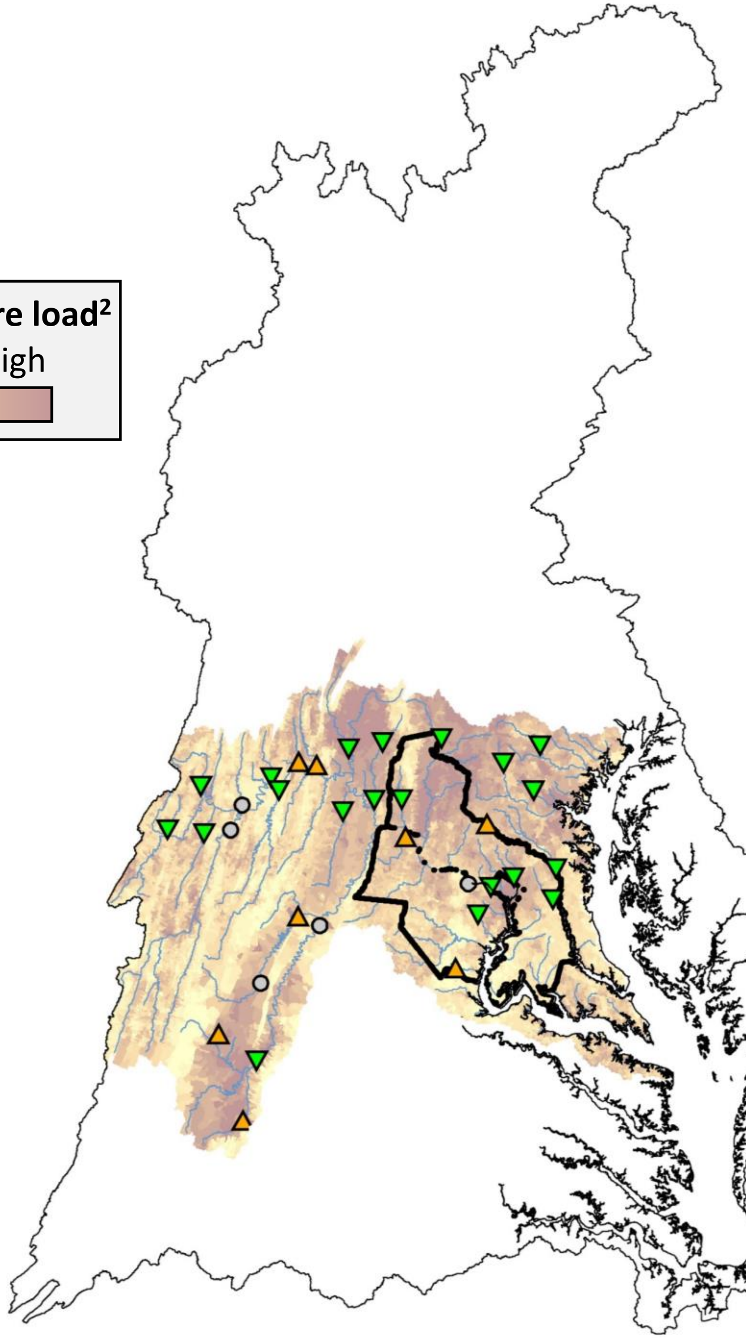
Trends in nitrogen loads result from changing nitrogen inputs or transport

In the most recent ten year period (2007 – 2016)[1]:

Nitrogen loads **(n=33)** have improved at **20**, degraded at **8**, and have no trend at **5** stations[2].

The median N improvement is **10%** and the median degradation is **5%**[2]





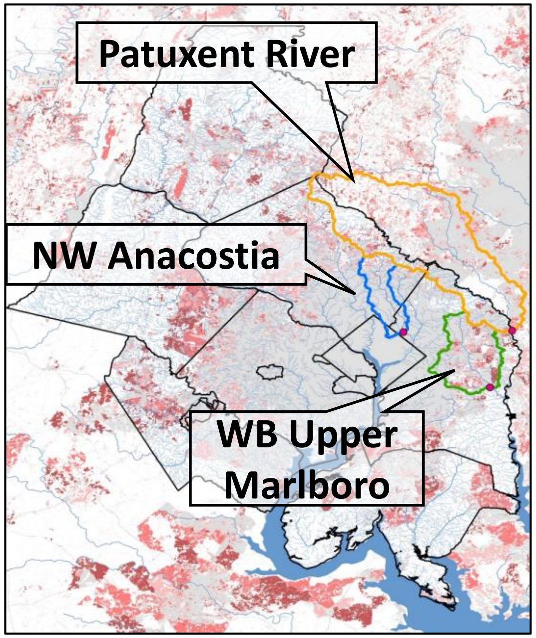
[1]Moyer and others, 2017

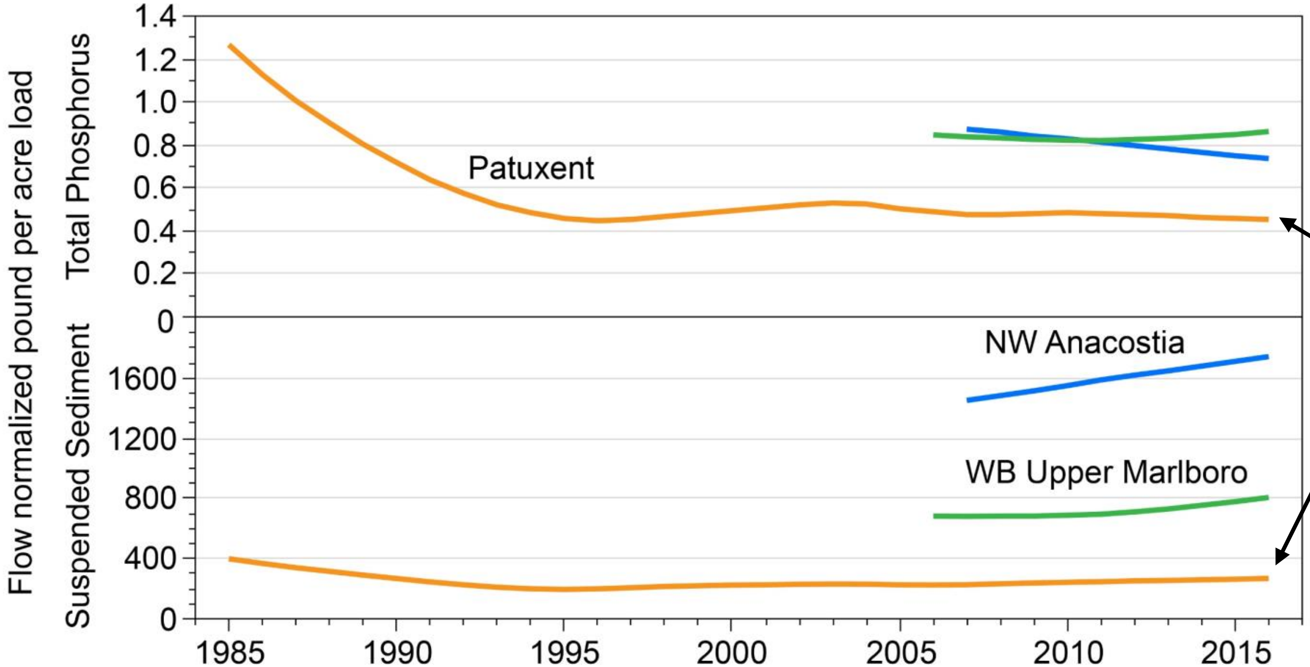
[2]Ator and others, 2011

TP and SSC Trend: NW Anacostia, WB Upper Marlboro, and Patuxent at Bowie

No trends are present in the TP or SSC loads at **NW Anacostia**[1], a watershed that has been fully developed for more than 30 years[2]. However, SSC and TP loads are relatively high in this watershed.

SSC loads are increasing in the **WB Upper Marlboro**[1], but there is no trend in TP. Urban area expanded by about 20% over the last 30 years in this watershed[2].





TP loads declined in the **Patuxent River** following WWTP upgrades, but SSC loads have degraded over the past 10 years[1].

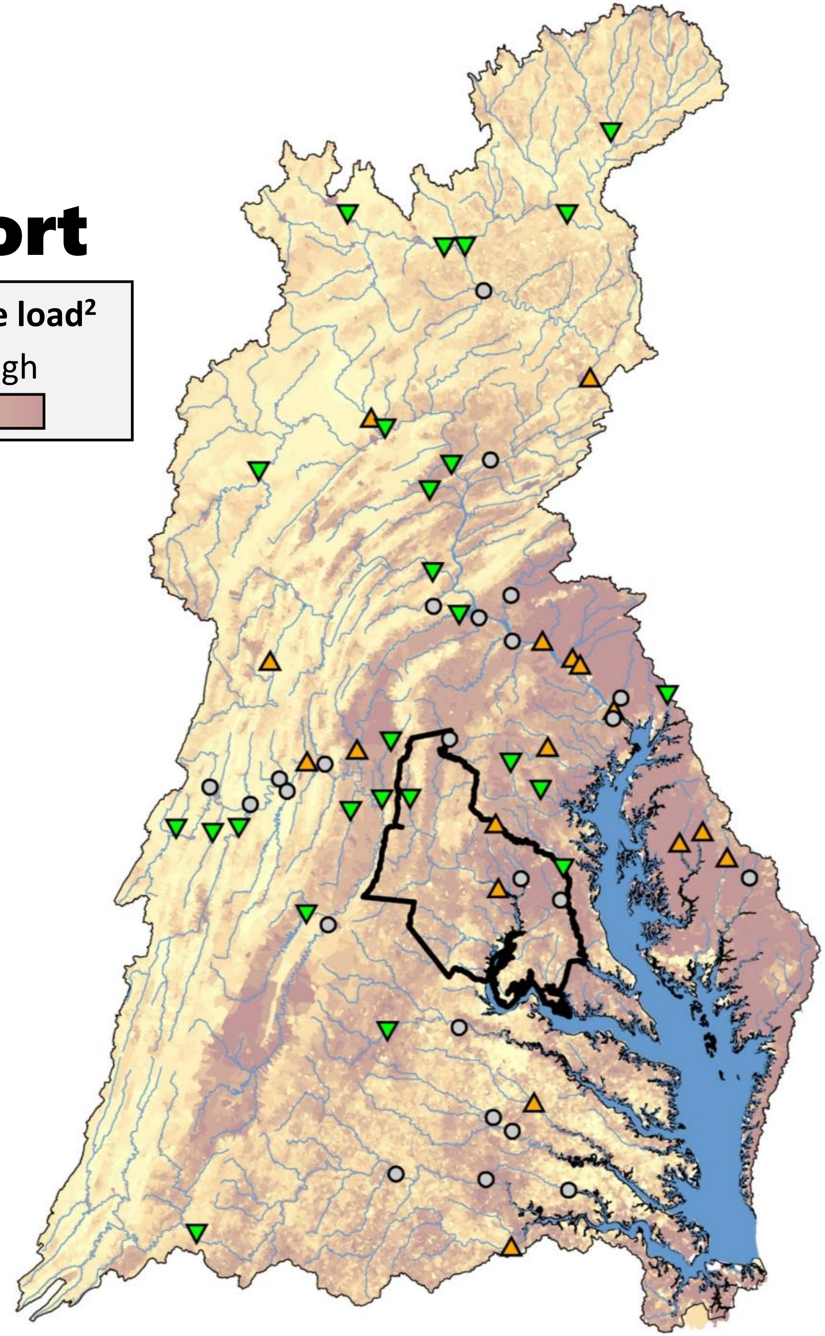
[1]Moyer and others, 2017 [2]Falcone, 2015

Trends in phosphorus loads result from changing phosphorus inputs or transport

In the most recent ten year period (2007 – 2016)[1]:

2002 TP per-acre load[2]

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]Moyer and others, 2017

[2]Ator and others, 2011

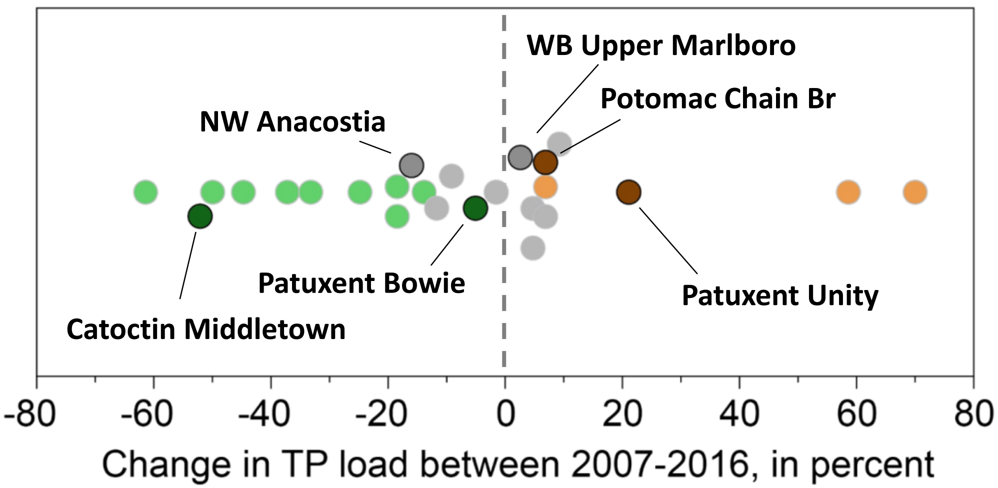
Trends in phosphorus loads result from changing phosphorus inputs or transport

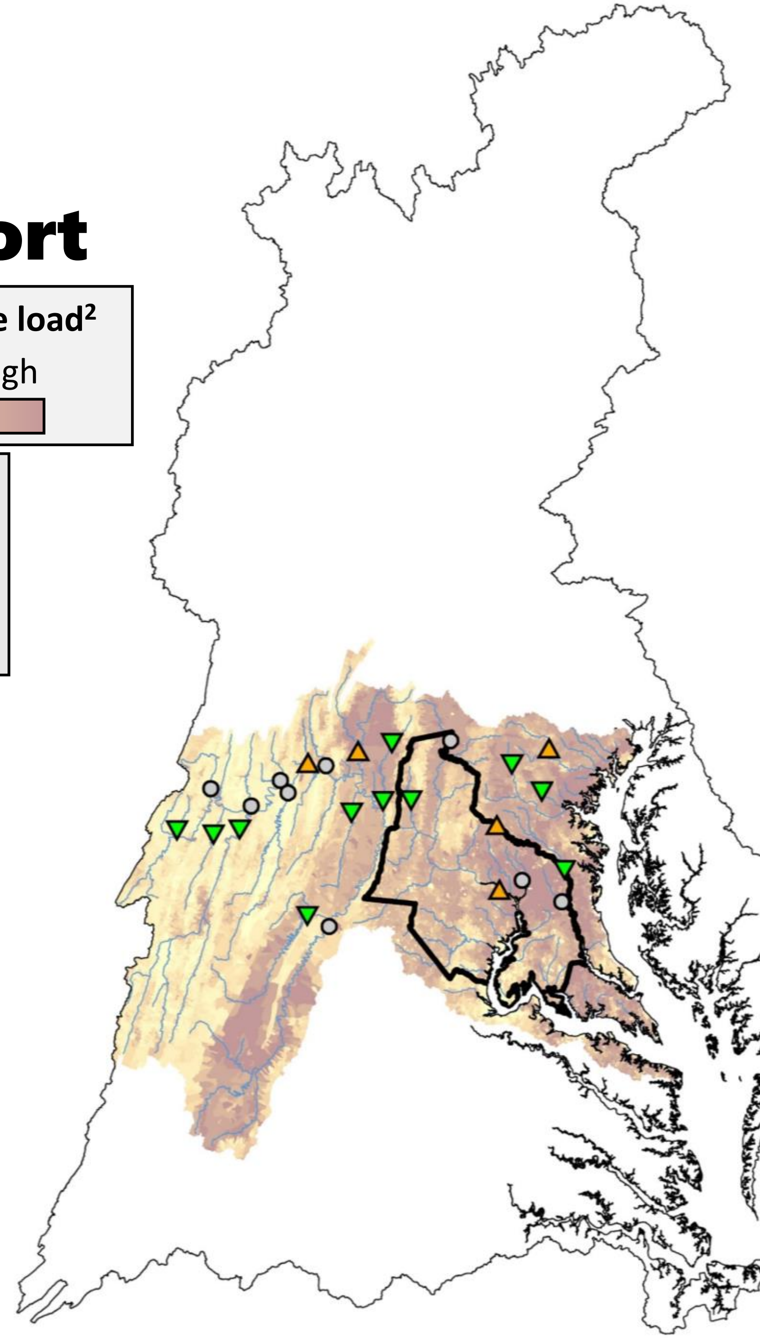
In the most recent ten year period (2007 – 2016)[1]:

2002 TP per-acre load[2]
Low ⟶ High

Phosphorus loads **(n=25)** have improved at **11**, degraded at **5**, and have no trend at **9** stations[2].

The median P improvement is **33%** and the median degradation is **21%**[2]





[1]Moyer and others, 2017

[2]Ator and others, 2011

Trends in suspended sediment load

In the most recent ten year period (2007 – 2016)[1]:

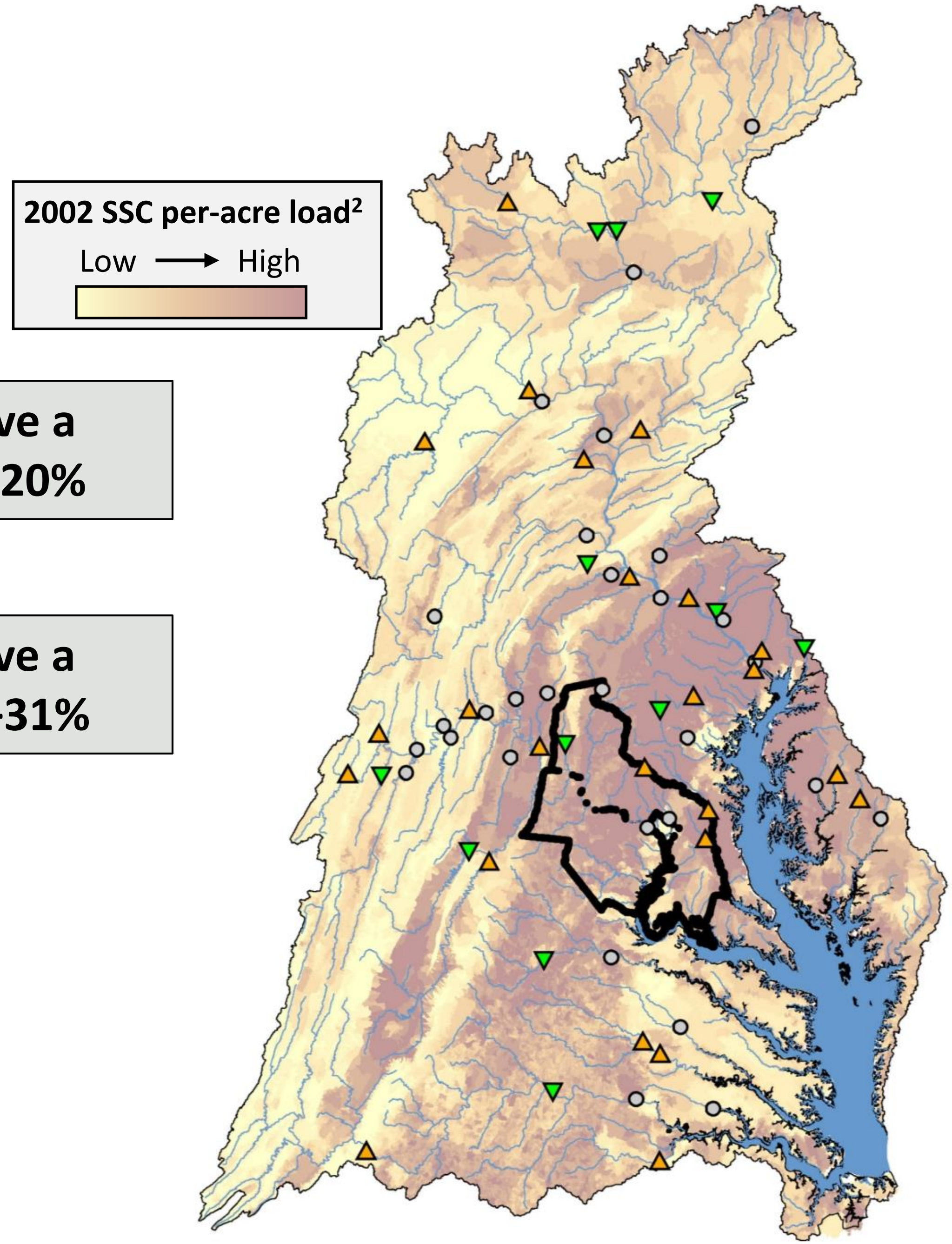
% of sites improving: **18%**

Improving sites have a median change of -20%

% of sites Degrading: **37%**

Degrading sites have a median change of +31%

% of sites with no trend: **45%**



[1]Moyer and others, 2017

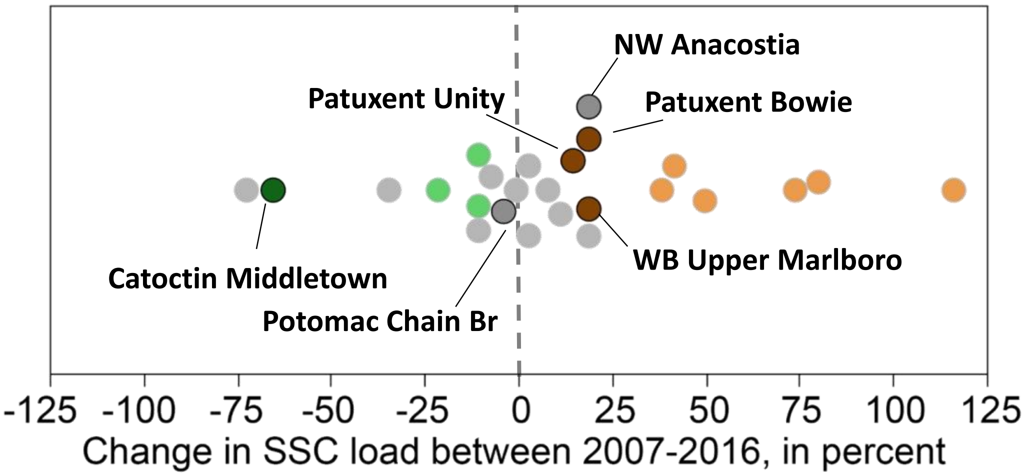
[2]Brakebill and others, 2010.

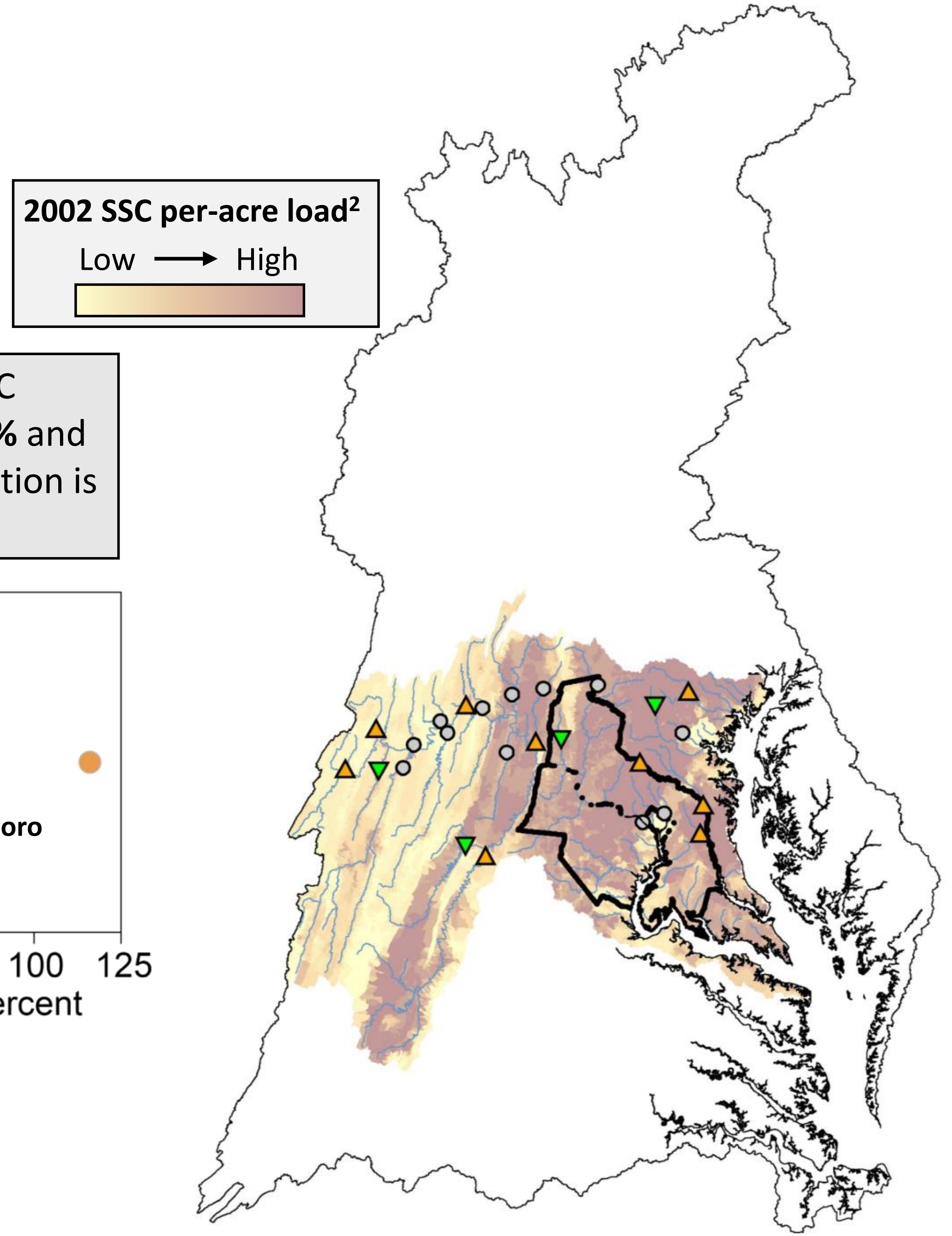
Trends in suspended sediment load

In the most recent ten year period (2007 – 2016)[1]:

SSC loads **(n=19)** have improved at **4**, degraded at **9**, and have no trend at **12** stations[2].

The median SSC improvement is **16%** and the median degradation is **41%**[2]

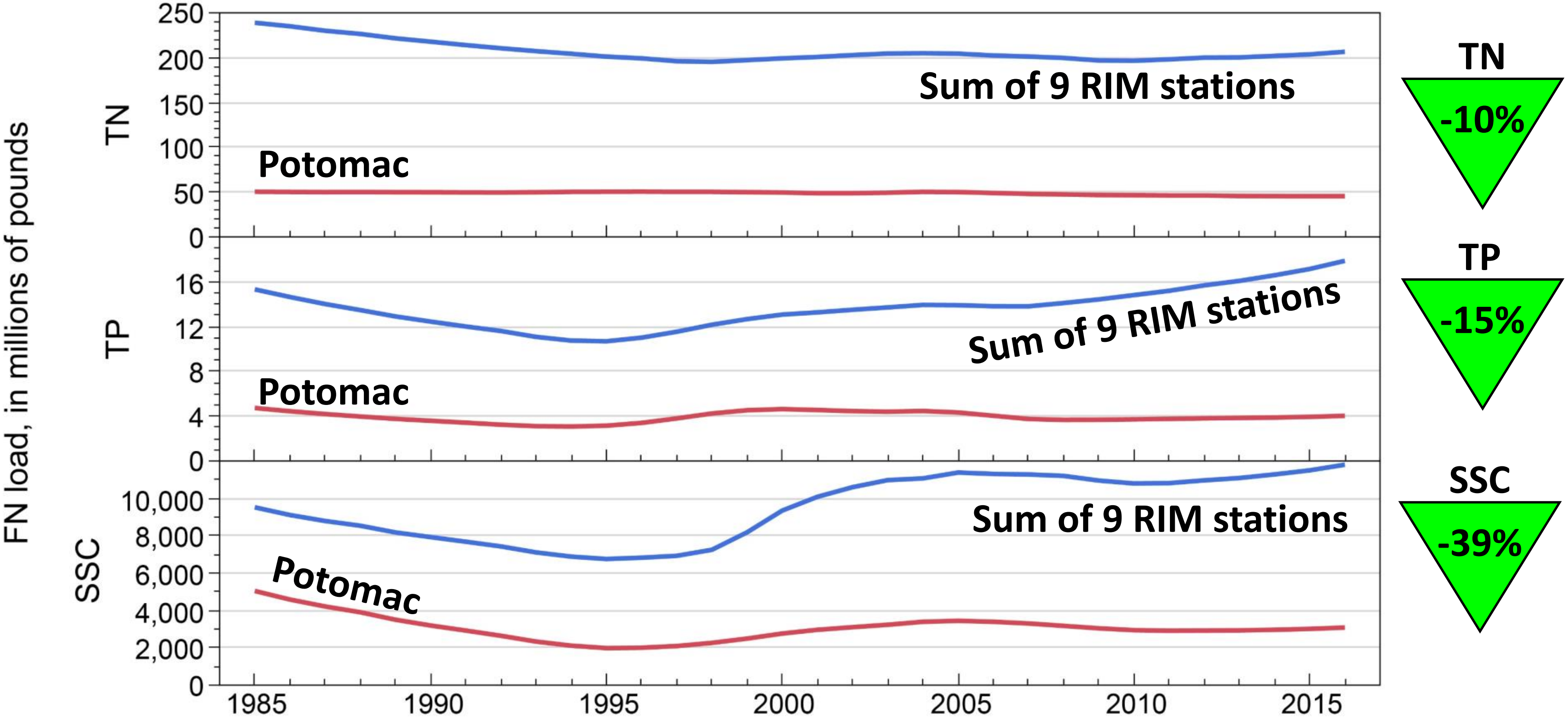




[1]Moyer and others, 2017

[2]Brakebill and others, 2010.

Nutrient and sediment trends at the Potomac River, Chain Bridge (1985-2016)[1]



[1]Moyer and others, 2017

Nutrient and Sediment Results and Management Implications

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

Where do we find high loading streams?

TN and TP:
- Occur in agricultural and urban areas that receive the largest amount of nutrient inputs

Sed:
- Occur in urban, Piedmont headwater streams and streams in agricultural regions from streambank and/or soil erosion and poorly connected floodplains

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

Effective management practices for reducing nutrients and sediment include:

Nitrogen
- Practices that reduce input and prevent groundwater enrichment

Phosphorus
- Practices that reduce input and sediment export

Sediment
- Practices that reduce upland and streambank erosion and better connects stream with floodplain

References

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.

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.=

Chesapeake Bay Watershed Model phase 6: https://cast.chesapeakebay.net/documentation/CalibrationInputsSoilsPlants

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.

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.

Gellis, A.C., M.K. Myers, G.B. Noe, C.R. Hupp, E.R. Schenk, and L. Myers. 2017. Storms, channel changes, and a sediment budget for an urban-suburban stream, Difficult Run, Virginia, USA. Geomorphology 278:128-148.

Gellis, A.C., C.C. Fuller, P.C. Van Metre, C. Filstrup, M.D. Tomer, and K. Cole. 2017. The sources and ages of fine-grained sediment using elemental analysis and fallout radionuclides for an agricultural stream, Walnut Creek, Iowa. Geological Society of America Abstracts with Programs 49(6), doi: 10.1130/abs/2017AM-305664; available at https://gsa.confex.com/gsa/2017AM/webprogram/Paper305664.html; accessed March 9, 2018

Terziotti, S., Capel, P., Tesoriero, A., Hopple, J., and Kronholm, S. Estimates of nitrate loads and yields from groundwater to streams in the Chesapeake Bay watershed based on land use and geology: U.S. Geological Survey Scientific Investigations Report 2017–5160, p. 20.