Water-Quality trends on the Eastern Shore

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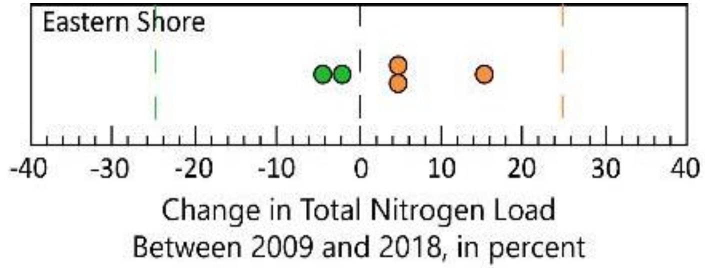

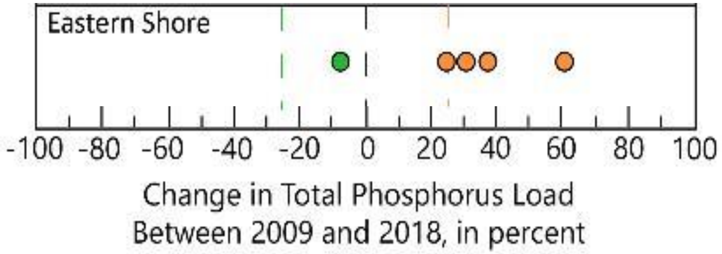

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Objective

Gain a better understanding of water quality trends on the Eastern shore and some factors affecting those trends.

1. Load and trend foundation
2. Comparison of the Eastern Shore to the Chesapeake Bay watershed
3. Examine recent and long term trends in sediment, phosphorus and nitrogen
4. Examine possible management impact/factors affecting trends

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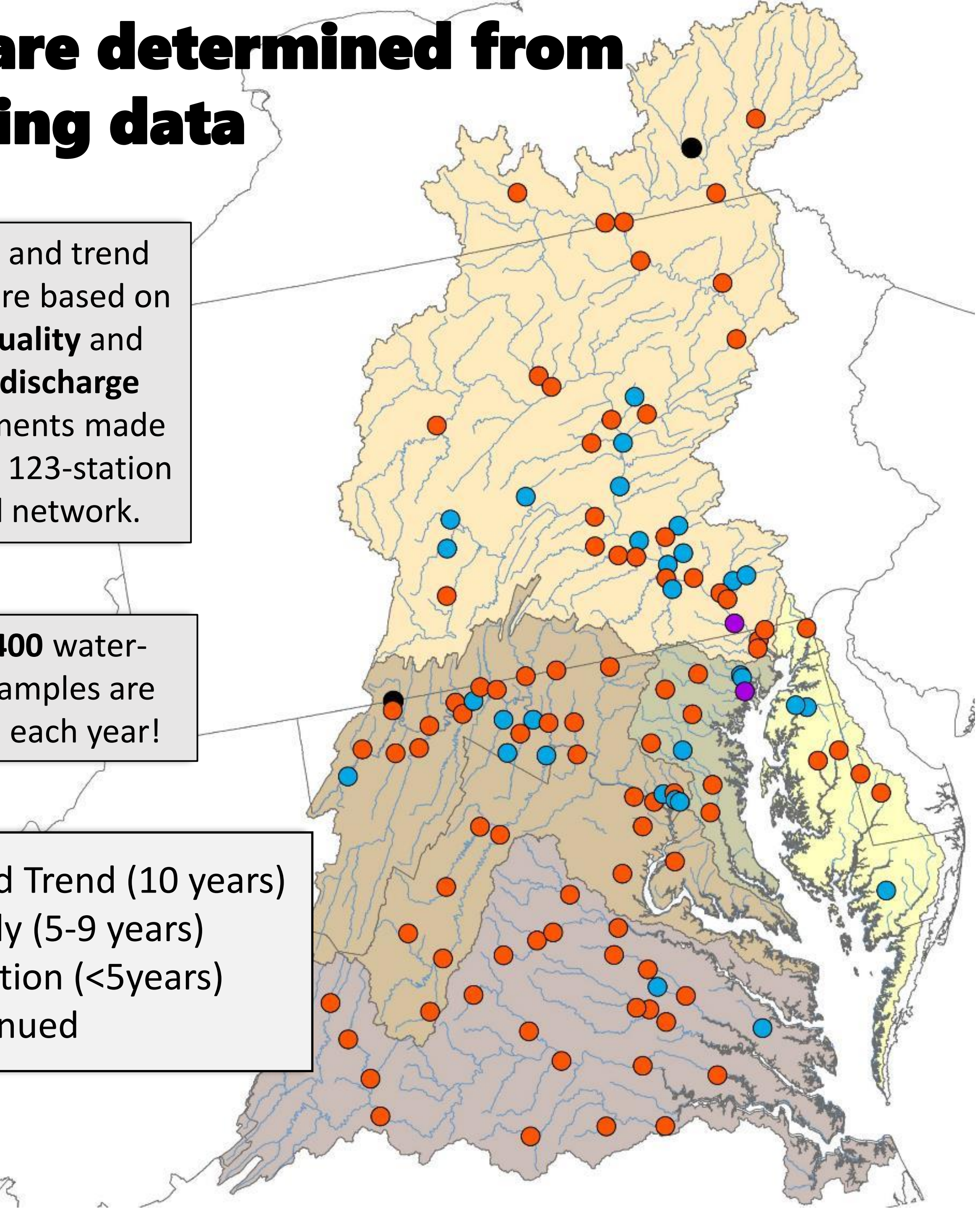
Loads and trend results are determined from a foundation of monitoring data

Our load and trend analyses are based on **water-quality** and **stream-discharge** measurements made across the 123-station nontidal network.

Over **2,400** water-quality samples are collected each year!

- Load and Trend (10 years)
- Load only (5-9 years)
- New Station (<5years)
- Discontinued



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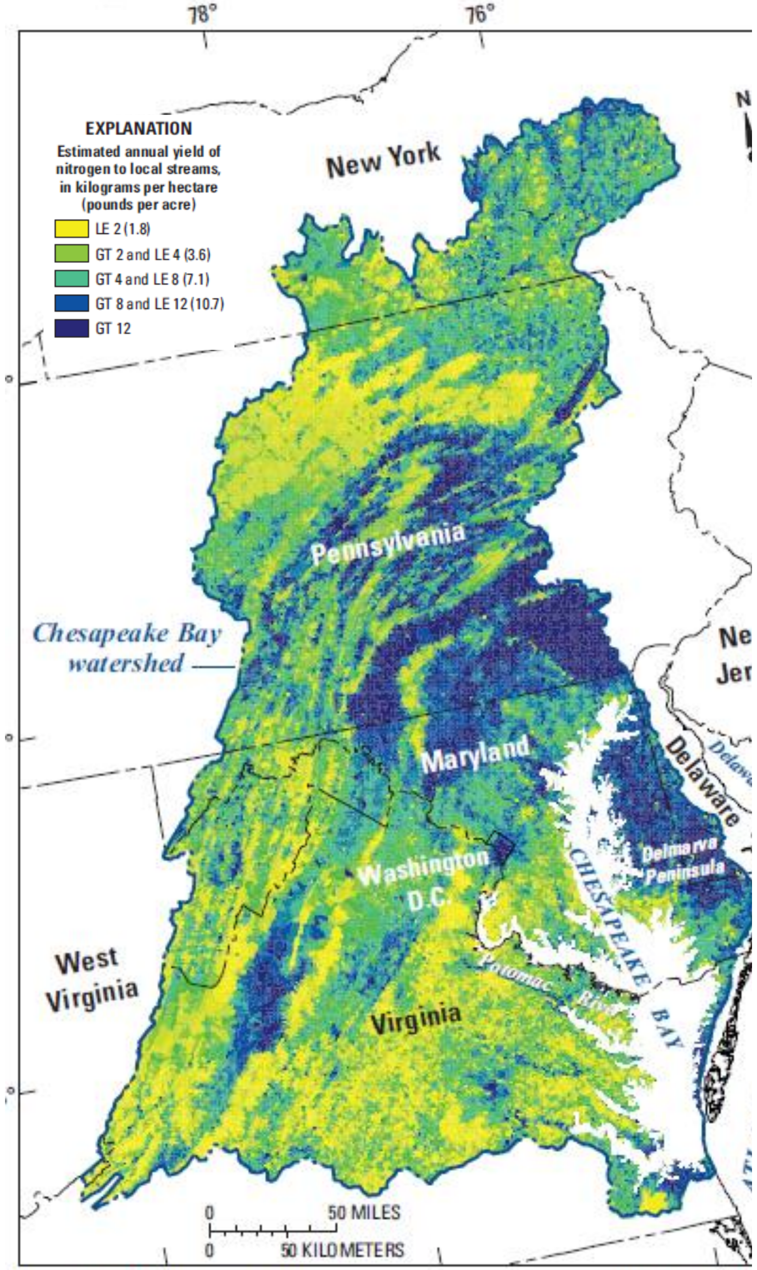
Non-Tidal data inform modeling of unmonitored areas

Eastern Shore has higher area normalized loads of nitrogen (N) and phosphorus (P) compared to the rest of the Chesapeake Bay watershed

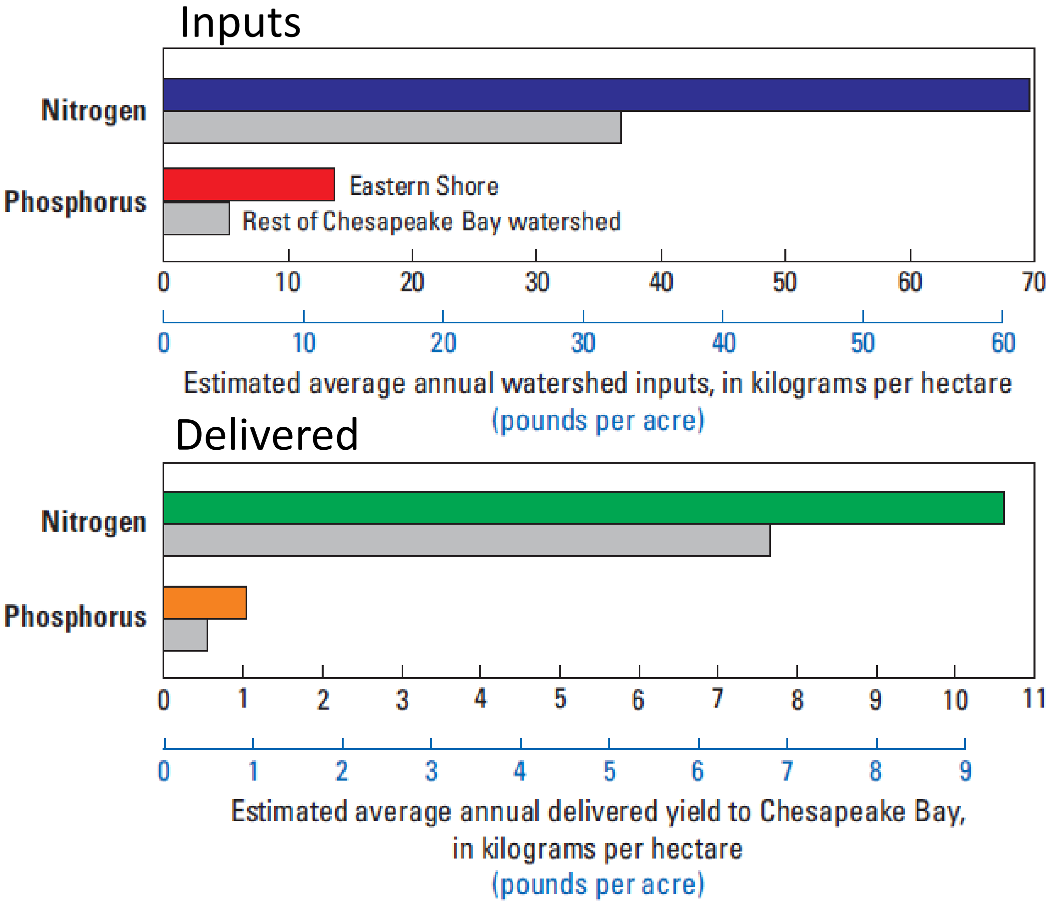
- Driven by high nutrient input and local transport factors

NITROGEN



Base from U.S. Geological Survey, 1:2,000,000 DLG, Albers Equal Area Conic Projection, NAD 83

Yield estimate
Ator and other



[Estimated inputs from Bachman and others, 1998, Wieczorek and LaMotte, 2010a, b, c, d, and Ator and others, 2011. Estimated yields from Ator and others, 2011.]

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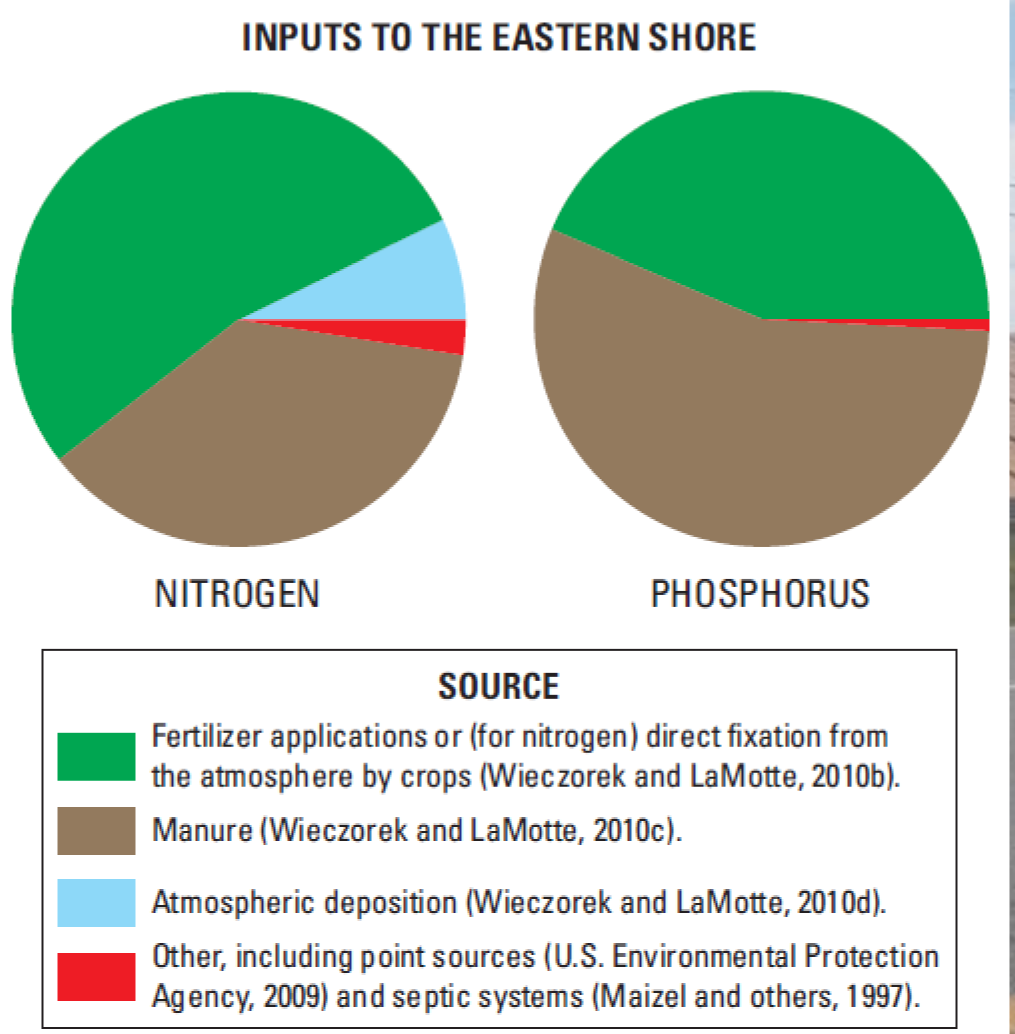
(Ator and Denver, 2015)

Agriculture inputs of nitrogen and phosphorus represent more than 90% of N and P inputs to the Eastern Shore



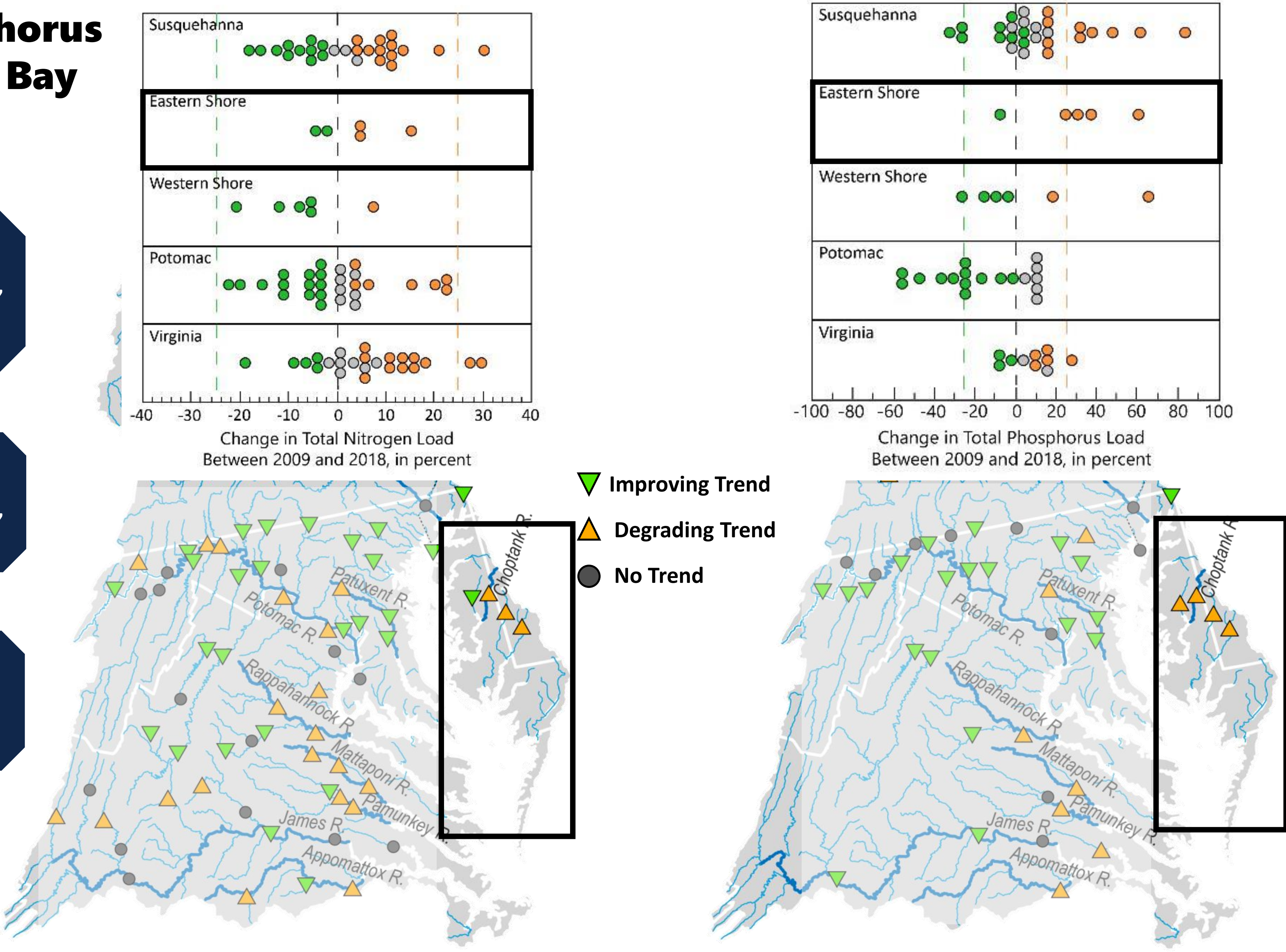
(Ator and Denver, 2015)

How have nitrogen and phosphorus loads changed throughout the Bay watershed?

Between 2009 – 2018, total nitrogen (TN) loads have improved at 41%, degraded at 40%, and shown no trend at 19% of NTN stations.

Between 2009 – 2018, total phosphorus (TP) loads have improved at 44%, degraded at 32%, and shown no trend at 24% of NTN stations.

Degrading trends are in all sites except, the Tuckahoe for total nitrogen



Trends in TN load between 2009 – 2018 from 90 NTN stations.

Trends in TP load between 2009 – 2018 from 66 NTN stations.

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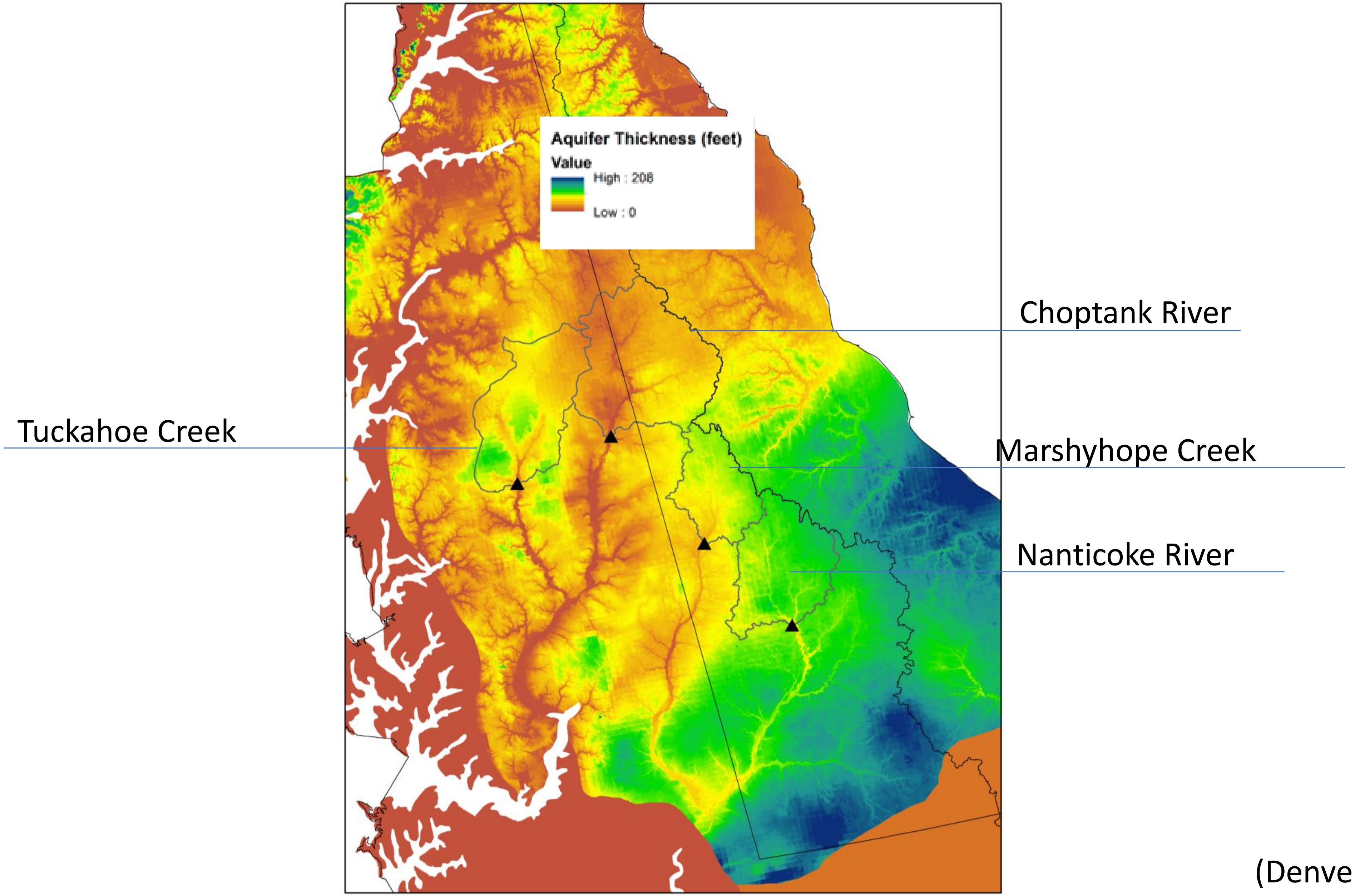
Moyer, D.L., and Langland, M.J., 2020, Nitrogen, phosphorus, and suspended-sediment loads and trends measured at the Chesapeake Bay Nontidal Network stations: Water years 1985-2018 (ver. 2.0, May 2020): U.S. Geological Survey data release, https://doi.org/10.5066/P931M7FT.

Non-Tidal stations and aquifer thickness



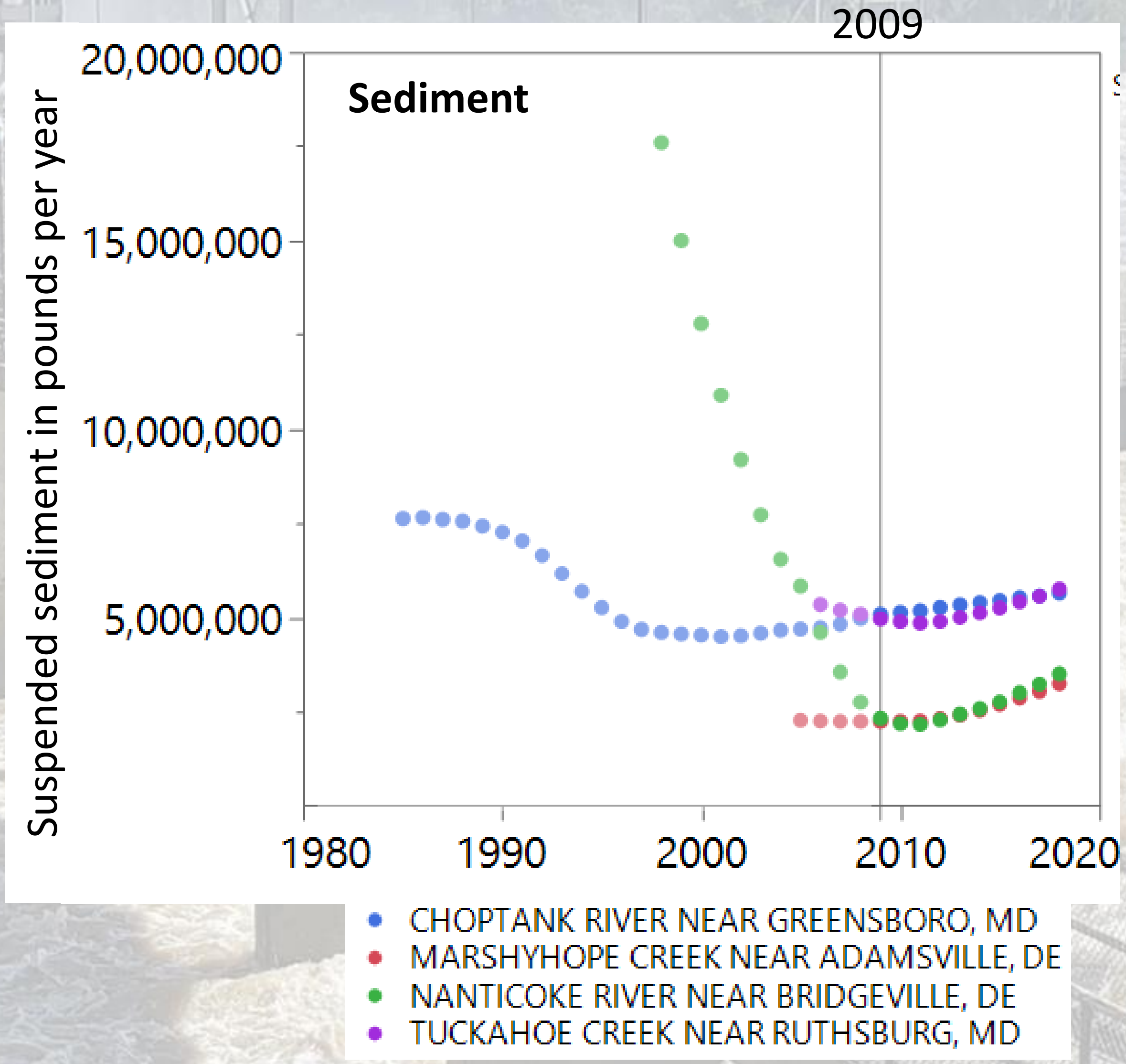
(Denver and Nardi, 2016)

Since 1985 sediment has seen an overall decrease with all stations show increased loading since 2009

Flat topography, shallow slopes and quick infiltration lead to low sediment transport volume.

Between 2009 – 2018, Suspended Sediment loads have increased by 30% on average

Transported sediment is high in phosphorous



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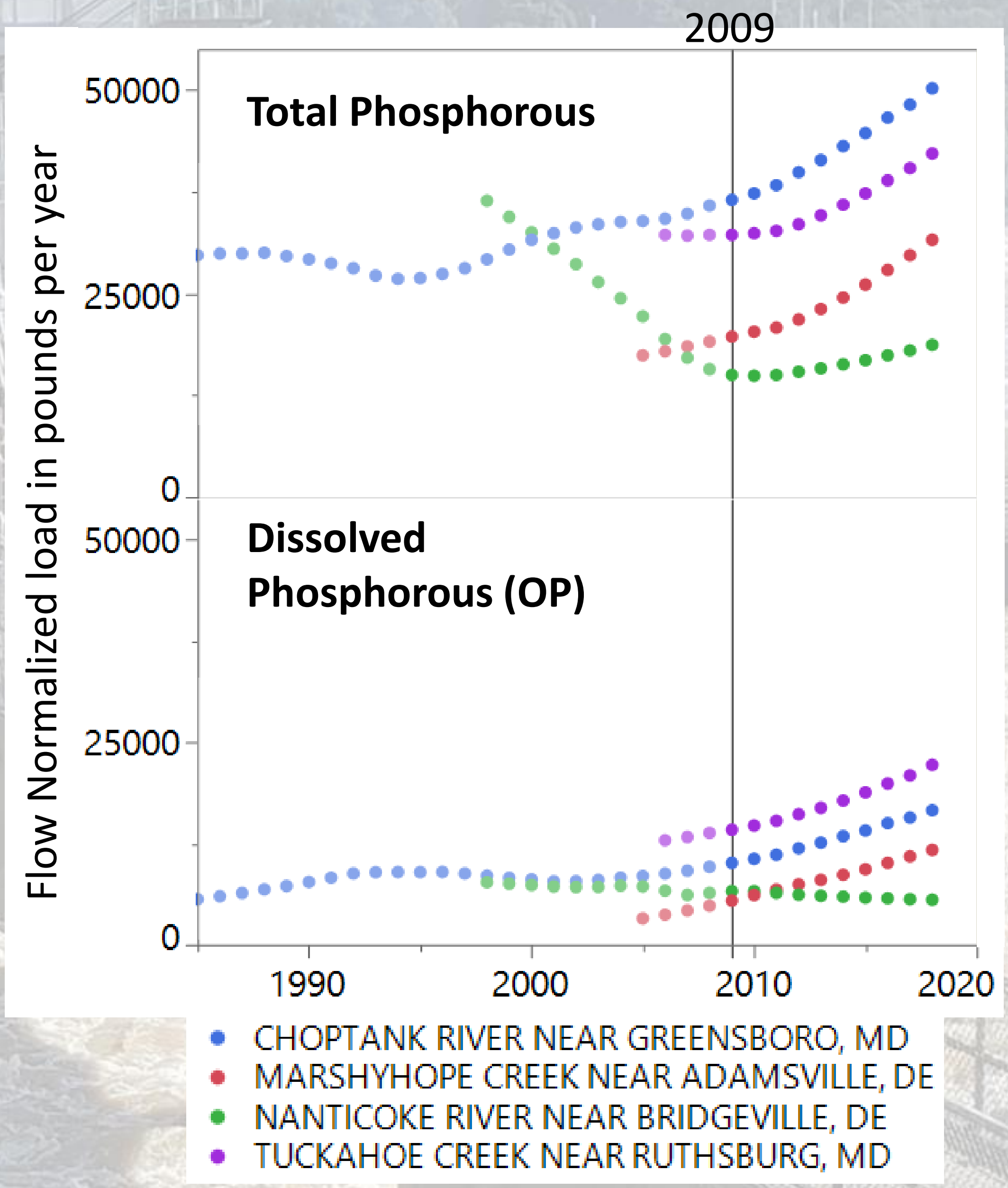
Phosphorous loads are increasing on the Delmarva

Between 2009 – 2018, all Delmarva NTN sites had degrading Total Phosphorous (TP) and all but one NTN site (Nanticoke) had degrading Orthophosphate (OP)

Between 2009 – 2018, average TP loads increased by 38%, sites with degrading OP increased FN-load by 79%

Nanticoke shows a long term decrease in TP, Recent increases in TP outweigh continued OP decline



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Phosphorus loads are changed by inputs to landscape and transport from landscape to stream

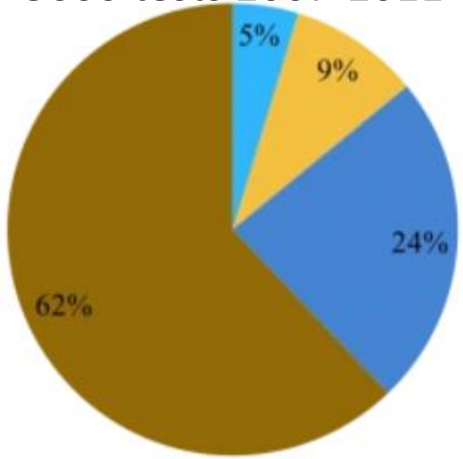
Phosphorus binds to sediment, and is primarily transported through sediment mobilization

High field soil P leads to high transported P

Increases in total phosphorus load and soil phosphorus saturation are important to orthophosphate concentrations

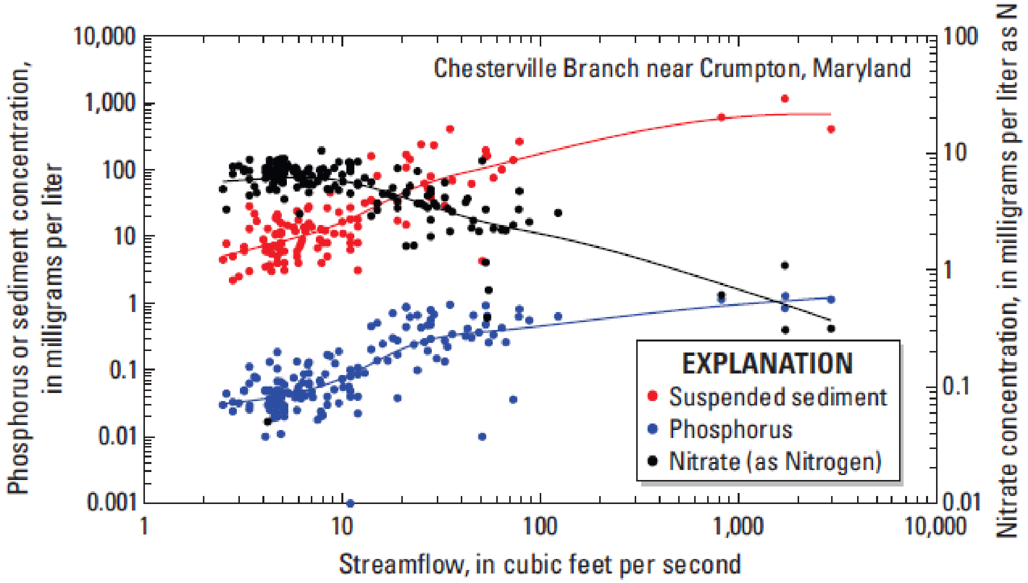
Increasing manure applications related to P and OP increases in the Choptank

Delaware soil P Index
5600 tests 2007-2011

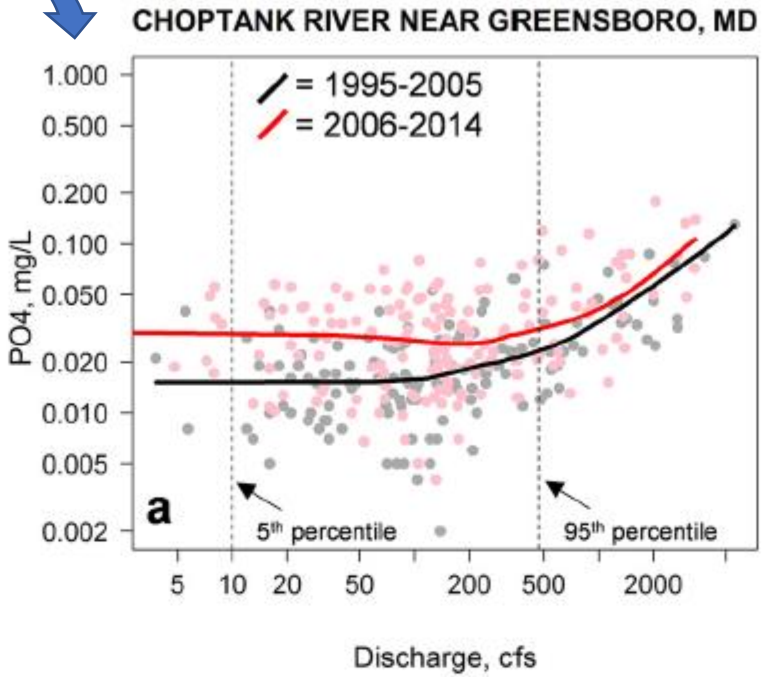


(Shober and Sims, 2016)

Low Medium Optimum Excessive



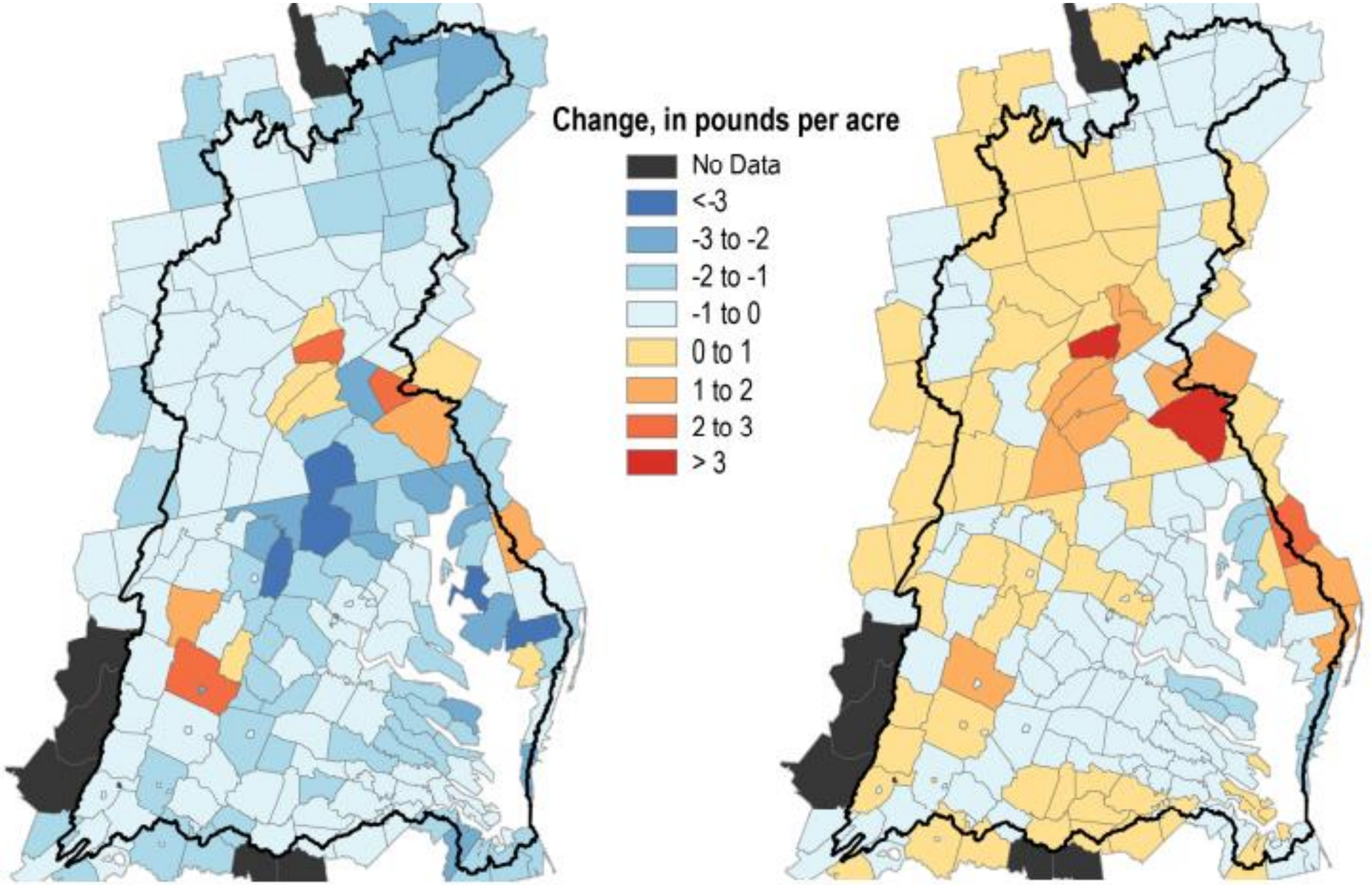
[From Ator, Denver, and Brayton, 2005.]



(Fanelli, Blomquist and Hirsch, 2019)

CAST input data describes long term decreases in P applications but recent increases in Delaware and select Maryland counties. Most MD counties show decreasing P applications

1985-2019 | 2009-2019



(Webber and others, 2021)
(Chesapeake Bay program, 2020)

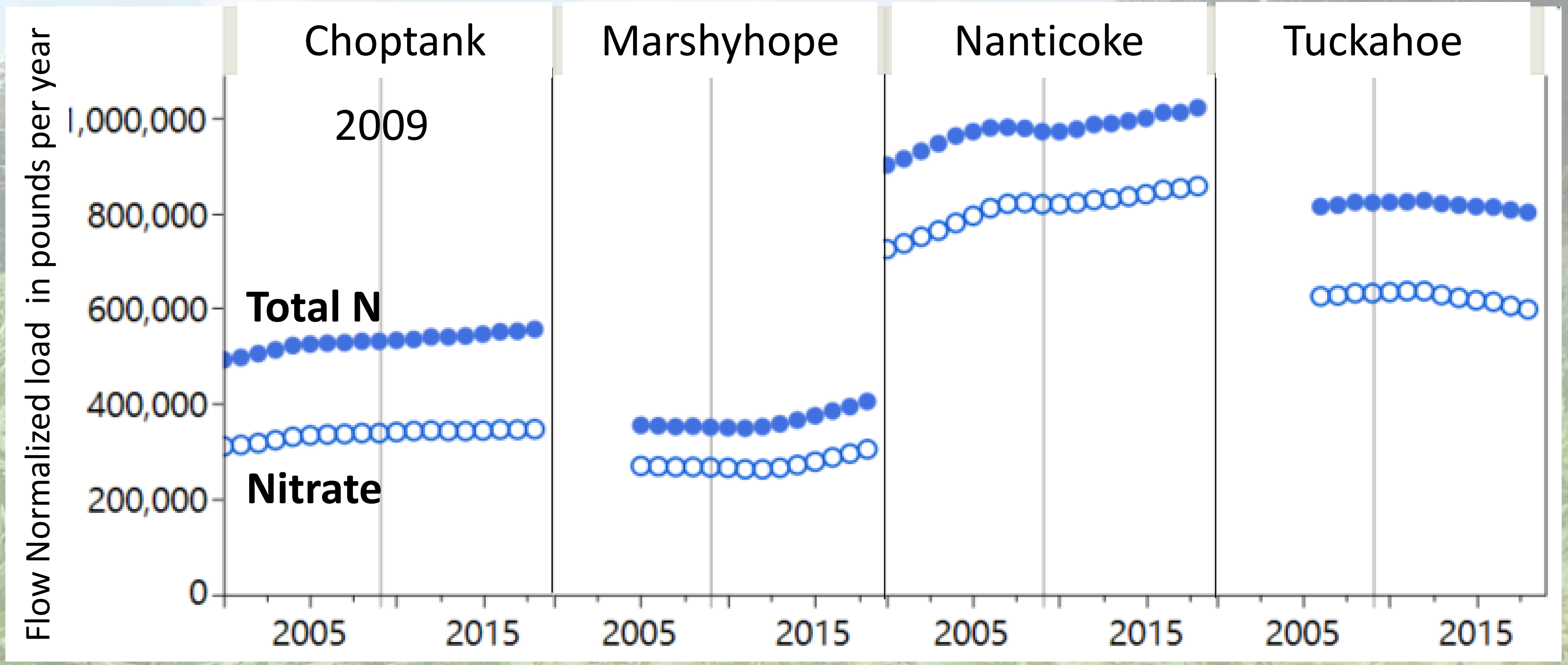
Changes in agricultural nutrient applications in Chesapeake Bay counties between ‘85-’87 to ‘17-’19 (long term) and ‘09-’11 to ‘17-’19 (Short term)

Nitrogen loads have increased in most monitored trend sites on the Delmarva

Between 2009 – 2018, All Delmarva NTN sites had increasing N loads **except for the Tuckahoe**

Between 2009 – 2018, average TN load increased by 8% while Tuckahoe decreased by -2.4%

Tuckahoe decrease is consistent with decreasing nitrate loads, the dominant form of nitrogen



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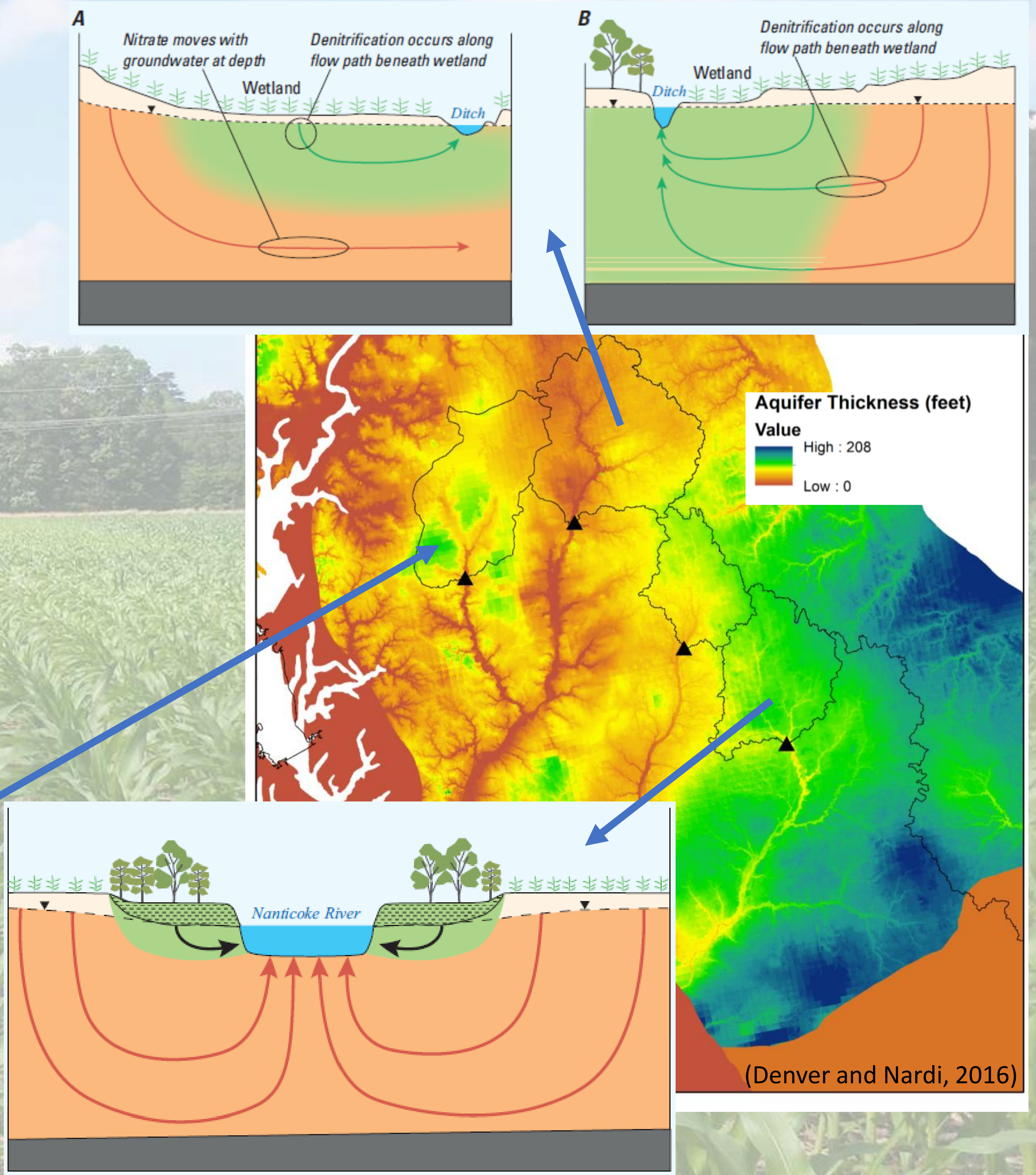
Landscape can control N transport and foster denitrification

- **Nitrate remains stable in much of the surficial aquifer due to oxygen rich conditions**
- **Choptank N loads are low likely due to hydric soils and a shallow water table promoting anoxic conditions and so, denitrification**
- **The Nanticoke lies on a thick portion of the surficial aquifer, allowing for continued N transport**
- **The Tuckahoe has a mixture of flowpaths but shorter residence time than Marshy or Nanticoke**



(Denver and Nardi, 2016)

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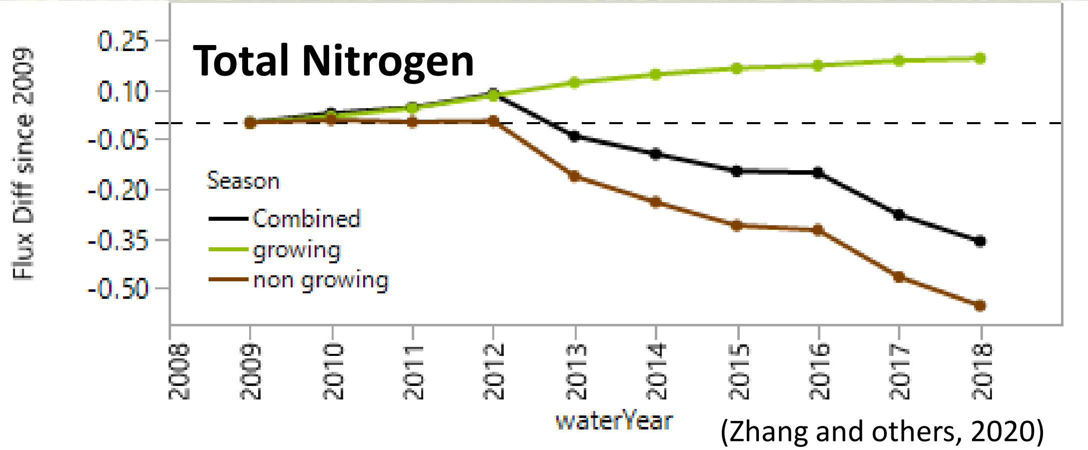
Tuckahoe total nitrogen loads differ between the growing season and non-growing season

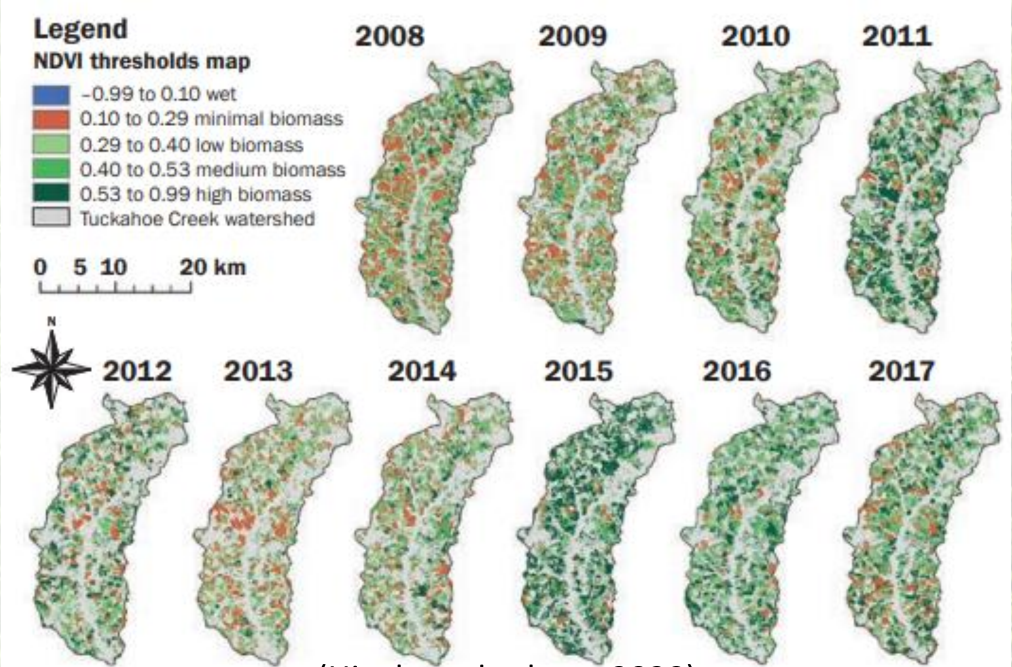
Total Nitrogen trend is driven by non-growing season loads which outweigh increasing growing season

The Tuckahoe has a high enrollment of conservation practices and CAST data suggests decreasing N applications. Strong cover crop performance has been linked to decreasing nitrate field losses

Fox and others (2021) show decreasing baseflow TN in Tuckahoe sub-watersheds



(Zhang and others, 2020)



(Hively and others ,2020)

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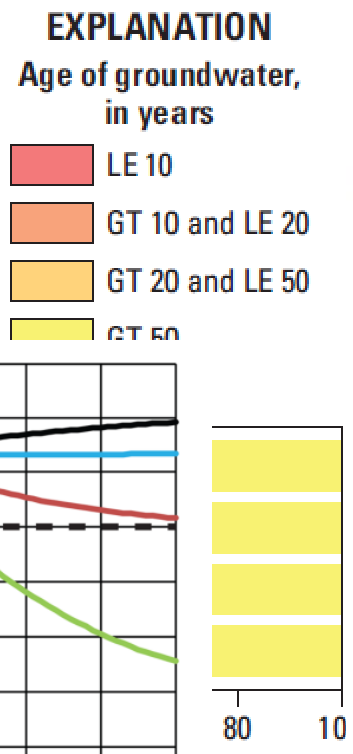
Groundwater extends time for nitrogen improvement.

Despite changes in management practice which may reduce loads to streams, groundwater is the dominant delivery mechanism of nitrogen and reflects past land use

- Fox and others (2021)
  - 53 (±11) years for improving subwatersheds to reach Bay total nitrogen concentration
- Sanford and Pope (2012)
  - 29 years with 40% reduction
- Other NTN stations: ?



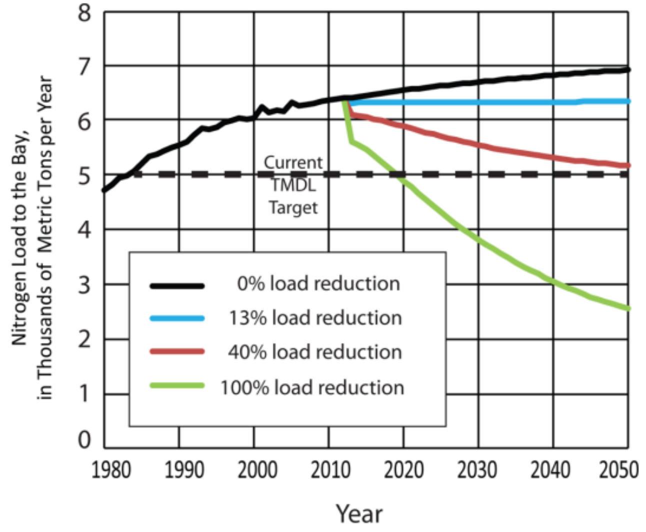
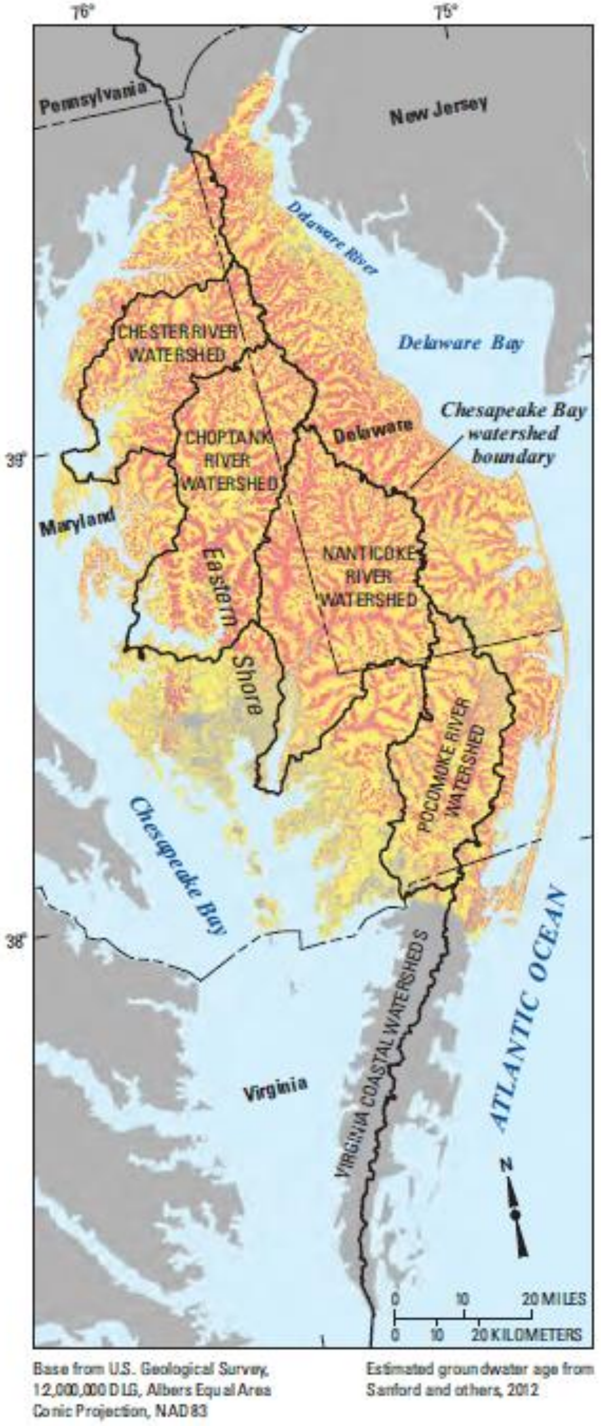


Figure 4. Forecast of total dissolved nitrogen (TDN) loading to the Chesapeake Bay from total streamflow from the Delmarva Peninsula study area based on the nitrogen mass-balance regression (NMBR) model that incorporated the simulated distribution of groundwater return times from the groundwater-flow (GWF) model. The dashed horizontal line represents the approximate 25% reduction TMDL target for this region proposed by the U. S. Environmental Agency in conjunction with the local states.[49]



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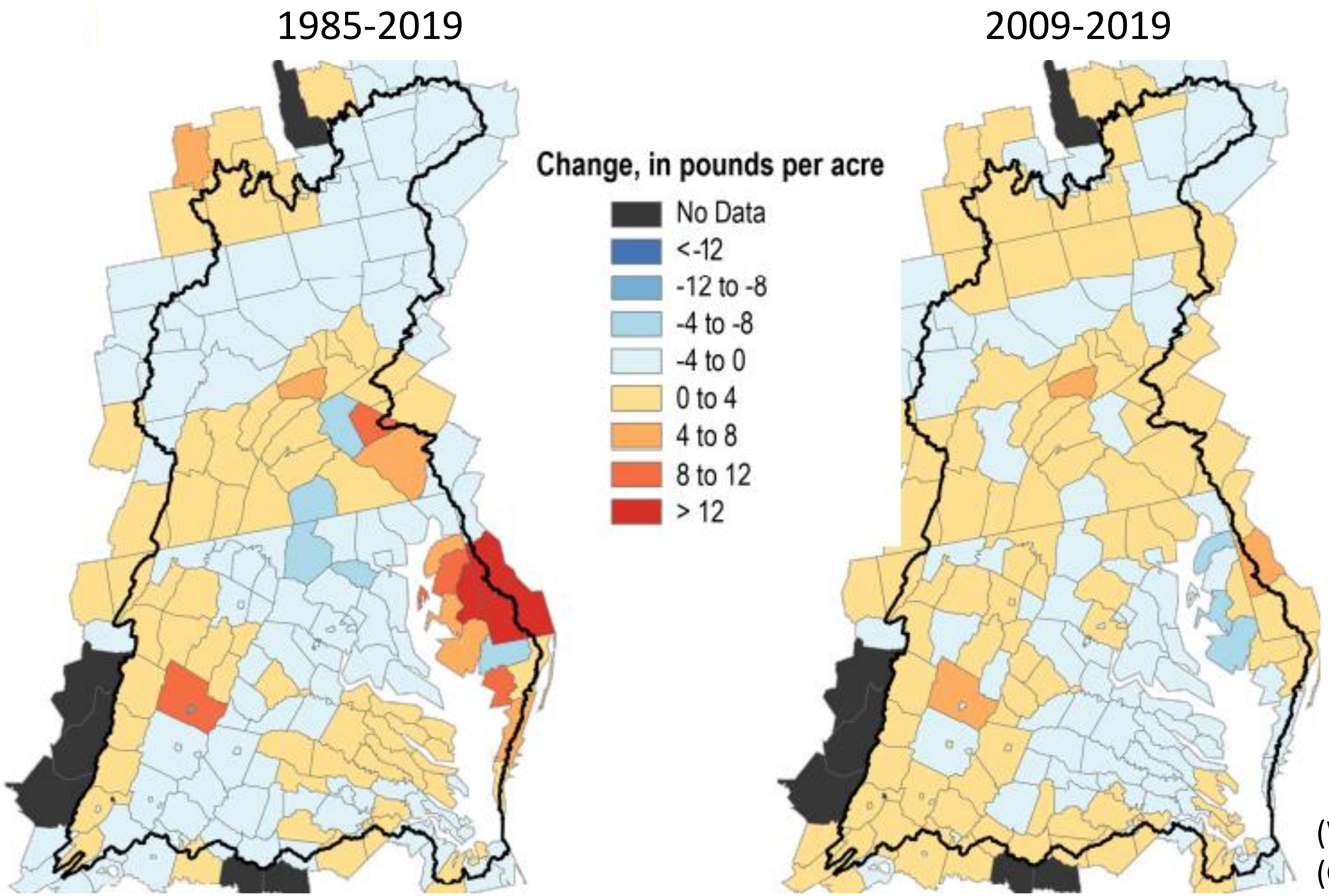
CAST input data describe increases in N applications since 1985 and in some counties after 2009



(Webber and others, 2021)
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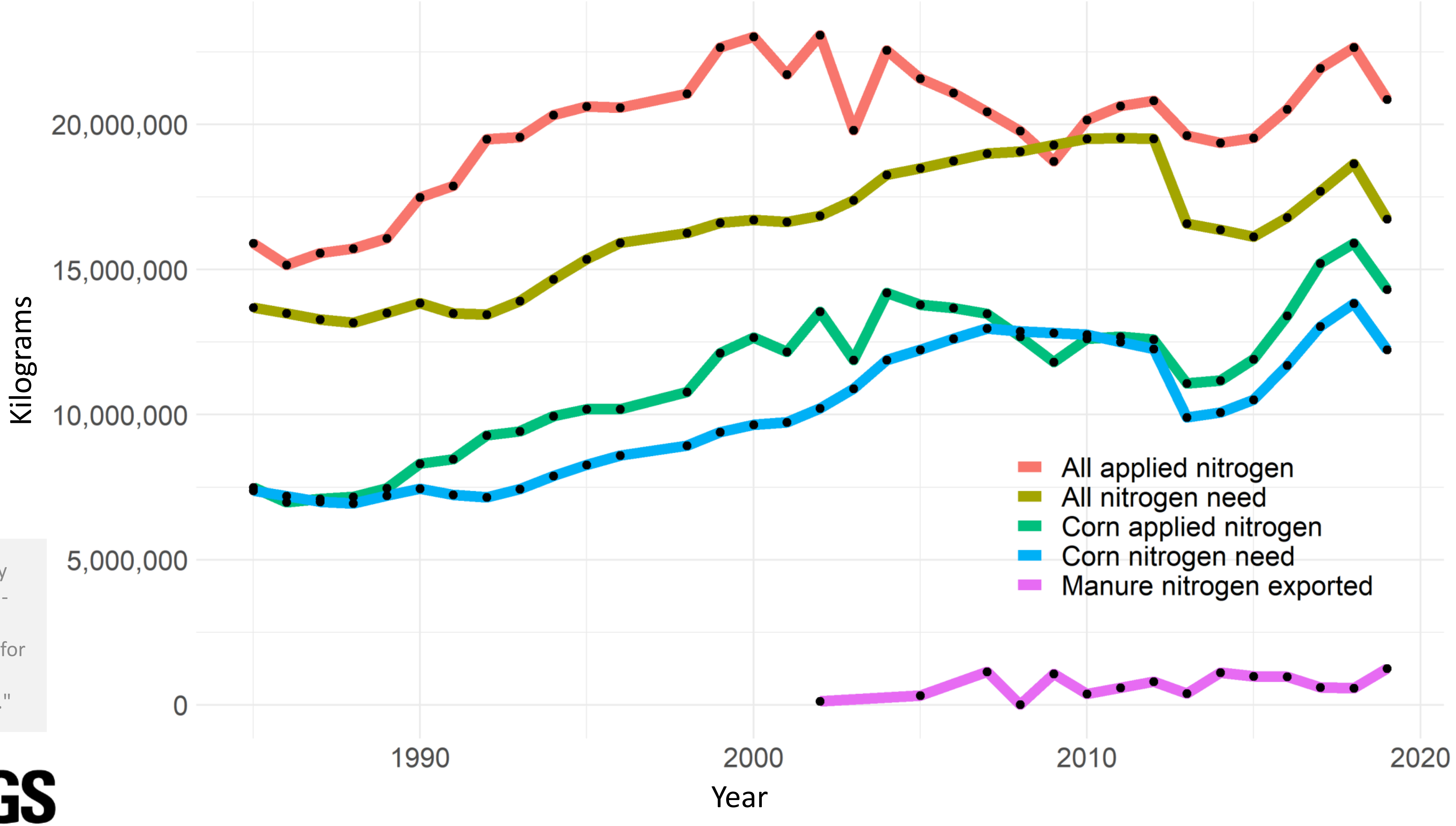
CAST data for applied nitrogen, crop need and exported nitrogen in Delaware



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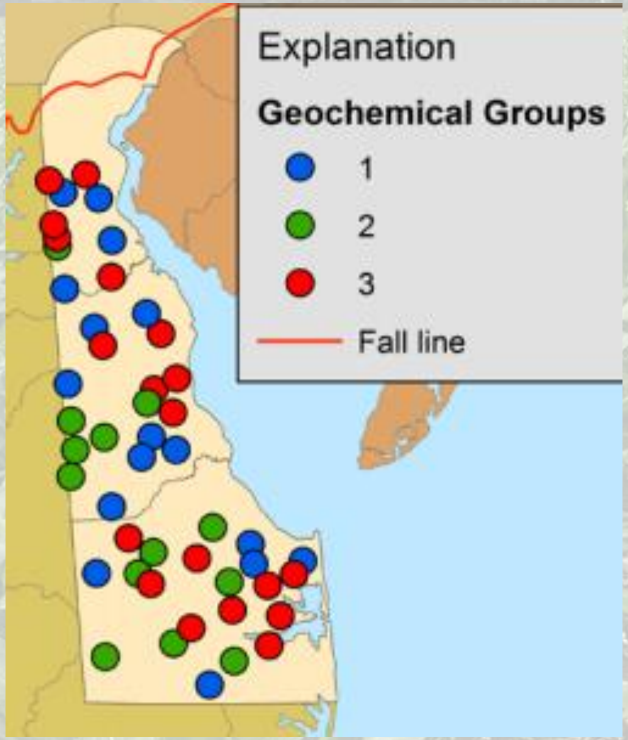
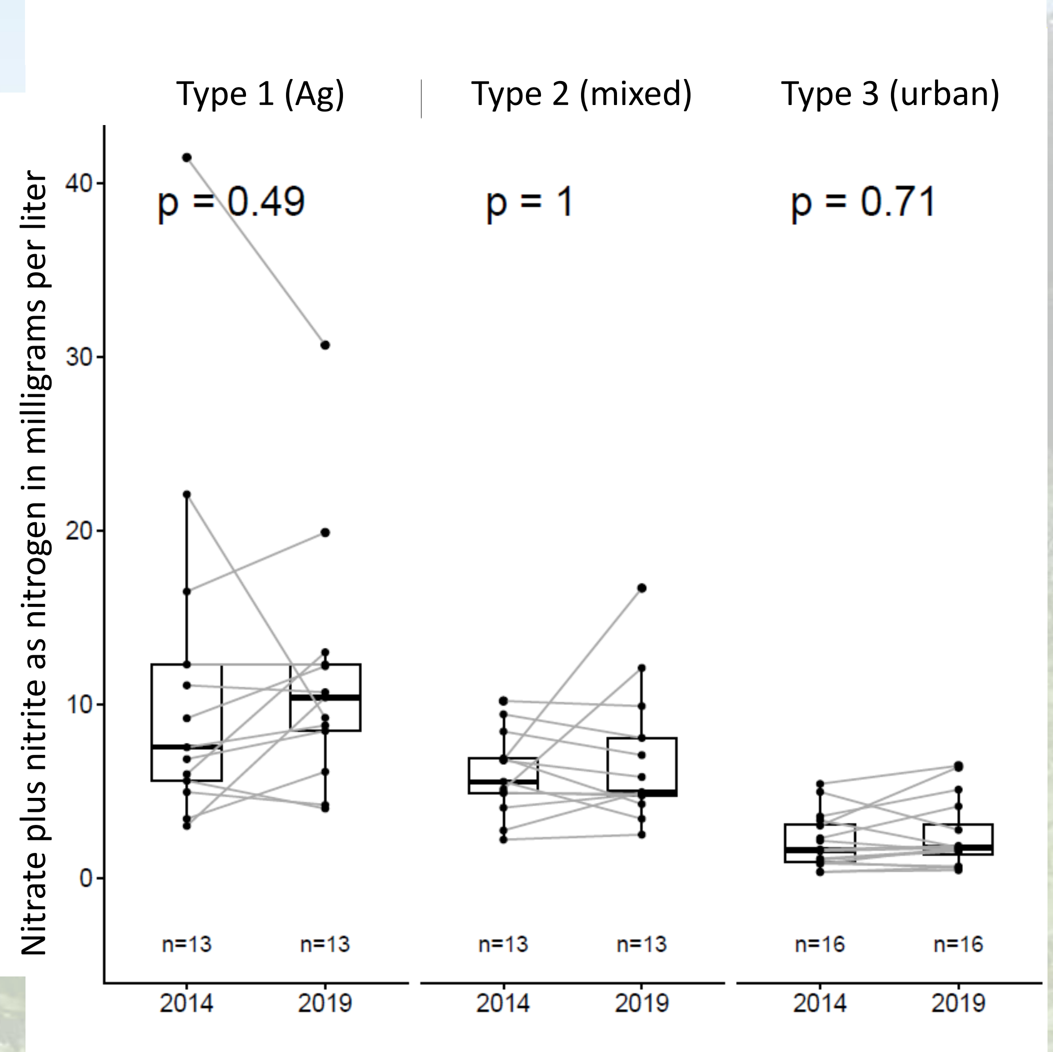
Insight into the future: The Delaware Shallow Aquifer sampling network

Recent (2019) sampling in Delaware shallow aquifer reveals no significant change in nitrate concentrations since 2014 in wells with agricultural type water, mixed or urban-type water.





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Final notes

- Despite long term decline, stations show increasing sediment and phosphorus loads from 2009 to 2018
- Nitrogen loads are increasing except for the Tuckahoe
- Management strategies are challenged by past, current inputs and the landscape

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Questions?
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