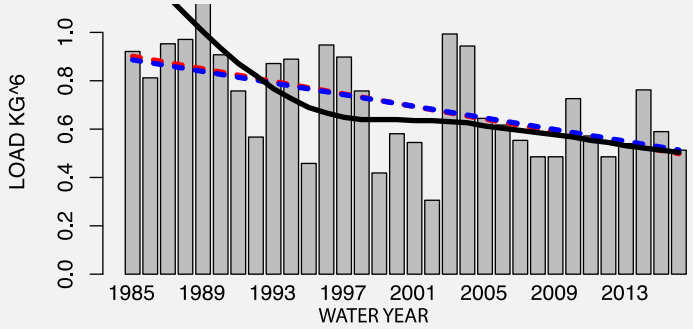
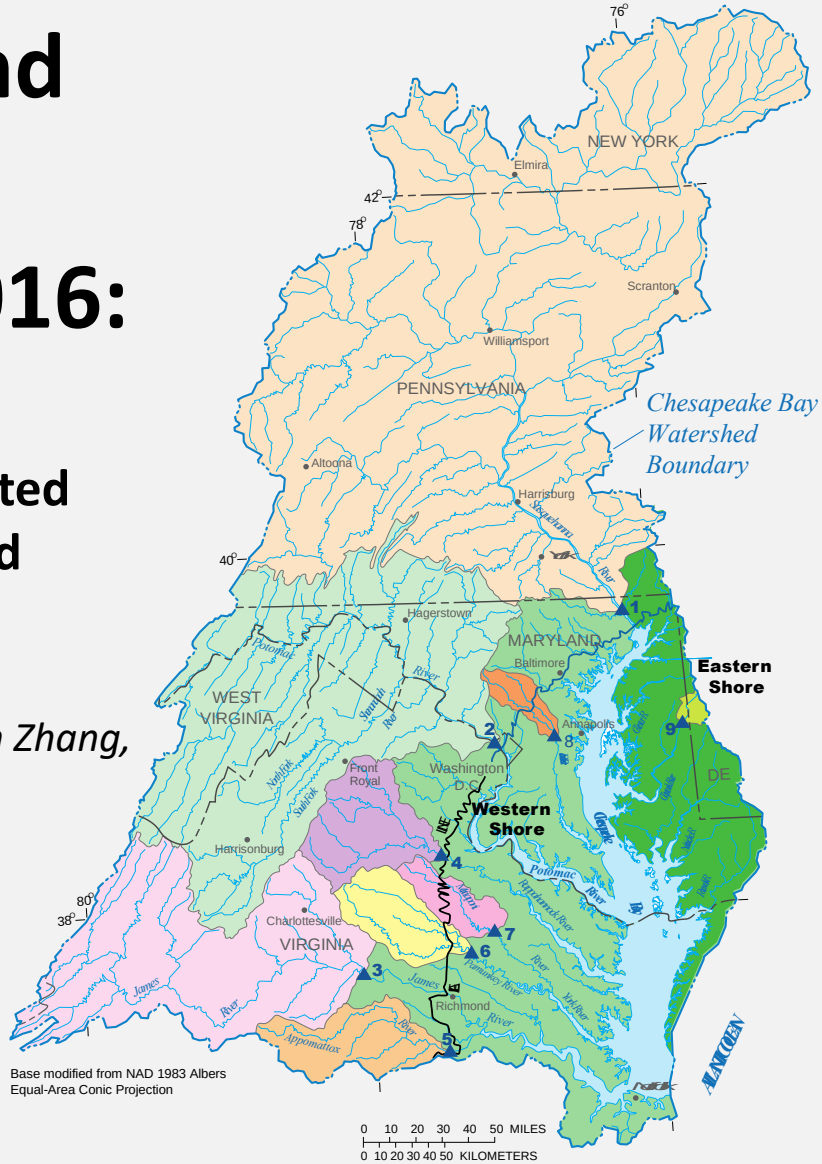
A History of Nutrient and Sediment Inputs to Chesapeake Bay, 1985-2016:

Three decades of monitoring and coordinated restoration in the Chesapeake Watershed

Joel D. Blomquist, Rosemary M. Fanelli, Jeni Keisman, Qian Zhang, Doug L. Moyer and Michael J. Langland





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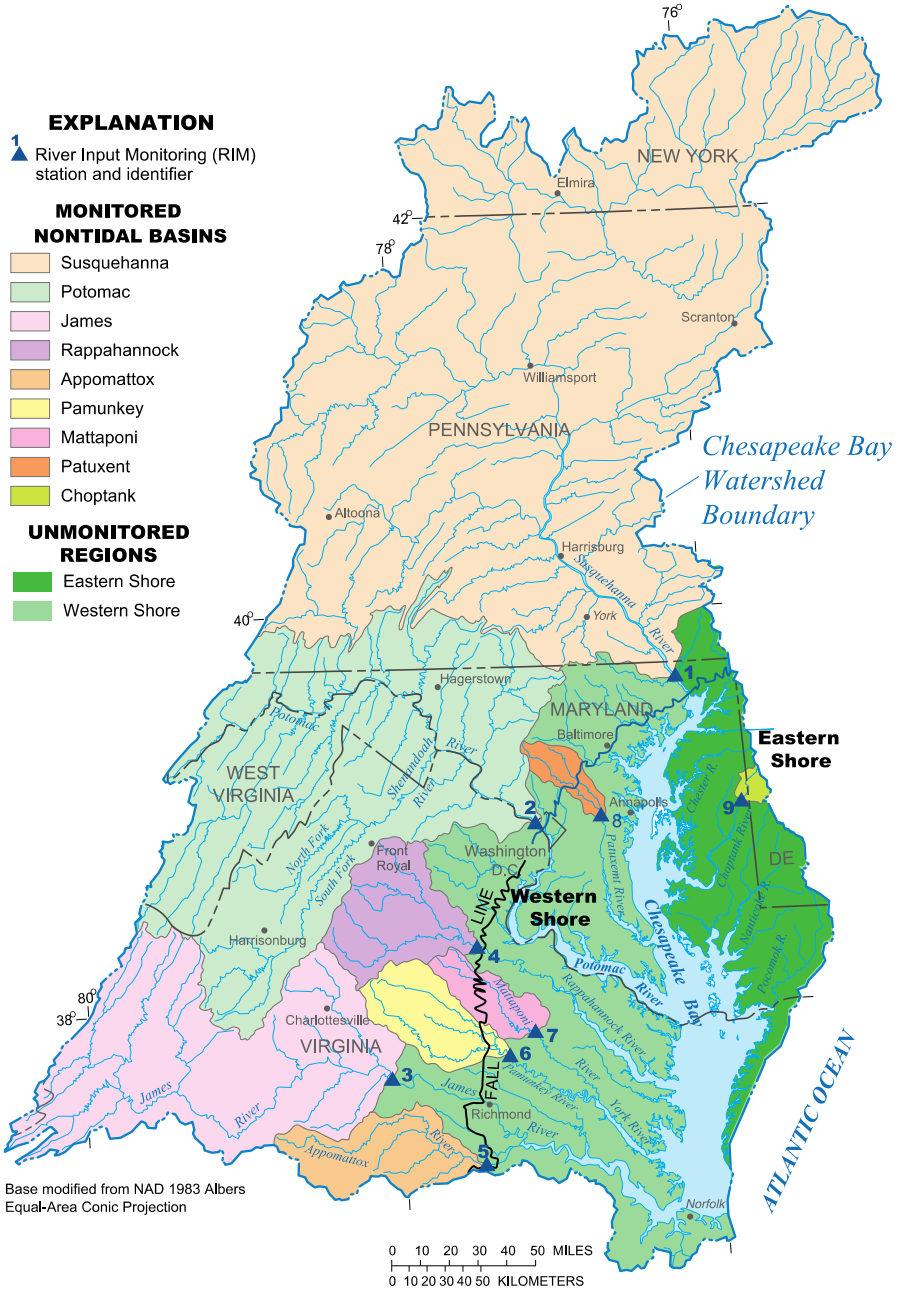
Purpose

1. Provide feedback on net observed changes in inputs to Chesapeake Bay
2. Clarify technical trend jargon for fluvial systems
3. Help bridge the understanding of watershed changes with estuarine response

Scope

1. River Monitoring[1] (RIM 1985-2016)
2. Watershed models (WSM6.0[3]) (SPARROW[2])
3. Wastewater inputs (CBPO[3])
4. Atmospheric Deposition (NADP[3])



[1] Moyer, D.L., Langland, M.J., Blomquist, J.D., and Yang, Guoxiang, 2017, Nitrogen, phosphorus, and suspended-sediment loads and trends measured at the Chesapeake Bay Nontidal Network stations: Water years 1985-2016, U.S. Geological Survey data release, https://doi.org/10.5066/F7RR1X68.

[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 Chesapeake Bay Program Office, 2018.

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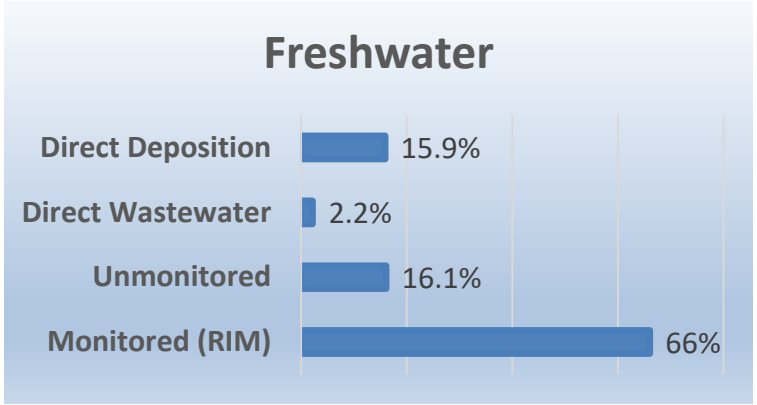
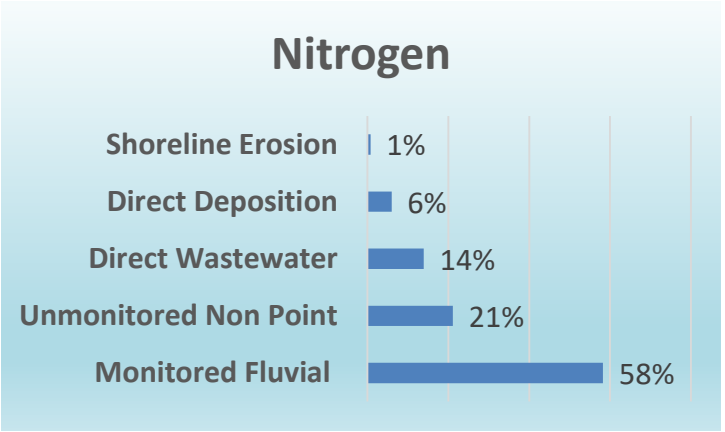
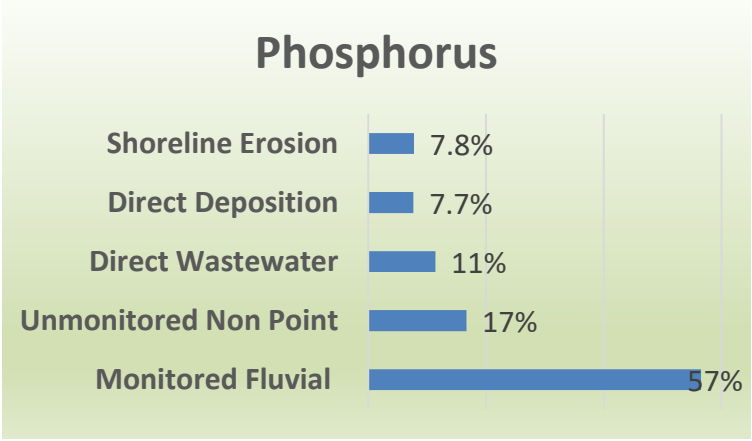
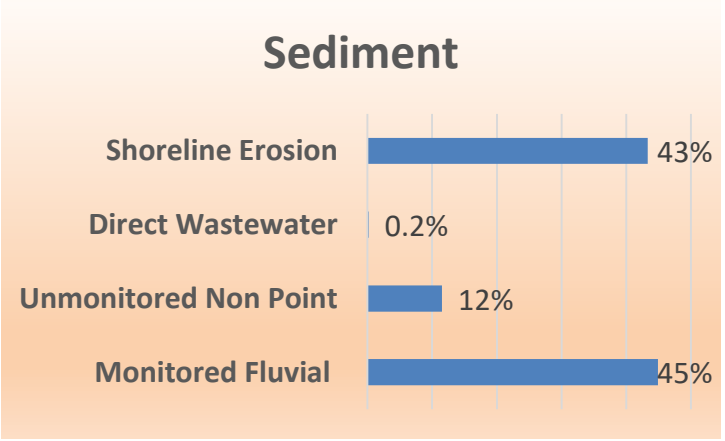
Average Inputs to Chesapeake Bay









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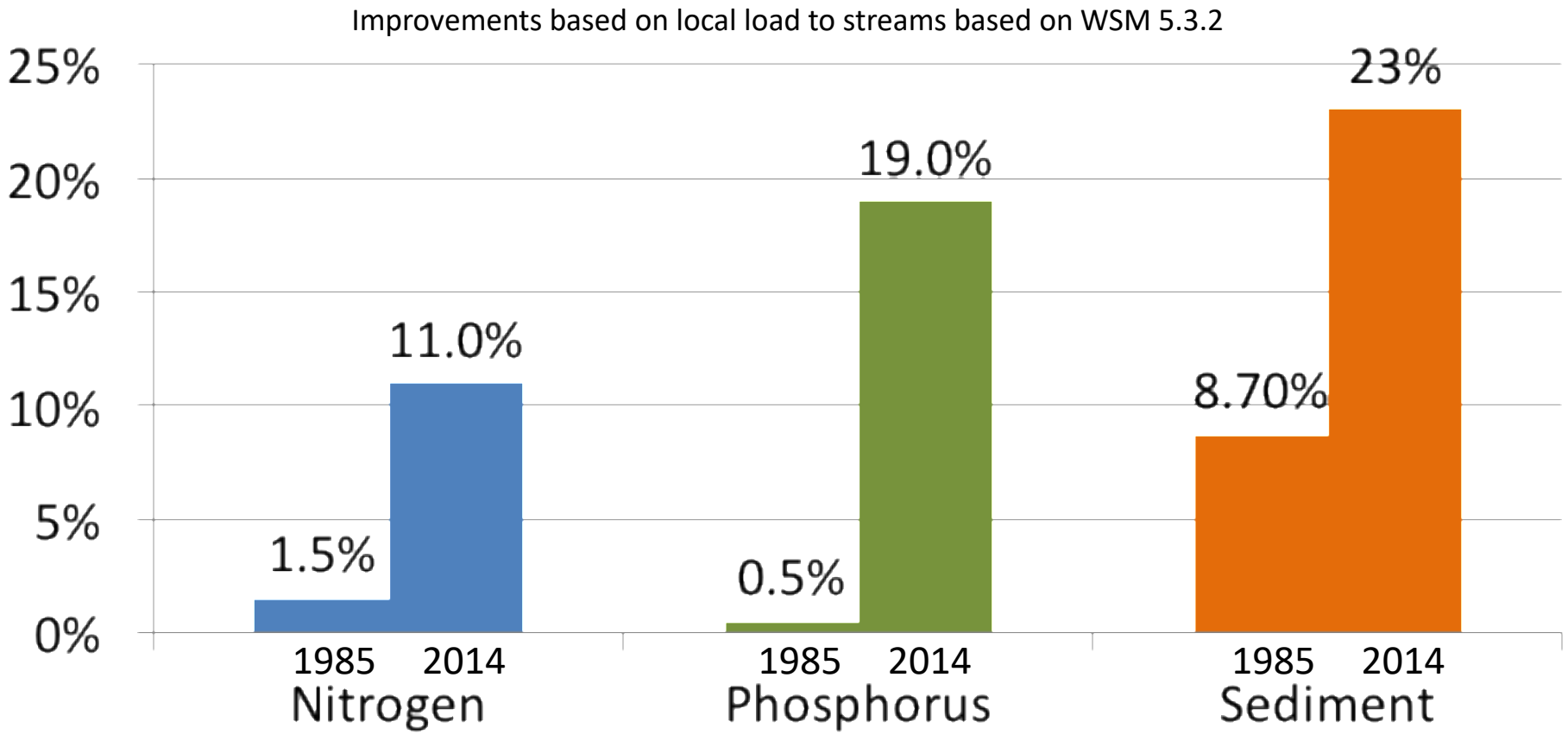
Expected Total Nutrient and Sediment Reduction Due to Agricultural and Developed BMPs



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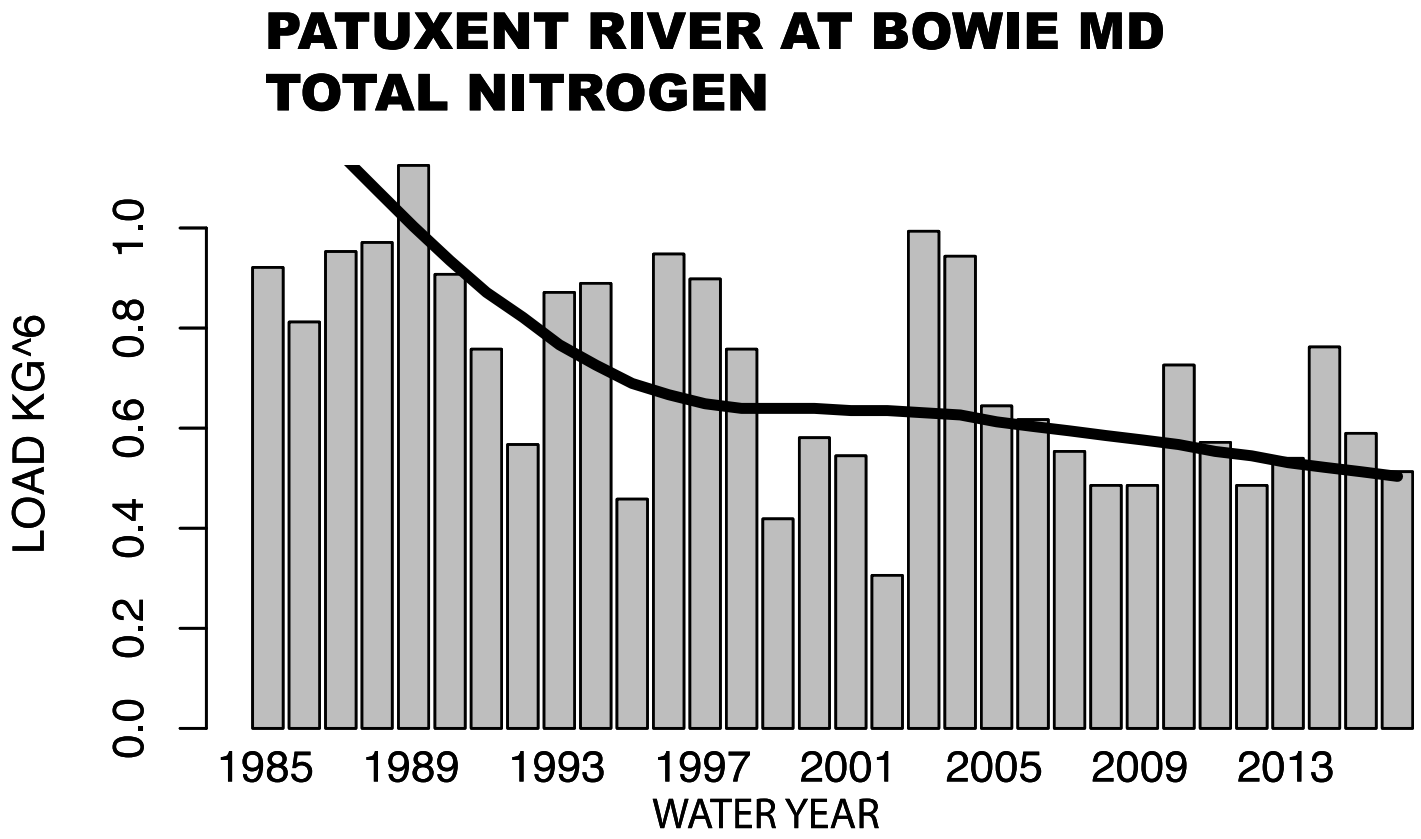
Flow Normalized Loads



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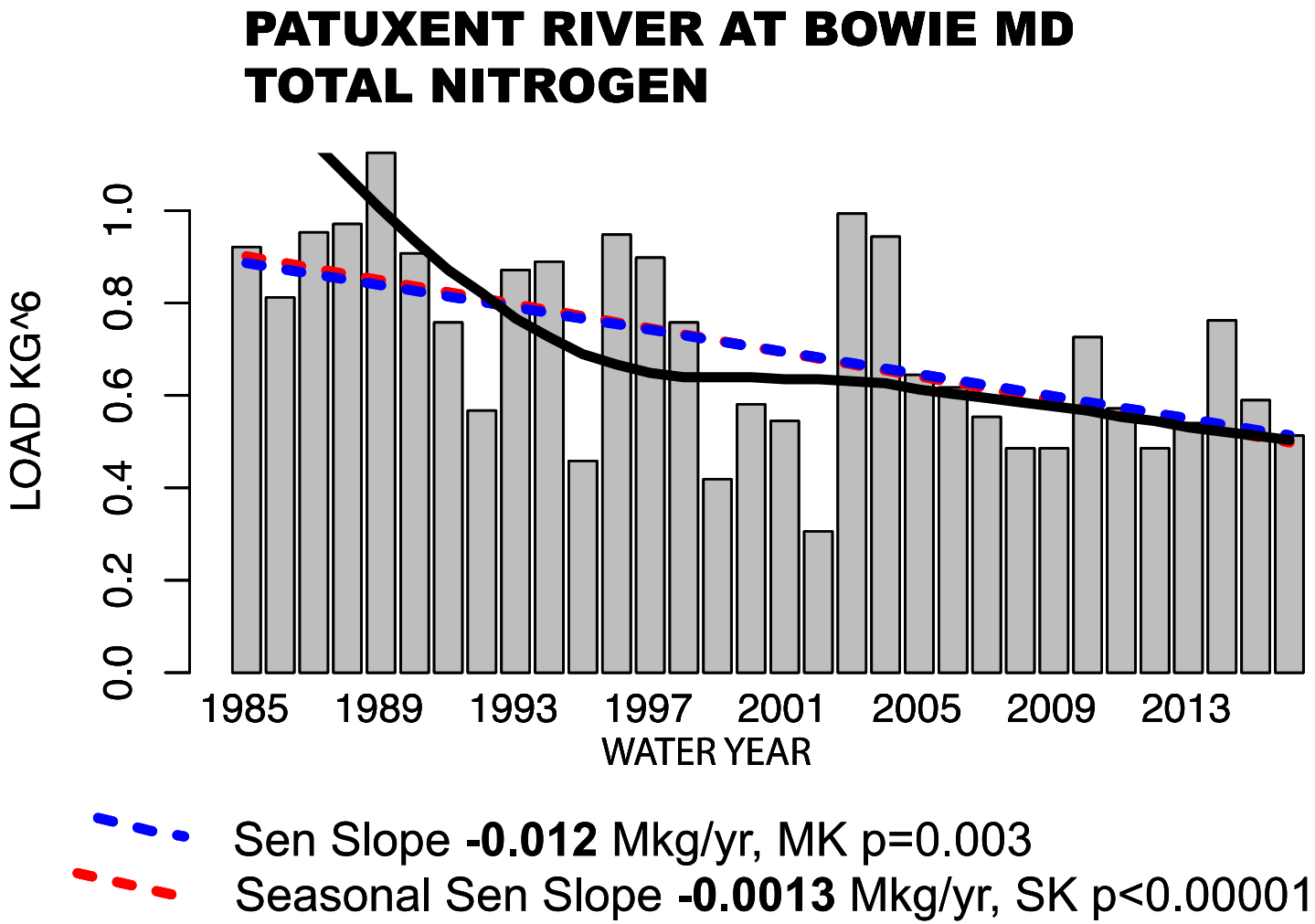
Characterizing Observed Changes in Annual Load

Test / Slope Estimate	Pros	Cons
Mann Kendall / Sen Slope	• Robust nonparametric trend test on annual data. • Slope scaled to annual time series	• Limited power relative to sampled observations
Seasonal Kendall / Seasonal Sen Slope	• Robust nonparametric trend test on seasonal (monthly) data. • Increased power in trend detection (12 seasons per year)	• Slope is scaled to monthly observation • Slope is insensitive to seasons with large change

Trends in Observed Loads



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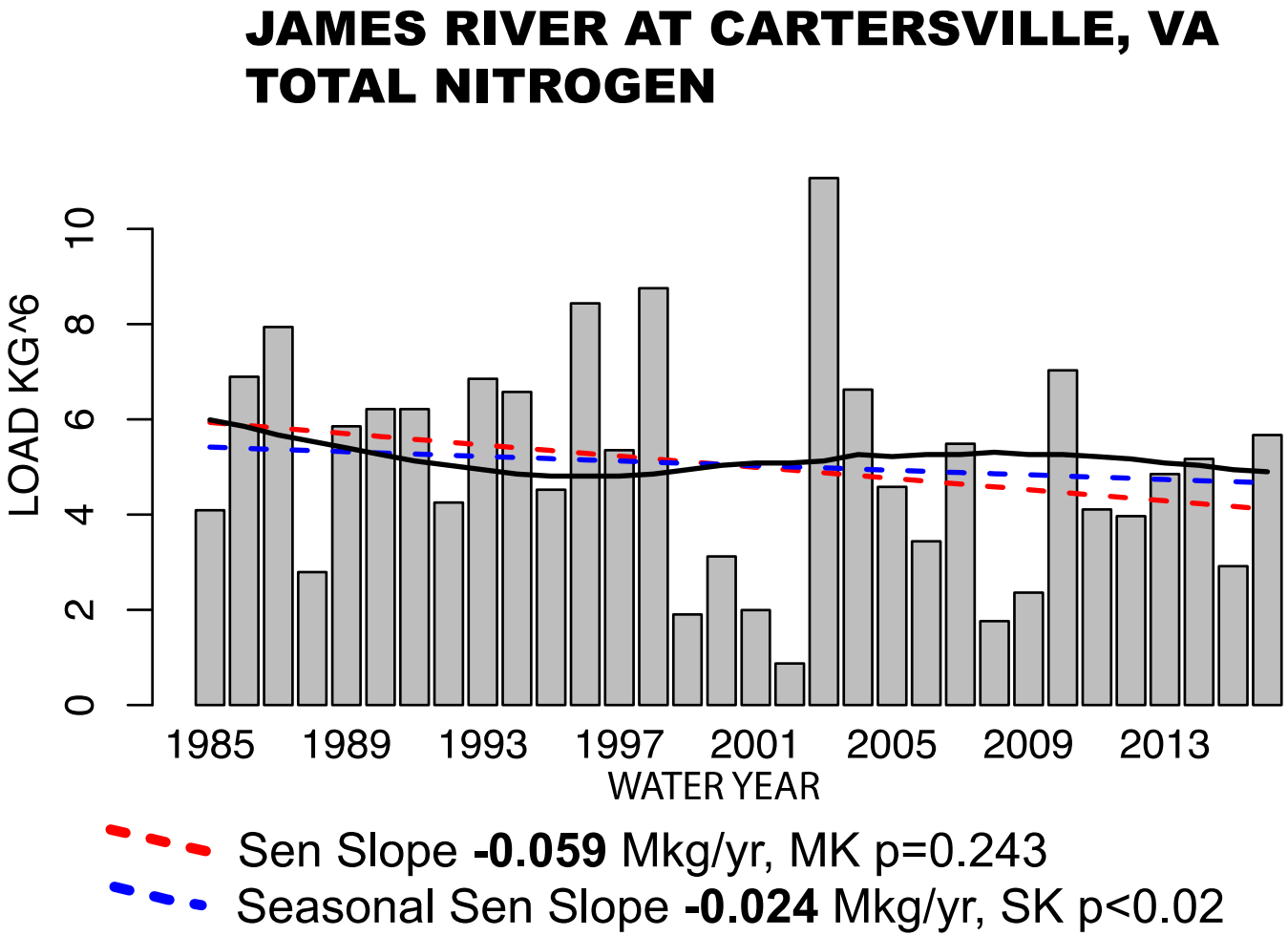
Trends in Observed Loads



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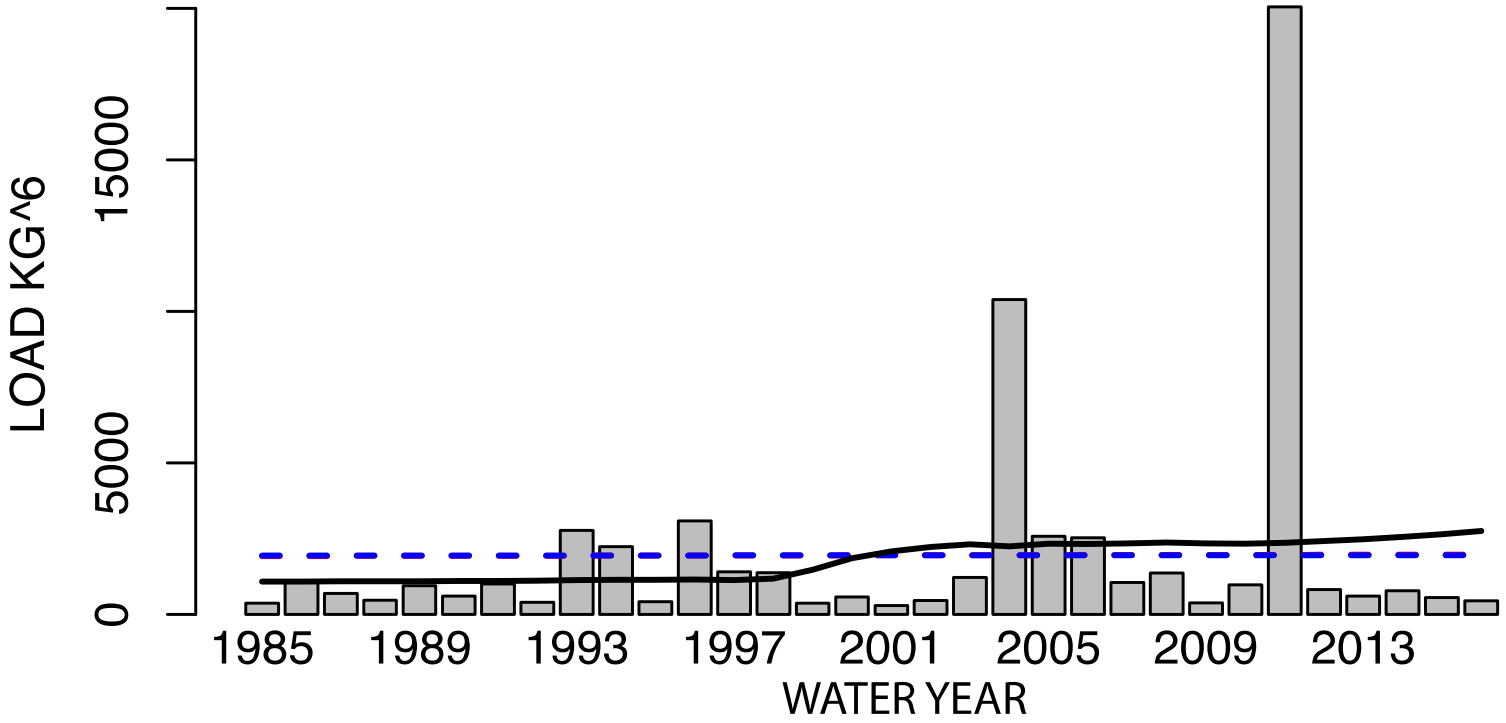
Trends in Observed Loads

SUSQUEHANNA RIVER AT CONOWINGO, MD
SUSPENDED SEDIMENT



Sen Slope **1.58** Mkg/yr, MK p=0.92
Seasonal Sen Slope **-0.294** Mkg/yr, SK p=0.8

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Summary of Observed and Flow-Normalized Change

	Total Nitrogen		Total Phosphorus		Suspended Sediment	
	Observed Slope	Flow-Normalized Slope	Observed Slope	Flow-Normalized Slope	Observed Slope	Flow-Normalized Slope
Choptank	**0.00406**	0.00701	**0.000453**	**0.00586**	**0.0332**	-1.06
Susquehanna	**-0.378**	**-10.1**	**0.6**	**2.03**	0.00227	**1660**
Patuxent	**-0.013**	**-0.816**	**-0.000497**	**-0.082**	**0.462**	-13.3
Potomac	-0.0475	**-2.33**	-0.00285	**-0.325**	-10.7	-891
Rappahannock	0.00305	**-0.541**	**0.00393**	0.0653	**2.83**	**85.1**
Mattaponi	-0.00333	0.00792	0.000409	**0.0277**	0.351	**20**
Pamunkey	0.000243	**-0.0213**	-0.0000166	-0.000218	0.00737	-0.39
James	**-0.0587**	**-1.12**	-0.0269	-0.626	-11.3	**163**
Appomattox	**-0.00499**	-0.0153	-0.000193	**0.0228**	**-0.135**	0.205

Slope reported in million kg/yr

Decreasing
Increasing

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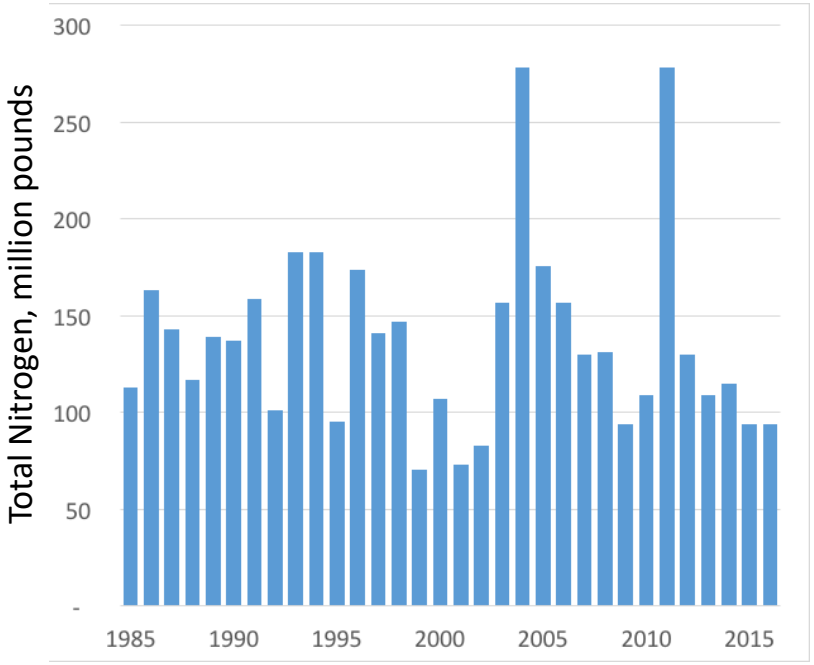
Load vs. Flow Weighted Concentration Trend

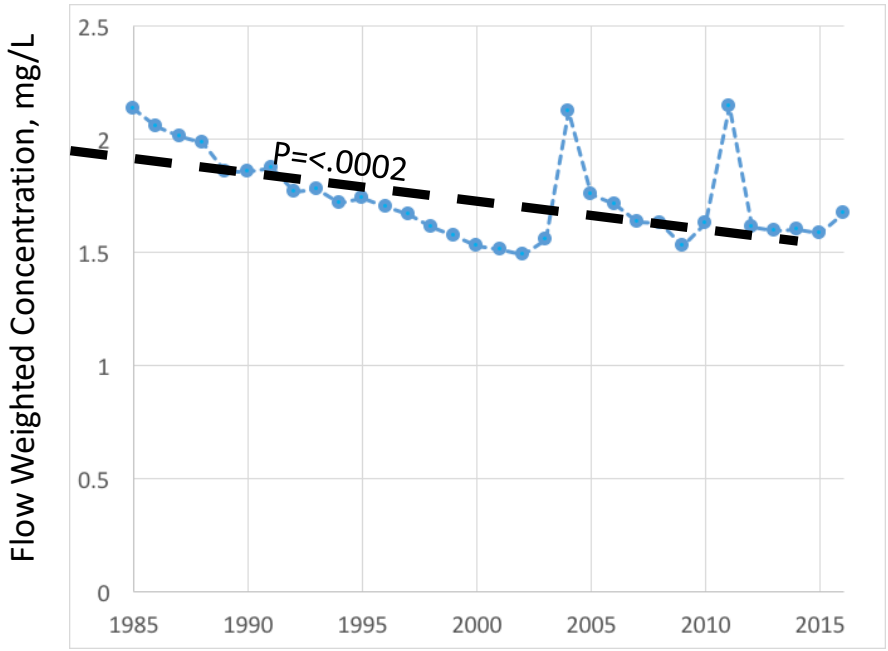
Susquehanna River at Conowingo, Md.

$$\text{Flow-Weighted Concentration} = \frac{\text{True Condition Load}}{\text{Annual Flow}}$$

True Condition Load



Flow-Weighted Concentration



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Summary of Flow Weighted Concentration Trends

	Mean annual FWC, mg L-1			Change in FWC, mg L-1		
	P00600	P00665	P80154	P00600	P00665	P80154
Choptank	1.7	0.1	16	0.12	0.021	0.57
Susquehanna	1.7	0.07	43	-0.18	1.00E-04	-0.47
Patuxent	2.2	0.17	68	-0.69	-0.05	1.1
Potomac	2	0.15	110	-0.13	-0.012	-2.9
Rappahannock	1.2	0.19	140	-0.039	0.0047	6.03
Pamunkey	0.74	0.09	44	0.015	0.014	5.3
Mattoponi	0.6	0.06	14	-0.018	-0.0007	0.049
James	0.78	0.17	110	-0.11	-0.061	-0.55
Appomattox	0.61	0.06	15	-0.004	0.0054	-0.83

Decreasing
Increasing

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A History of Nutrient and Sediment Inputs to Chesapeake Bay: 1985-2016

ESTIMATED LOADS DOWNSTREAM FROM MONITORING

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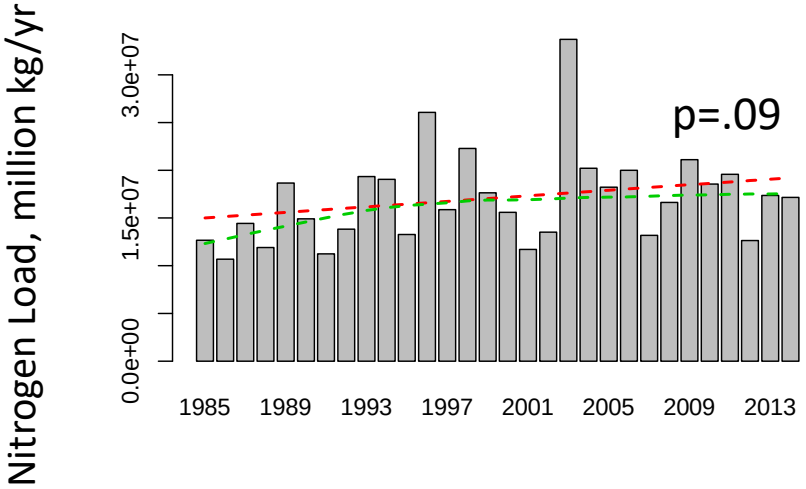
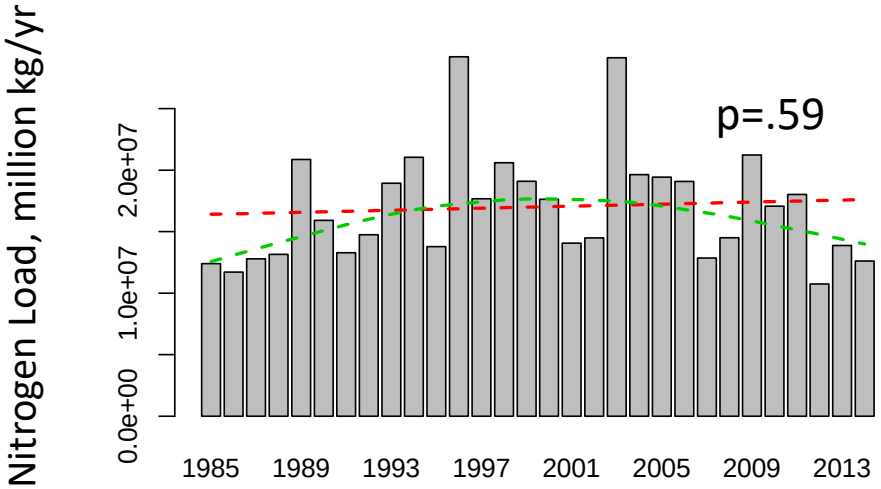
Unmonitored Nonpoint source Nitrogen

From CBP WSM 6.0 Calibration runs

Western Shore



Eastern Shore



Sen Slope Line

Loess Smooth

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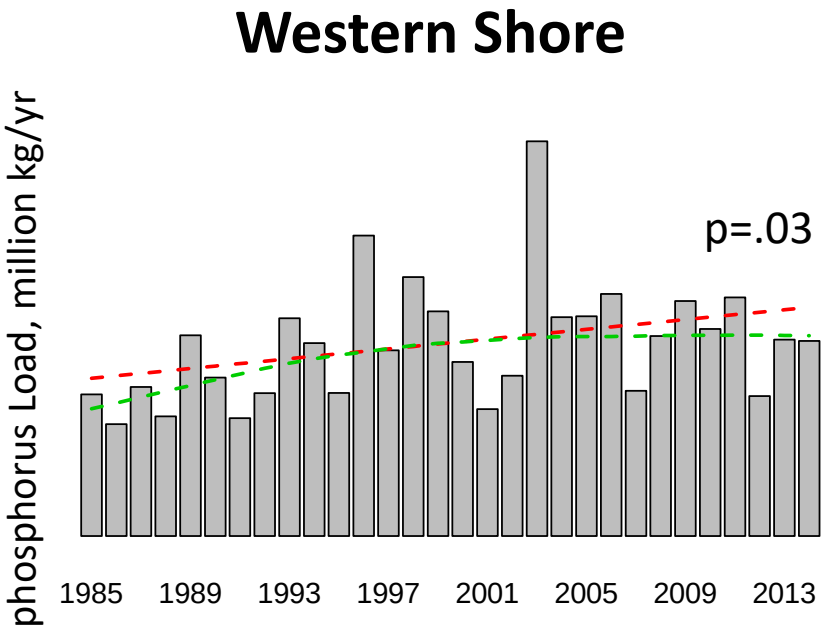
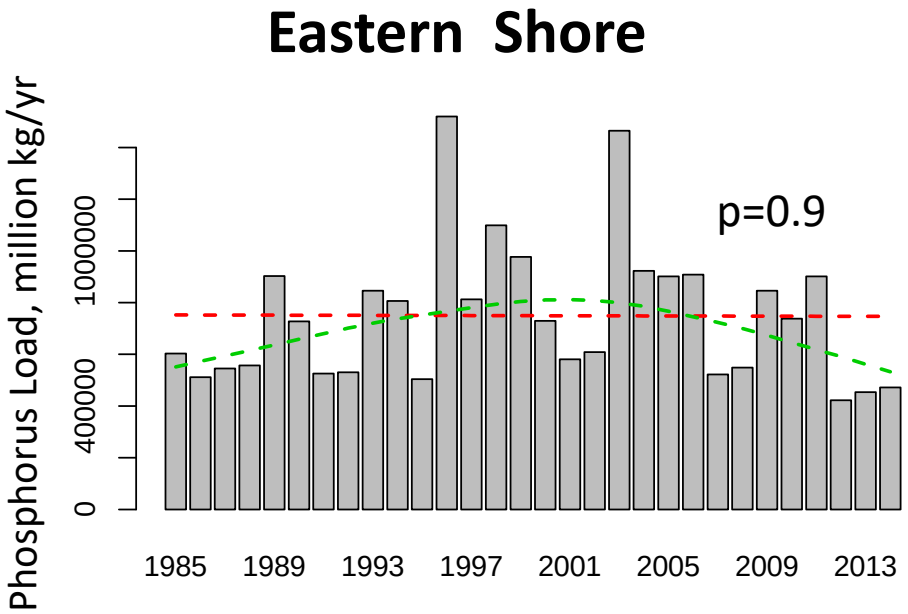
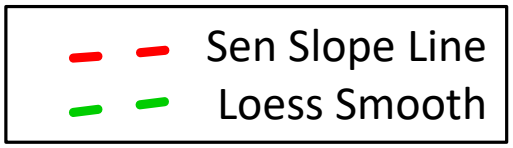
Unmonitored Nonpoint source Phosphorus

From CBP WSM 6.0 Calibration runs







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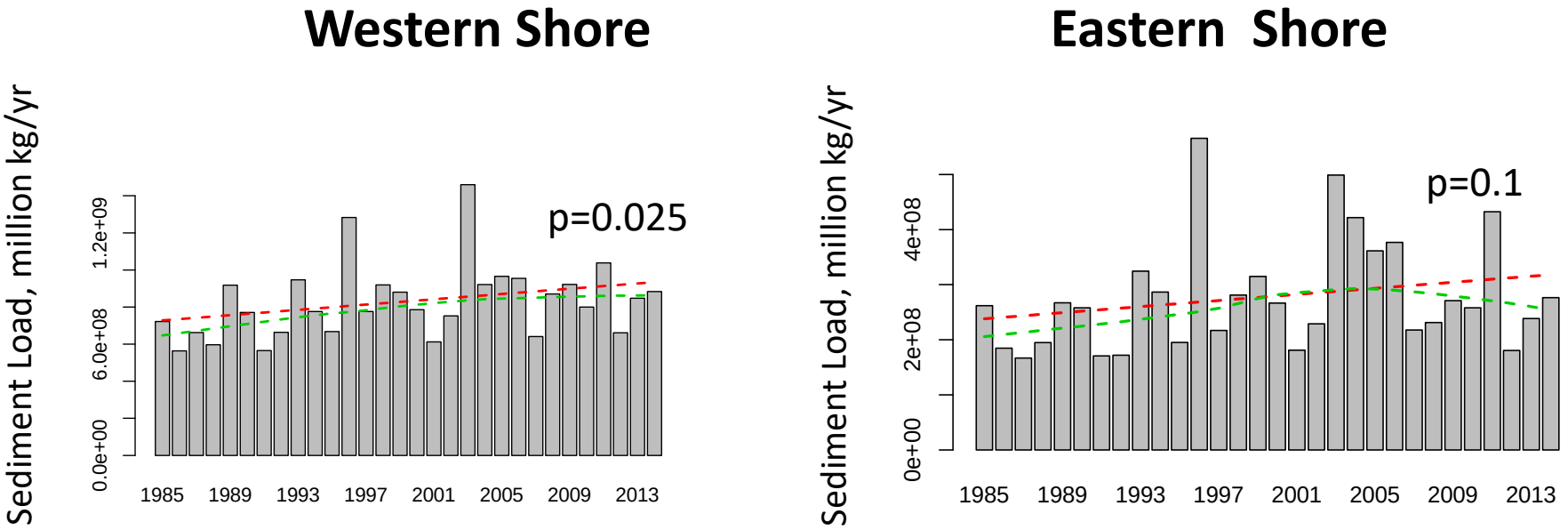
Unmonitored Nonpoint source Suspended Sediment

From CBP WSM 6.0 Calibration runs



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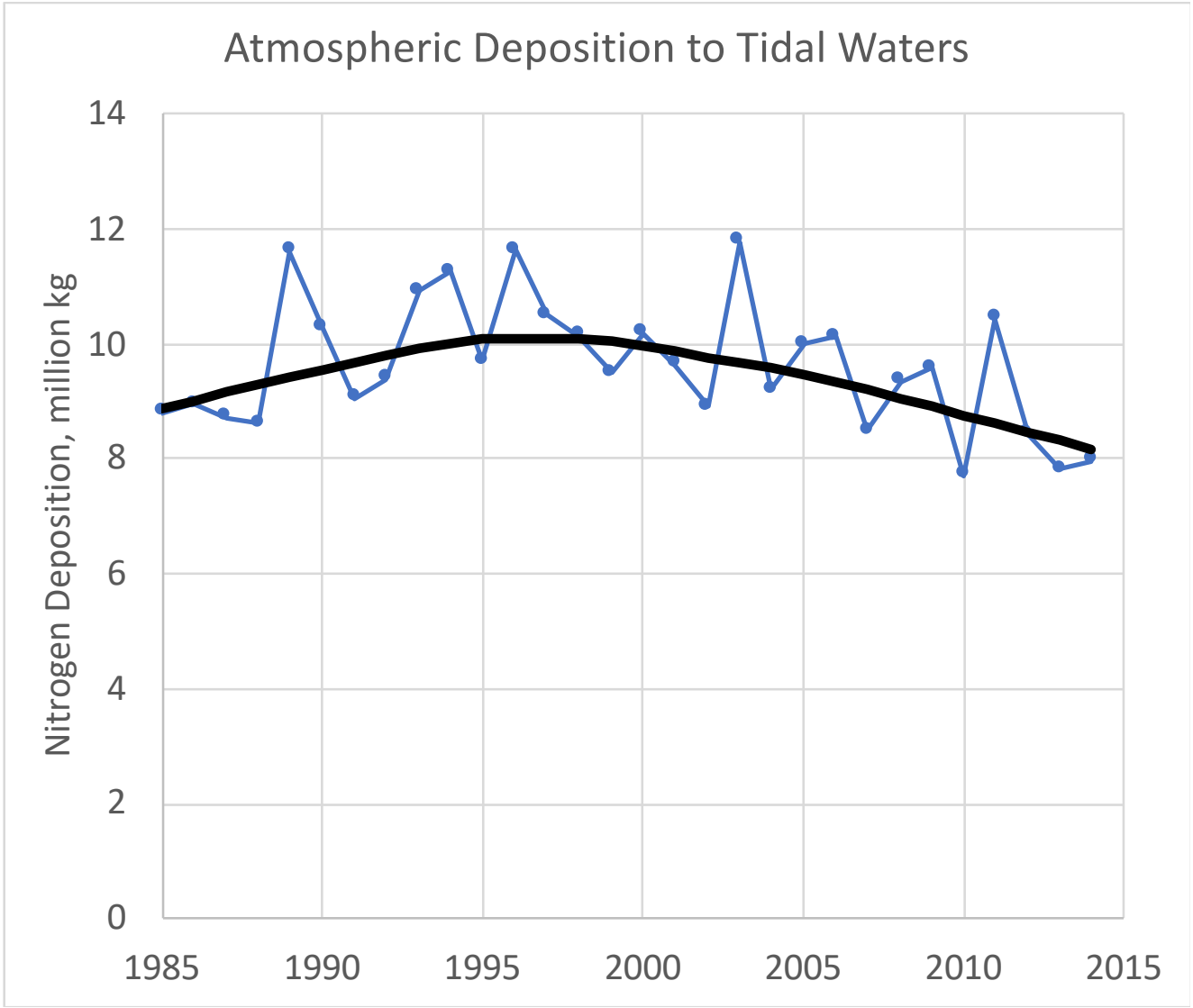
Direct Nitrogen Deposition to Tidal Waters



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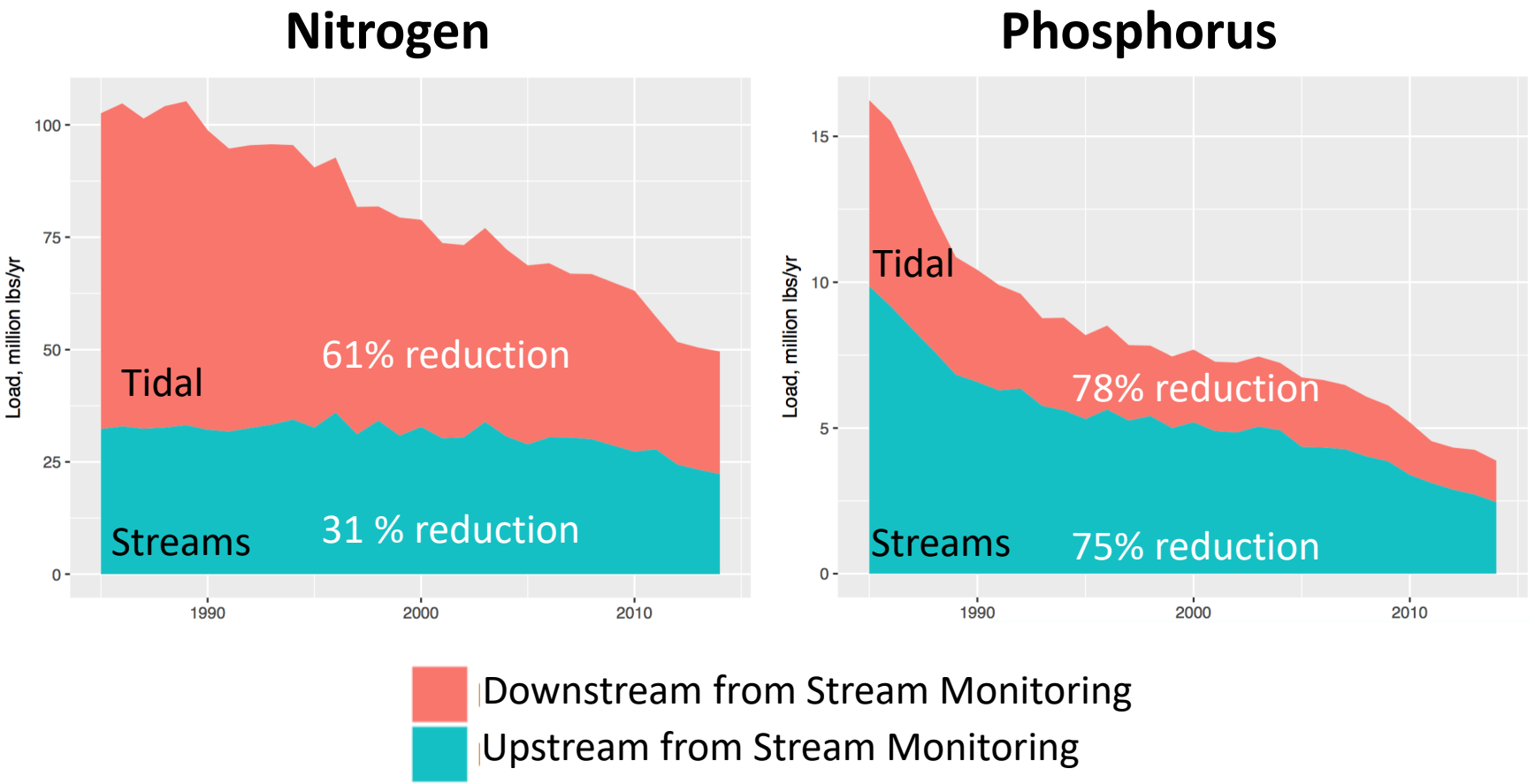
Wastewater Load Reduction



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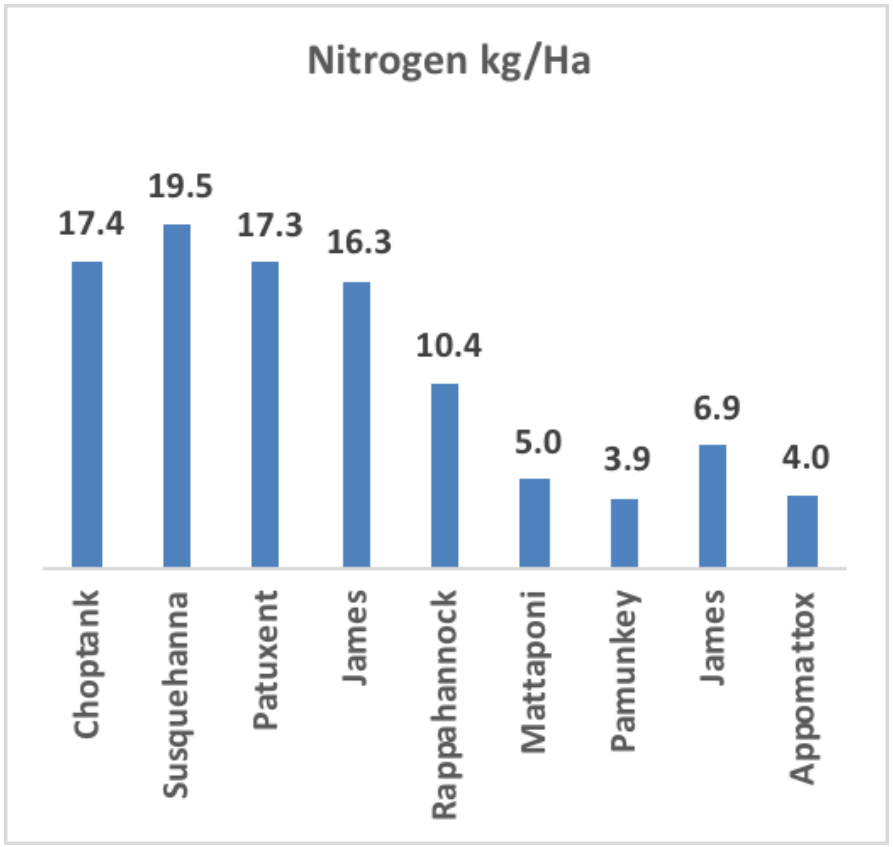
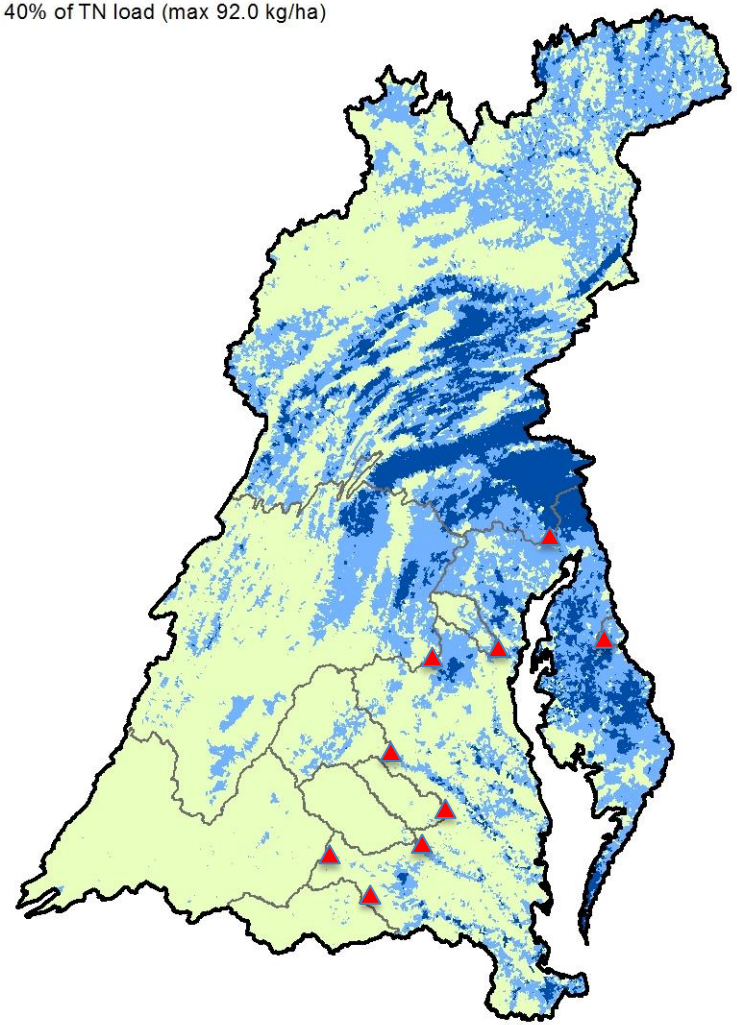
Nitrogen Sources





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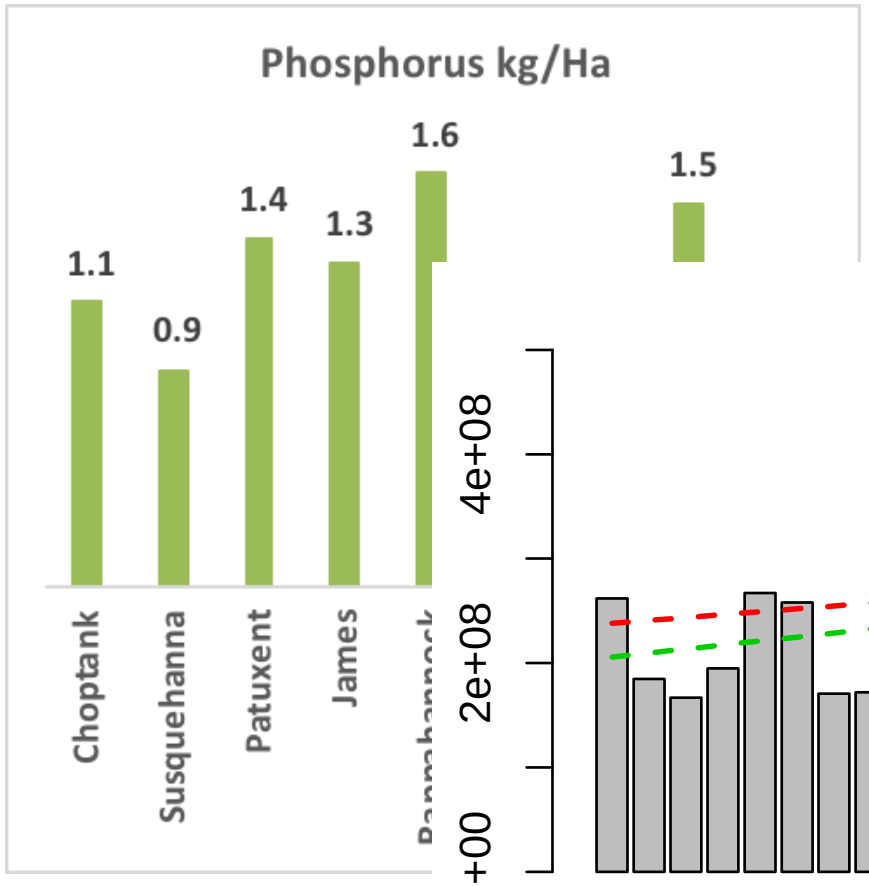
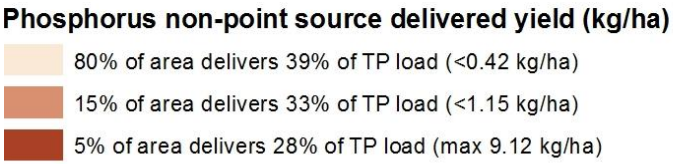
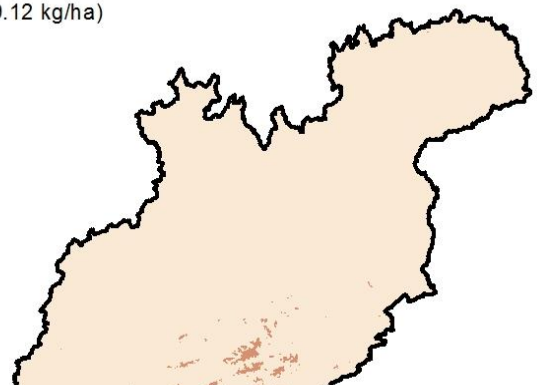
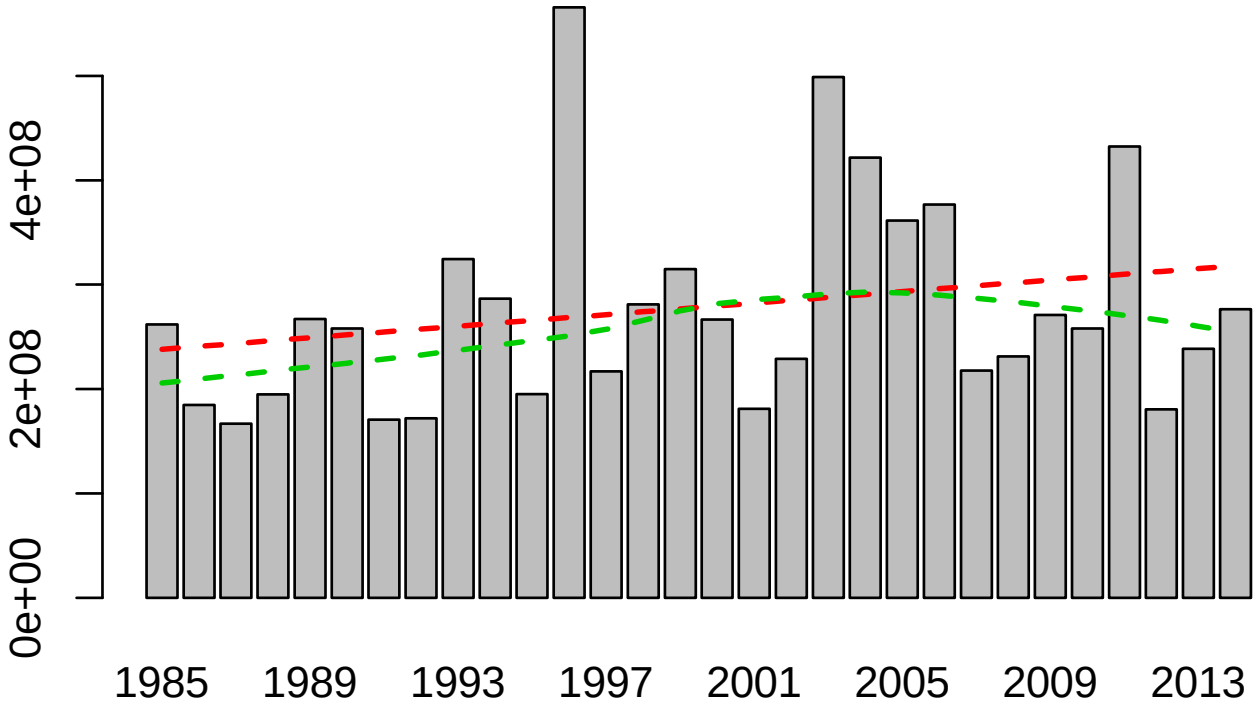
Phosphorus Yields









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Summary of Findings

- Observed long-term trends in loads at times differ from flow-normalized trend estimate.
- Realized changes are often considerably smaller than flow-normalized results suggest.
- Interannual variations in weather and streamflow can mask real changes in mass flux delivery to the bay.
- Flow-Weighted concentration trends indicate a real difference in the quality of water entering the bay.

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Implications from measures of progress

- Eastern Shore NPS show little change, yet Choptank River continues to Show increasing trends.

- Watershed model results for the Western shore shows continued slight increases in loads, which are consistent with development in unmonitored regions.

- Sediment and phosphorus trends at the Susquehanna River at Conowingo suggest that impacts of reservoir infill on Chesapeake Bay are largely episodic.

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