



# Developing County Level Time Series of Nutrient Inventories and Trend Maps

Presentation of Draft Manuscript and other Updates

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**Modeling Workgroup Quarterly Review**

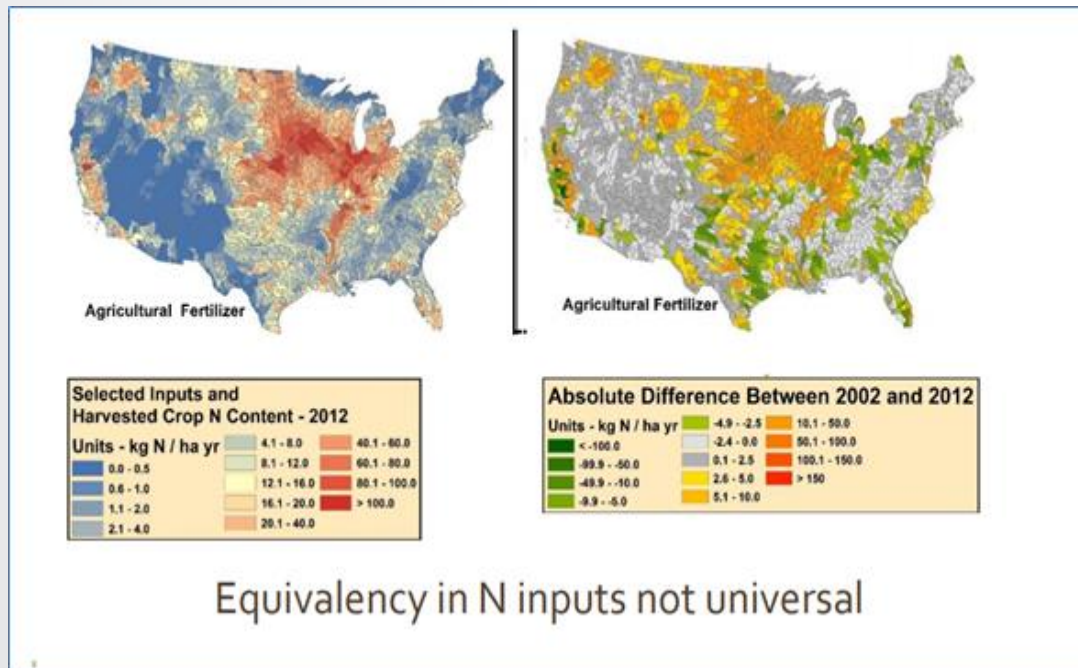
**January 6, 2021**

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- Overview of the Chesapeake Bay Inventory and associated products
- Presentation of the Draft Chesapeake Bay Inventory Manuscript
  - Agricultural Nutrient Efficiency
  - Agricultural Surplus
  - Atmospheric N Deposition
  - Point Source Loads
  - State Level Effects
- Discussion on next steps

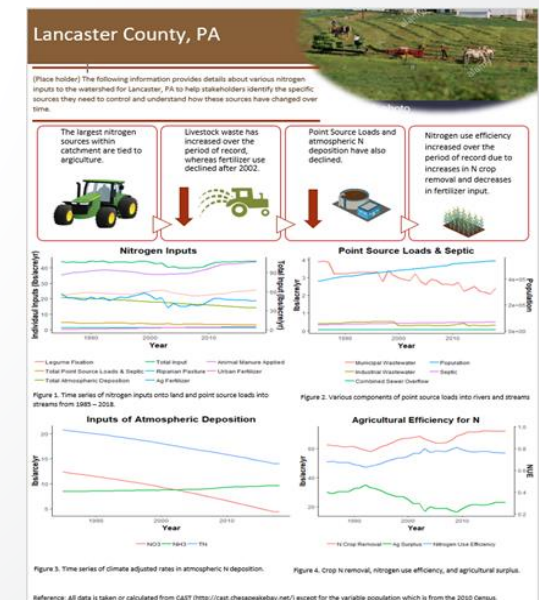
# A reminder...

**Previous Work:** a national nutrient inventory.



**Our Work:** a Chesapeake Bay Watershed nutrient inventory:

- Factsheets to show N/P fluxes
- **Manuscript introducing the inventory**



# What is in the Chesapeake Bay Nutrient Inventory?

All counties, 1985-2019

## Nitrogen

Municipal Wastewater Treatment Plant Load
Industrial Wastewater Treatment Plant Load
Combined Sewer Overflow Loads
Septic (normalize by County Total Area)
Total point source load = MWTP+IWTP+CSO
Total N removed by crop
Atmospheric Oxidized Nitrogen Deposition
Atmospheric Reduced nitrogen Deposition
Atmospheric Organic Nitrogen Deposition (deposited to surface water only)
Total Atmospheric Nitrogen Deposition
Poultry Manure Applied
Livestock Manure Applied
Poultry and Livestock Manure Applied
Livestock Manure Deposited into Stream/Riparian Area
Agriculture Biosolids
Urban Biosolids (ag biosolids put on developed sector)
Direct Manure Deposited on Pasture
Agriculture Fertilizer
Urban Fertilizer
Total Agricultural Application
Total N Fixed by Legumes
Total Nitrogen Input
Agricultural Surplus
Nitrogen Use Efficiency

## Phosphorus

Municipal Wastewater Treatment Plant Load
Industrial Wastewater Treatment Plant Load
Combined Sewer Overflow Loads
Septic (normalize by County Total Area)
Total point source load ( MWTP+IWTP+CSO)
Total P Removed by Crop
Atmospheric Inorganic P Deposition (deposited onto water)
Atmospheric Organic P Deposition (deposited onto water only)
Total Atmospheric P Deposition (PO4LbsPerAcre+ORGLbsPerAcre)
Poultry manure applied
Livestock manure applied
Poultry and Livestock manure applied
Livestock manure deposited into stream/riparian area
Agriculture Biosolids
Urban Biosolids
Direct manure deposited on pasture
Agriculture Fertilizer
Urban Fertilizer
Total Agricultural Application
Mass of P in the Soil
Total Phosphorus Inputs
Agricultural Surplus
Phosphorus Use Efficiency



# Statewide and county level progress in decreasing likely sources of nutrient pollution to surface water in the Chesapeake Bay watershed

Manuscript introducing the Chesapeake Bay Inventory

- Compile nutrient inventory of relevant inputs and outputs at the county level from CAST (1985-2019) for N and P
- Derive relevant metrics
- Describe the spatiotemporal variability and potential trends of the inventory with particular emphasis on:
  - Agricultural Nutrient Efficiency
  - Agricultural Surplus
  - Atmospheric N Deposition
  - Point Source Loads
- Evaluate state level effects to *statistically* explore potential jurisdictional influence on county level trends
- Assess summed changes in inventory variables at the state level

# Reminder on how we calculated agricultural surplus and nutrient use efficiency

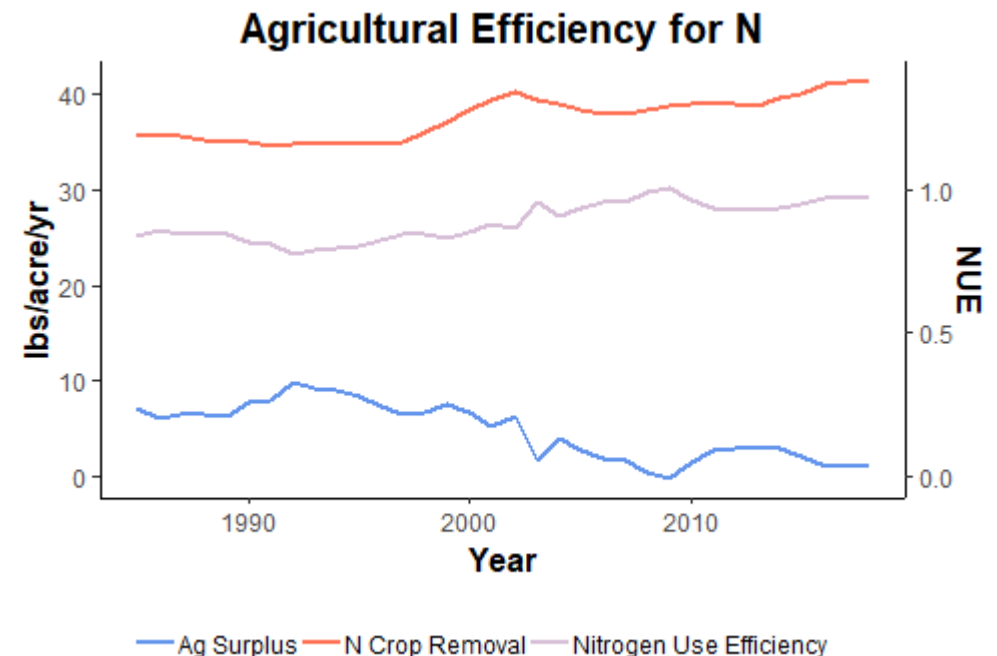
**Ag Surplus** is the extra N ag inputs not removed in crops

- **Ag Surplus** = Legume + Animal Manure Applied + Atm Dep On Ag Land + Ag Fertilizer + Direct Deposited Manure - N Crop Removal

**Nitrogen Use Efficiency (NUE)** is the proportion of N inputs removed from the field after harvest (crop out for N put in).

- **NUE** = N Crop Removal / (Legume + Animal Manure Applied + Atm Dep On Ag Land + Ag Fertilizer + Direct Deposited Manure)

## Washington County, MD





# Statistics to evaluate temporal trends and state level mean differences

## County Level Trend Test on all Inventory Variables

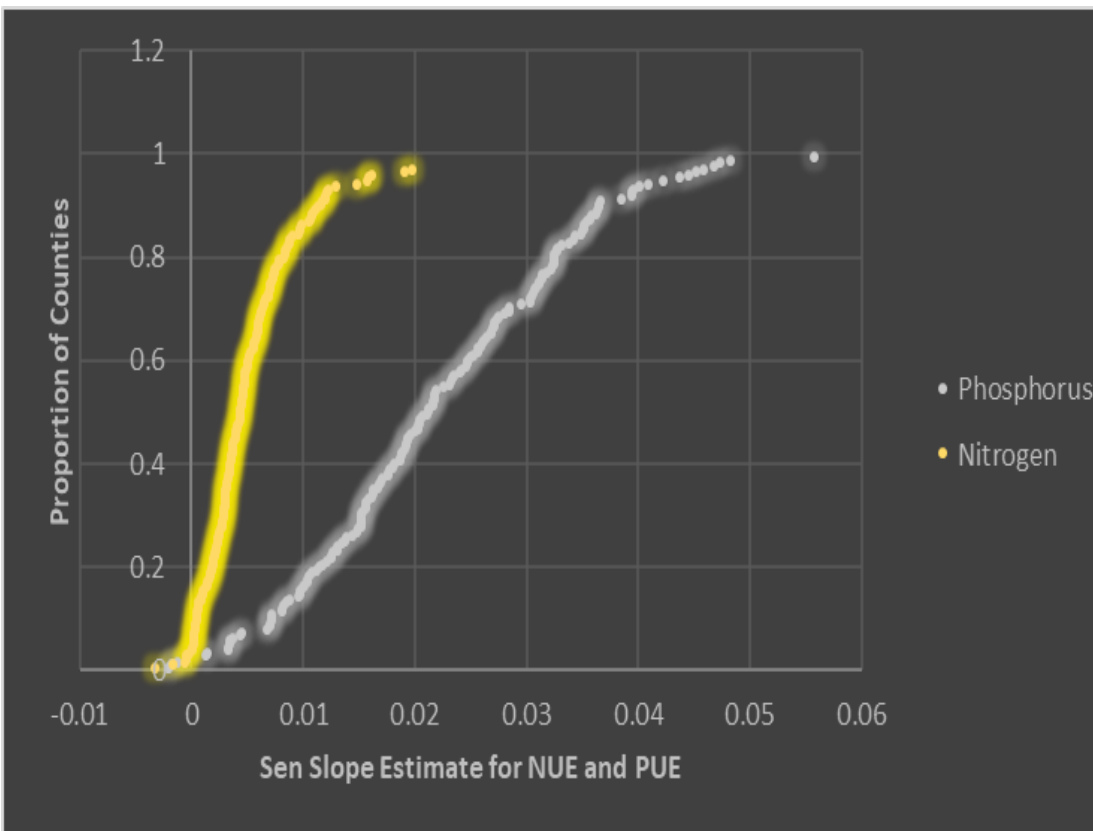
- Mann-Kendall trend test
  - Evaluated for monotonic increasing or decreasing trends through 1985-2019
- Theil-Sen Slope estimates
  - Non-parametric linear slope estimate

## Test for state level differences in mean trend slopes on a subset of variables

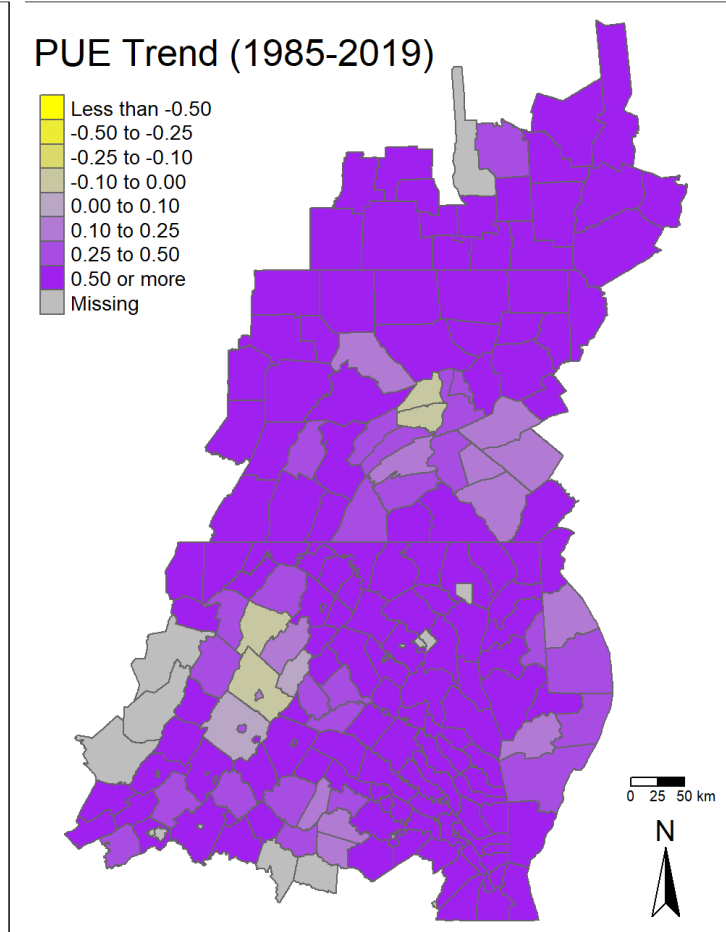
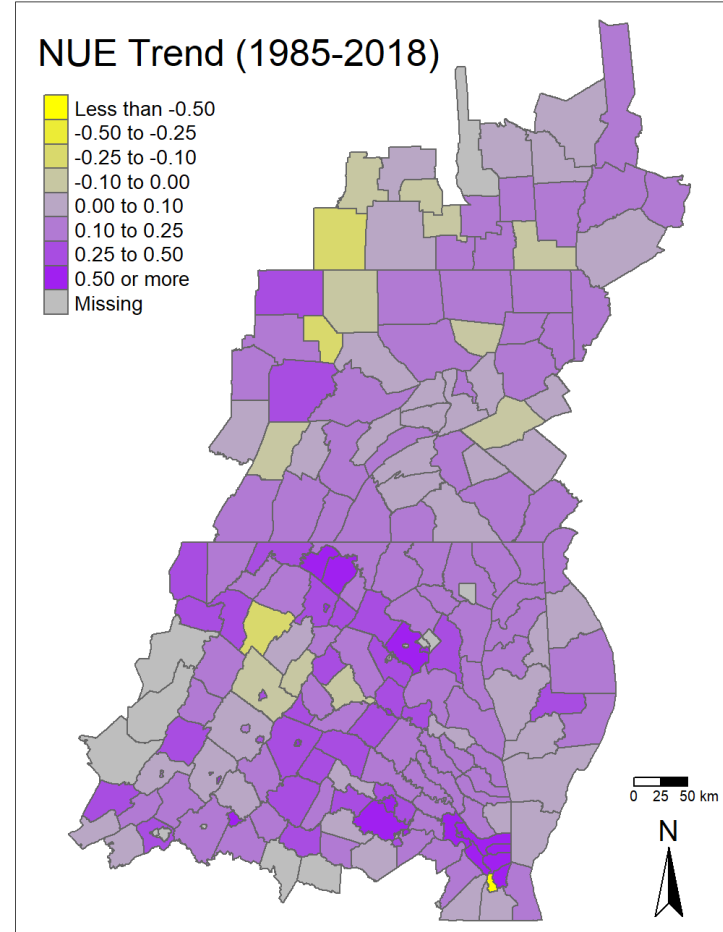
- GLM/ANCOVA (Analysis of Covariance)
  - Unlike ANOVA, ANCOVA can account for covariates that may bias the mean
  - We account for the magnitude of 1985 inventory values before evaluating differences in state level means



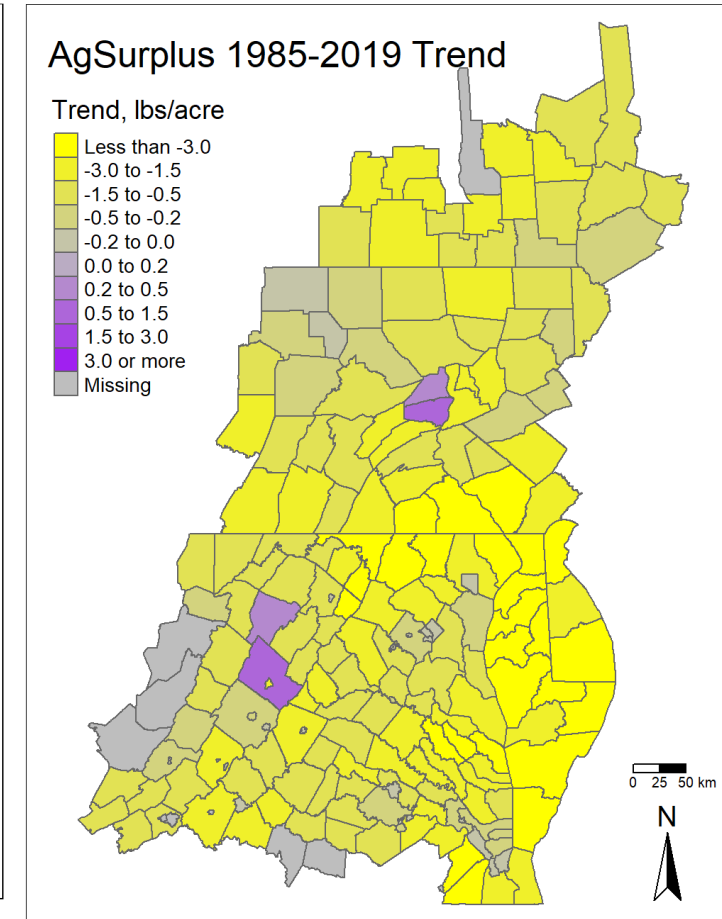
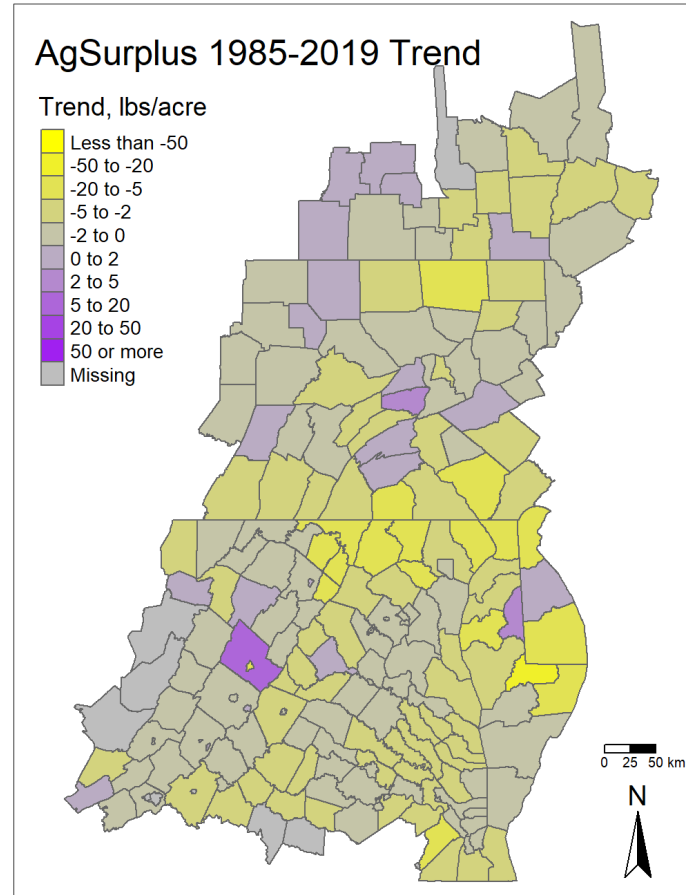
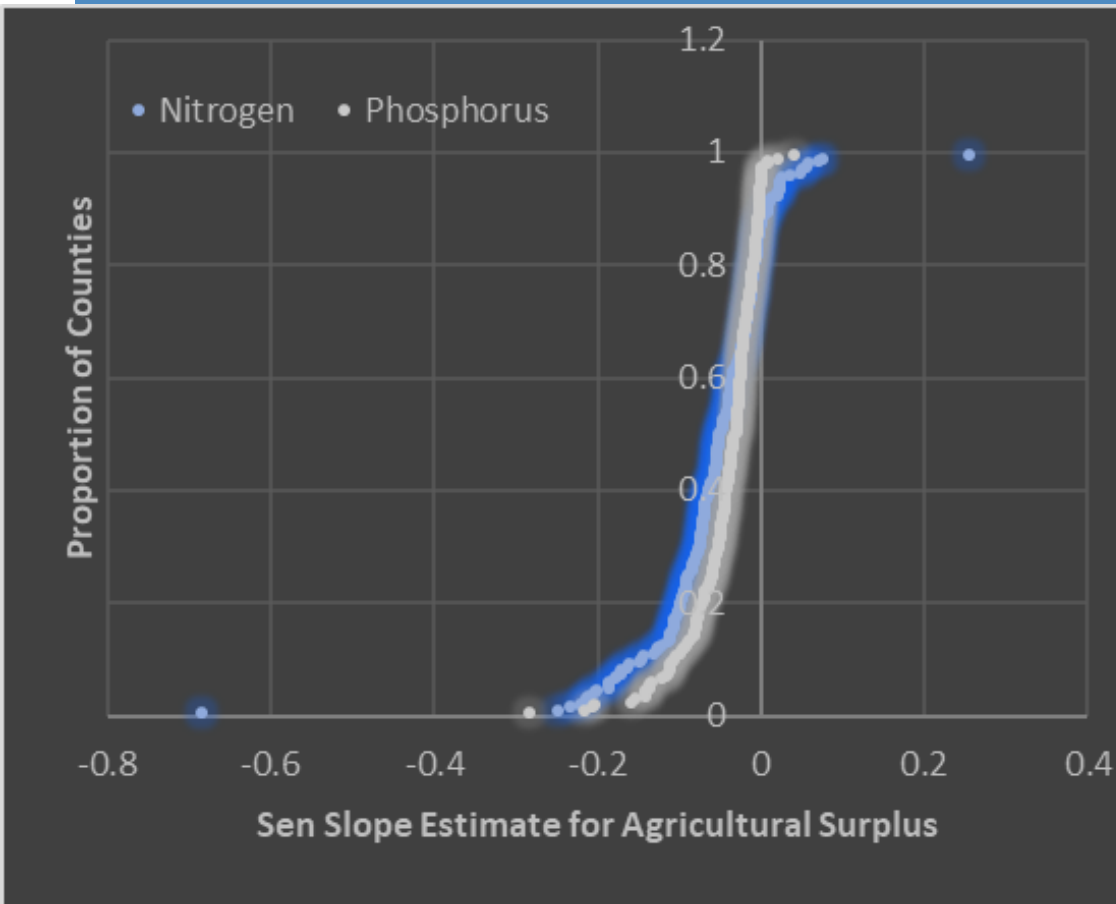
# County level trends in NUE and PUE: agriculture is becoming more efficient in throughout the Chesapeake



1. Phosphorus use efficiency has increased at a greater rate compared to nitrogen
2. Only a few of the major agricultural counties had declines in nutrient use efficiency

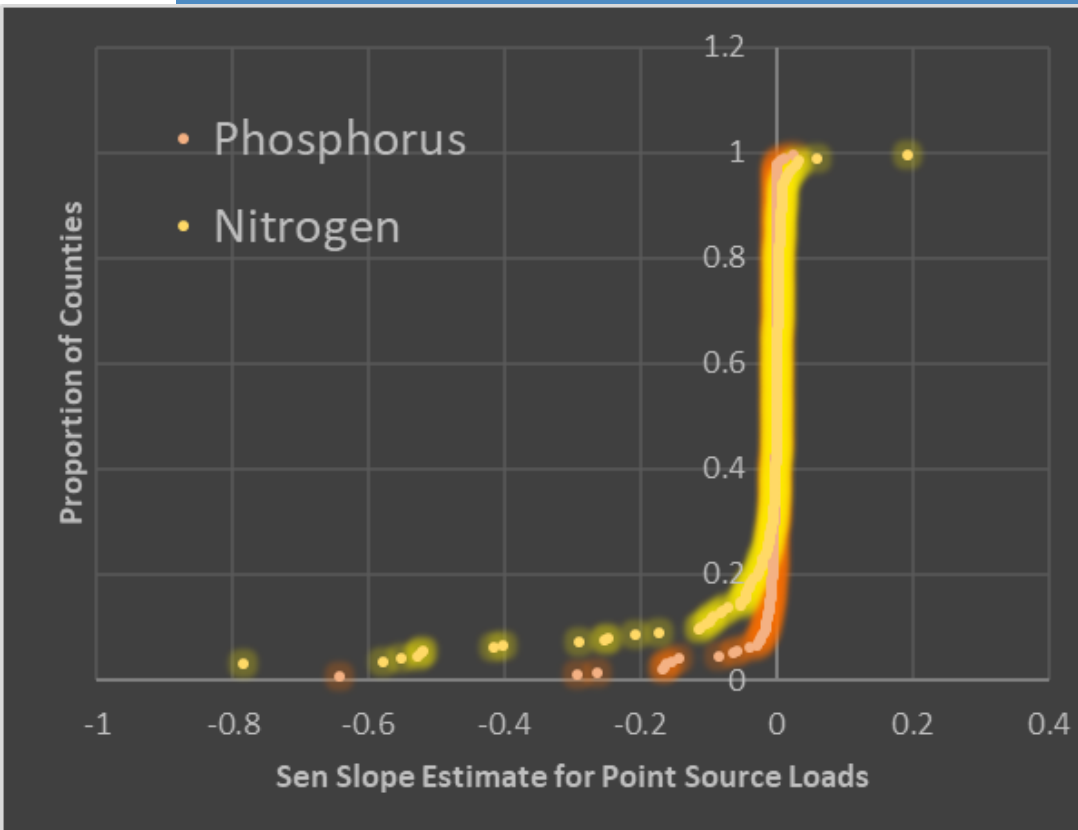


# County level trends in agricultural surplus: non-point source pollution from agriculture likely to decline or continue to decline if trends persist

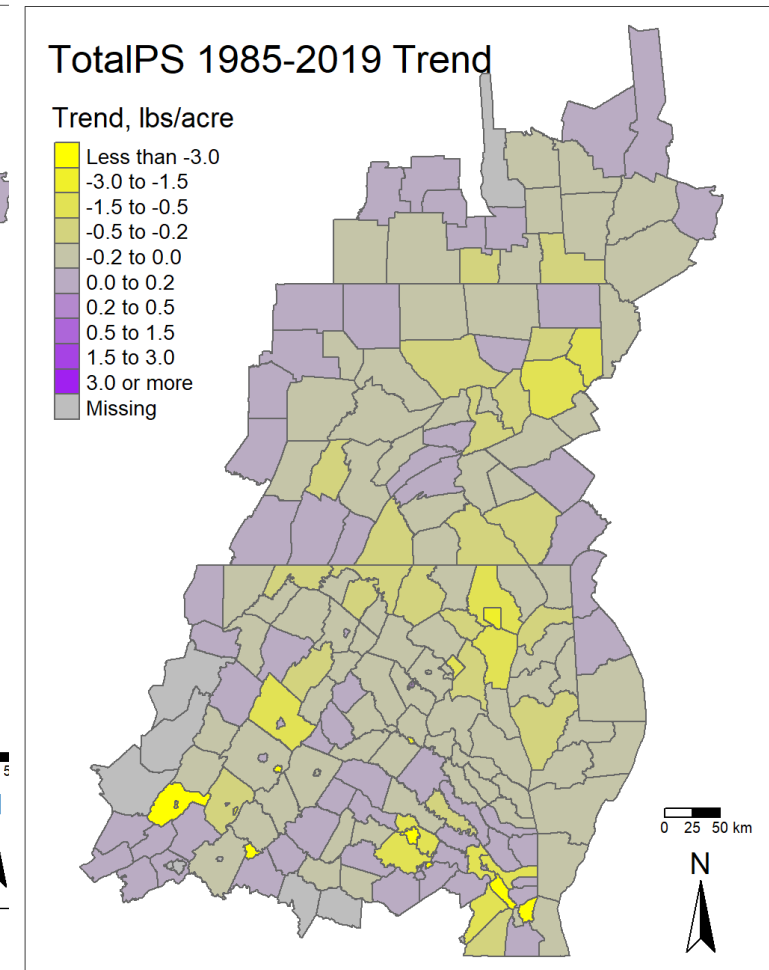
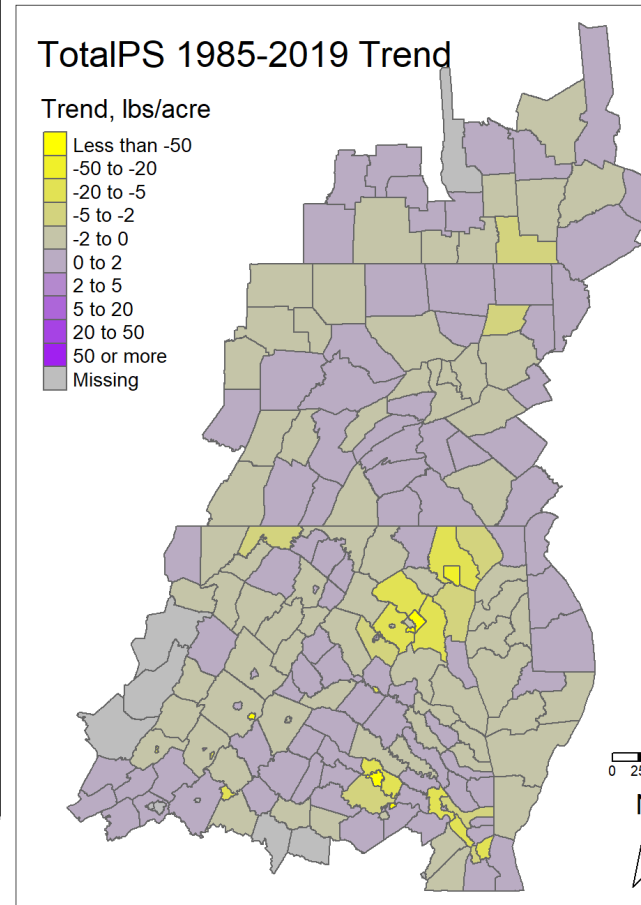


- Agricultural nutrient surplus has largely declined, especially for P
- Wicomico County, MD had the greatest decline in surplus and Rockingham County, VA had the biggest increase over the period of record (please note this analysis did not consider short-term trends)

# County level trends in point source loads: largely declining in urban areas

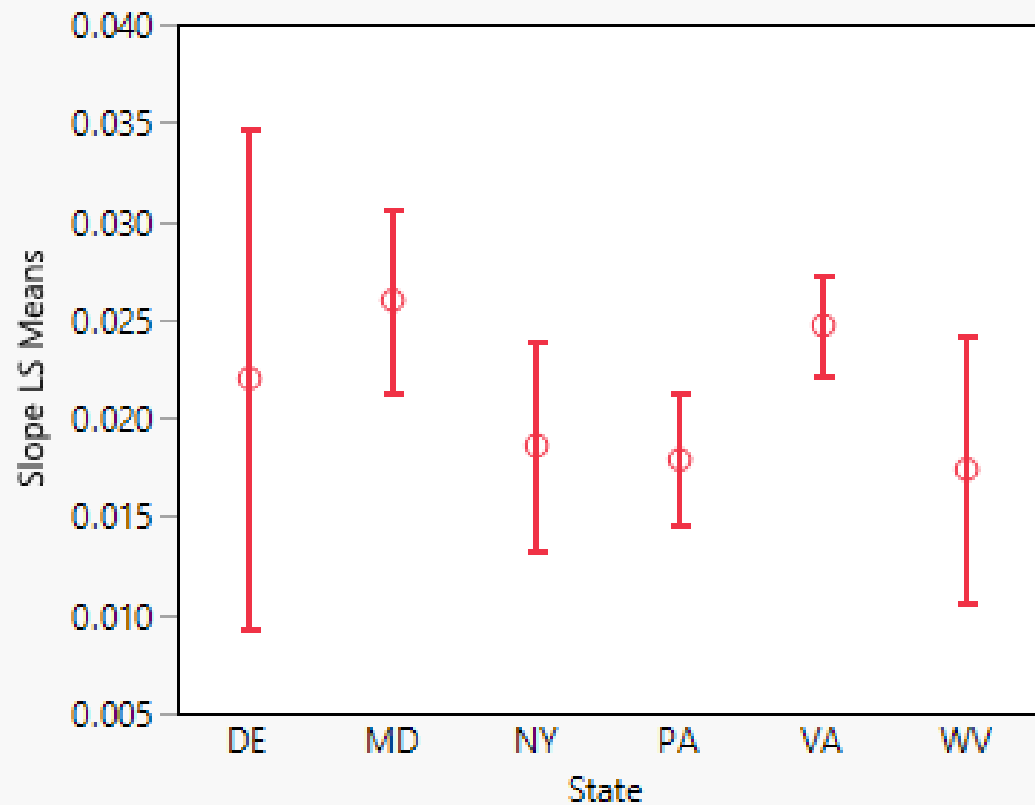


1. For N, Hopewell, Alexandria, DC, Richmond, and Waynesboro had slopes  $< -1$ 
  - a. Likely due to industrial decline (for the small VA cities) and/or major upgrades to WWTP and small city area

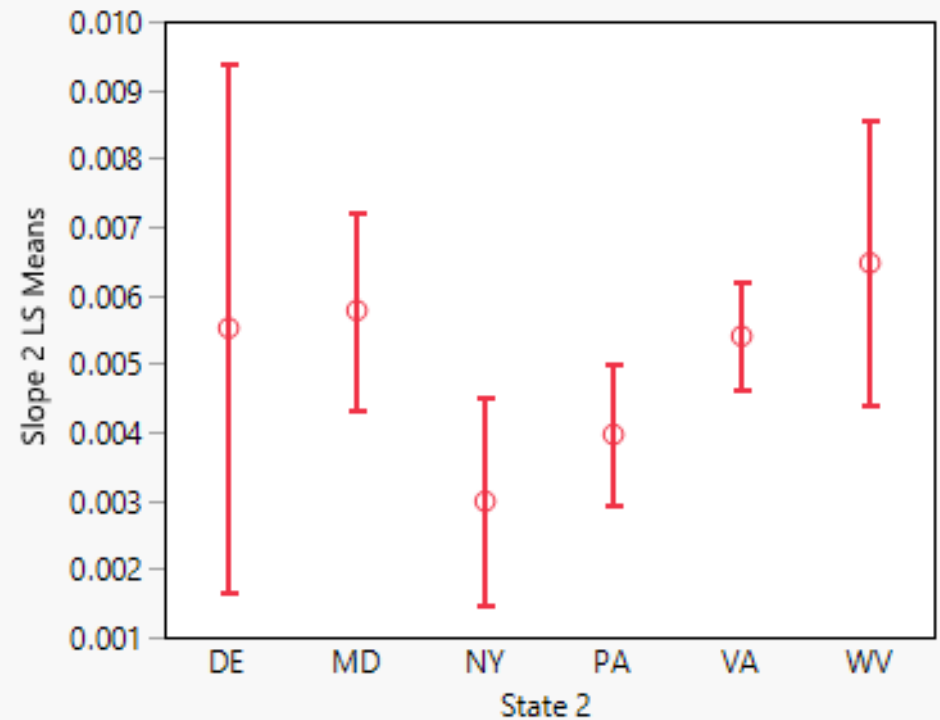


# Maryland and Virginia generally had the biggest gain in nutrient use efficiency

PUE

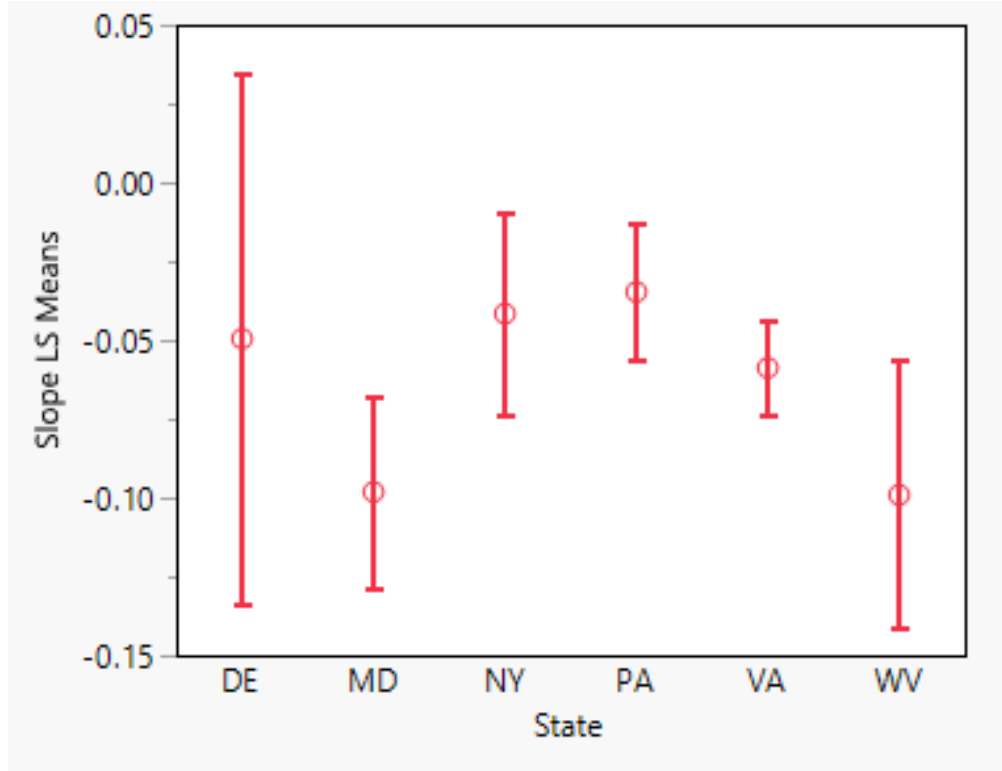


NUE

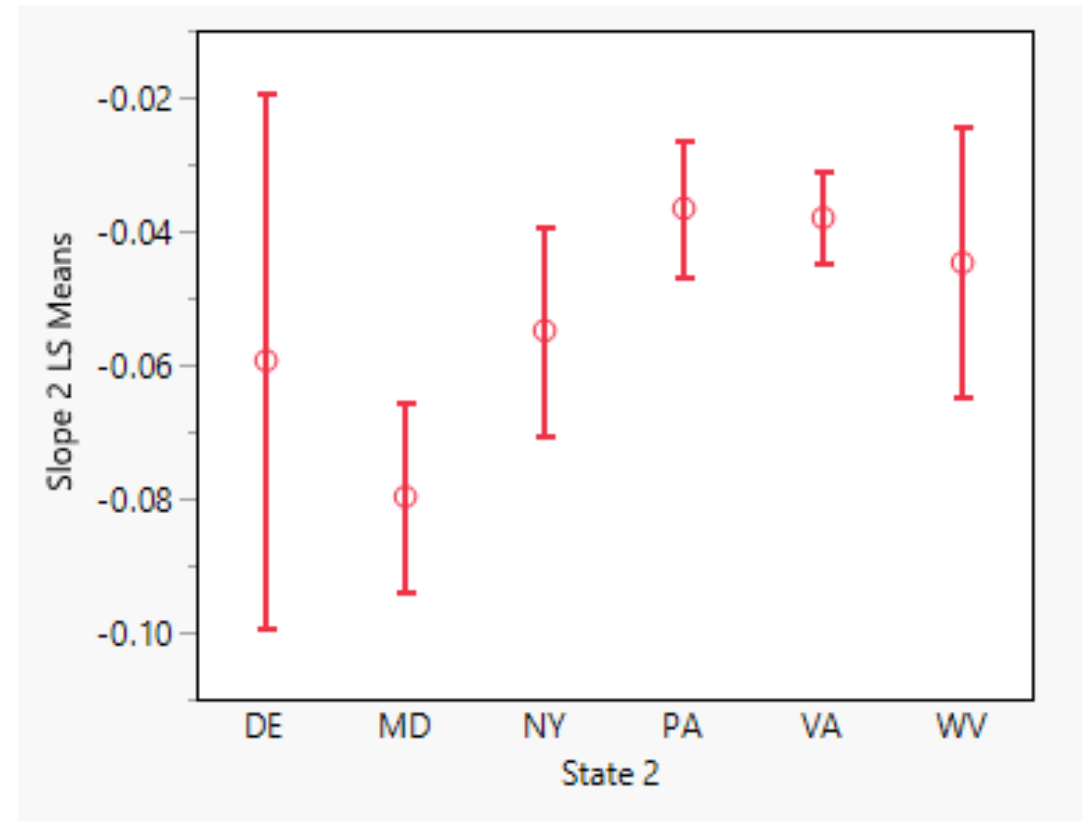


# Maryland had the largest mean decline in agricultural surplus

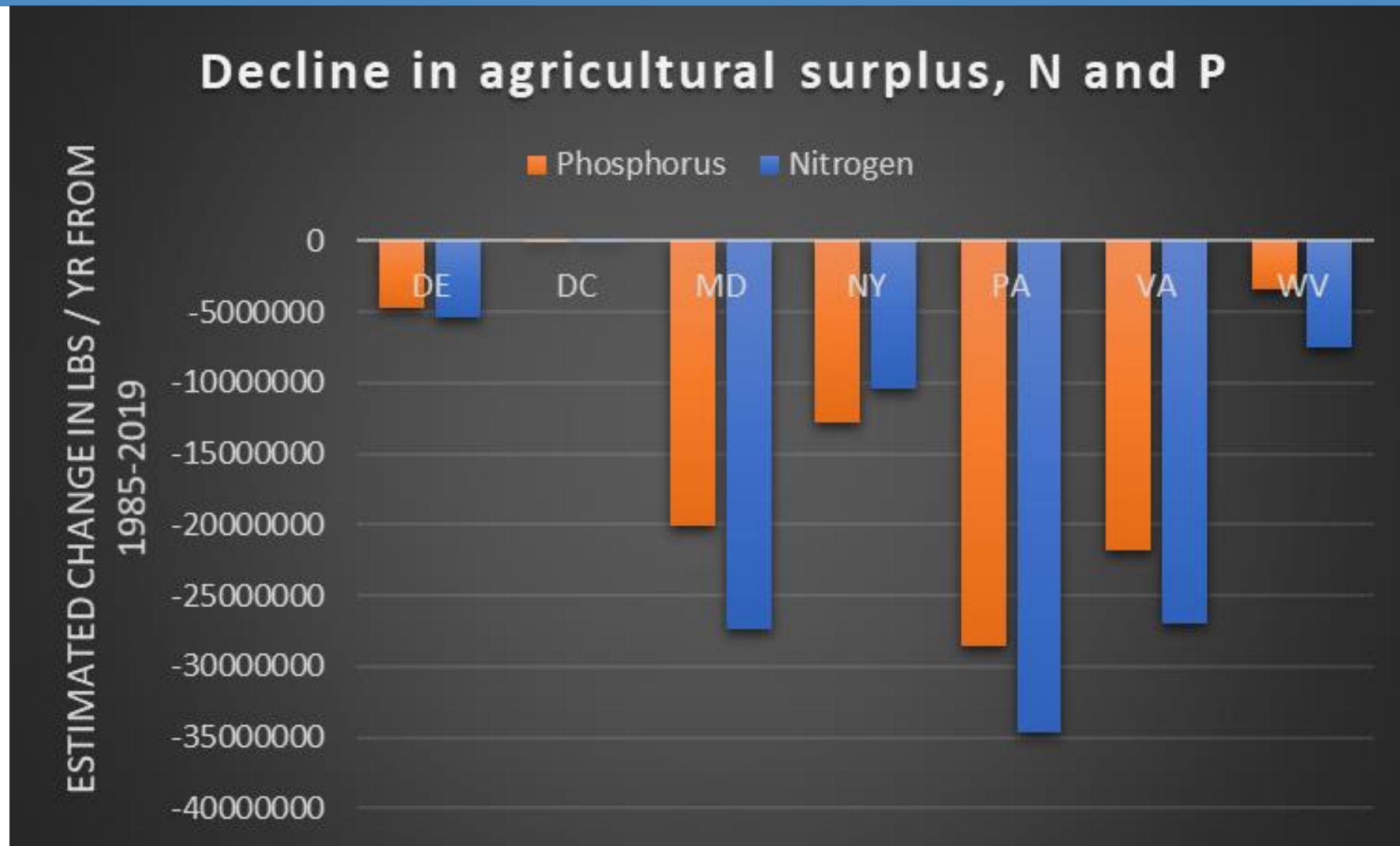
## Nitrogen Surplus



## Phosphorus Surplus

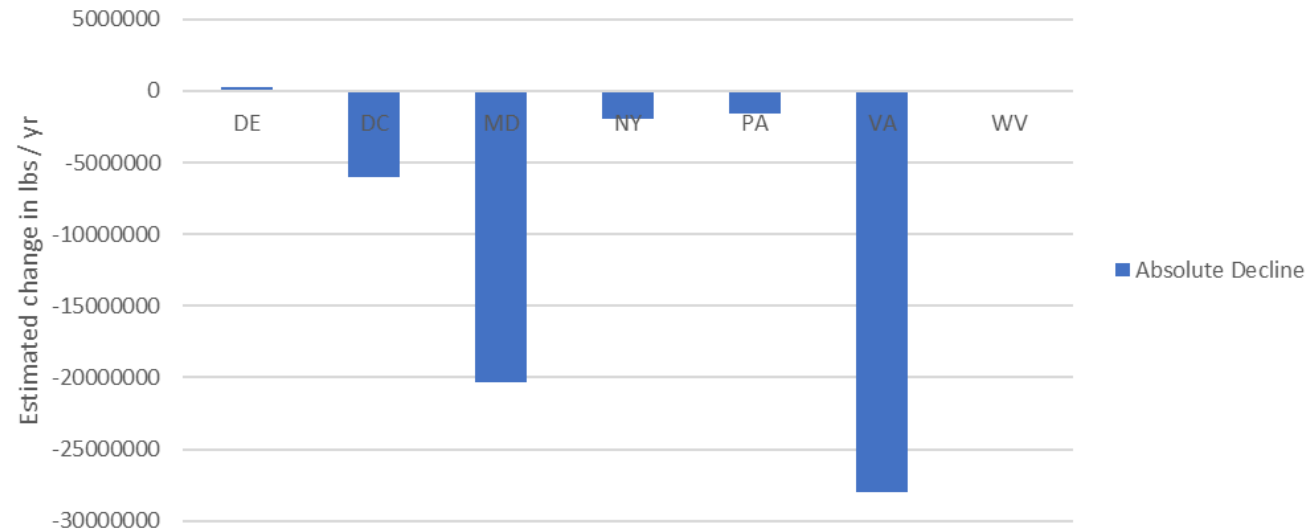


# Large declines in agricultural surplus

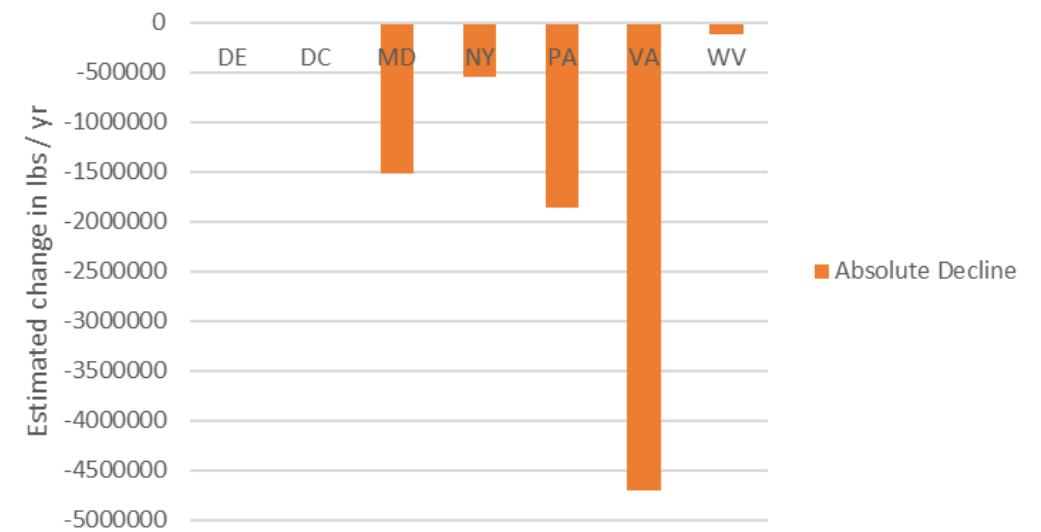


# No difference in mean slopes among jurisdictions for point source loads, so relied on estimated total reductions

Decline in point source loads by state, N



Decline in point source loads by state, P

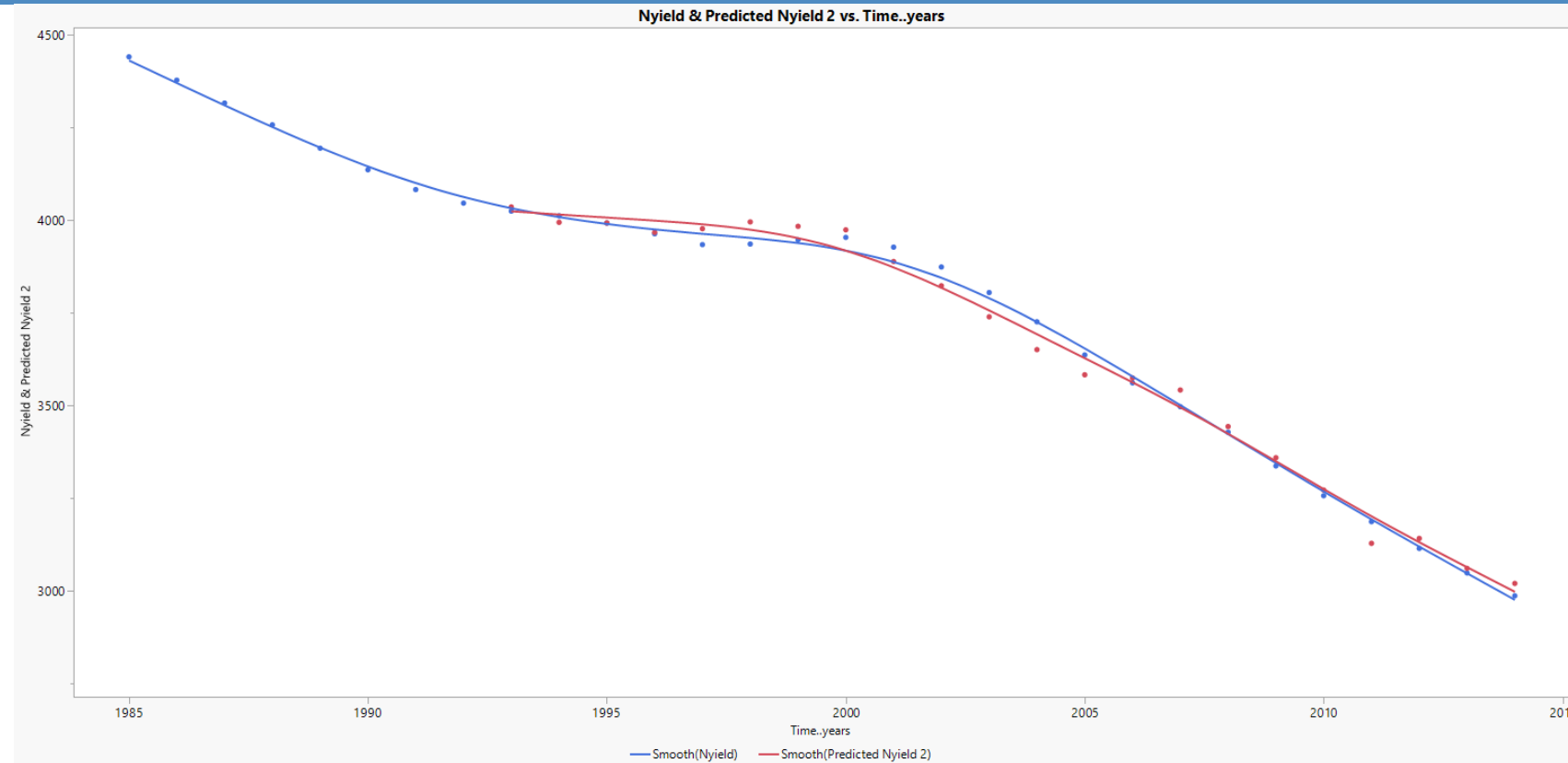




# Discussion

- Likely sources of point and non-source pollution in the Chesapeake are largely declining throughout the Bay watershed
  - Atmospheric deposition essentially declined Bay-wide
  - Agricultural surplus is decreasing with P surplus declining at a greater relative rate
  - Point source loads are declining in major urban areas and smaller industrial towns and cities.
- Significant difference in agricultural trends among states
  - MD generally has had the biggest mean gains in efficiency and decreases in surplus
  - PA had the largest decline in surplus
- No state level effect detected on mean slopes in total point source loads
  - MD and VA have the largest reductions, however.
- What's driving these statewide differences?

# Linking CAST/Inventory to observed shifts in water quality



- CBP Factors Team are down-scaling CAST input data to develop empirical models to explain observed changes in nutrient loads
  - Proposal developed by Jeff Chanat
- Example to the left, declines in agricultural surplus largely explain flow-normalized annual load time series for the Conestoga
  - 7-8 year lag, most efficient predictors using BIC
  - Significant negative time trend (statistical evidence of BMPs making Conestoga more retentive?)

# Next steps

- Develop code to mass produce county level fact sheets with relevant time series and infographics
- Share introduction of the fact sheets with willing reviewers
- Finish Chesapeake Bay Inventory manuscript
- Link nutrient inventory and other CAST data to WRTDS annual nutrient loads
  - Multiple research groups are coordinating via the Factors Team
  - Using a universal input database to cut down on issues interpreting inter-model variability



# Questions?

**Thank you!**

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