SIMULATING SUBSTITUTABLE WATER QUALITY POLICIES: PAYMENTS FOR OUTCOMES VERSUS PAYMENTS FOR PRACTICES

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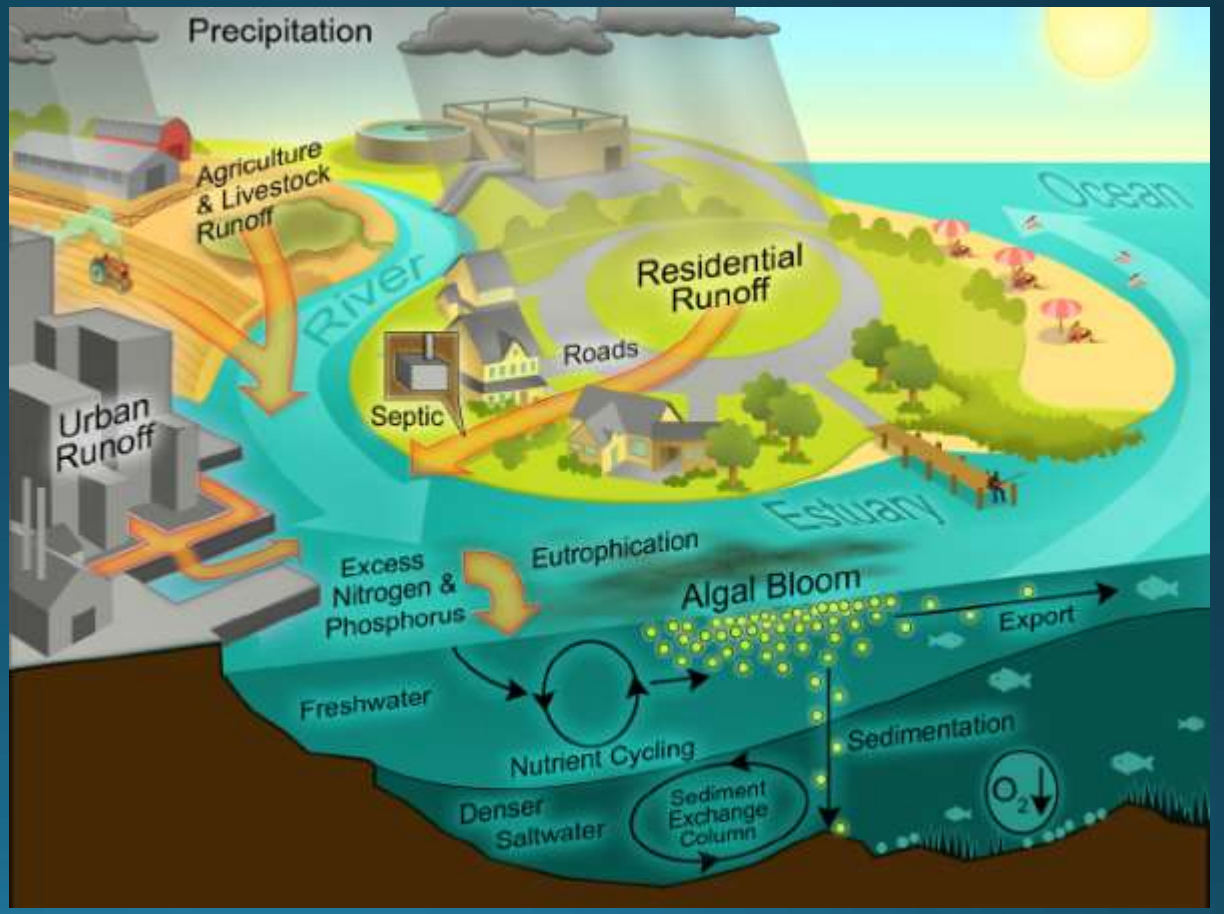
Photograph by NASA/Earth Observatory, 2011

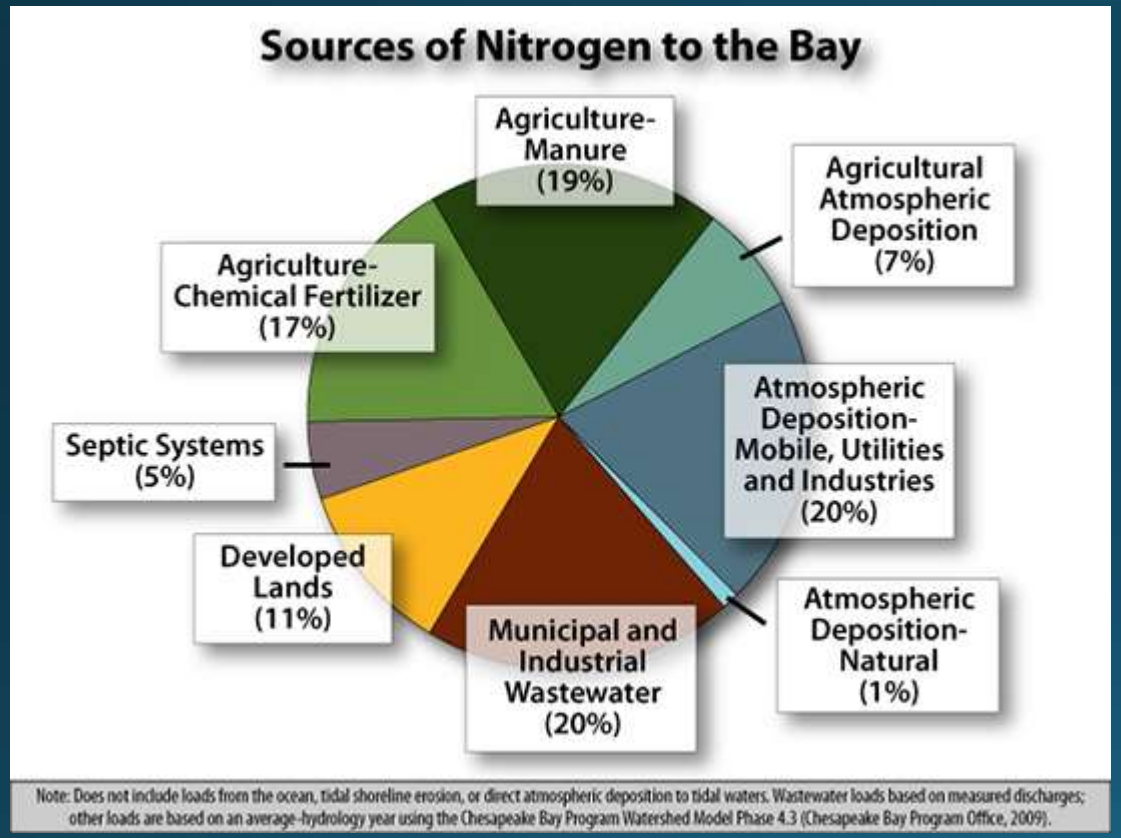
Photograph by NASA/Earth Observatory, 2015

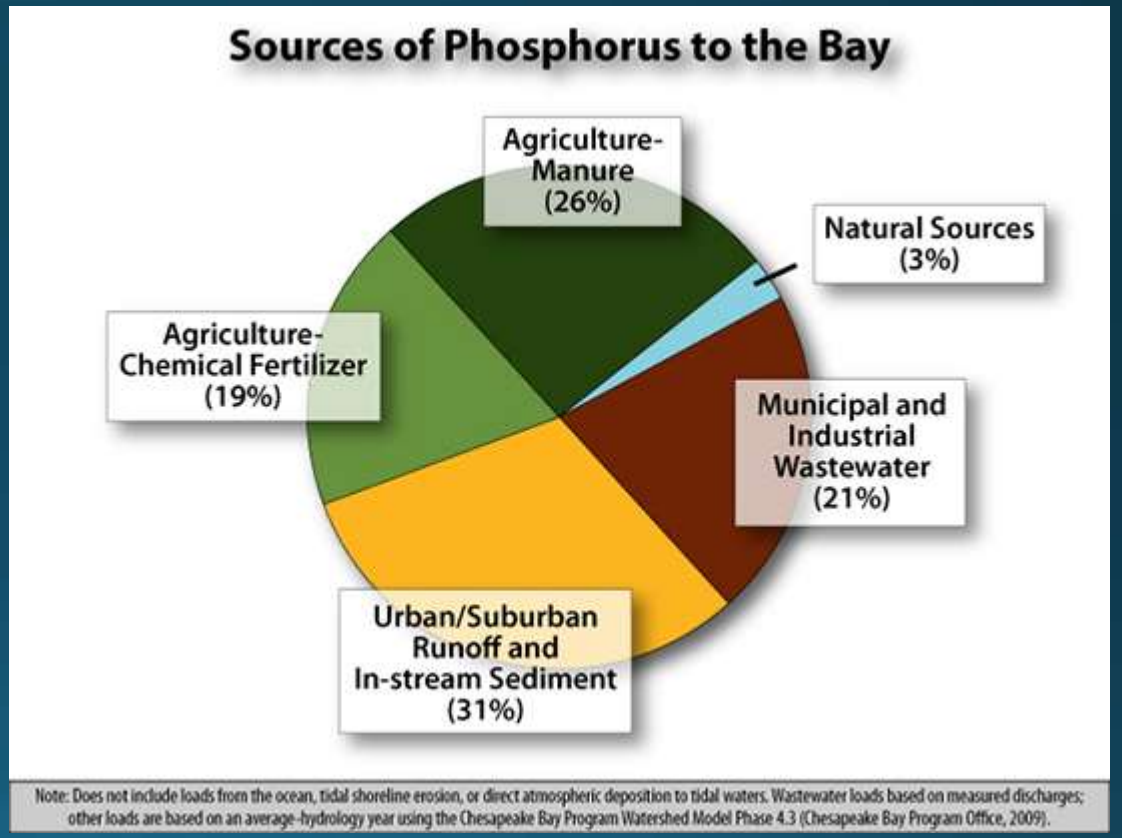
http://news.nationalgeographic.com/news/2014/08/140804-harmful-algal-bloom-lake-erie-climate-change-science/

umces.edu



http://www.wri.org/our-work/project/eutrophication-and-hypoxia/sources-eutrophication





http://www.chesapeakebay.net/blog/post/question_of_the_week_what_are_the_main_sources_of_pollution_to_the_bay

Nutrient pollution

- Nutrients (nitrogen and phosphorous) are part of natural processes
- Problematic (or pollution) when added to water in excess of natural system capacity of the
- There are two broad categories (by law) of nutrient "sources"
  - Point
  - Nonpoint

Research Goals

- Policy challenges faced in the agricultural sector
- Agricultural production includes externality of nonpoint source nutrient enrichment to local and regional waters
- Comparative Analysis methods to assess:
  - Substitutable policy solutions to address nonpoint source pollution
    - Payment for environmental services (PES)
    - Nutrient trading, Water Quality Trading (WQT)

Policy substitution

- Two policies have same goal
- Jeopardize ability of governments to achieve goals, create confusion (rules, prices)
  - Air markets
  - Incoherence
- Water quality trading (WQT) and payment for environmental service (PES)
  - Same goal, different approaches
  - Different rules
  - Prices on nutrients?
  - Procurement efficiency

Literature

- Lower agricultural cost-share rates with joint policy implementation (Caplan, 2013)
- Efficiency gains possible
  - Targeting cost share programs in the presence of water quality trading programs (Horan et al., 2004)
- Improved market performance
  - Partnerships between federal cost-share programs and the market: "brokering," "screening," or "recruiting" farmers (Breetz and Fisher-Vanden, 2007, p. 210)

Questions

Chesapeake Bay nonpoint source nutrient abatement

- Supply heterogeneous in N and P abatement?
- Do PES incentivize least cost abatement?
- Will the existing PES policy impact participation in WQT, or will WQT impact participation in PES?
- Will WQT take high productivity abaters from PES such that PES is less cost effective?

Methods

For sample of fields i and treatments k:

H_0 *(Within treatment homogeneity)*

$N_i^1 = N_j^1, \forall\ i \neq j; \quad P_i^1 = P_j^1, \forall\ i \neq j$

H_0 (*Between treatment homogeneity*)

$N_i^k = N_i^l\ \forall\ \mathrm{k} \neq \mathrm{l}; \quad P_i^k = P_i^l, \forall\ \mathrm{k} \neq \mathrm{l}$

H_0 (*Global homogeneity*)

$N_i^k = N_i^l\ , \forall\ \mathrm{i} \neq \mathrm{j}, \forall\ \mathrm{k} \neq \mathrm{l}; \quad P_i^k = P_i^l, \forall\ \mathrm{i} \neq \mathrm{j}, \forall\ \mathrm{k} \neq \mathrm{l}$

1) Upward sloping supply curve from farmers (some lower price than others)
2) PES are random (do not select based on productivity)
3) WQT should select on productivity leaving lower productive fields in PES

Economic Model

- $PRICE_N{}^{WQT}$ and $PRICE_P{}^{WQT}$
- $PRICE_k{}^{PES}$

- $PRICE_N{}^{WQT} N_i^k + PRICE_P{}^{WQT} P_i^k = PRICEkP^{ES}$ (substitutability for any k or i)

- $PRICE_N{}^{WQT} N_i^k + PRICE_P{}^{WQT} P_i^k \geq PRICE_k{}^{PES}$ (price floor dictated from PES)

Nutrient Index

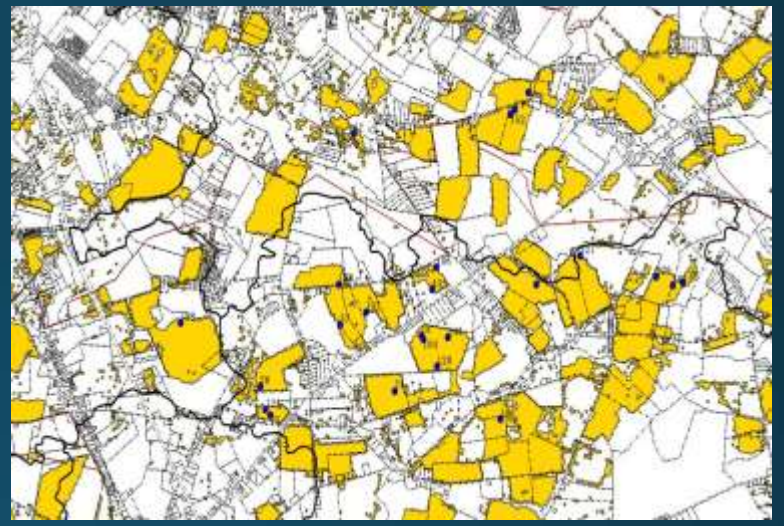
- Index for possible range of PriceN and PriceP
- $c_i^{N,k} = PRICE_k^{PES}/N_i^k$ and $c_i^{P,k} = PRICE_k^{PES}/P_i^k$

- N and P are purchased together in PES
- $\pi = PRICE_N^{WQT} / (PRICE_N^{WQT} + PRICE_P^{WQT})$
- $IIPC_i^{\pi' k} = \pi c_i^{N,k} + (1 - \pi)c_i^{P,k} = \frac{\pi PRICEkPES}{N_i^k} + (1 - \pi)PRICE_k^{PES/P_i^k}$

- Simulate WQT supply curve(s) with sensitivity

Data Collection

- Random sample of corn fields in Chesapeake Bay drainage, quantitative geographic information systems (QGIS)
- Agronomic assumptions, input into Chesapeake Bay Nutrient Trading Tool (CBNTT)
- 'Future practice' 12 cover crop treatments (BMP options)
- Record CBNTT output for nutrient reductions
- Cover Crop participation data (2014-2015) from Queen Anne's County, MD



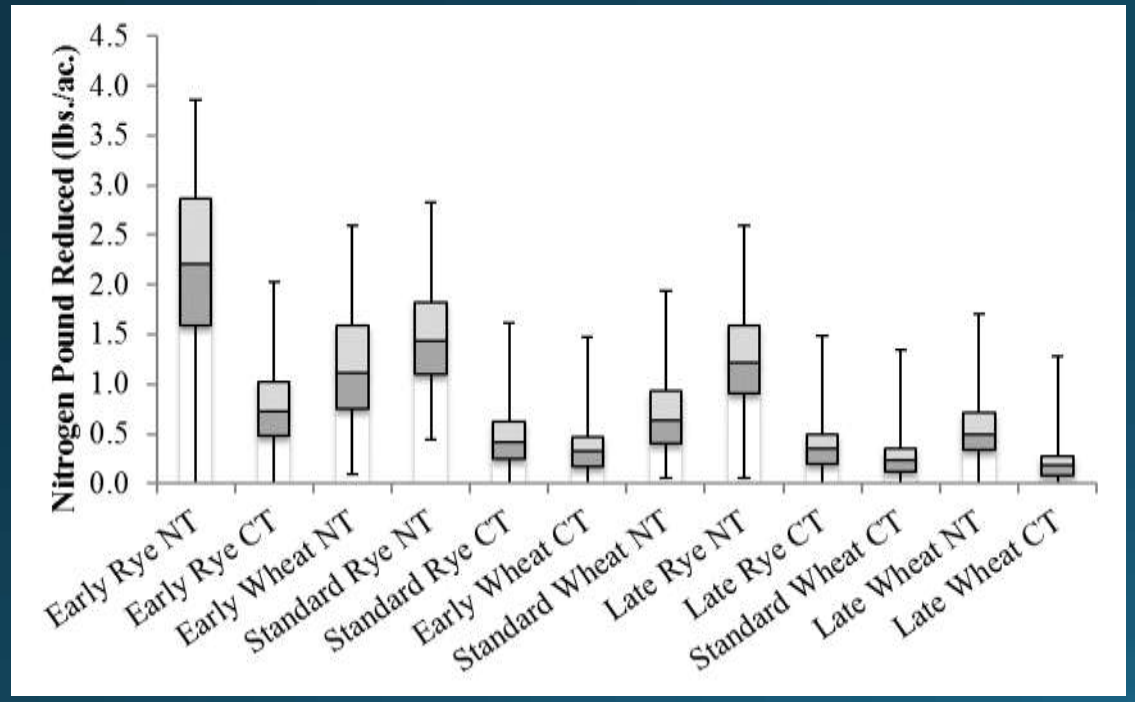
Example of QGIS data set: data points (circles with numerical ID), corn fields (shaded polygons), roads and road names, Hydrologic Unit Code 12 watershed boundaries (black outline).

	No-till			Other-Till		
	Early	Standard	Late	Early	Standard	Late
Seed	9/30	10/15	10/30	9/30	10/15	10/30
Rye **Acres planted (est. per acre payment)**	0 ($90)	377.8 ($80)	530.4 ($70)	203.8 ($80)	559.3 ($75)	1283.9 ($70)
Wheat **Acres planted (est. per acre payment)**	0 ($80)	3690.0 ($70)	7212.1 ($60)	0 ($70)	17175.7 ($65)	14726.1 ($60)

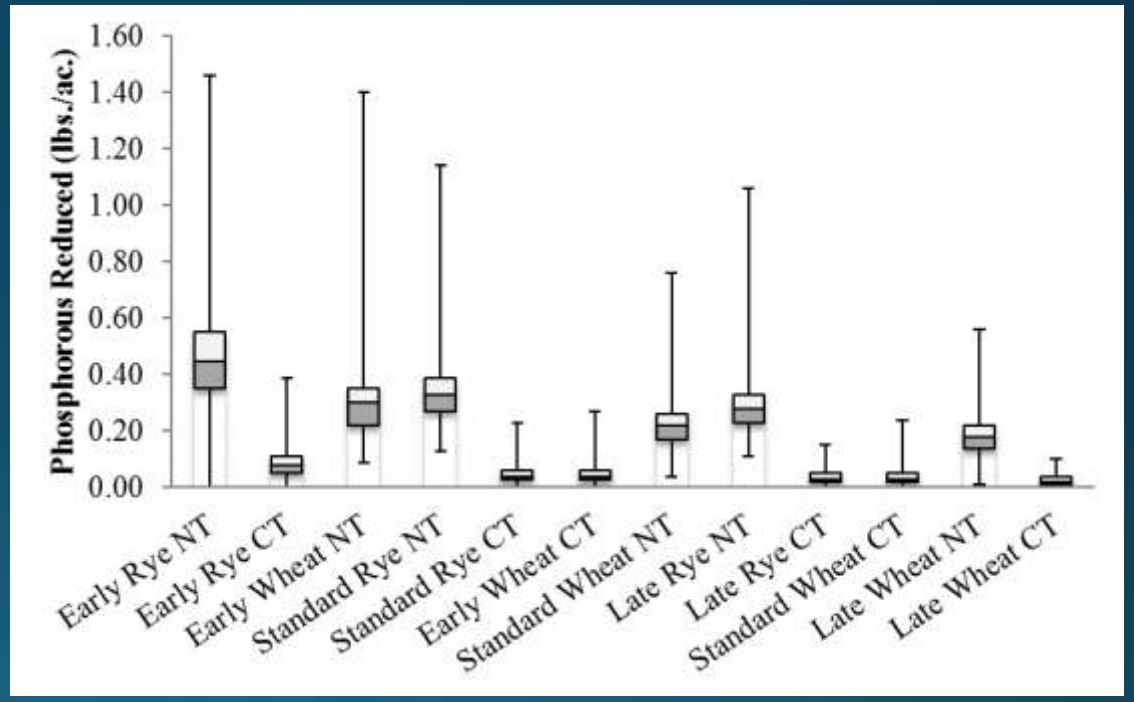
***Data on cover crop acreage received from the Queen Anne's Soil Conservation District Manager (June 2 and June 5, 2015) via e-mail communication. CC planting dates selected for data herein. Payments per acre correspond to Maryland Cover Crop program, however counties may distribute payments slightly different.**

Results

Null hypothesis test – Homogeneity cannot be assumed



Modeled pounds of nitrogen reduced



Modeled pounds of phosphorous reduced

Parameter Estimates				
	P		N	
Variable	Random Effects Estimate	OLS Estimate	Random Effects Estimate	OLS Estimate
Intercept	0.057*** (0.019)	0.119*** (0.010)	1.069*** (0.062)	0.792*** (0.043)
Current (N or P) Load	0.159*** (0.008)	0.117*** (0.005)	0.022*** (0.006)	0.060*** (0.004)
Tillage[1]	-0.094*** (0.009)	-0.139*** (0.007)	-0.928*** (0.028)	-1.056*** (0.027)
Standard[2]	-0.061*** (0.005)	-0.062*** (0.006)	-0.416*** (0.025)	-0.400*** (0.028)
Late[2]	-0.085*** (0.005)	-0.089*** (0.006)	-0.554*** (0.025)	-0.523*** (0.028)
Seed Type[3]	0.083*** (0.004)	0.084*** (0.005)	0.583*** (0.02)	0.583*** (0.023)
Irrigation[4]	-0.076*** (0.011)	-0.069*** (0.005)	-0.253*** (0.060)	-0.304*** (0.026)
Soil P	-0.0001 (0.0001)	0.0000 (0.0001)		
Sussex	0.074*** (0.015)	0.054*** (0.007)	0.326*** (0.059)	0.407*** (0.026)
R-squared	0.7718	0.7326	0.6578	0.6228

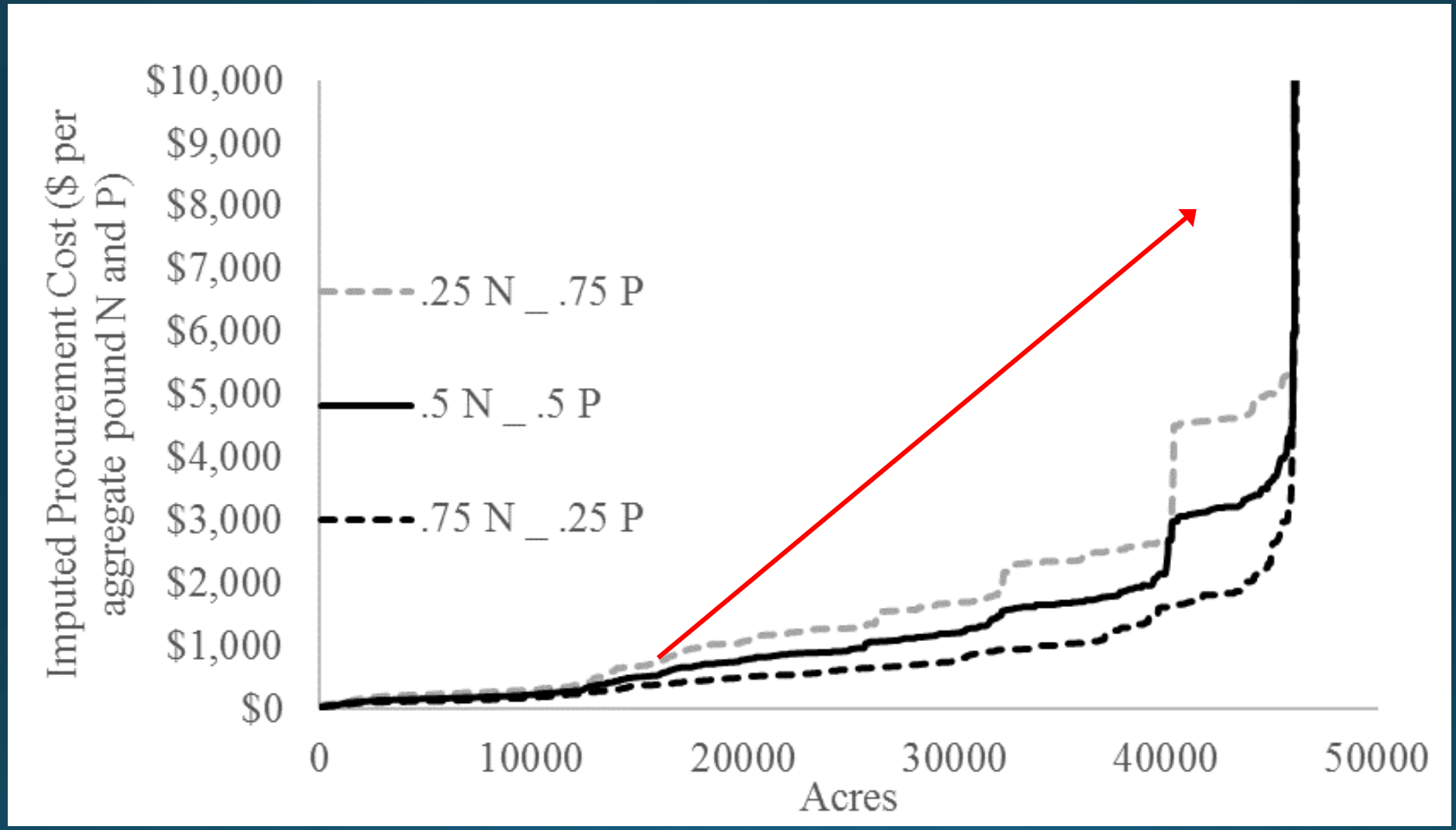
N=144
***indicates 0.01 level of significance;
** indicates 0.05 level of significance.
Notes:
Base cases:
1) Tillage, no-till
2) Early planting
3) Wheat seed
4) No irrigation
5) Kent County

Statistical model summary

- Two models OLS and Random Effect
- Compare average reductions in treatment categories (lb/ac)
- No-till>conservation, Early>standard or late, rye>wheat, irrigated>non-irrigated, soil P does not change average P reduction
- Overall, incentive payments increase for the "higher" reductions
- Range and incremental differences of modeled reductions may indicate some payments are not cost effective
- **Payments are unable to capture true heterogeneity**

A Supply Curve for the Nutrient Abatement Index

- PES payments are questionably cost effective, not reflective of nutrients reduced
- Theoretically, matching payments for one nutrient could potentially be compensated by adjustments in the other nutrient
- $IIPC_i^{\pi k} = \pi c_i^{N,k} + (1 - \pi) c_i^{P,k} = \frac{\pi PRICEkP^{ES}}{N_i^k} + (1 - \pi) PRICE_k^{PES/P_i^k}$
- $IIPC_i^{\pi,k}$, at three levels π=0.25, , π=0.5, and π=0.75



Imputed index procurement cost of modeled nitrogen and phosphorous load reduction based on reported payments made for cover crops (per acre) in Queen Anne's county, Maryland 2014-2015.

Supply Curve Interpretation

- Most frequently planted treatment
  - (k=S, R, CT; 17,175 acres, $65/ac.)
- Median modeled load reduction N = 0.24 lbs./ac
- Imputed payment N: $67.00/lb. ($\pi$ = 0.25), $203.00/lb. ($\pi$ = 0.75)
- Median modeled load reduction P = 0.03 lb./ac
- Imputed payment P: $541/lb. ($\pi$ = 0.25), $2,166/lb. ($\pi$ = 0.75)
- **Imputed cost per acre: between $744 (.75 N + .25 P) and $2,233 (.25 N + .75 P) per aggregate N + P pound**

Conclusions

- Supply heterogeneous in N and P abatement?
  - Highly heterogeneous (expected)
- Does PES incentivize least cost abatement?
  - No the payments in PES do not match heterogeneity in abatement (expected)
- Will the existing PES policy impact participation in WQT?
  - Supply curve with sensitivity demonstrated price floor, potential to collapse WQT by reducing gains from trade
- Will WQT take high productivity abaters from PES such that PES is less effective?
  - Well functioning market "take" low cost providers?

Limitations

- Sample of fields as opposed to farms is a potential limitation due to the choices farmers make being at farm-scale rather than a single field scale
- Data on participation in early planted crop payments are not within this study
- Uncertainty of bundling of nitrogen and phosphorous as a service
- PES pay for multiple services and scientific bounds on partitioning of payment for service