Manure & Fertilizer Inputs to Land in the Chesapeake Bay Watershed, 1950-2012

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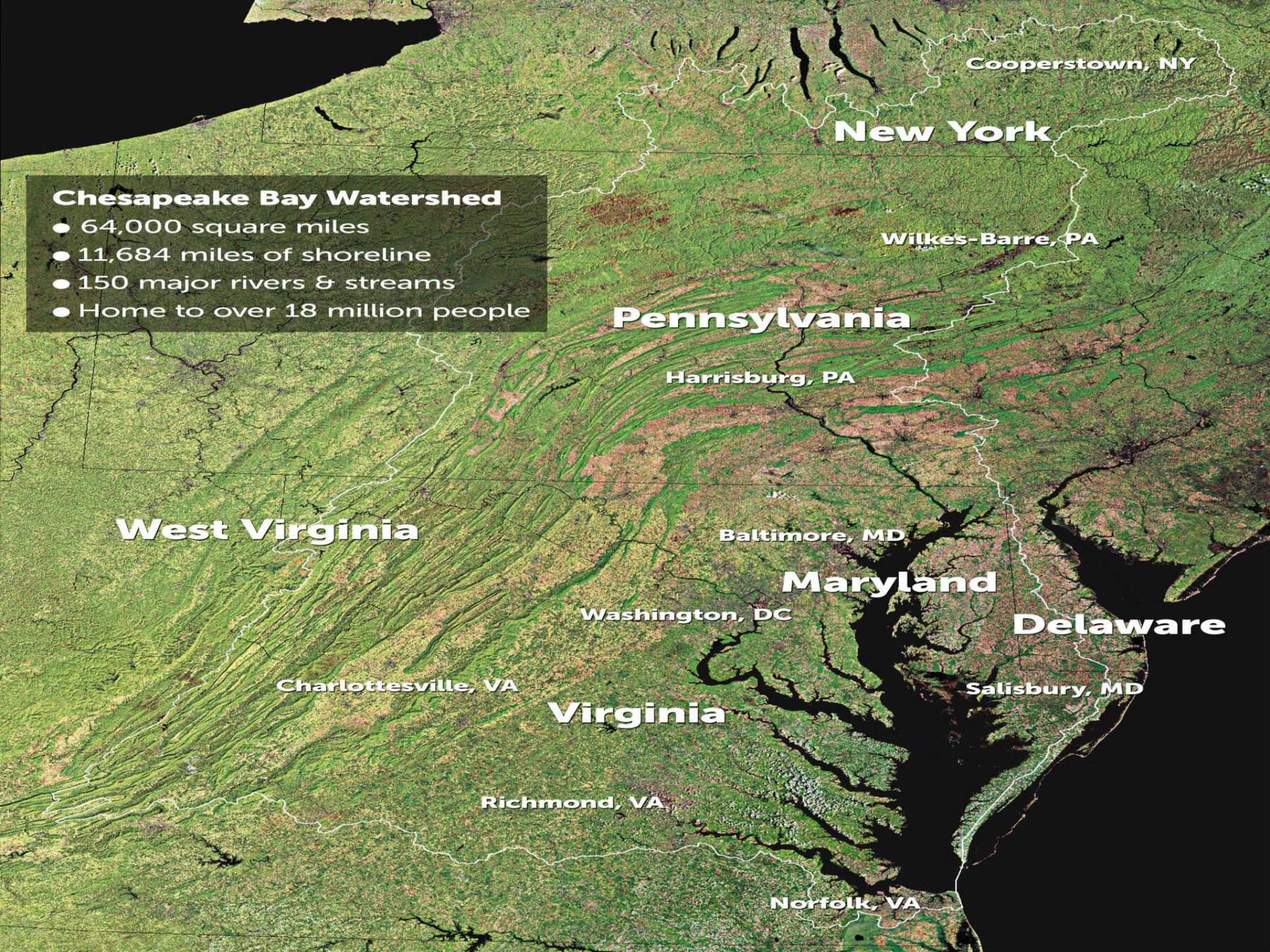
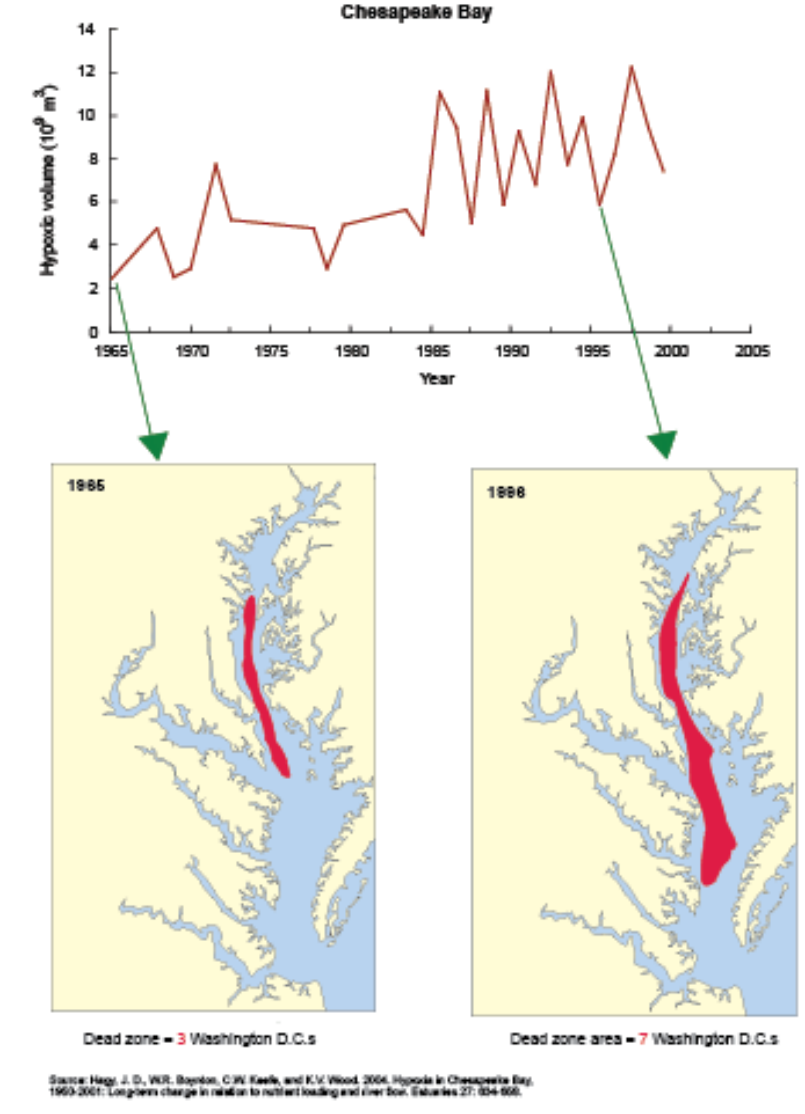

Chesapeake Bay Watershed
• 64,000 square miles
• 11,684 miles of shoreline
• 150 major rivers & streams
• Home to over 18 million people
Cooperstown, NY
New York
Wilkes-Barre, PA
Pennsylvania
Harrisburg, PA
West Virginia
Baltimore, MD
Maryland
Washington, DC
Delaware
Salisbury, MD
Charlottesville, VA
Virginia
Richmond, VA
Norfolk, VA

Nutrient Inputs from Manure and Fertilizer

Chesapeake Bay Degradation



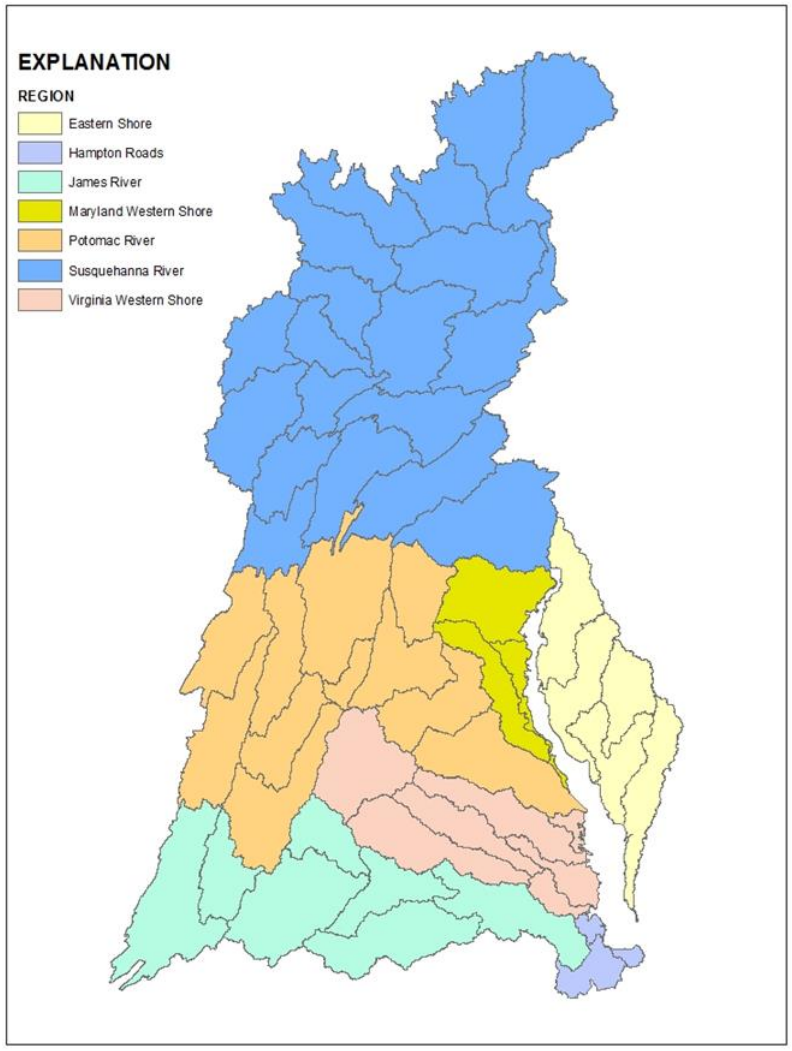
Credit Chesapeake Bay Program

http://www.teachoceanscience.net/teaching_resources/education_modules/dead_zones/explore_trends/chesapeake_story/

Credit Jonathan Lefcheck

Nutrient Inputs From Manure and Fertilizer

53 Basins; 7 Regions; Entire Watershed

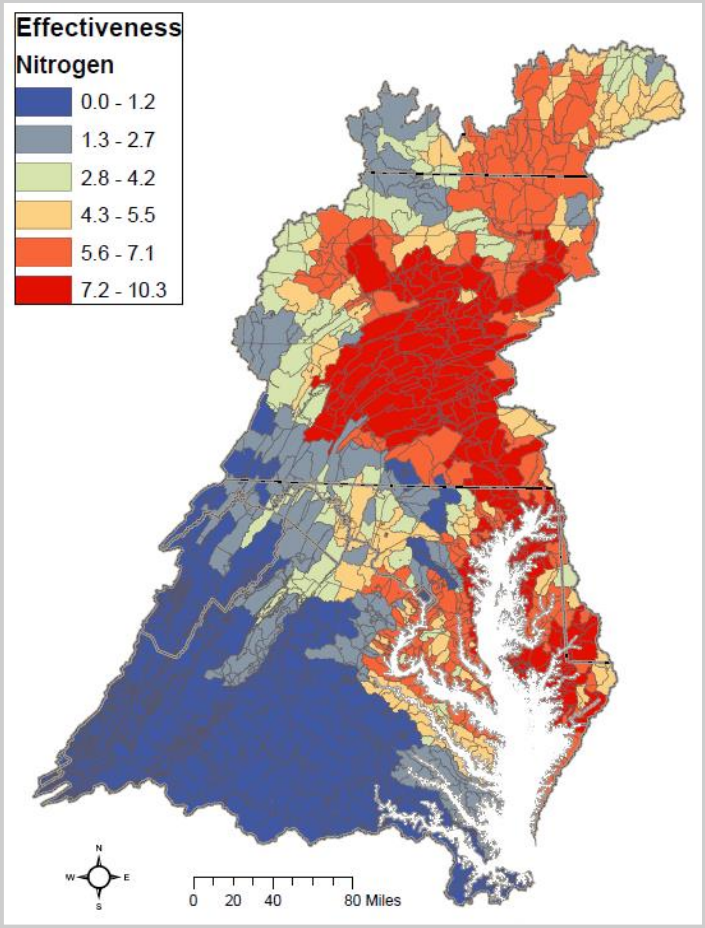


- We investigated changes in nitrogen and phosphorus inputs from manure and commercial fertilizer for:
  - 53 hydrologic basins in
  - 7 regions and
  - the watershed as a whole
- We compared changes to patterns in agricultural practices
- We briefly reviewed expected changes in inputs from reported conservation practices

Nutrient Inputs from Manure and Fertilizer

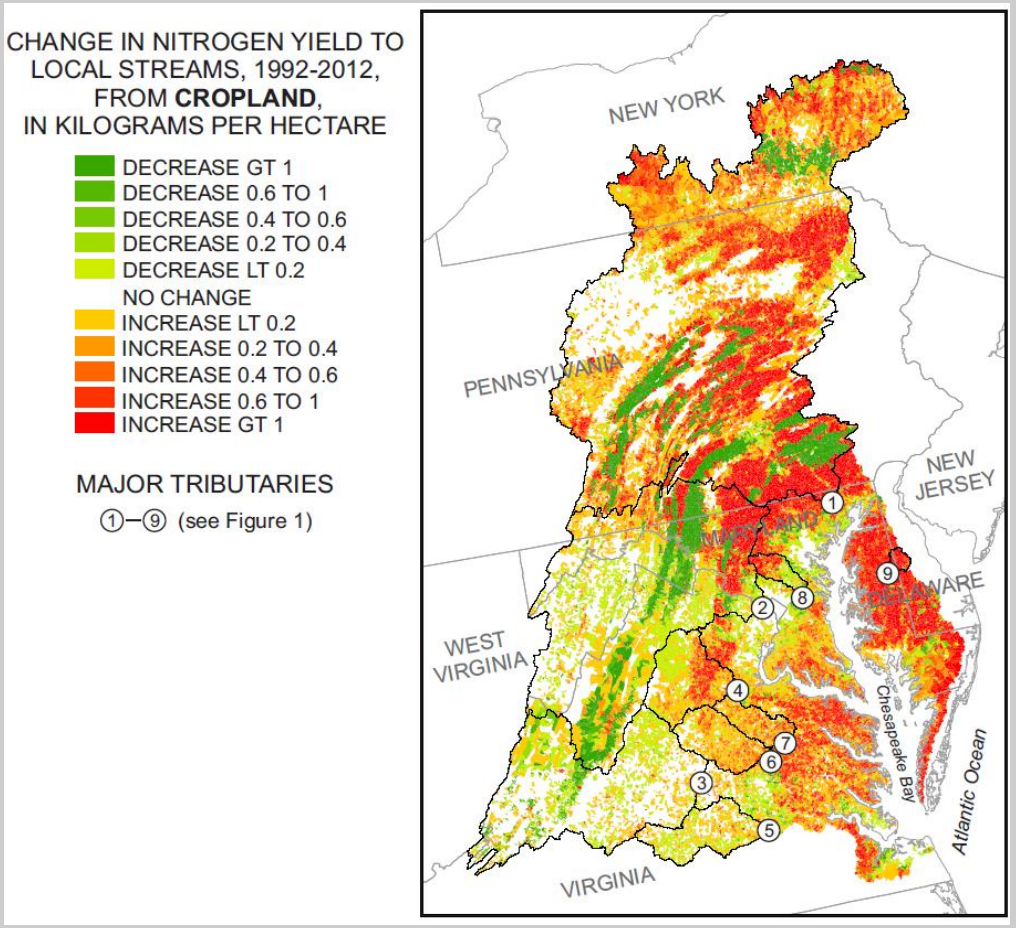
Motivations: Explaining Results; Geography Matters

Geography affects impacts on the estuary



Linker et al. 2013 (JAWRA) 1-21. DOI: 10.1111/jawr.12105

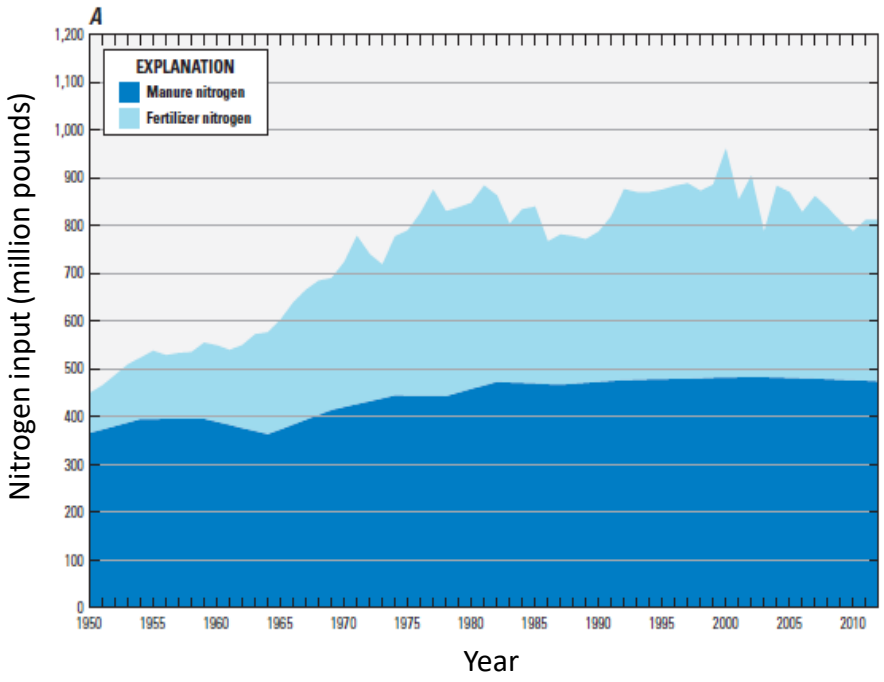
Change in N yield to streams, 1992-2012

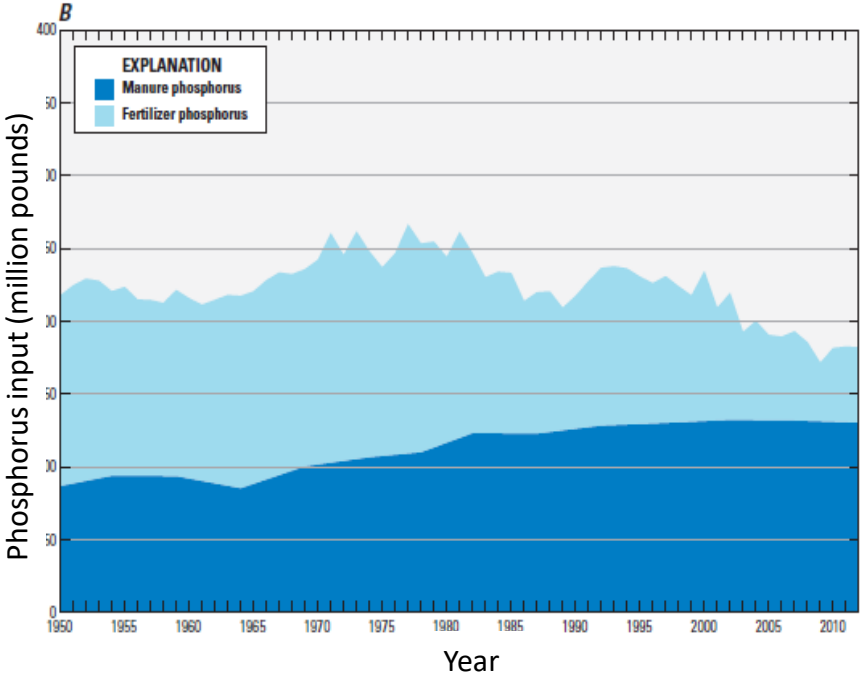


Ator and Garcia, *in review*

Manure and Fertilizer Inputs Over Time

Watershed Scale





- Increasing fertilizer use drove an approximate doubling of N inputs from 150 to the mid-1970's.
- Declining use of phosphorus fertilizer has been evident since about 1980, compensating for increases in manure-P production.

Crops And Cropland

Watershed Scale

year	harvested cropland	acres harvested	percent of acres harvested					
			barley	corn	hay	oats	soybeans	wheat
1950	7,482,192	6,963,107	4%	25%	40%	8%	2%	17%
1954	7,391,219	7,014,994	4%	26%	41%	9%	4%	12%
1959	6,853,237	6,612,321	4%	25%	43%	8%	6%	10%
1964	6,456,300	6,261,867	4%	27%	43%	6%	8%	9%
1969	5,558,307	5,209,184	5%	32%	39%	5%	9%	7%
1974	6,027,832	5,980,615	4%	35%	35%	4%	11%	9%
1978	6,448,196	6,302,192	4%	36%	38%	3%	12%	5%
1982	6,693,000	6,893,963	3%	38%	34%	3%	14%	7%
1987	6,061,504	6,281,869	3%	33%	39%	3%	14%	7%
1992	5,942,293	6,312,714	3%	31%	37%	2%	17%	8%
1997	6,259,273	6,507,061	2%	31%	38%	1%	18%	8%
2002	6,087,411	6,275,296	2%	30%	42%	1%	17%	7%
2007	5,855,584	6,033,221	2%	34%	39%	1%	17%	7%
2012	5,992,953	6,174,823	2%	32%	37%	1%	19%	8%

1950-2012	-20%	-11%
1982-2012	-10%	-8%

Barley, oats, and wheat cultivation declined in favor of soybeans and corn

Animals

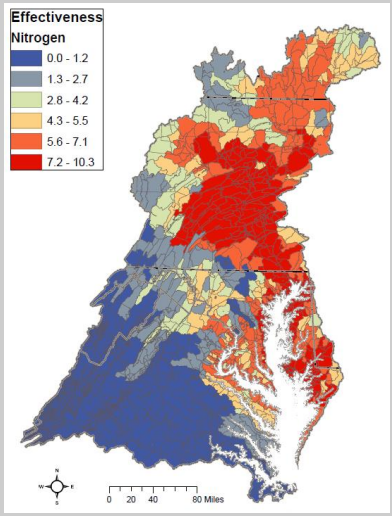
Watershed Scale

year	Livestock Units	All Cows	All Poultry	Horses	Sheep	Hogs
1950	2,704,741	81%	4%	7%	2%	6%
1954	2,774,677	89%	3%	1%	2%	5%
1959	2,745,509	87%	3%	3%	2%	6%
1964	2,504,474	92%	3%	0.4%	1%	4%
1969	3,090,371	69%	24%	3%	1%	4%
1974	2,758,342	84%	9%	2%	1%	4%
1978	2,717,878	79%	11%	3%	1%	6%
1982	2,984,540	78%	12%	3%	1%	6%
1987	2,878,661	75%	15%	4%	1%	5%
1992	2,900,215	74%	17%	3%	1%	6%
1997	2,951,438	71%	19%	3%	1%	5%
2002	2,889,034	69%	19%	5%	1%	6%
2007	2,795,117	67%	21%	6%	0.5%	6%
2012	2,720,190	69%	20%	6%	0.5%	5%

1950-2012 change in animal units was negligible, but cows declined in favor of poultry

Nutrient Inputs from Manure and Fertilizer

Manure & Fertilizer Input Change, 1982-2012 (million pounds)



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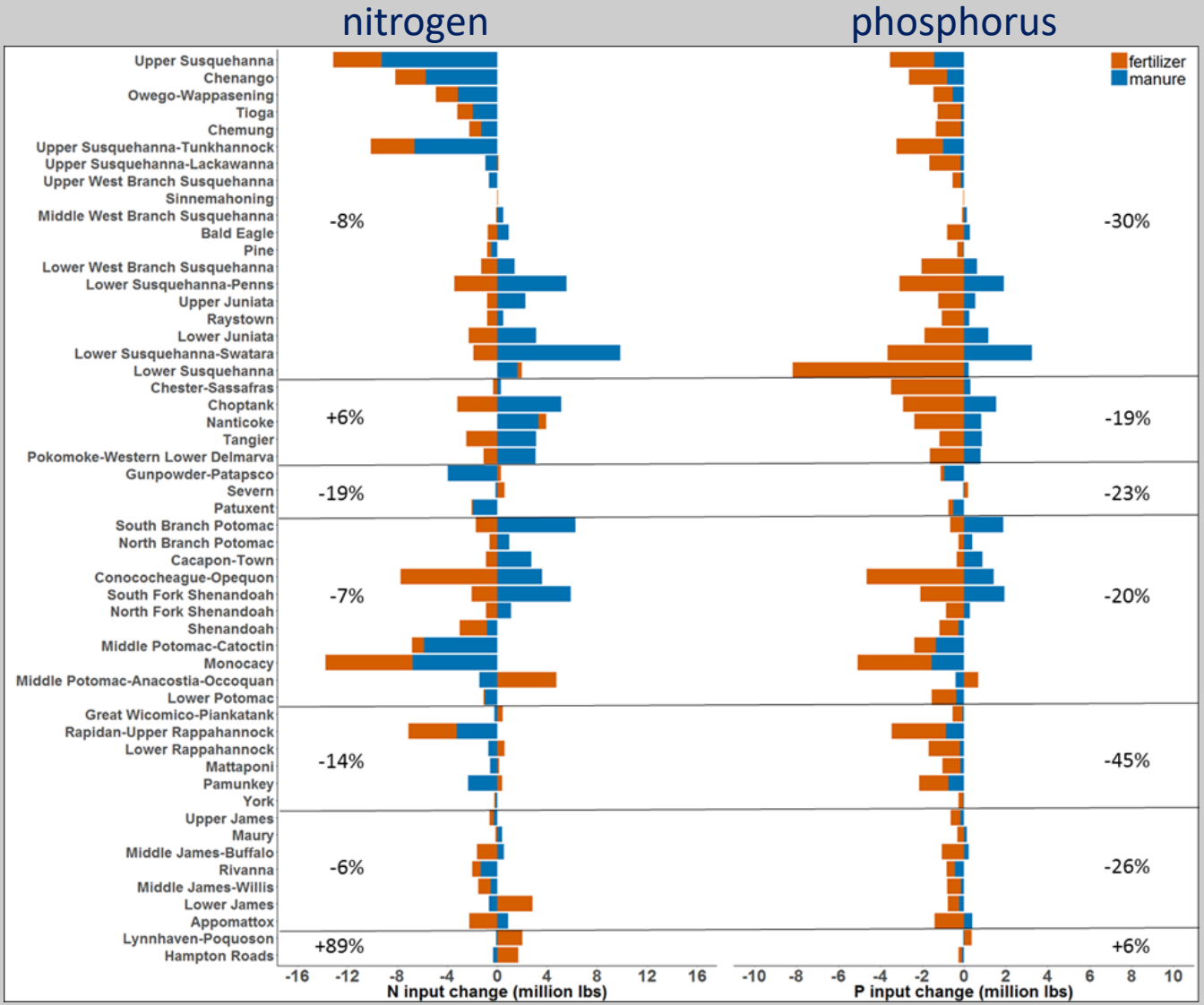
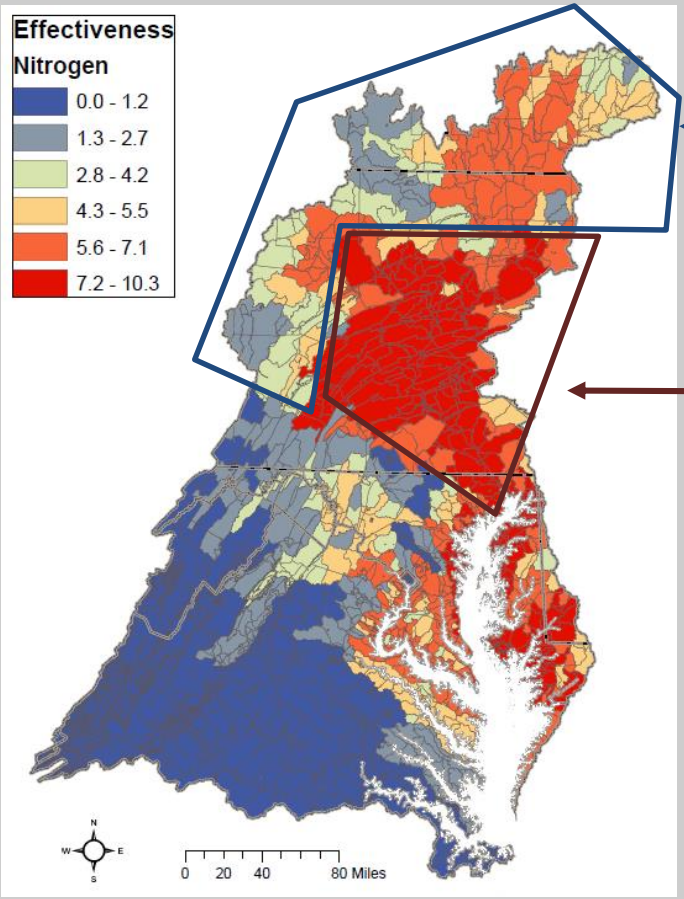
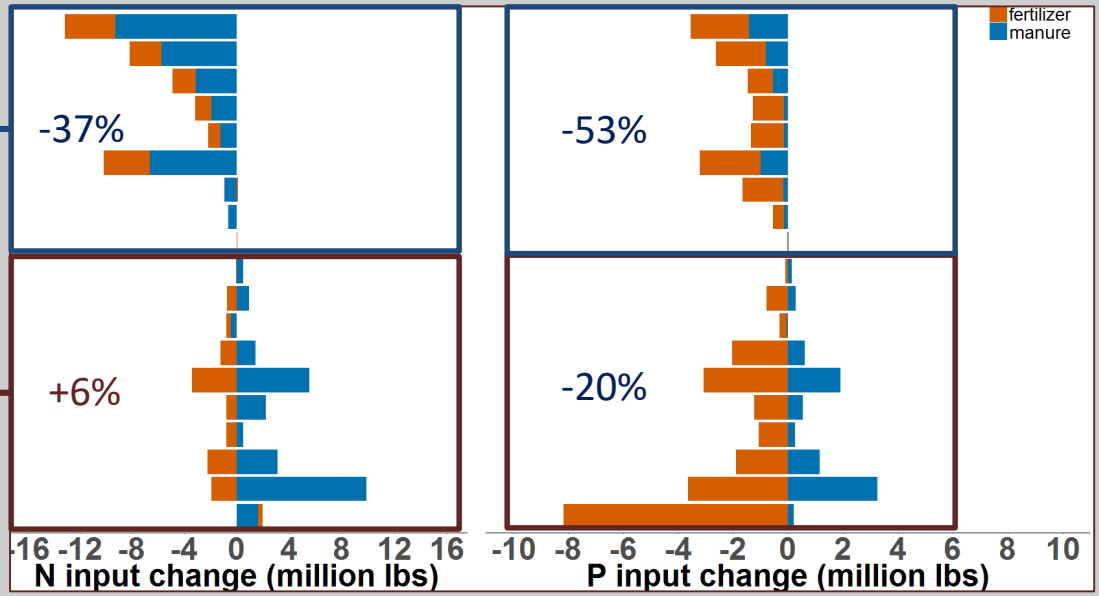


Geography Affects Impact

Susquehanna Region Inputs, 1982-2012

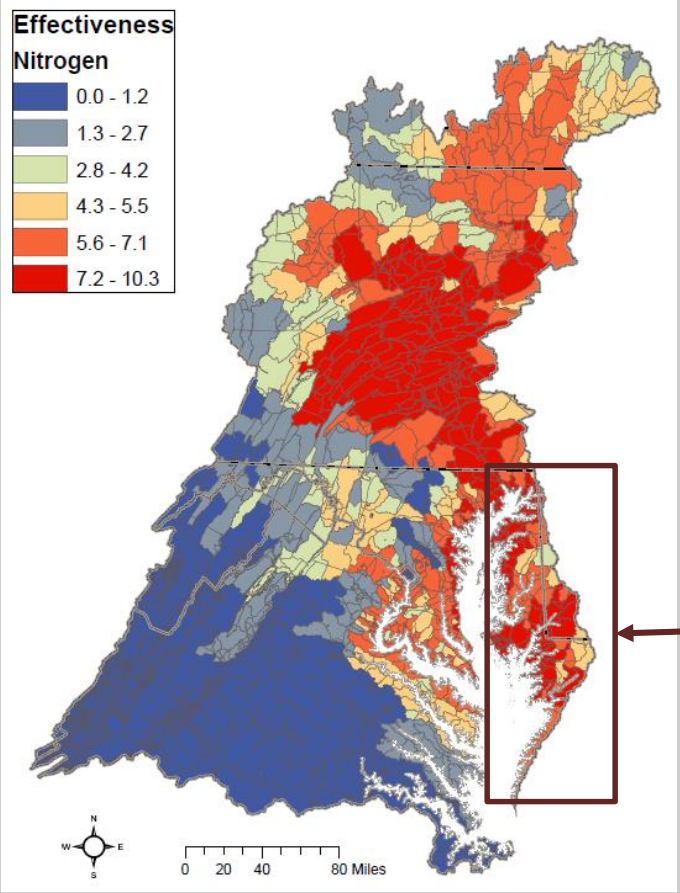




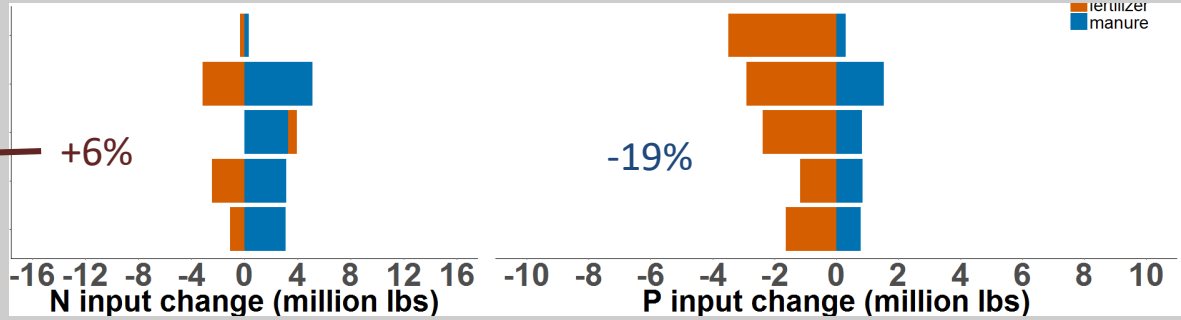
- Phosphorus inputs declined throughout region
- Nitrogen inputs declined in less influential areas of the Susquehanna basin
- Nitrogen inputs increased in more influential areas of the Susquehanna basin

Geography Affects Impact

Eastern Shore Region Inputs, 1982-2012



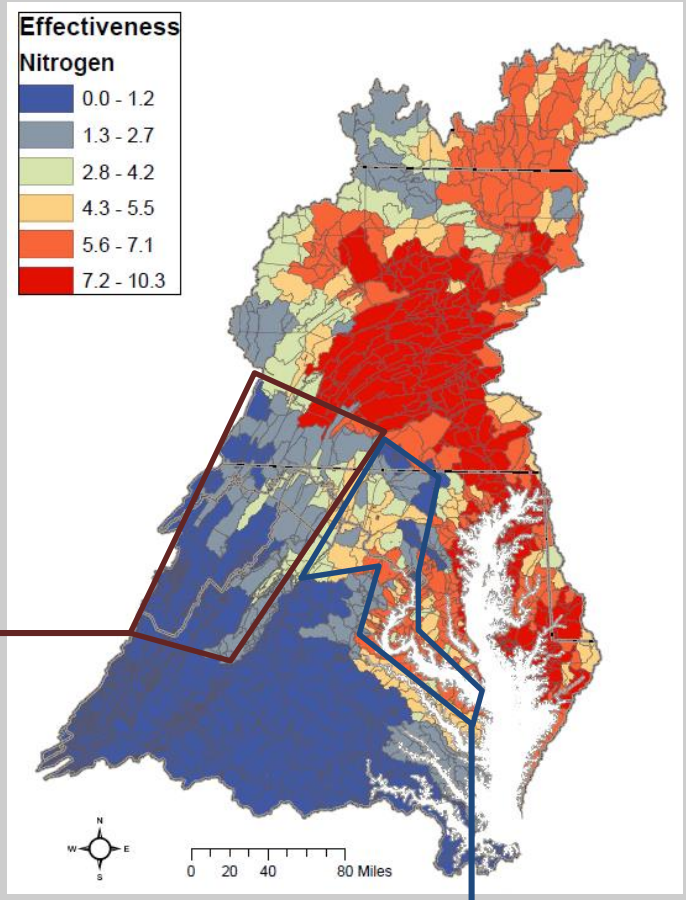
- Increased manure production drove an increase in nitrogen inputs
- Reduced fertilizer-P use counteracted manure-P increases for a net decline in P inputs

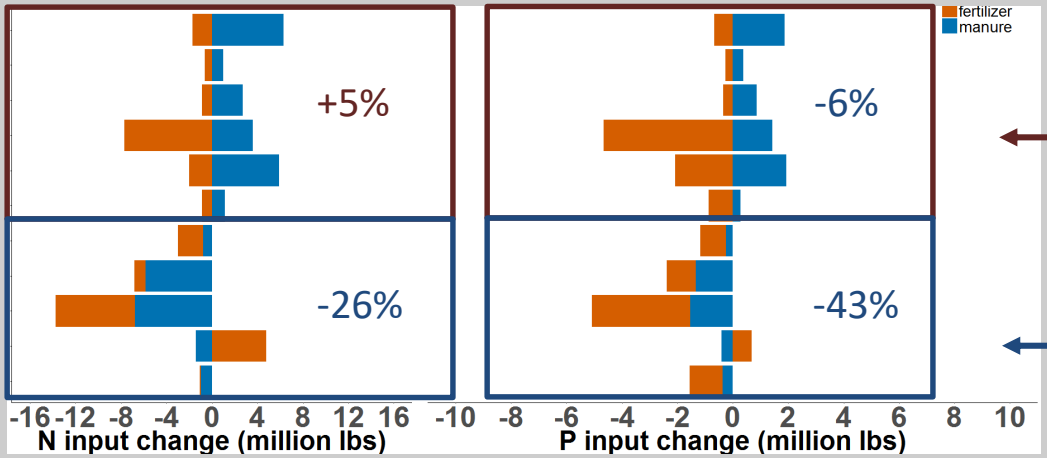


Geography Affects Impact

Potomac Region Inputs, 1982-2012

- In the Potomac basin, N increases were in areas with ***less*** influence on Chesapeake Bay hypoxia
- Higher-influence areas experienced declining nitrogen inputs from manure and fertilizer

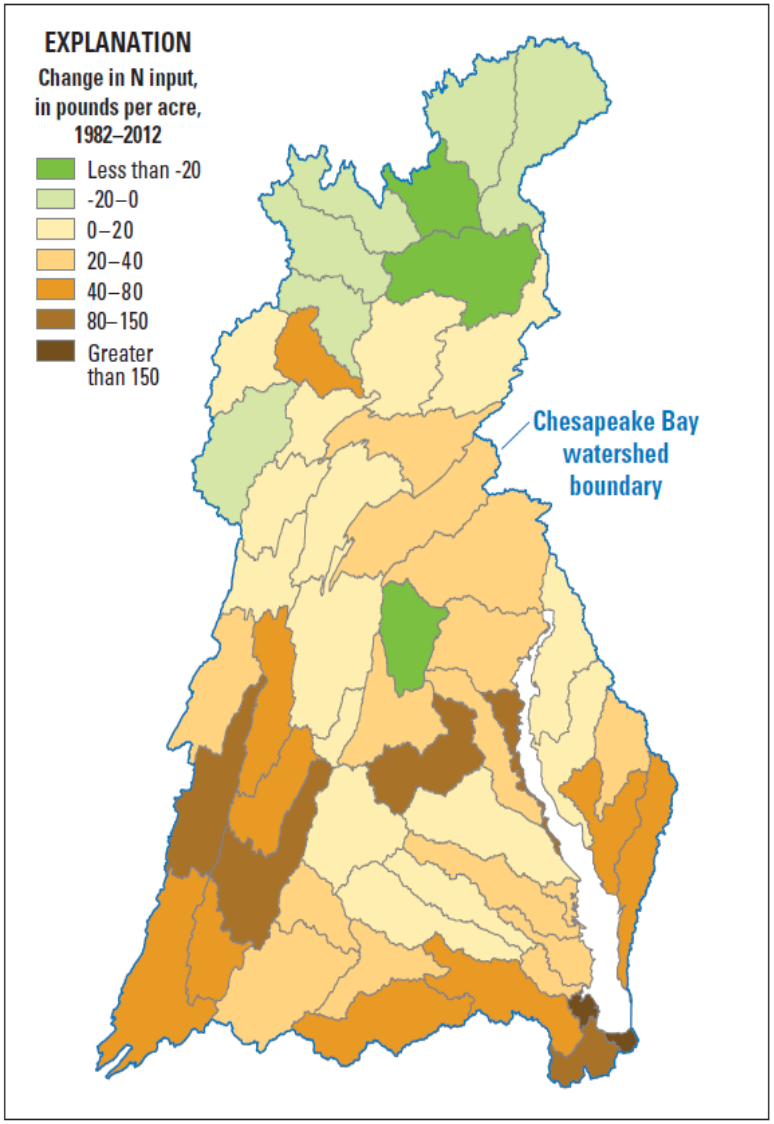




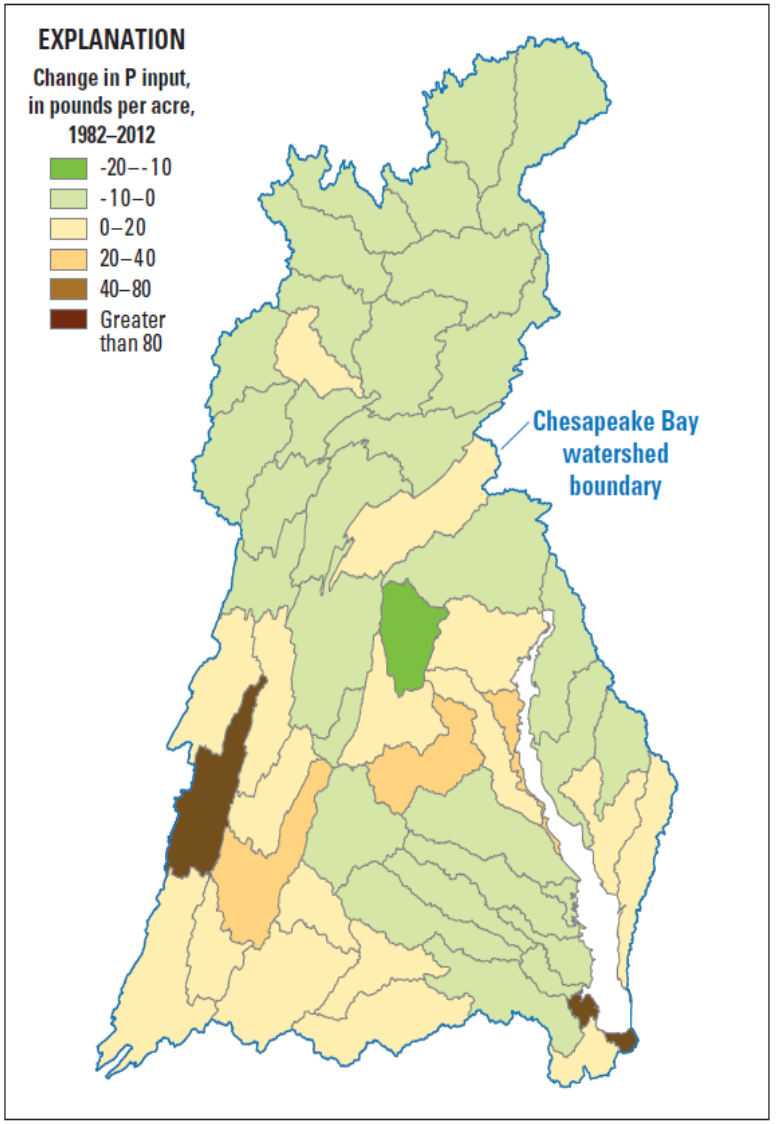
Nutrient Inputs from Manure and Fertilizer

Changes in N and P Input Intensity, 1982-2012

N input/acre of cropland

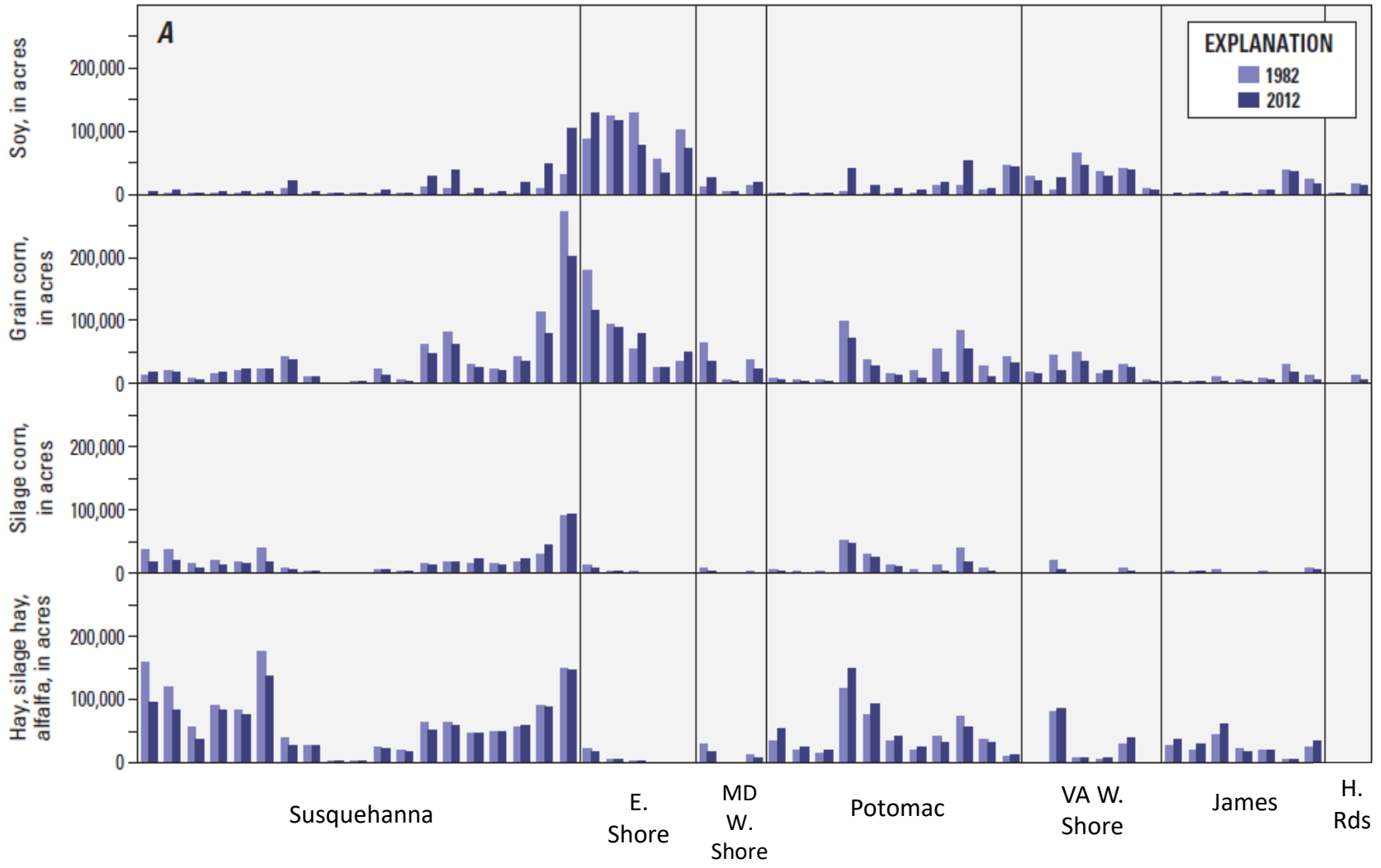


P input/acre of cropland



Nutrient Inputs from Manure and Fertilizer

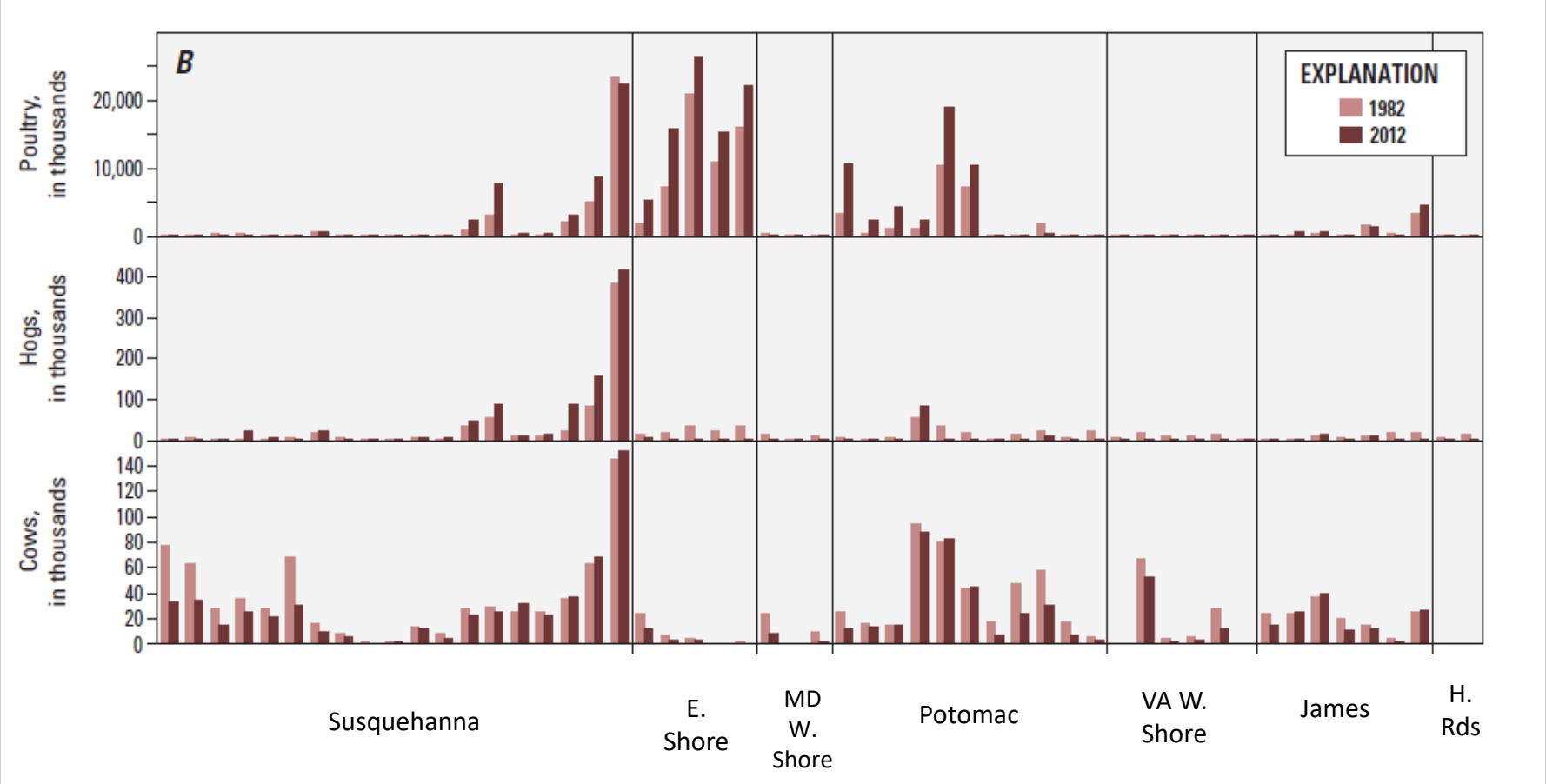
Regional Distribution of Major Crops



- Northern Susquehanna has mostly hay/silage
- Southern Susquehanna has everything
- E. Shore specializes in grain corn and soy
- Potomac has a bit of everything

Nutrient Inputs from Manure and Fertilizer

Regional Distribution of Animals

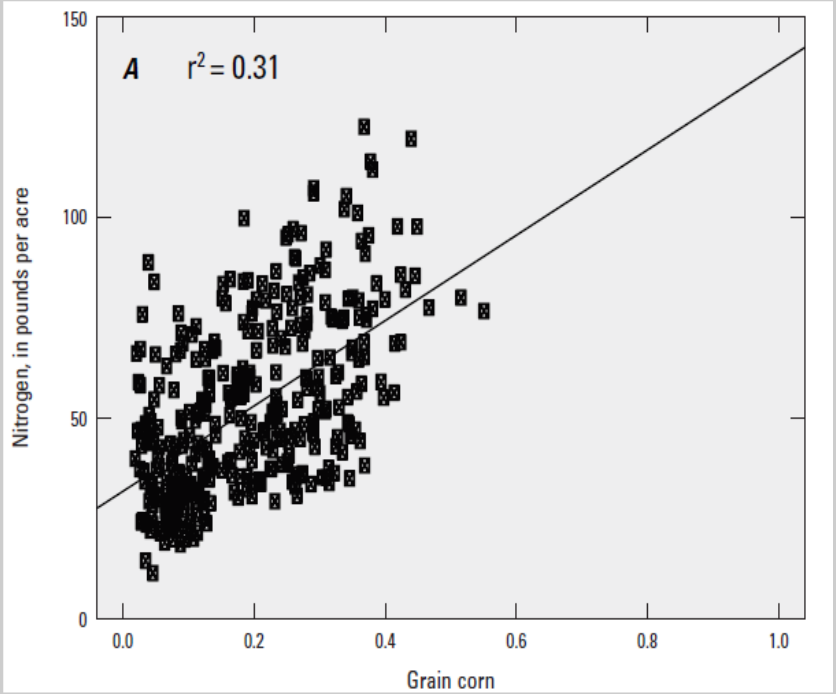


- In Susquehanna and Eastern Shore regions, animal distributions match crops
- In Potomac:
  - Hay and silage crops are consistent with livestock populations
  - Poultry population growth in the western HUC8s independent of crop production

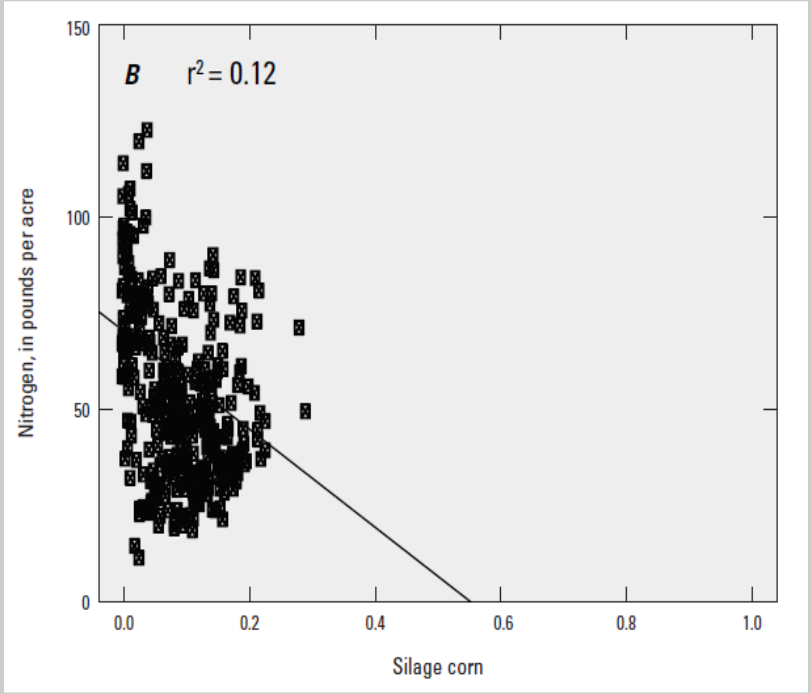
Manure & Fertilizer Applications To Land

Does fertilizer-N use increase with grain corn cultivation?

Fertilizer-N input intensity correlates with grain corn cultivation…



…but not with silage corn cultivation.



more use of livestock manure?

Manure & Fertilizer Inputs To Land

Nutrient Input BMPs

Land Use Change BMPs reduce inputs through conversion from a high- to a low- or no-application use.

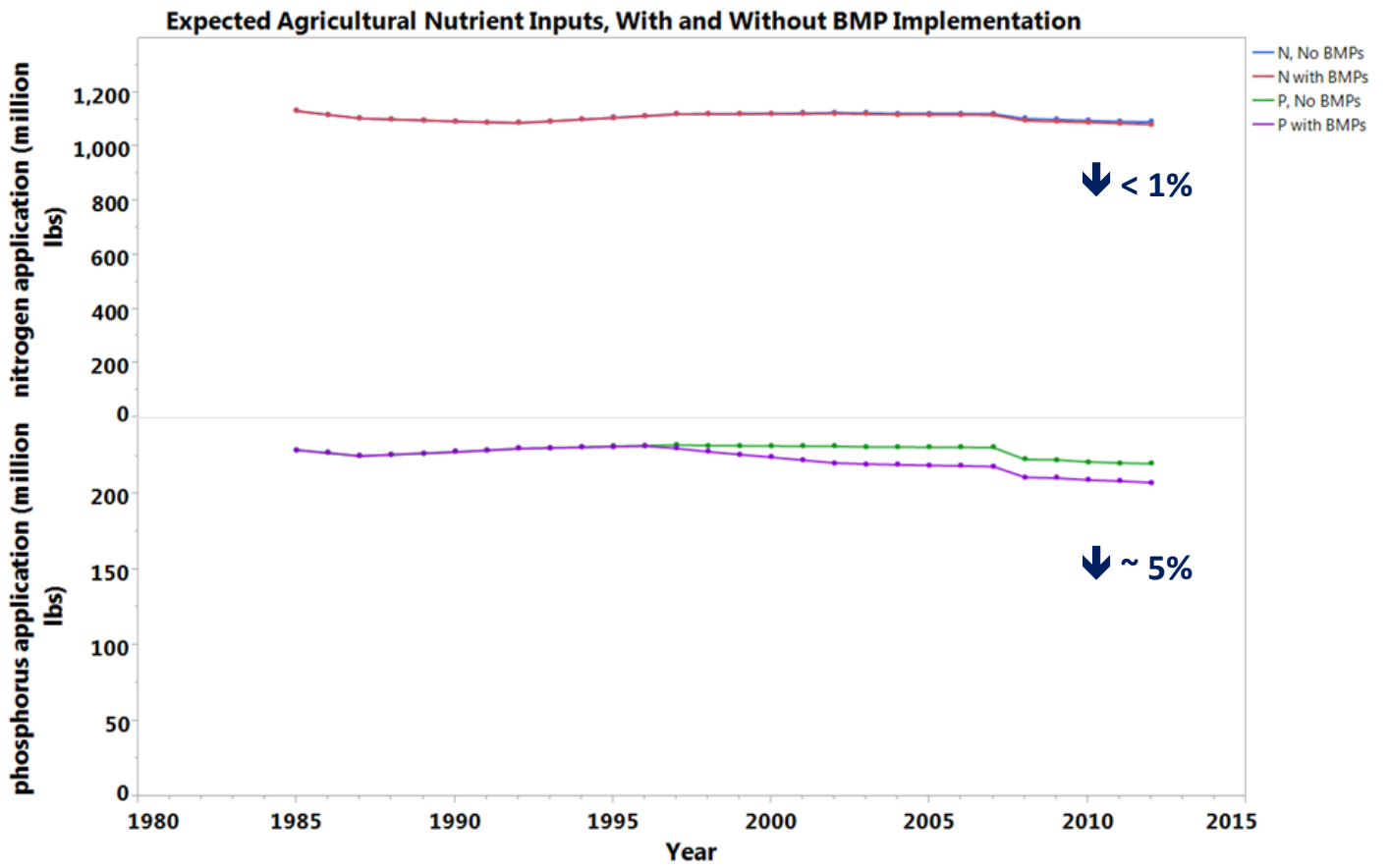
From Land Use	Land Use Change BMPs (Agriculture to Forest)	To Land Use
alfalfa	Forest Buffer, Tree Planting, Wetland Restoration	Forest
hightill without manure		
hightill with manure		
hay without nutrients		
hay with nutrients		
pasture		
degraded riparian pasture		

Animal BMPs	Nitrogen Reduction	Phosphorus Reduction	Applicable Animals
Dairy Precision Feeding/Forage Management	24%	25%	Dairy
Poultry Phytase	0%	Varies by jurisdiction and animal type	Poultry
Swine Phytase	0%	17%	Swine
Transport			All
Composters	100% of dead animals		All animal types

Some animal BMPs reduce inputs by reducing feeding rates and/or nutrient content of manure

Manure & Fertilizer Inputs To Land

Potential Effects of Animal and LU Change BMPs 1985-2012

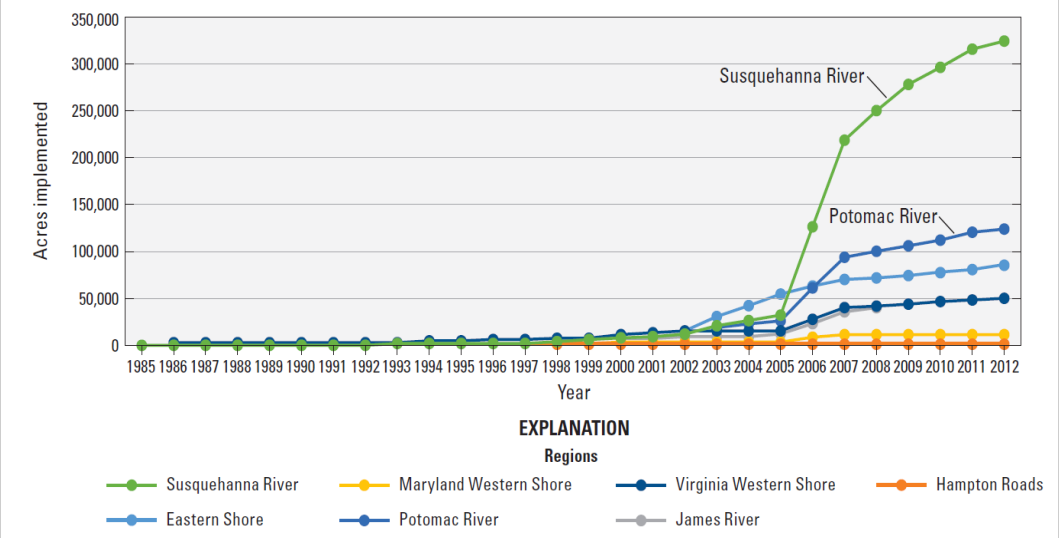


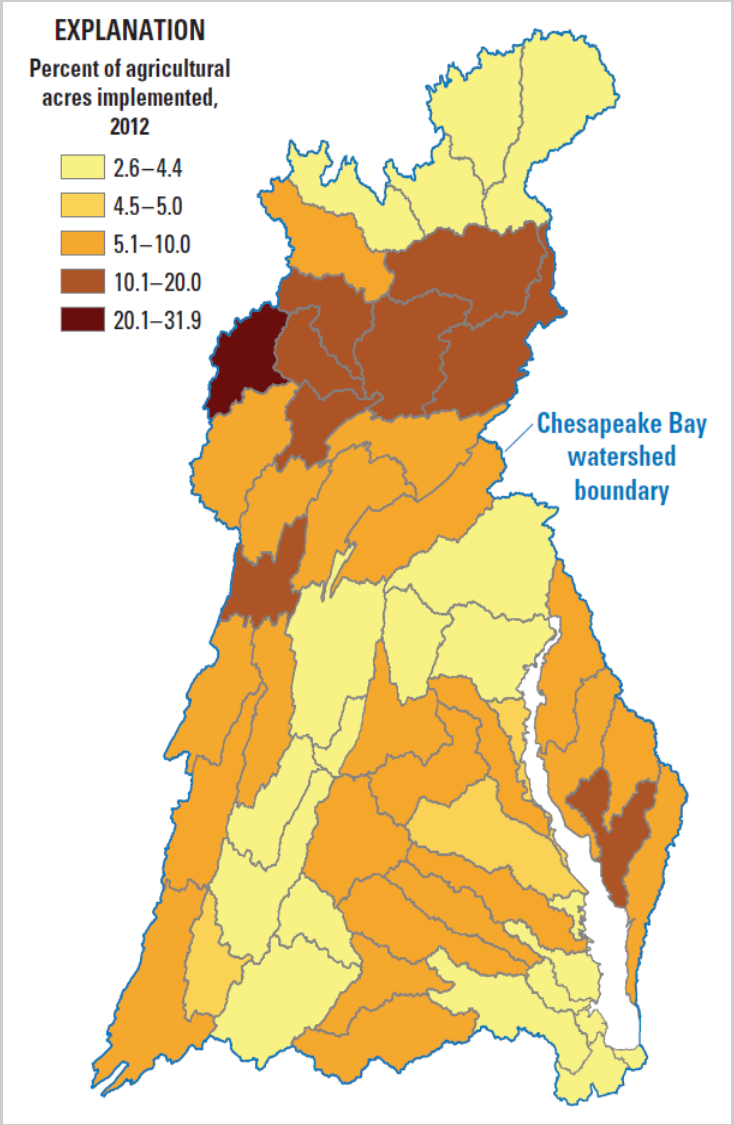
Predicted effects of reported nutrient **input** BMP implementation were pretty small, especially for nitrogen (Phase 5.3.2 WSM)

Manure & Fertilizer Inputs To Land

Potential Effects of Animal and LU Change BMPs 1985-2012

Implementation of land-use change BMPs ranged from 2.6 to 31 percent of eligible agricultural acres (Phase 5.3.2 WSM)





Manure & Fertilizer Applications To Land

Summary

At the watershed scale:

- N inputs to land increased by over 90% between 1950 and 1982, driven largely by increased fertilizer-N use. Post-1982 years are marked by more inter-annual variability
- Phosphorus inputs increased by about 13% between 1950 and 1982, after which it declined steadily through 2012 (26%).

At the Regional Scale

- P inputs declined everywhere but Hampton Roads
- N inputs were re-distributed in some regions, particularly the Susquehanna and Potomac
- N Inputs on the Eastern Shore increased

At the 8-digit HUC scale

- Some basins experienced increases N inputs, largely due to increasing animal populations
- N input intensity increased in 44 HUC8 basins
- P input intensity declined in more than half of HUC8 basins. Exceptions included urbanizing basins and those with high poultry populations

Reported BMP implementation was expected to have minimal impact on nutrient ***inputs*** between 1985 and 2012

Thank You

Questions?


Olivia Devereux


Andy LaMotte

Andy Sekellick


Joel Blomquist

Manure & Fertilizer Applications To Land

Data Sources

Fertilizer: Annual 1950-2012

Annual 1950-2012.

Sekellick 2017 USGS Data Release. Derived form Alexander and Smith (1990), Battaglin and Goolsby (1995), and Brakebill, Gronberg, and Spahr (2016).

Manure: 5-year intervals 1950-2012

Sekellick 2017 USGS Data Release. Derived from USDA Ag Census animal count data using methods from Brakebill & Gronberg 1990. Spatially distributed using cropland estimates from NLCD 2001.

Agricultural Land Use & Practices: 5-year intervals 1950-2012

Derived from county-level estimates reported in the USDA Agricultural Census (LaMotte 2015). Spatially attributed to 8-digit HUCs using agricultural land uses from Falcone (2015).

BMP implementation: Annual 1985-2012

Devereux 2017 USGS Data Release, in review. Estimates obtained from the Chesapeake Bay Program (CBP) in 2016. Produced using the Chesapeake Bay Program Phase 5.3.2 Watershed Model. Devereux et al. 2017 in review

Land Use/Land Use Change: 1974, 1982, 1992, 2002, 2012

Falcone, J.A., 2015. USGS Data Series 948.