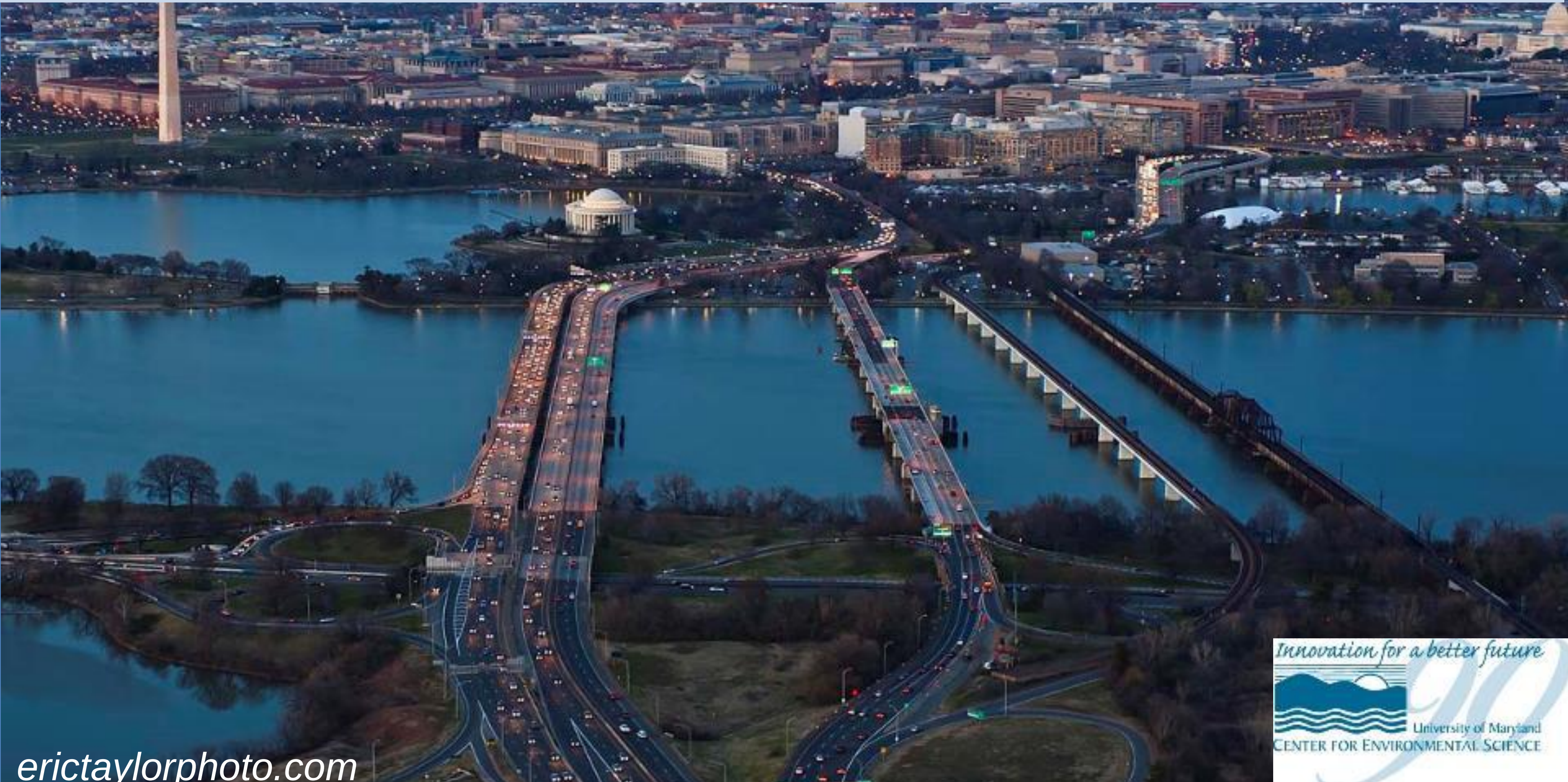
Documenting Impacts of Climate, Clams, and a Changing Watershed on the Potomac Estuary

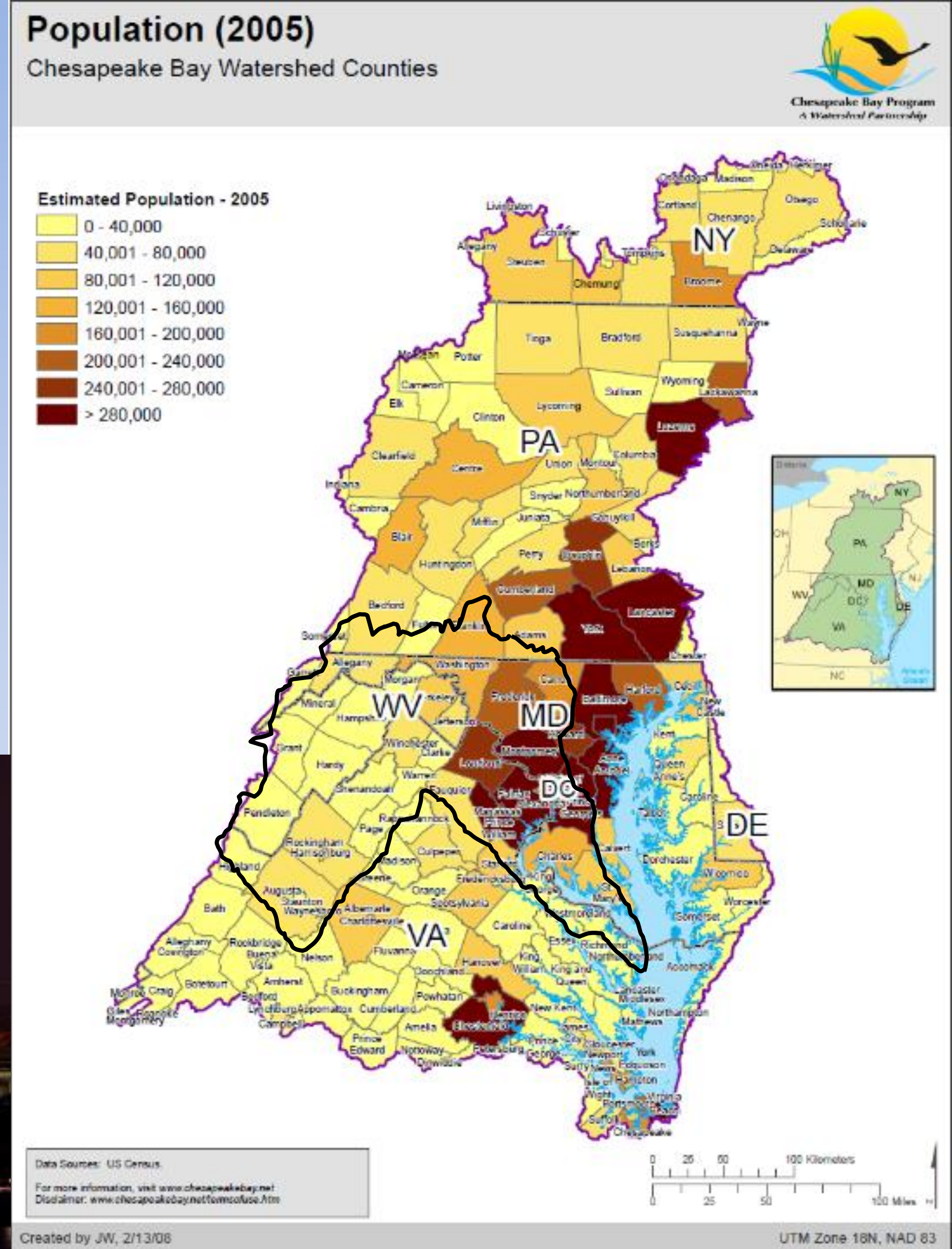
Lora Harris, Rebecca Murphy, Robert Sabo, Keith Eshleman, Ryan Woodland, Dong Liang, Hal Walker

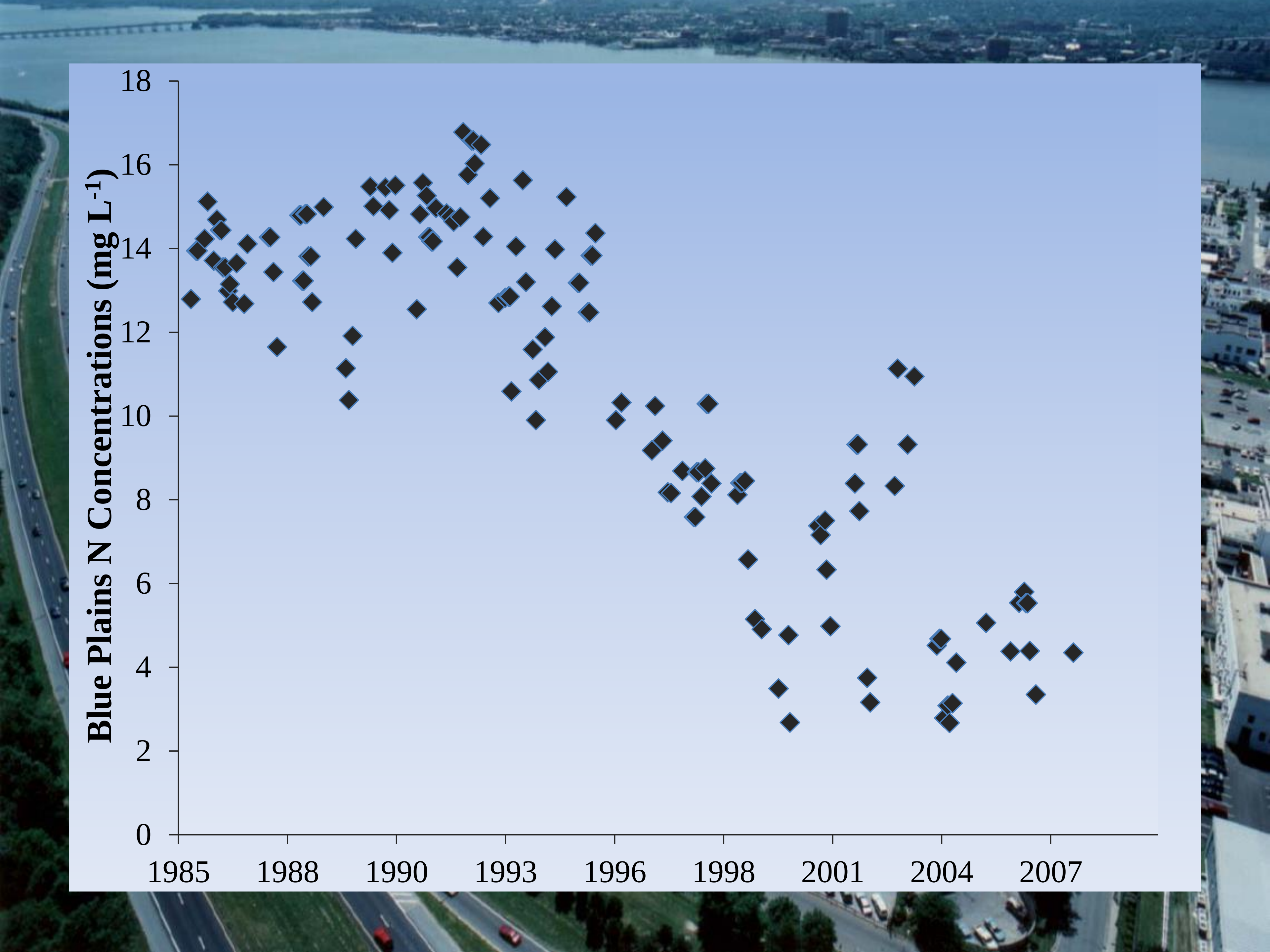


Innovation for a better future
University of Maryland
CENTER FOR ENVIRONMENTAL SCIENCE

POTOMAC ESTUARY

- Largest Tributary of CBay
- Watershed covers four states and Washington, DC
- Lower Population Density in Mesohaline portion of estuary

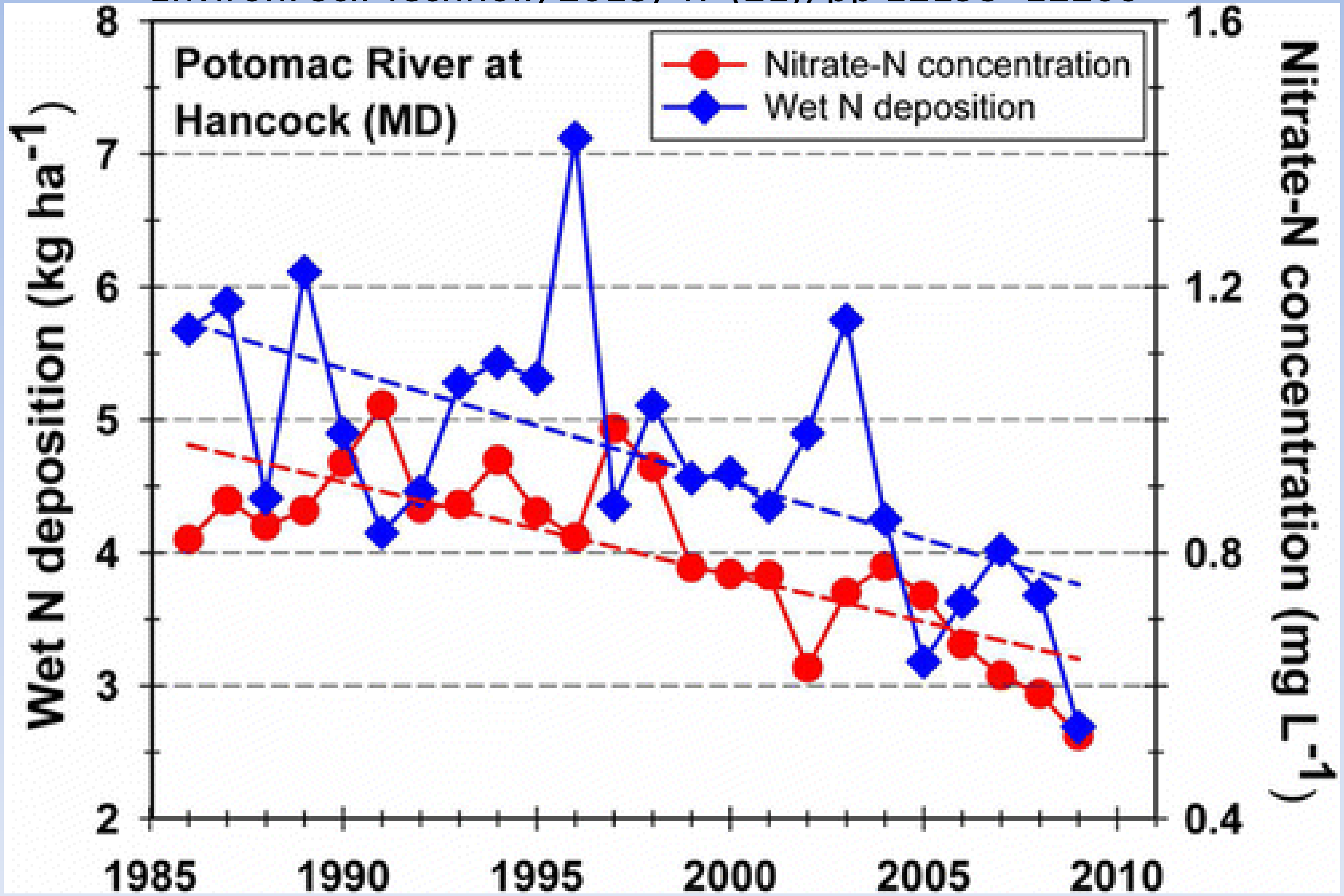



Blue Plains N Concentrations (mg L-1)
18
16
14
12
10
8
6
4
2
0
1985
1988
1990
1993
1996
1998
2001
2004
2007

Surface Stream Water Quality Is Improving due to Declining Atmospheric N Deposition

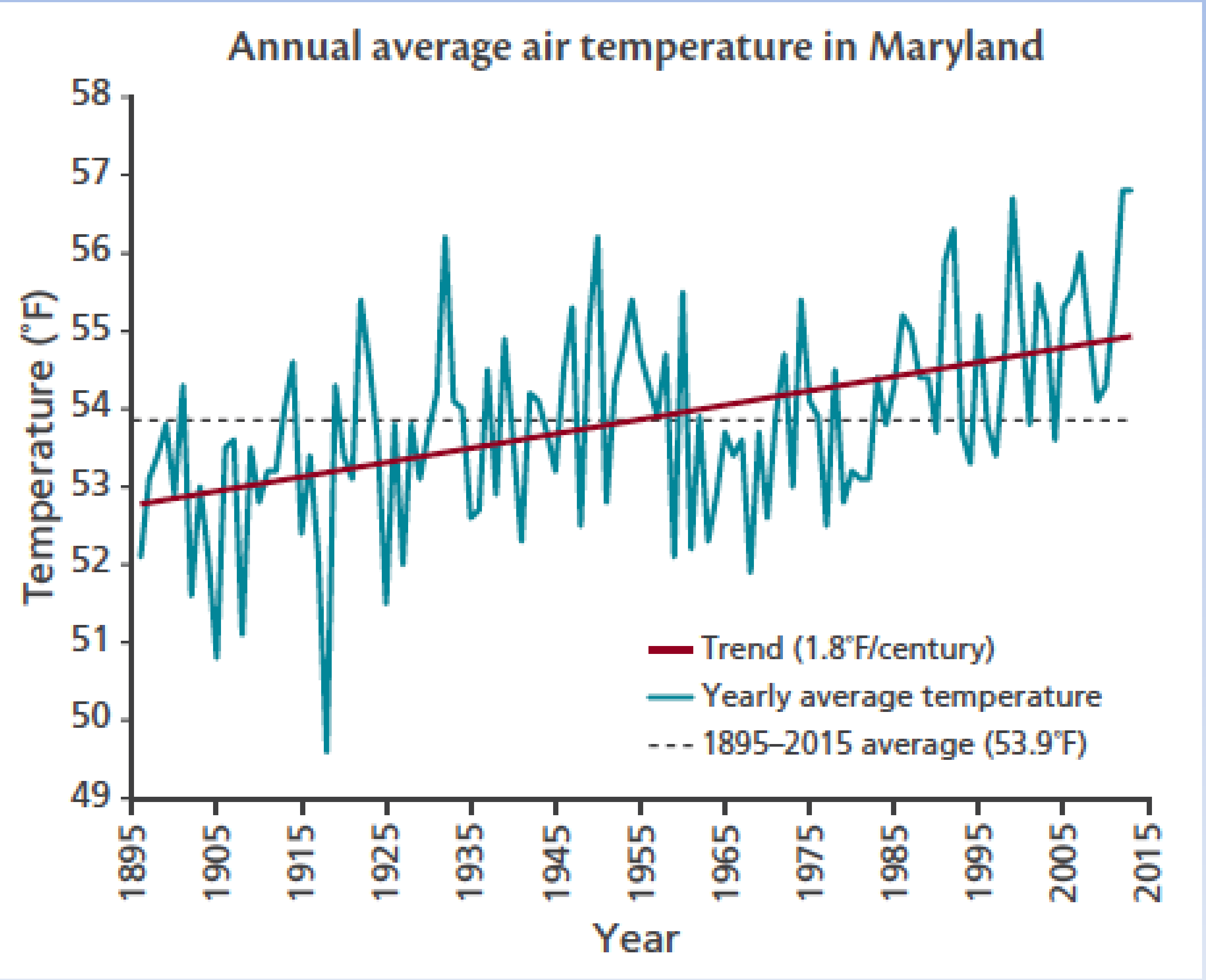
Keith N. Eshleman*, Robert D. Sabo, and Kathleen M. Kline

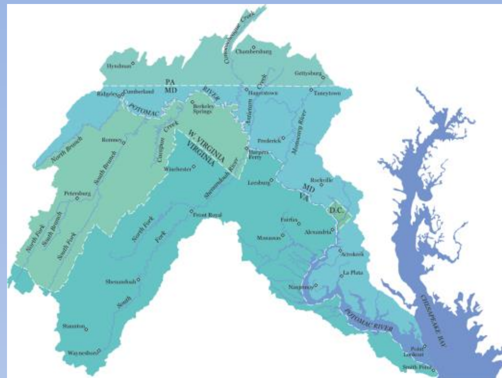
†*Environ. Sci. Technol.*, 2013, 47 (21), pp 12193–12200

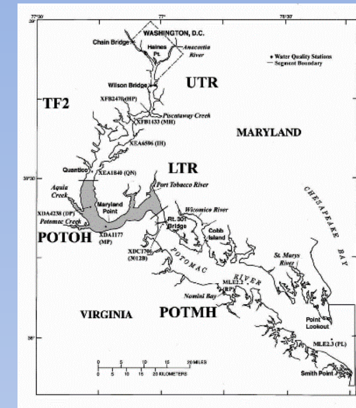


Climate Indicators Show Impacts on Chesapeake Region

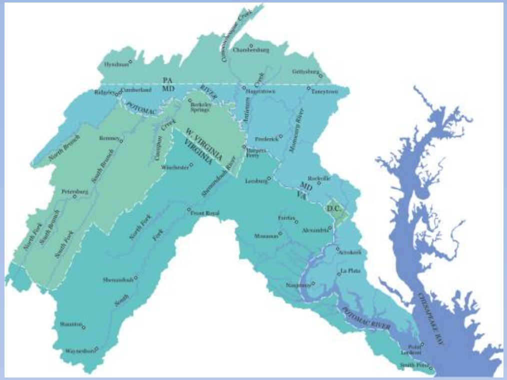
National Climatic Data Center
from http://climatechange.maryland.gov/science/





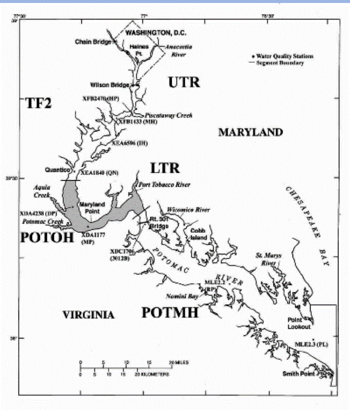

WASHINGTON, D.C.
UTR
TF2
MARYLAND
LTR
POTOH
VIRGINIA
POTMH

Analytical Approach:
The Watershed



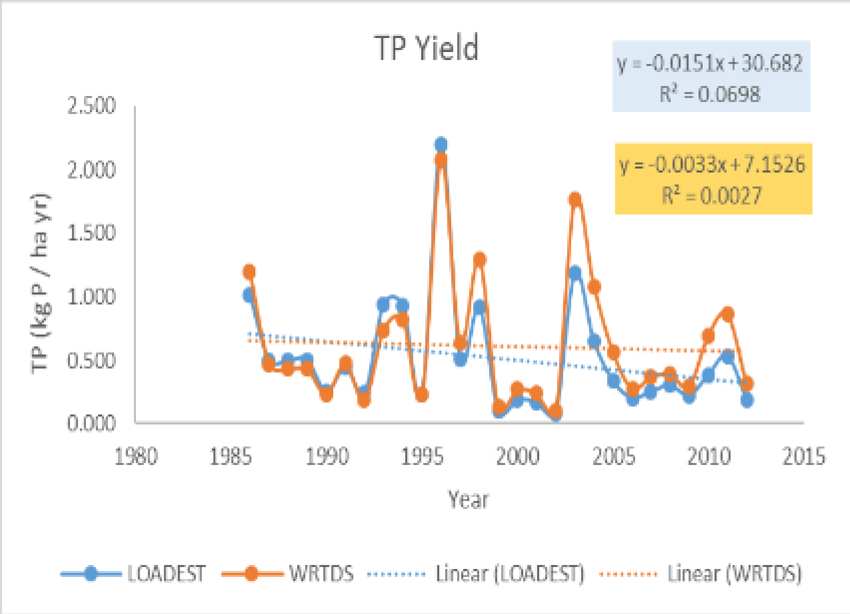
- Examine fall line loads and trends
- Determine sources contributing to fall line loads
- Use source analysis to assess role of inputs

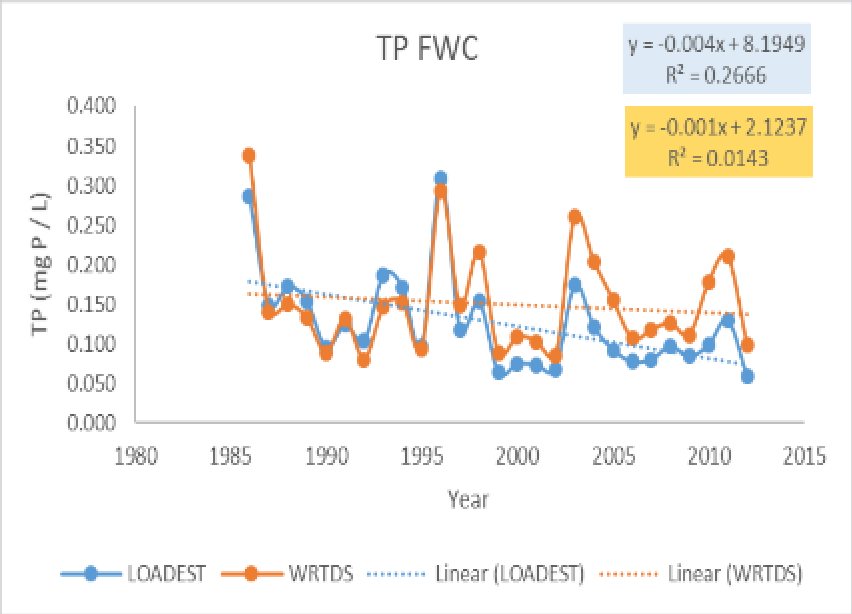
Analytical Approach:
The Estuary

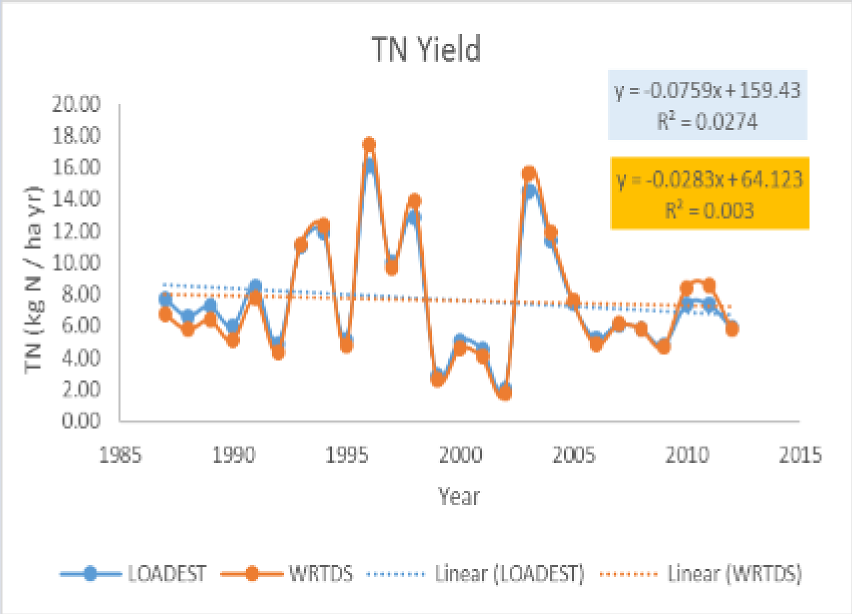


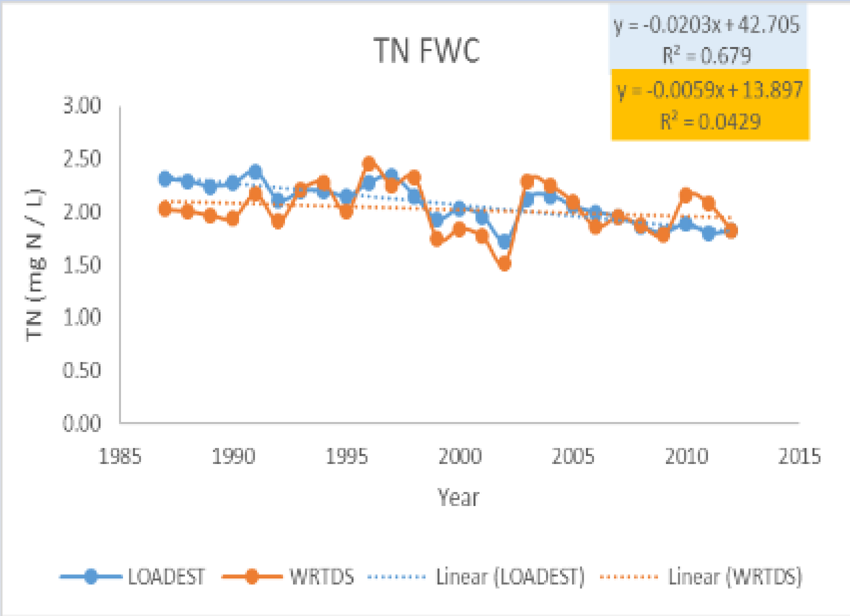
- Test explanatory models related to water quality variables of interest (GAMs)
- Tidal fresh vs Mesohaline
- Think outside the box for explanations

The Watershed

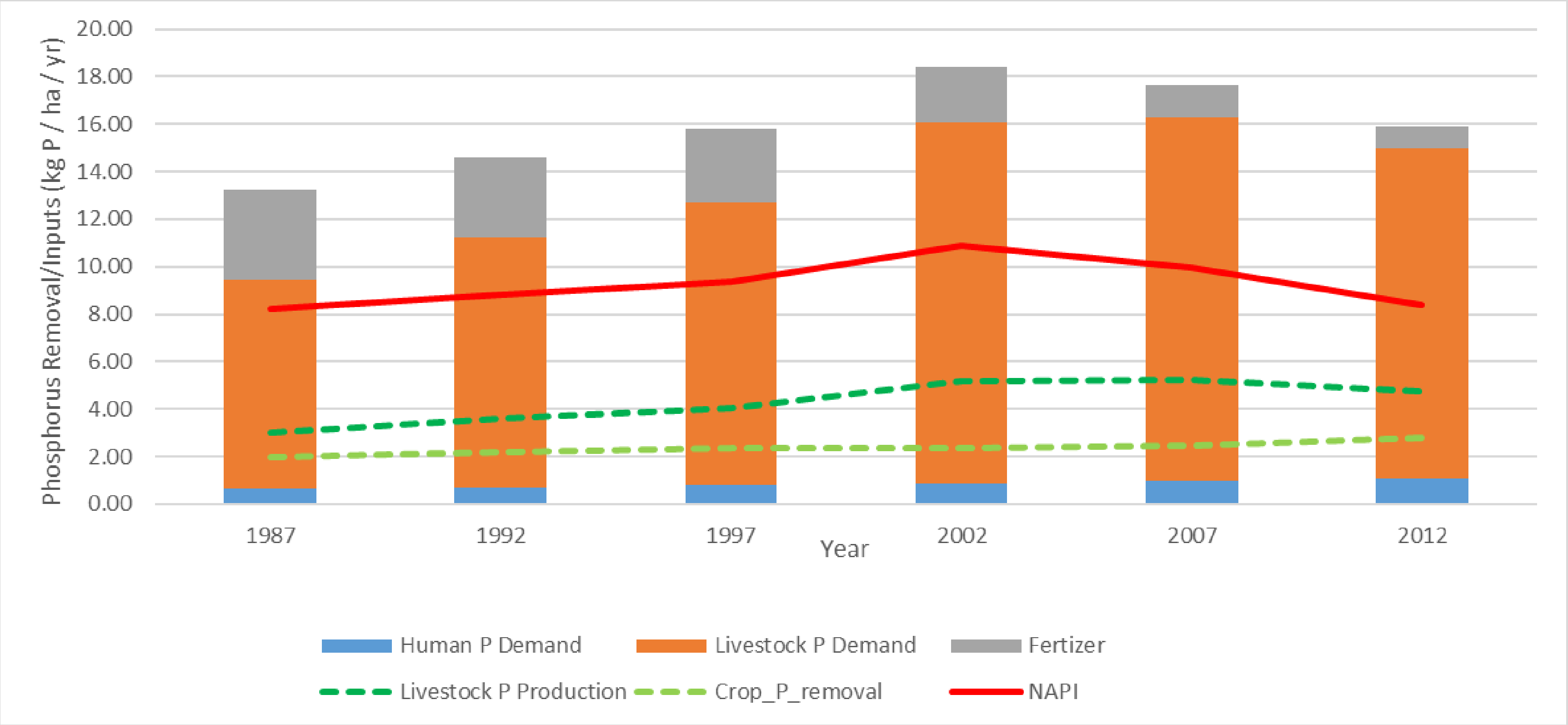




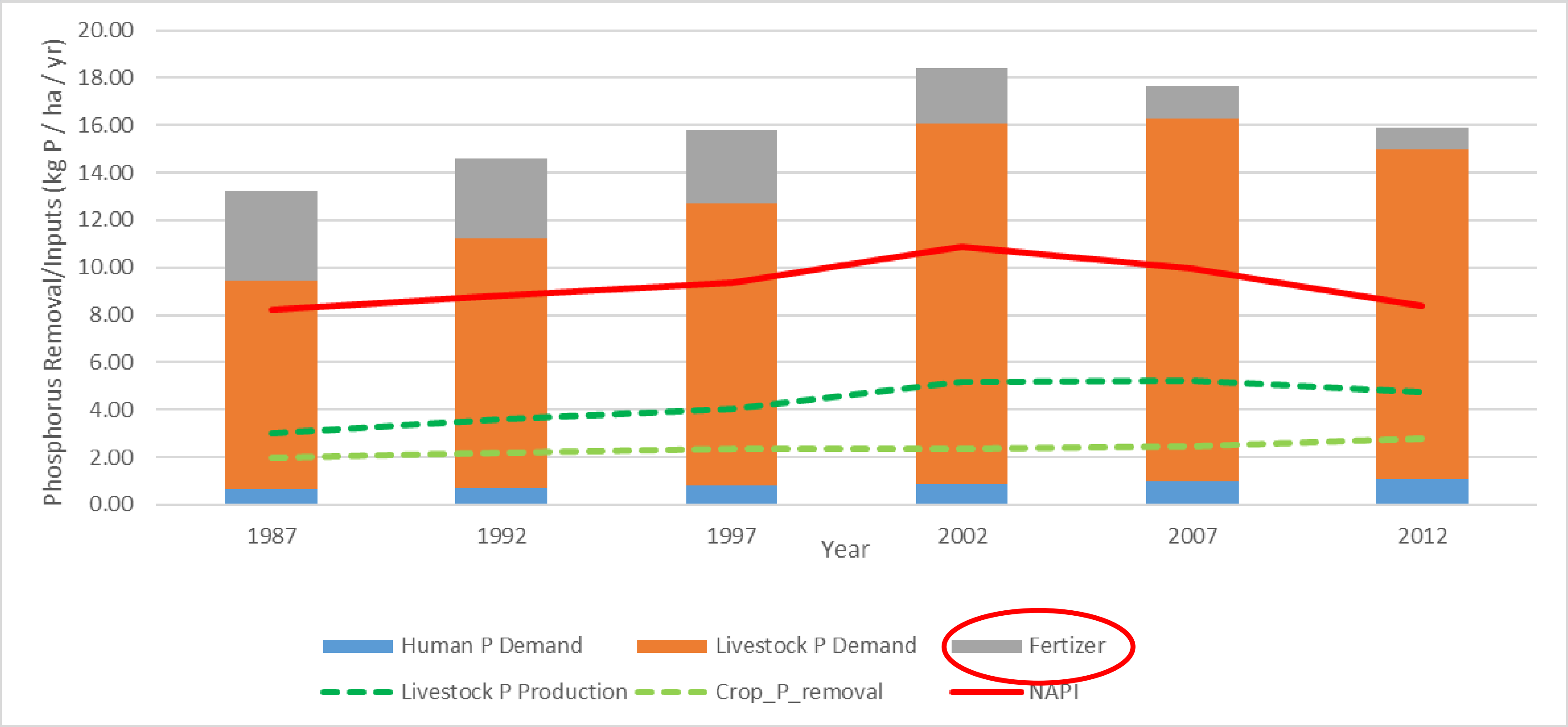




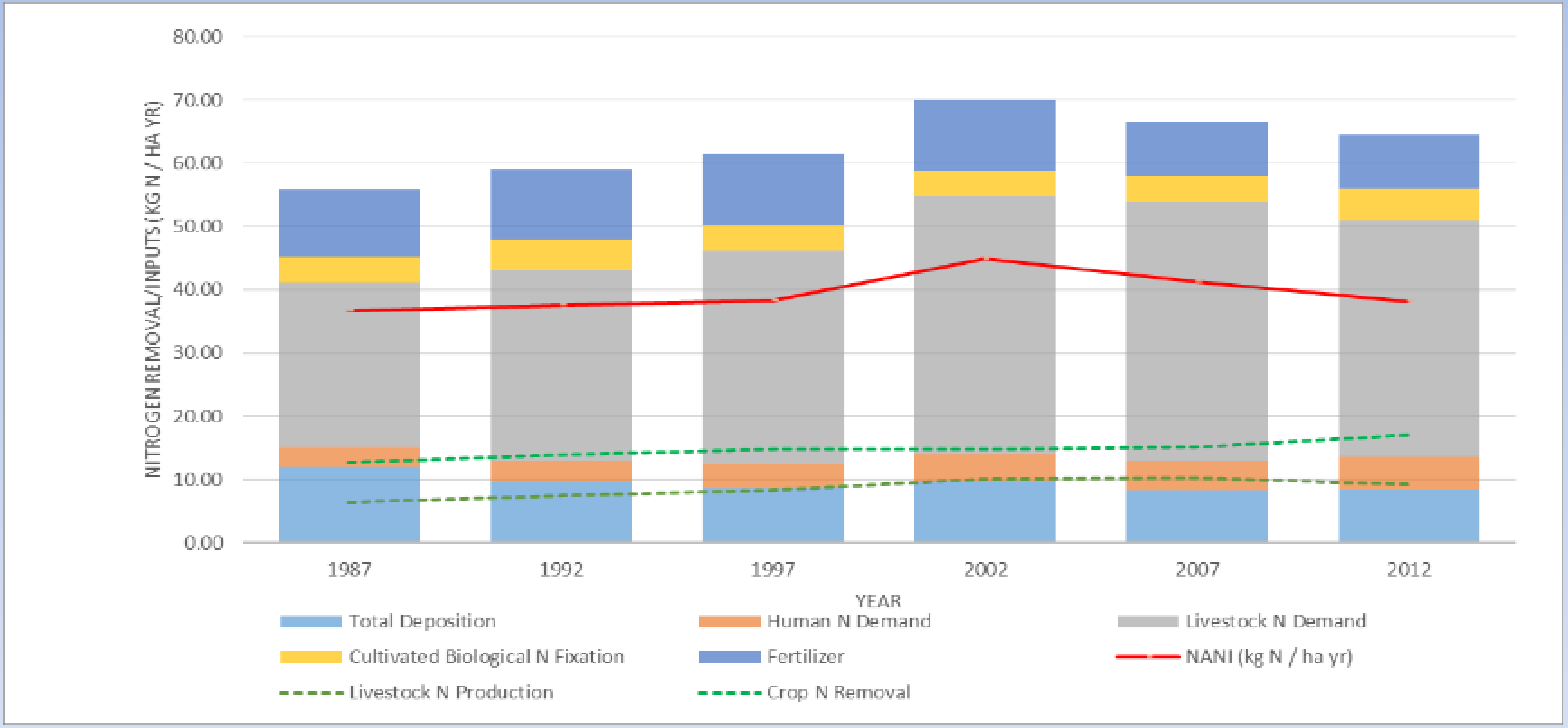
Net Anthropogenic Inputs - Phosphorus



Net Anthropogenic Inputs - Phosphorus



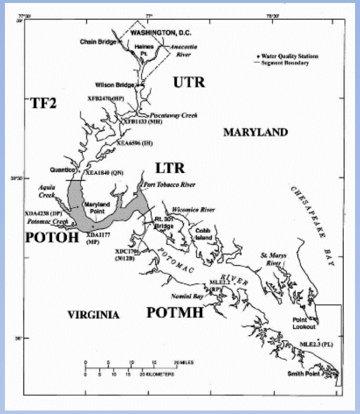
Net Anthropogenic Inputs - Nitrogen



Net Anthropogenic Inputs - Nitrogen

	MANN KENDALL	LINEAR REGRESSION			GAM		
	Tau	Δ(abs) (kg N ha^{-1} yr^{-1})	95% C.I. of Δ(abs)		Δ(abs) (kg N ha^{-1} yr^{-1})	95% C.I. of Δ(abs)	
LIVESTOCK N CONSUMPTION	**0.73**	**15.05**	**11.80**	**18.31**	**14.92**	**13.61**	**16.47**
AGRICULTURAL N FIXATION	-0.24*	-0.23	-0.75	0.29	-0.19	-0.67	0.20
LIVESTOCK N PRODUCTION	**0.73**	**3.76**	**2.95**	**4.58**	**3.75**	**3.36**	**4.14**
FERTILIZER N APPLICATION	**-0.41**	**-3.64**	**-4.94**	**-2.35**	**-3.63**	**-4.59**	**-2.80**
CROP N PRODUCTION	**0.80**	**2.56**	**1.38**	**3.75**	**2.41**	**0.99**	**3.51**
HUMAN N CONSUMPTION	**1.00**	**2.13**	**2.08**	**2.18**	**2.12**	**1.93**	**2.28**
POINT SOURCE TN LOADS	**-0.81**	**-0.45**	**-0.55**	**-0.36**	**-0.45**	**-0.50**	**-0.40**
TOTAL N DEPOSITION	**-0.48**	**-3.64**	**-5.65**	**-1.64**	**-3.40**	**-5.30**	**-1.73**
NANI	0.26*	3.33	-0.76	7.43	3.36	0.74	6.23

Analytical Approach: *The Estuary*



- Freshwater:

chla ~ seas + s(doy, bs = "cc") +s(flow,by=seas) + s(PAR,by=seas) + s(wtemp,by=seas) +s(bivalves,by=seas)+s(WWtn,by=seas) +s(RIM-TN,by=seas)+s(RIM-TP,by=seas)

- Mesohaline:

chla ~ seas + s(doy, bs = "cc") +s(stratification,by=seas) + s(PAR,by=seas) + s(wtemp,by=seas) +s(main-TN,by=seas)+s(main-TP,by=seas) +s(RIM-TN,by=seas)+s(RIM-TP,by=seas)

Trends in Global Cloud Cover in Two Decades of HIRS Observations

Donald Wylie

Space Science and Engineering Center, University of Wisconsin—Madison, Madison, Wisconsin

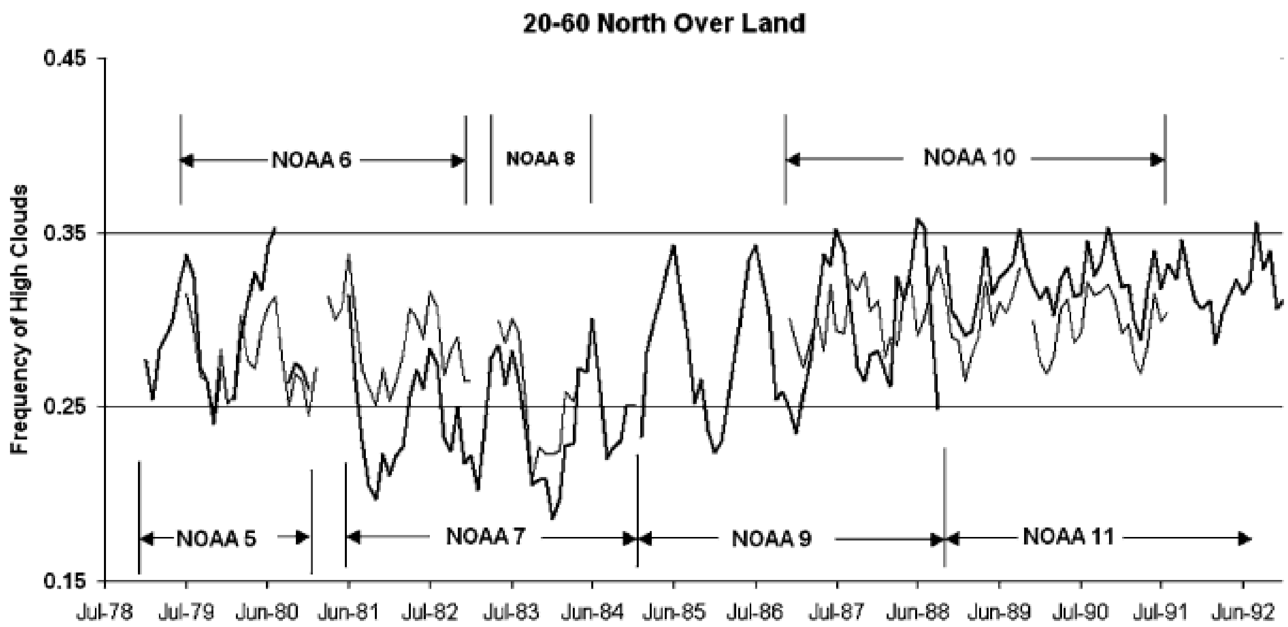
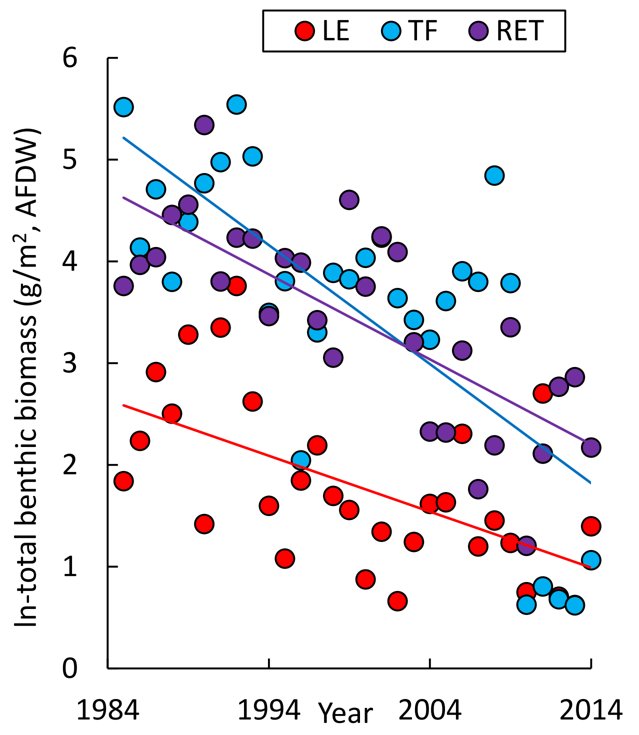
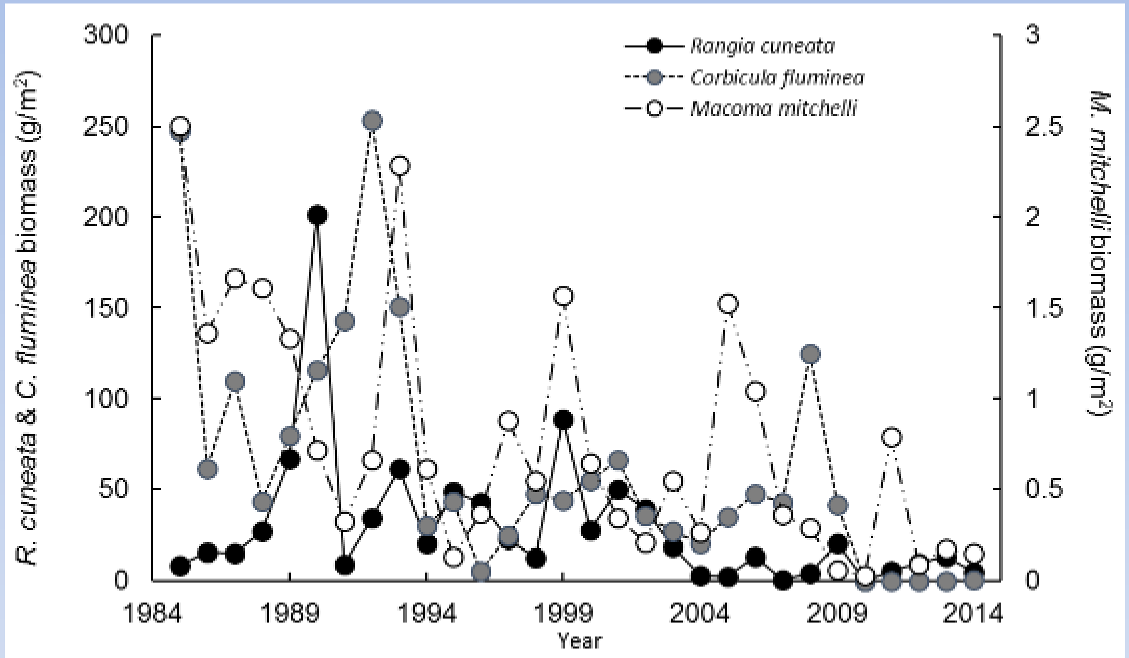


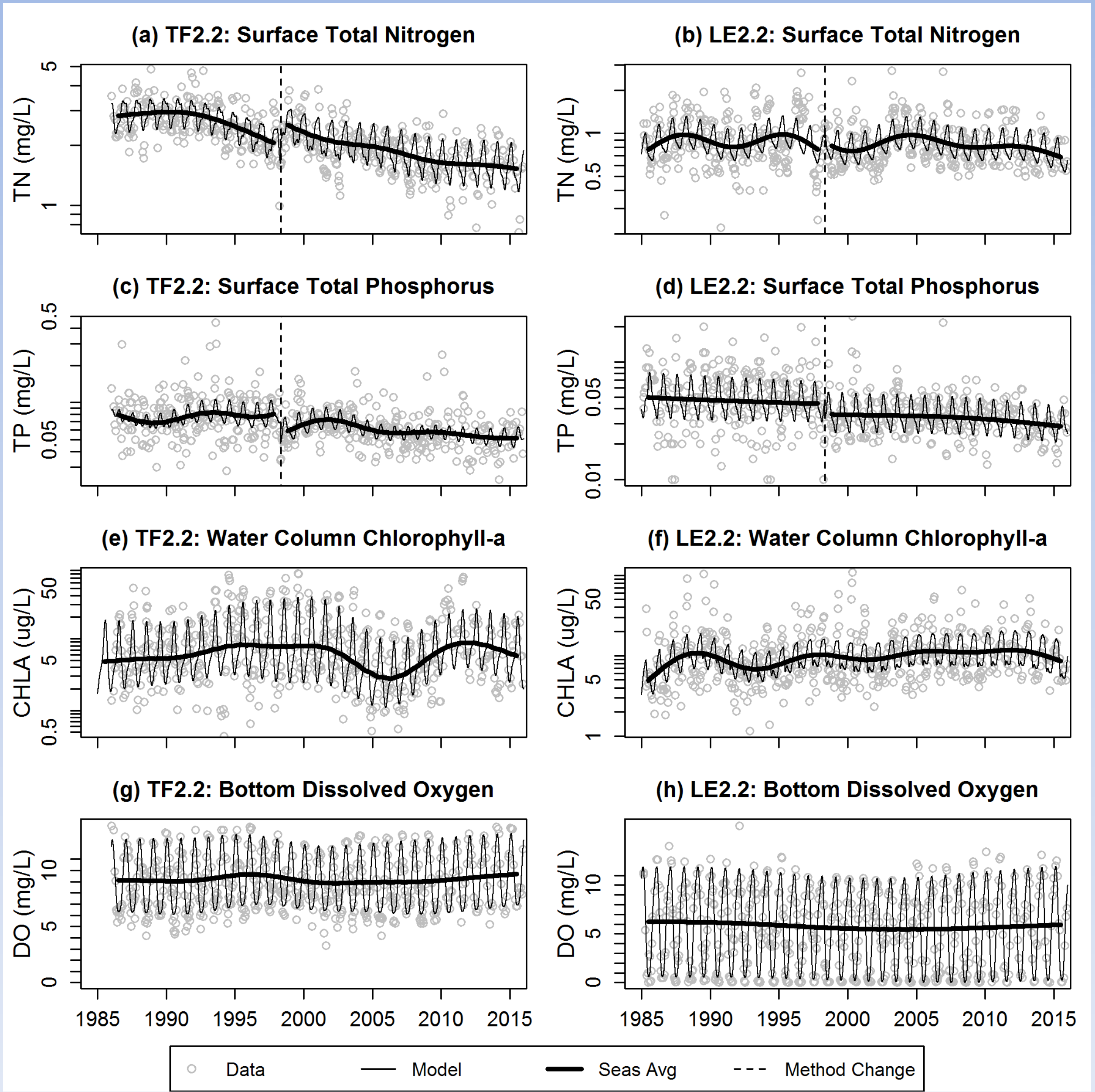
Fig. 3. The monthly average frequency of high clouds from 20° to 60°N showing the time period of individual satellites.

Clams Tell A Story…

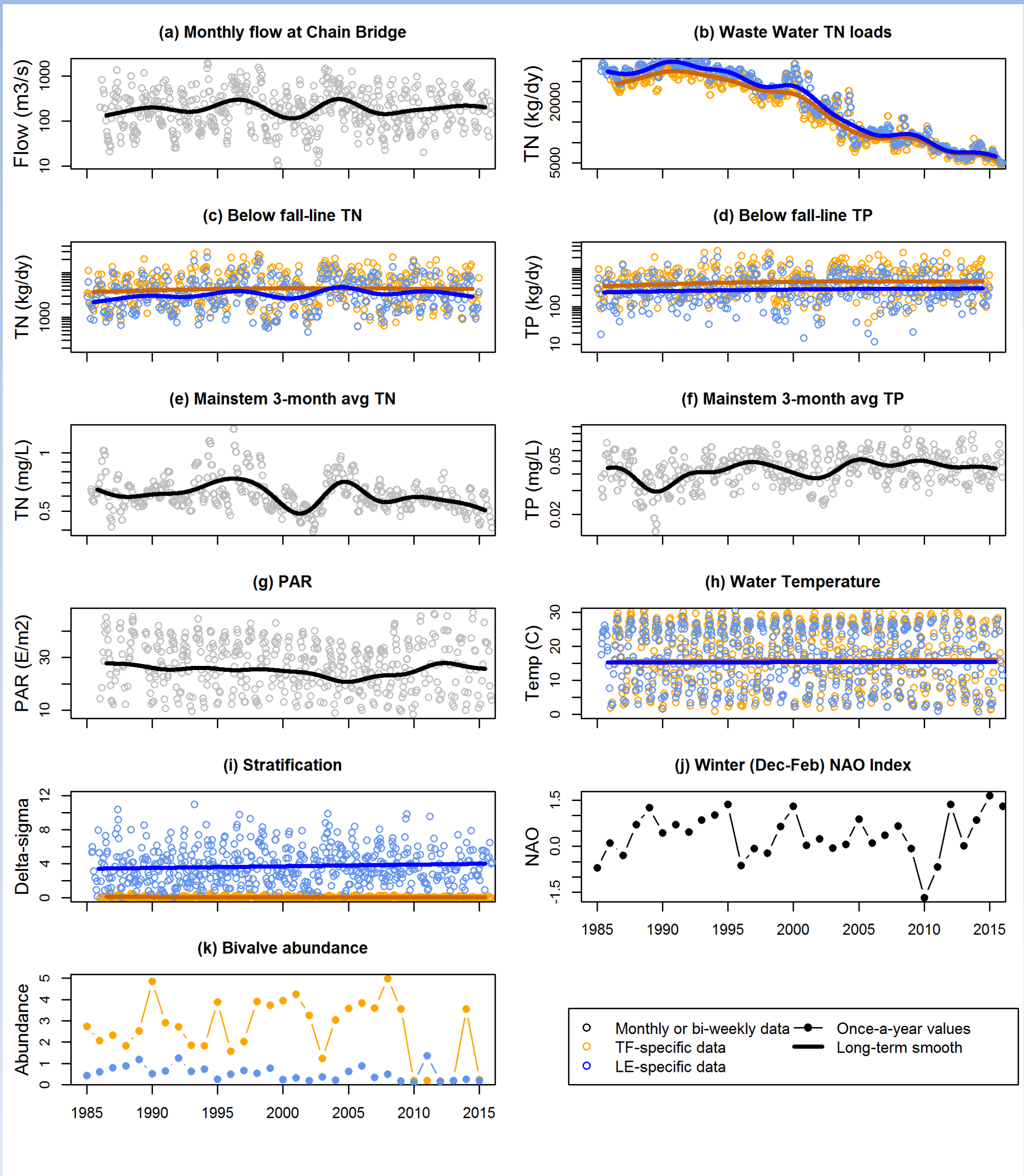




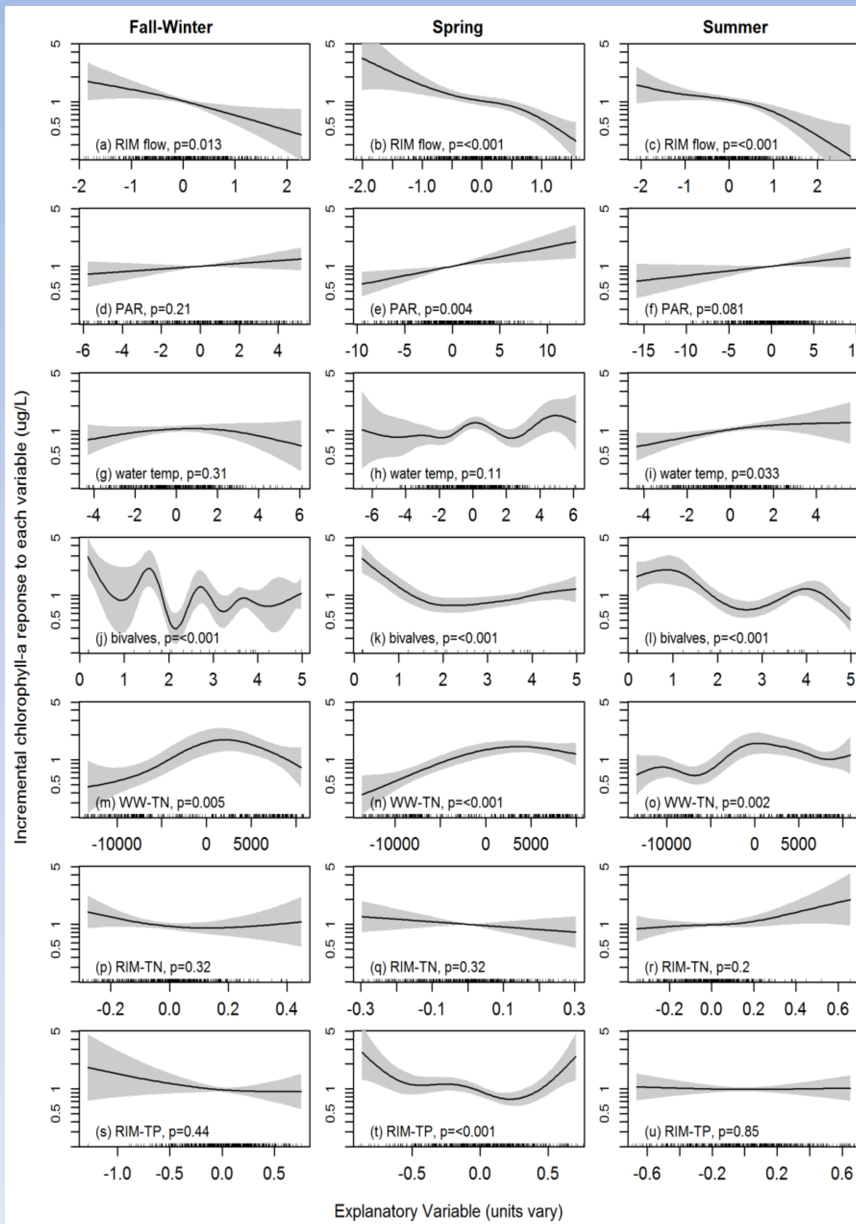
Response Variables

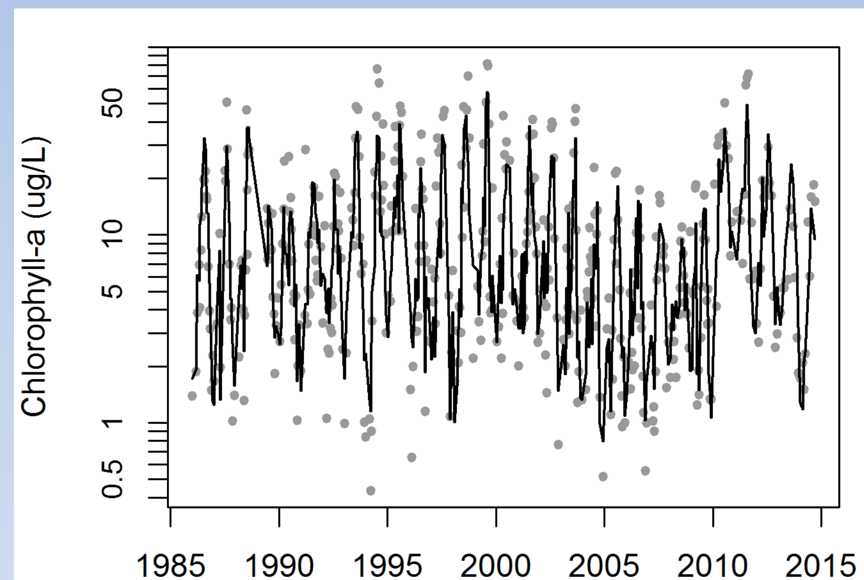


Explanatory Variables

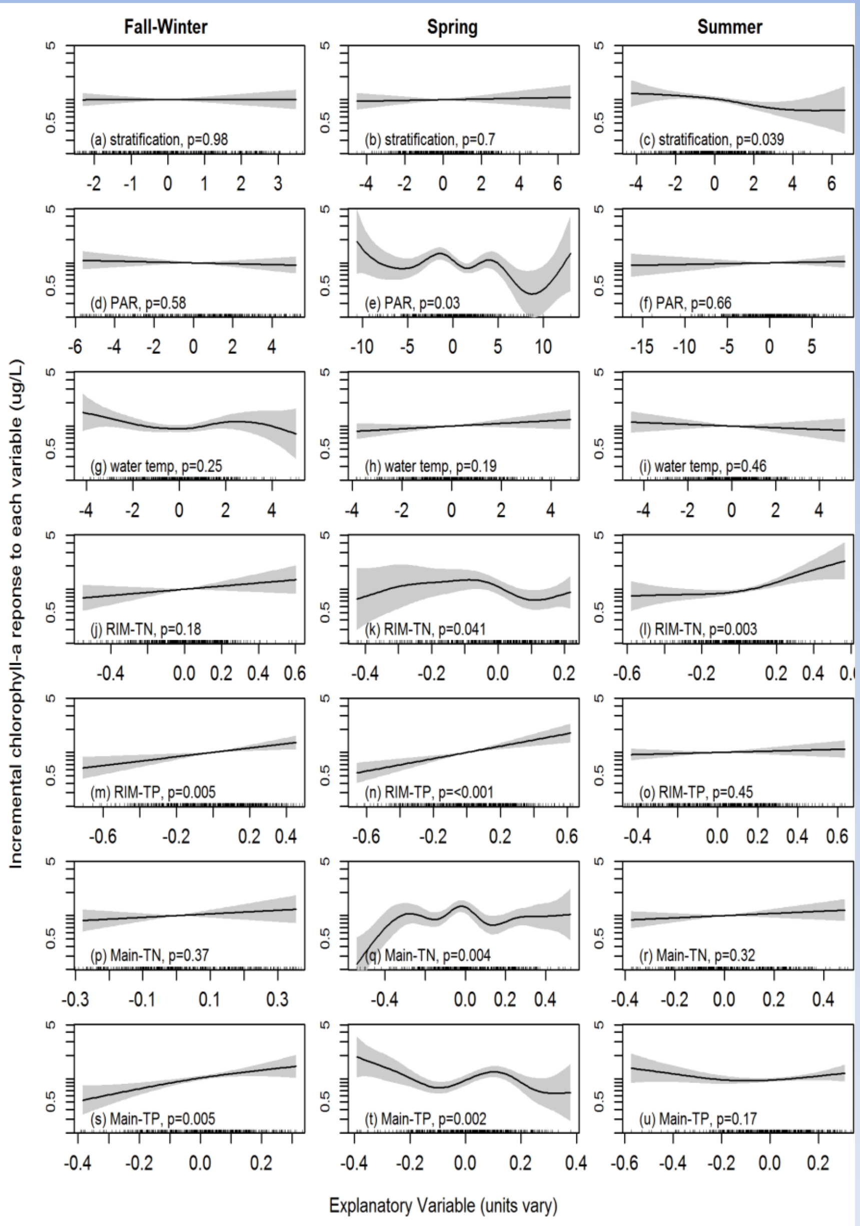


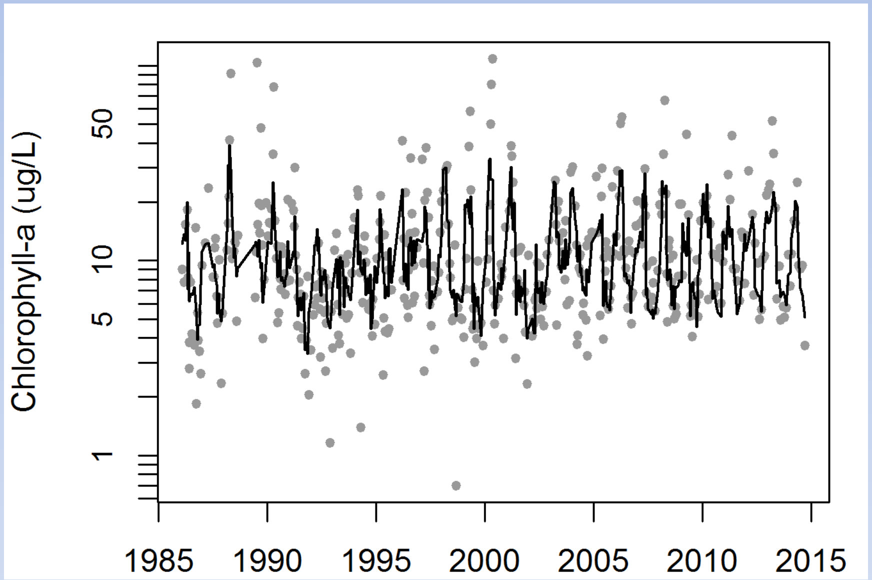
Fitted GAM components - FW



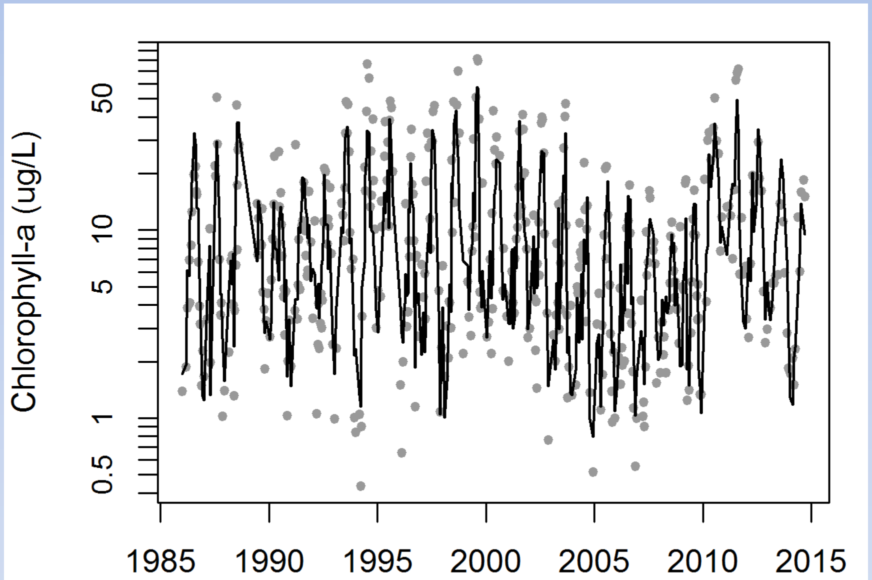


Fitted GAM components - MESO

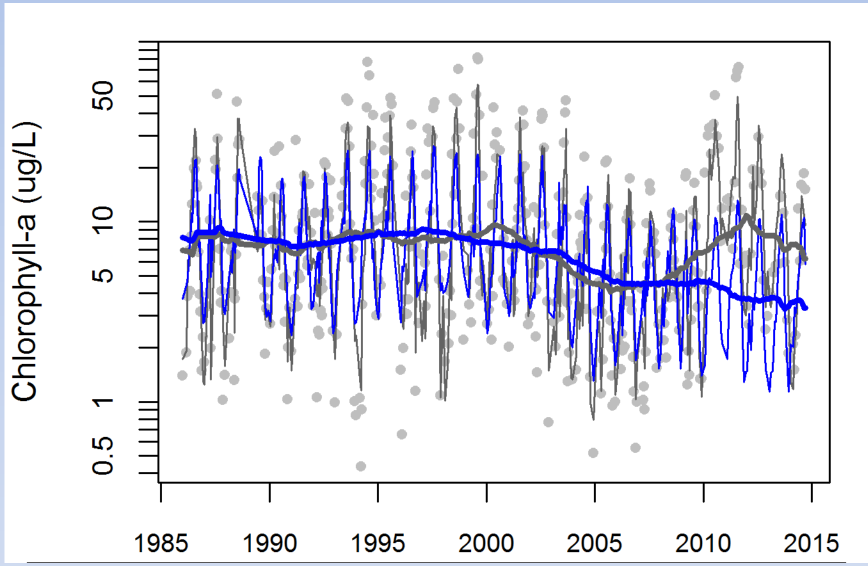




Fun with GAMs:
What would Chl look like in a less variable world?

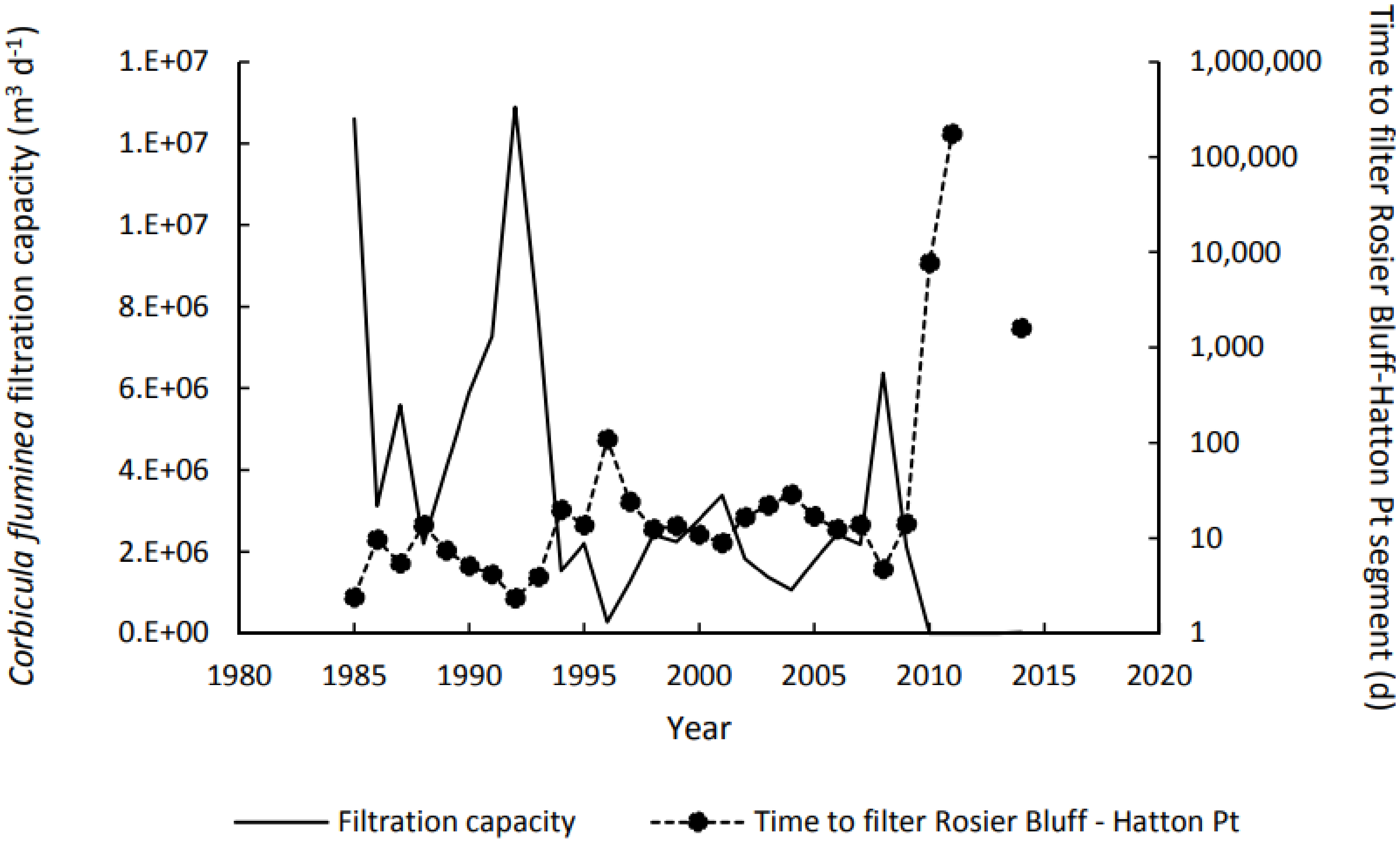


With time series untouched….

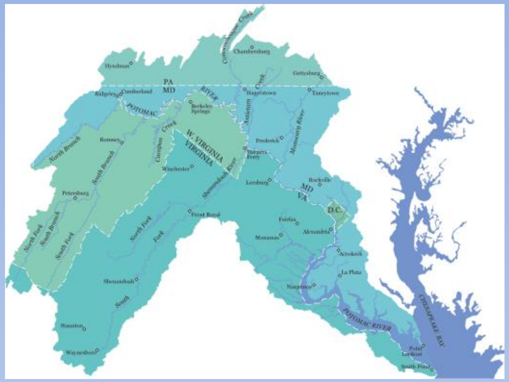


Manipulating Clams and Climate

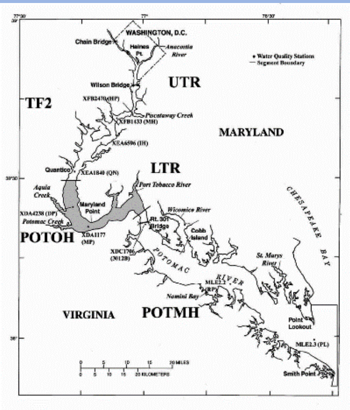
Corbicula!



Corbicula fluminea filtration capacity (m³ d⁻¹)
1.E+07
1.E+07
1.E+07
8.E+06
6.E+06
4.E+06
2.E+06
0.E+00
1980
1985
1990
1995
2000
2005
2010
2015
2020
Year
1,000,000
100,000
10,000
1,000
100
10
1
Time to filter Rosier Bluff-Hatton Pt segment (d)
Filtration capacity
Time to filter Rosier Bluff - Hatton Pt



Conclusions



- **Quantifying** management effects is possible from empirical data
- **Changing** agricultural practices mask some declines in nutrient sources
- **Climatic** factors & **Ecological** considerations helpful in understanding lack of expected response
- Potomac Estuary water quality responsive to different factors in **tidal fresh versus mesohaline**

With Gratitude:

Chesapeake Bay Program
Science. Restoration. Partnership.

ITAT Co-Chairs: Jeni Keisman, Jeremy Testa, Rebecca Murphy

Melinda Forsyth

Versar Environmental Services





Net Anthropogenic Inputs - Phosphorus

	MANN KENDALL	LINEAR REGRESSION			GAM		
	Tau (%)	Δ(abs) (kg P ha^{-1} yr^{-1})	95% C.I. of Δ(abs)		Δ(abs) (kg P ha^{-1} yr^{-1})	95% C.I. of Δ(abs)	
HUMAN P CONSUMPTION	0.74	0.43	0.42	0.44	0.43	0.39	0.46
LIVESTOCK P CONSUMPTION	0.74	6.84	5.48	8.19	6.80	6.31	7.43
LIVESTOCK P PRODUCTION	-0.92	2.33	1.87	2.79	2.32	2.13	2.49
FERTILIZER P APPLICATION	0.82	-3.02	-3.51	-2.53	-2.93	-3.74	-2.10
CROP P PRODUCTION	-0.90	0.48	0.29	0.67	0.44	0.19	0.62
POINT SOURCE TP LOADS	0.45	-0.13	-0.15	-0.11	-0.13	-0.14	-0.12
NAPI	0.74	1.45	0.38	2.53	1.51	0.76	2.10