

Small watershed and subestuary studies link drivers and management practices to system responses

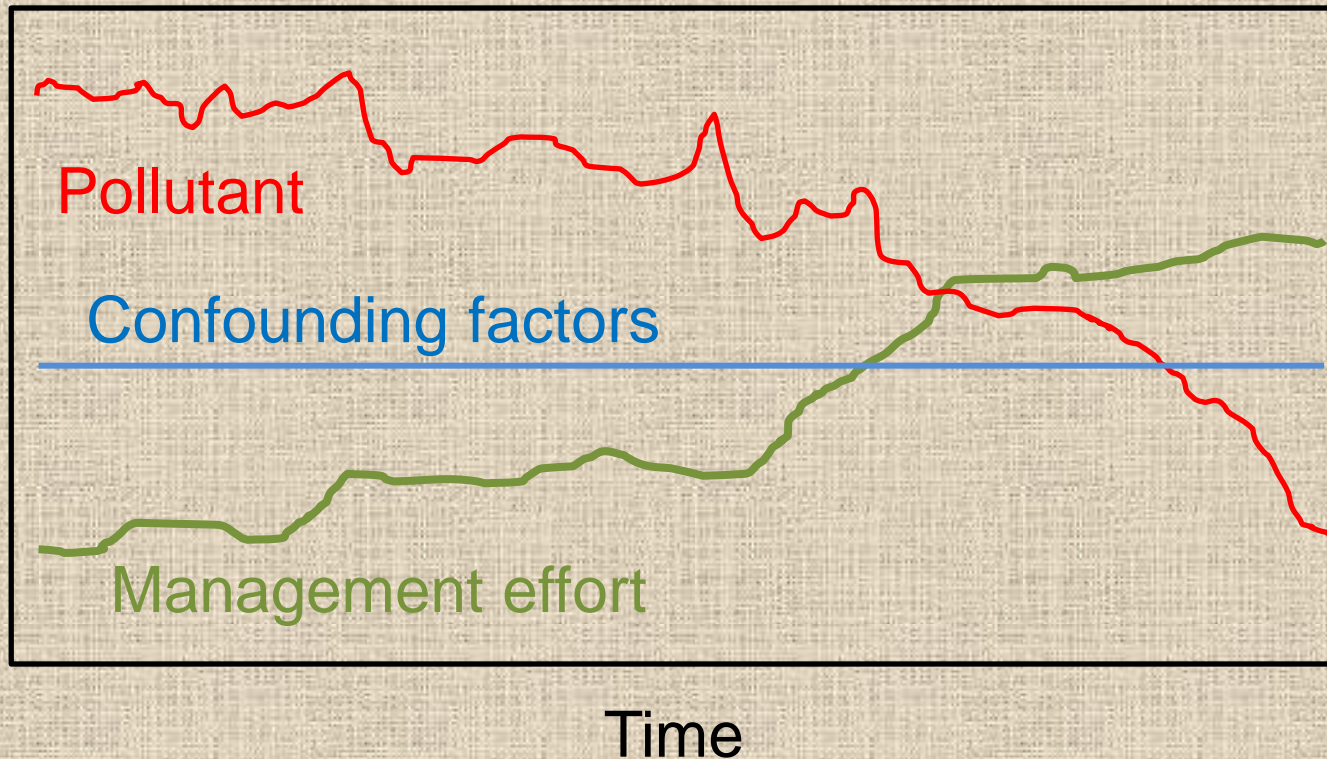
Don Weller, Tom Jordan, Chris Patrick (SERC)
Matt Baker (UMBC)



Smithsonian Environmental
Research Center

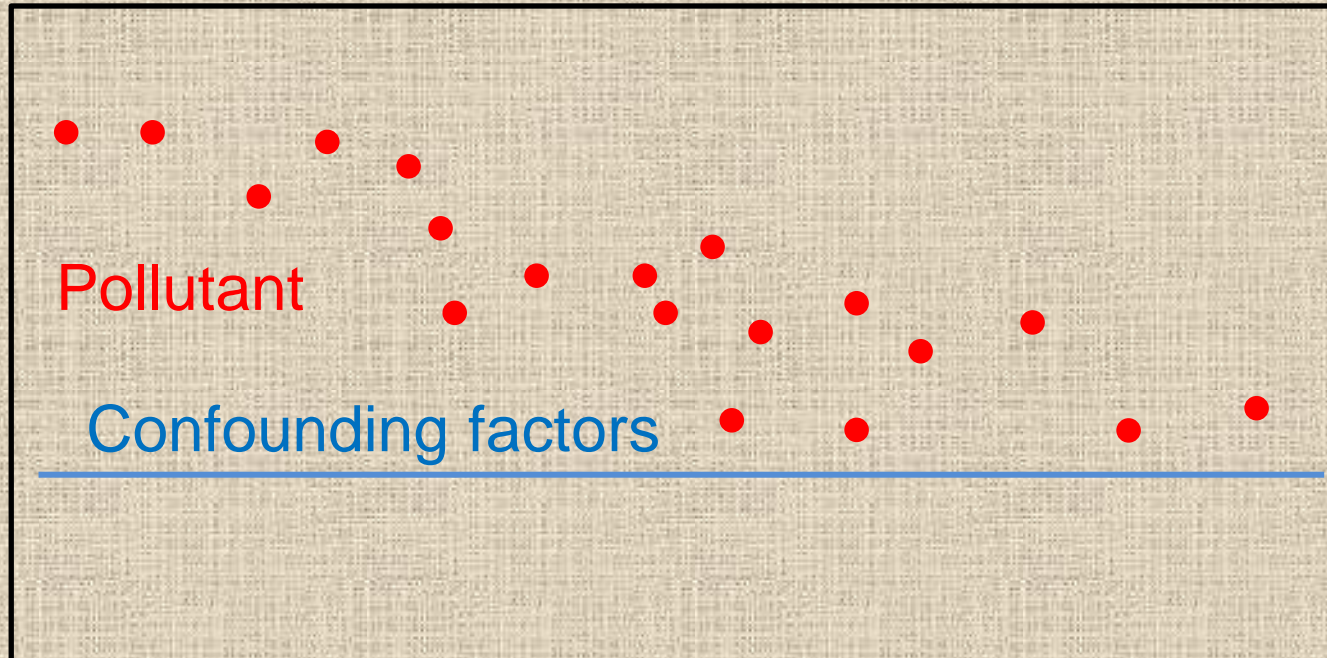
UMBC
AN HONORS UNIVERSITY IN MARYLAND

Connecting water quality to management



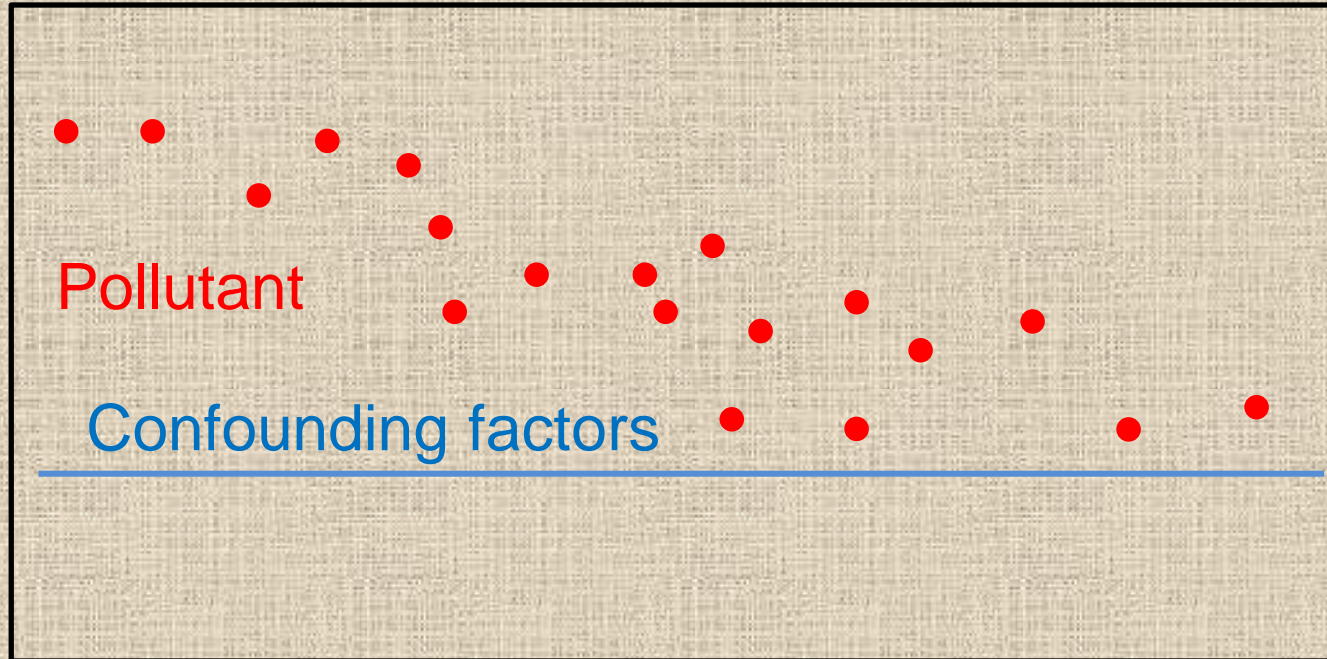
- Gold standard, but patience is required
- Adaptive management needs early feedback

Another approach



Management effort
One site through time

Another approach



Management effort
Different sites

- Can provide quicker feedback

Small Watershed Monitoring Designs

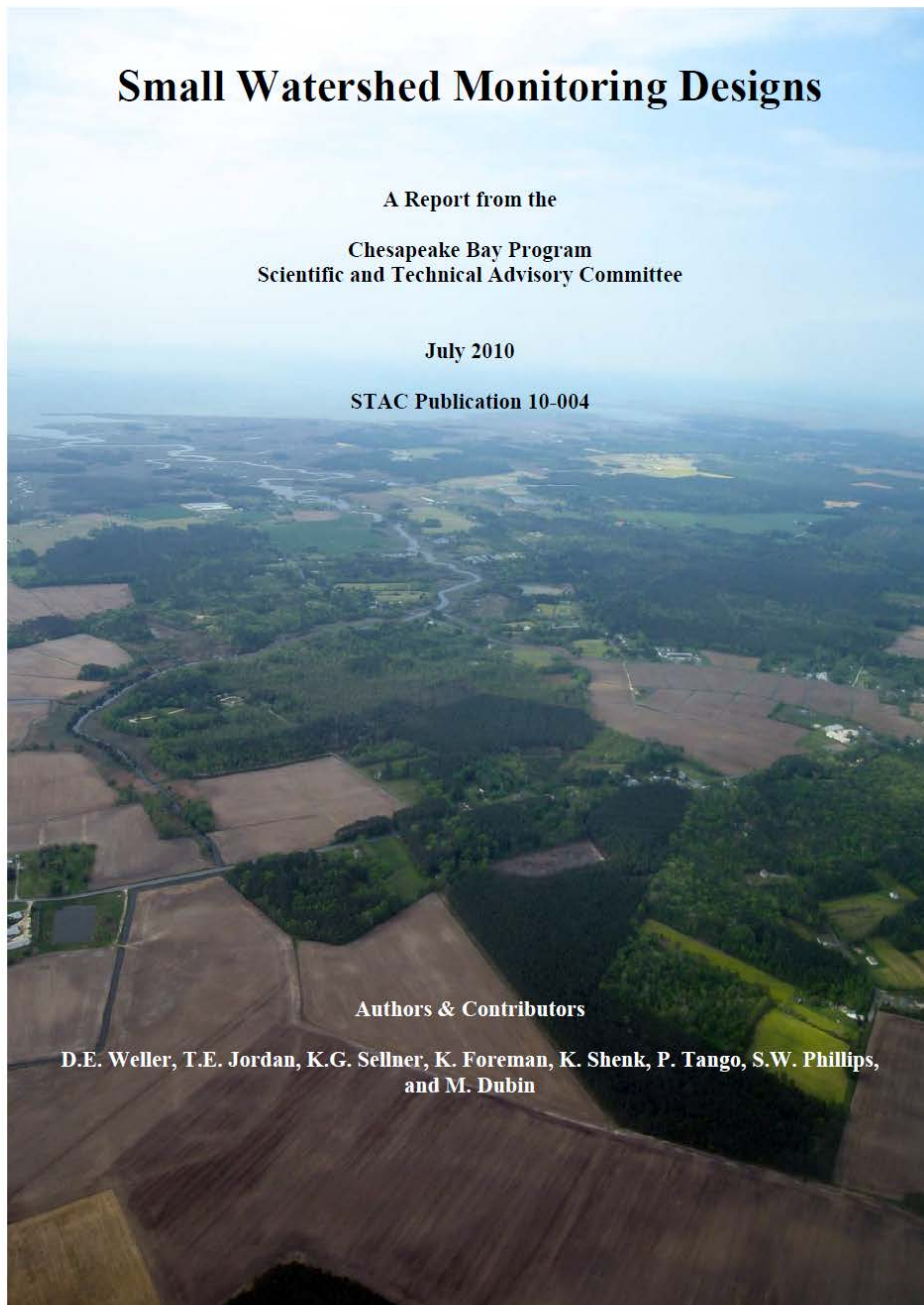
A Report from the
Chesapeake Bay Program
Scientific and Technical Advisory Committee

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Authors & Contributors

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Favorite recommendations

- Study lots of small watersheds with contrasting patterns
- Include many watersheds with high ag & high BMPs
- Use space-for-time analysis as well as time series
- Use easy-to-measure water quality responses
- Assemble data on BMPs and weather, crops, fertilizer, & animals
- Measuring water quality is the easy part
- Tracking BMPs & drivers is the hard part

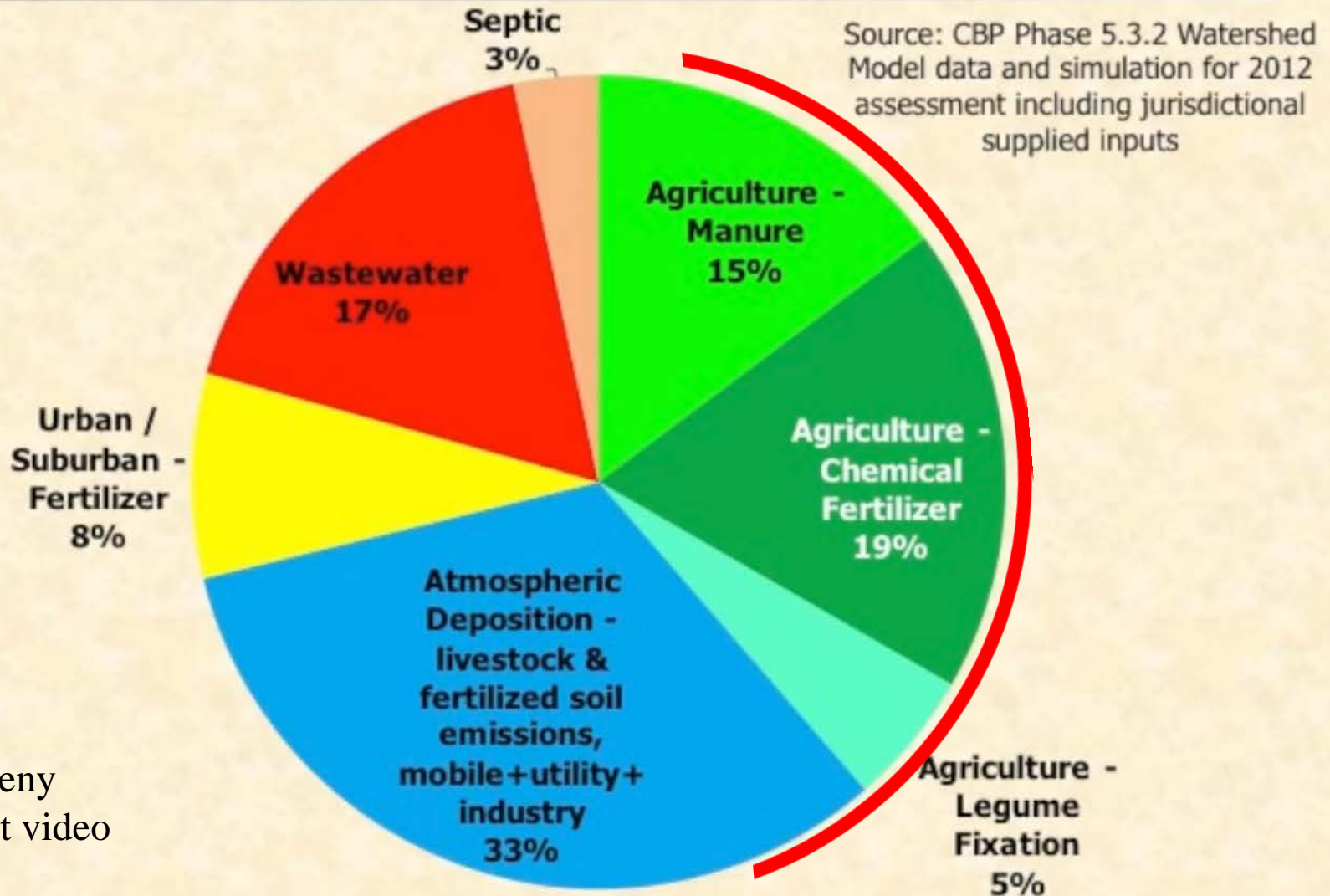
Two examples from SERC research

Small watershed studies
quantify Bay-wide cropland
nitrate removal by riparian
buffers

Cropland--number 1 land use N source

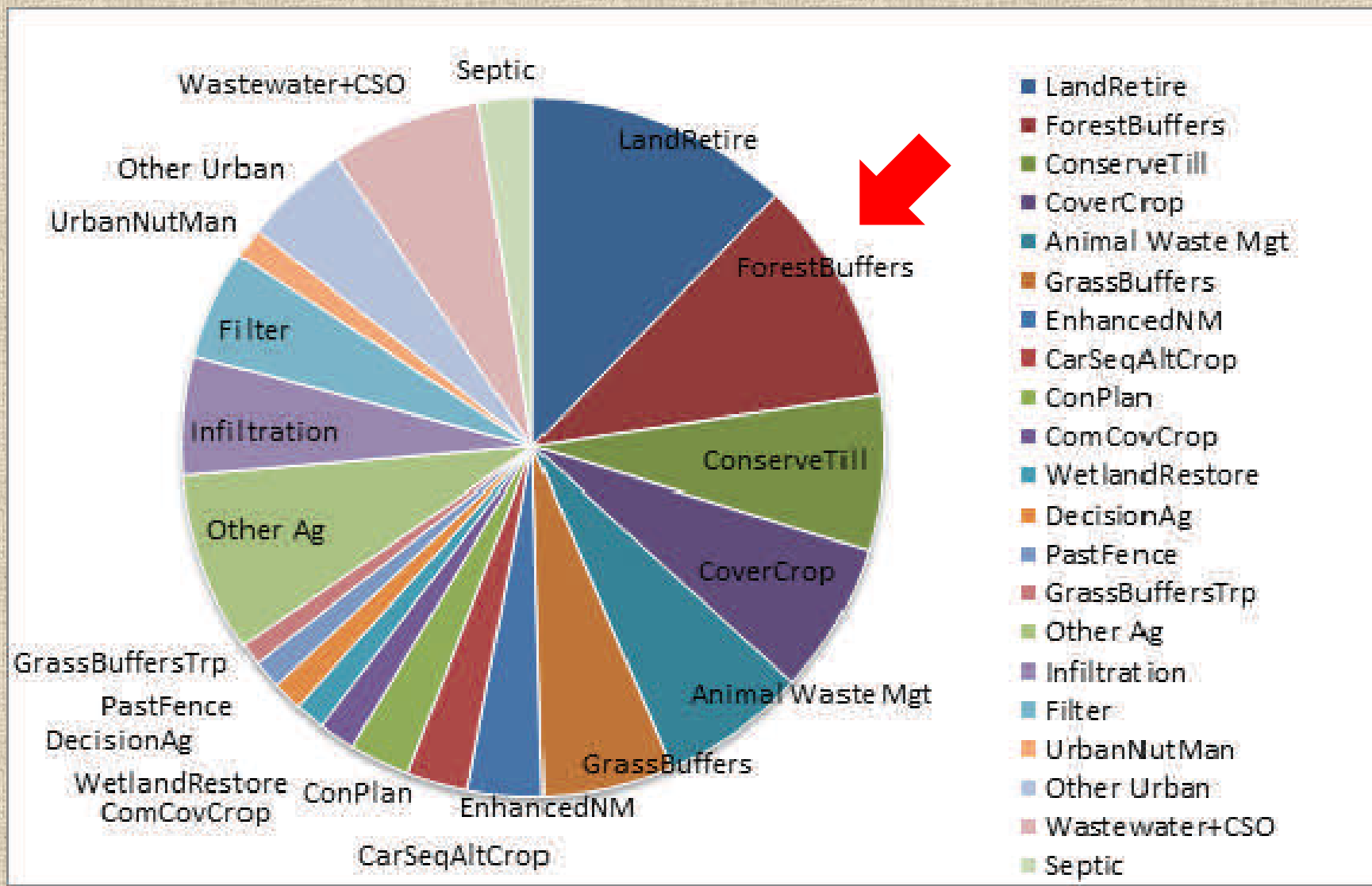


Nitrogen Loads to the Chesapeake Bay Root Sources

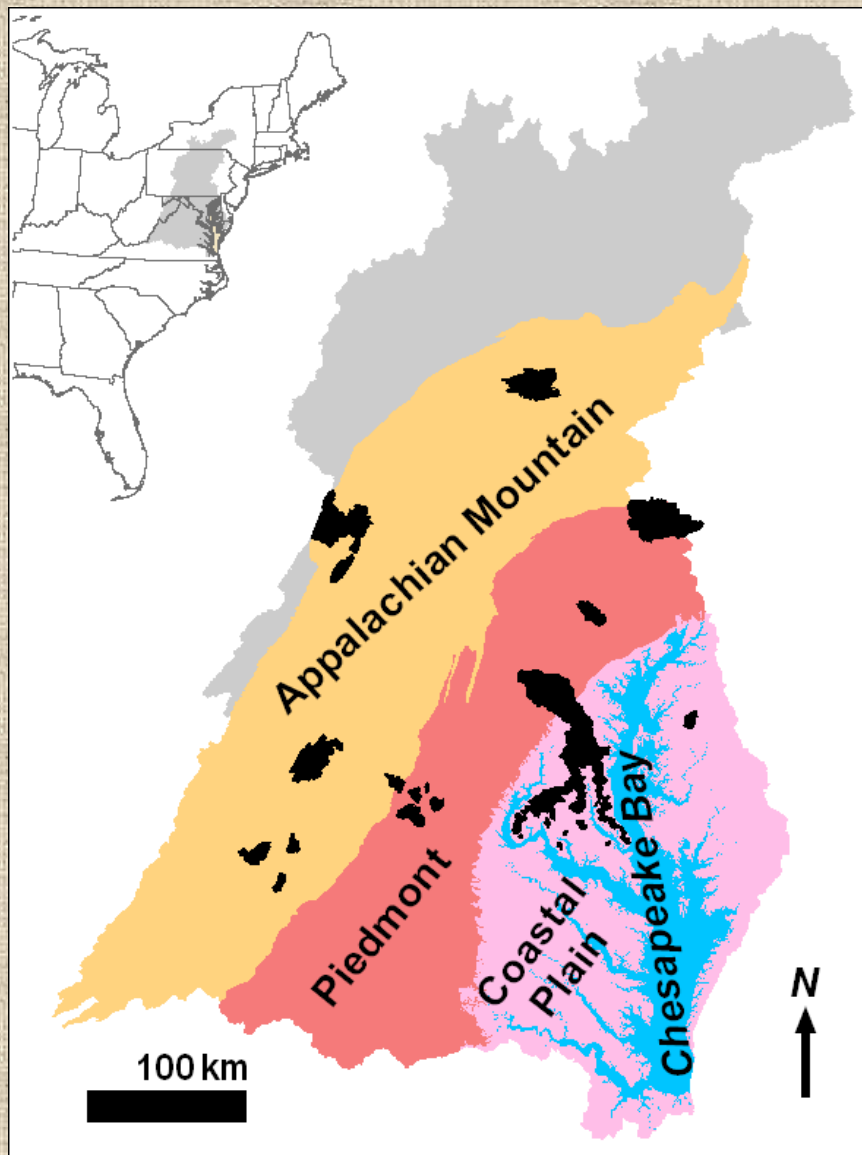


Jeff Sweeny
jumpstart video

Number 2 WIP BMP 1985-2025



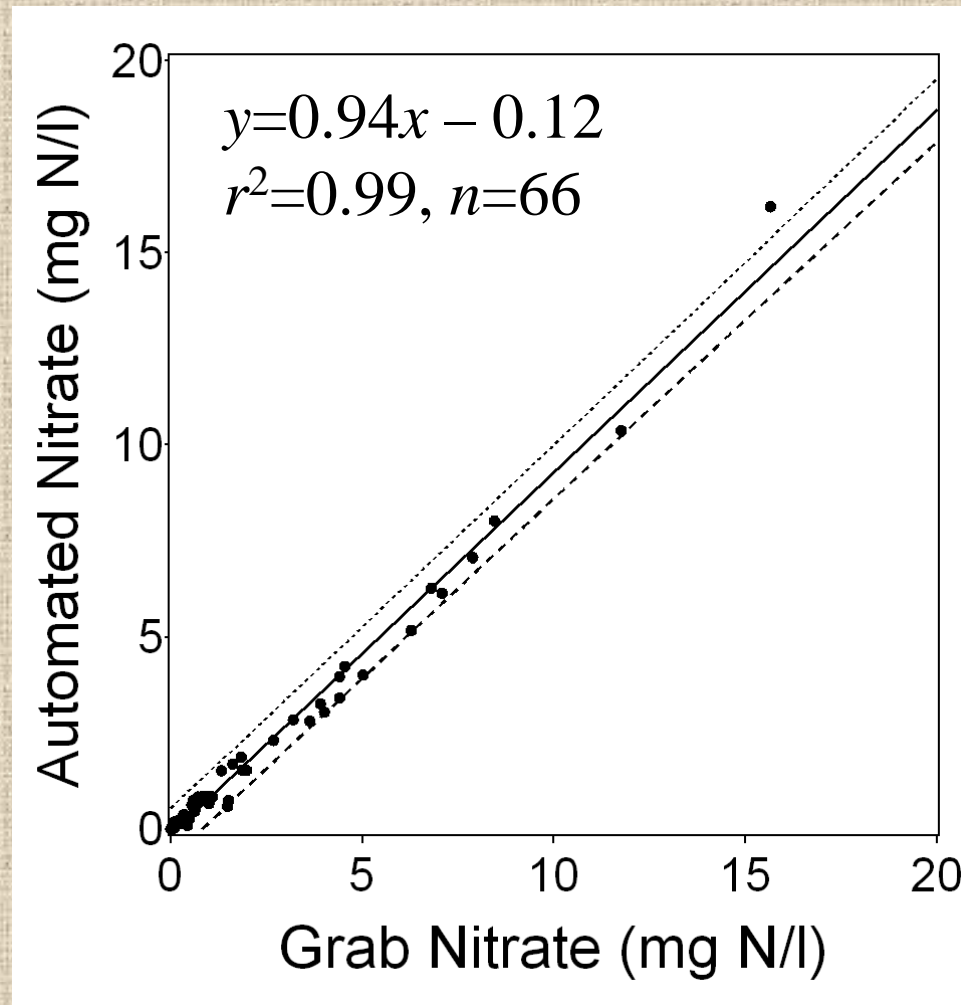
SERC watershed study



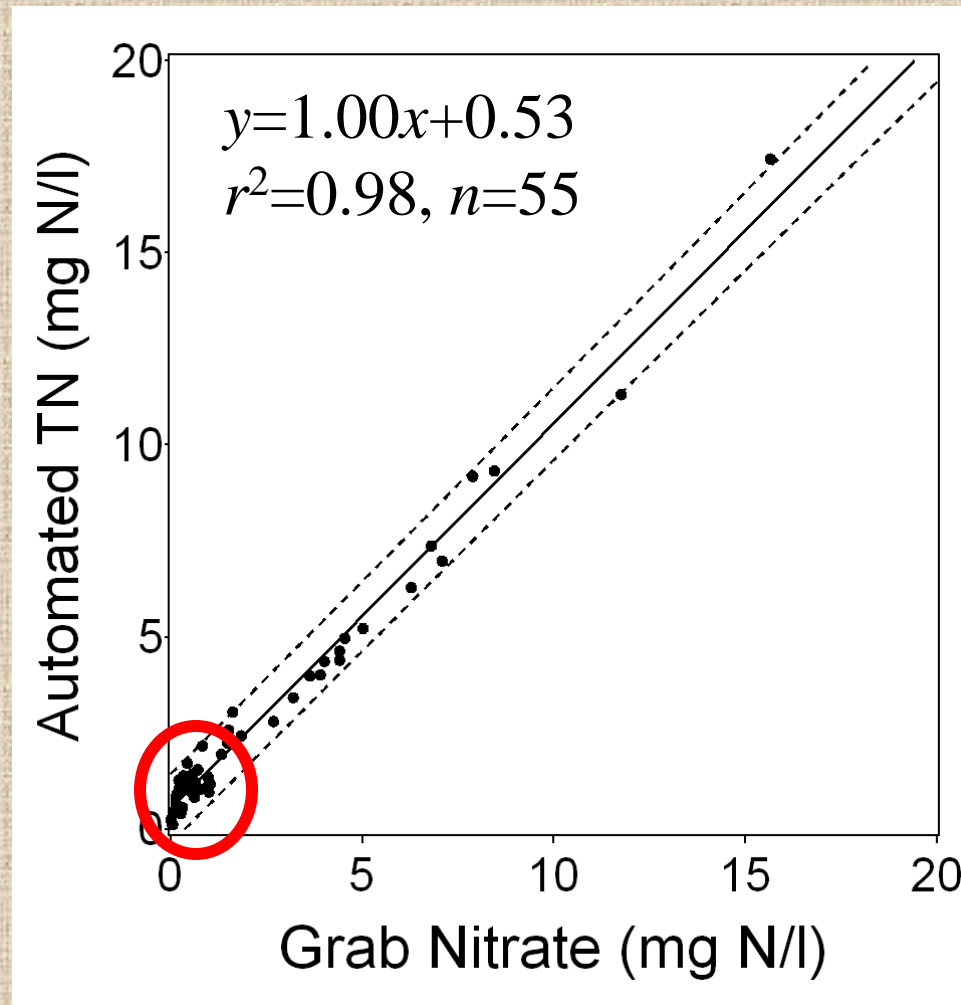
Sampling design

- 321 watersheds
- 12 clusters
- 3 physiographic provinces
- mostly rural watersheds
- measured baseflow nitrate concentration

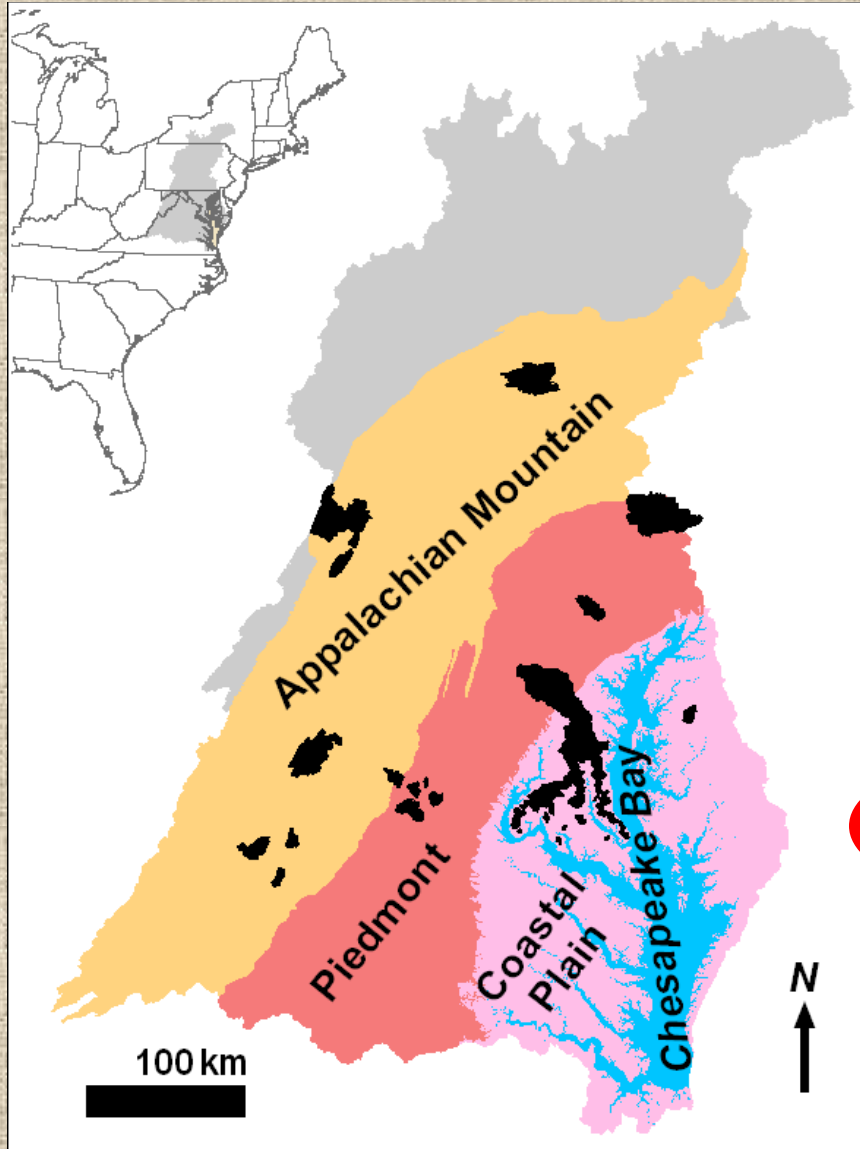
Baseflow nitrate was a great indicator of flow-weighted annual average nitrate . . .



. . . and total-N concentration



Spatial data and analysis



Spatial data

- National Land Cover Dataset 1990 (30 m pixels)
 - Cropland
 - Forest/wetland (buffers)
- 1:24K topography (DEM)
- 1:24K stream maps

Flow path metrics

- Buffer gaps below cropland distinguish buffered and unbuffered cropland

Bare bones of the statistical approach

- Resolved buffered from unbuffered cropland

$$\text{NO}_3 = \beta_0 + \beta_c C + \beta_u C_u$$

- Fit separate β s for 3 physiographic provinces
- Used information theory to compare models with & without buffers

Buffer effect demonstrated!

- $\Delta_{AIC}=18$ (buffer model lower)

Support for weaker model

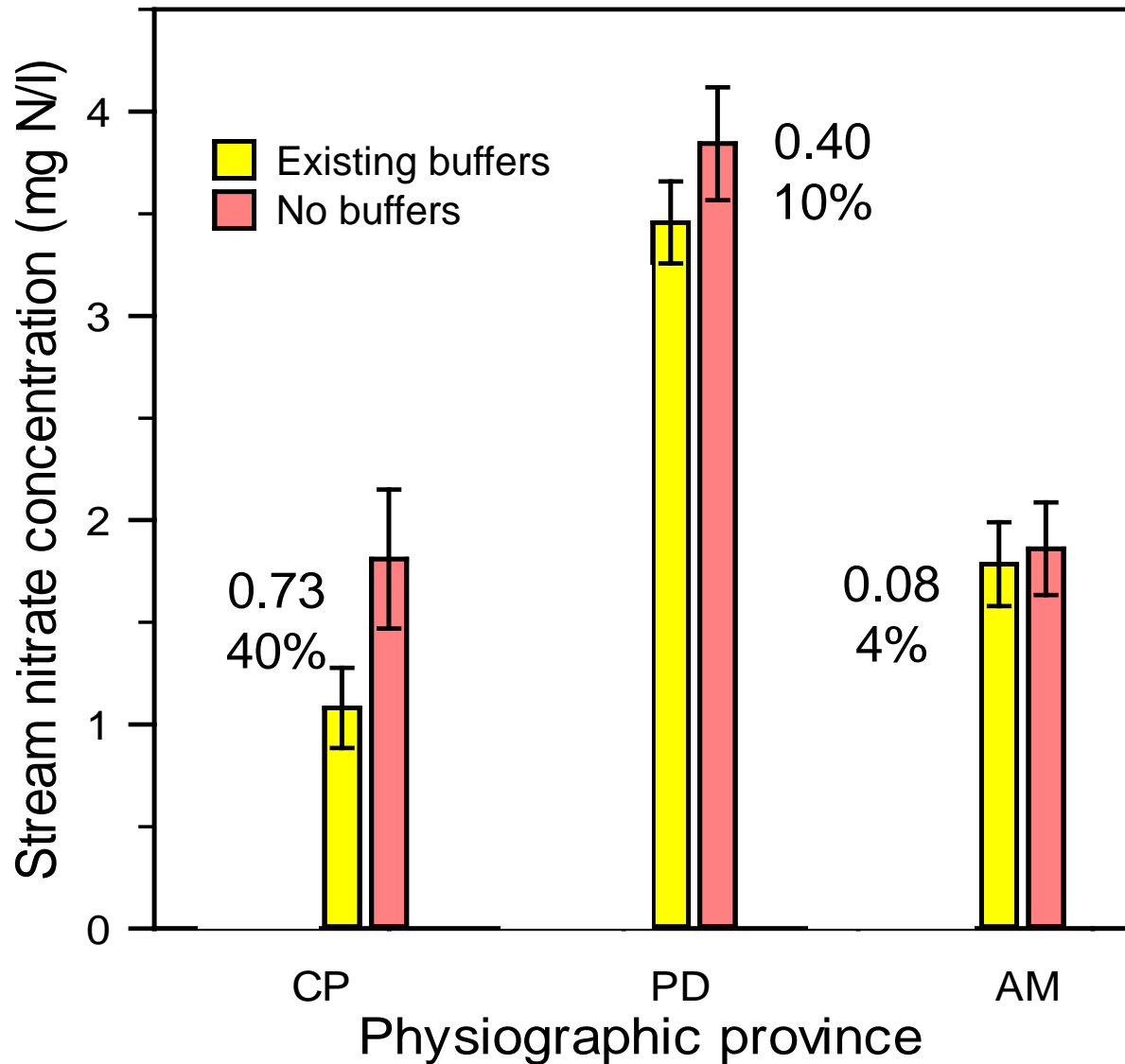
0-2 Substantial

4-7 Considerably less

>10 Essentially none

- Akaike weight (probability) of buffer model = 0.9999
- ~7000 times more likely than no buffer model)

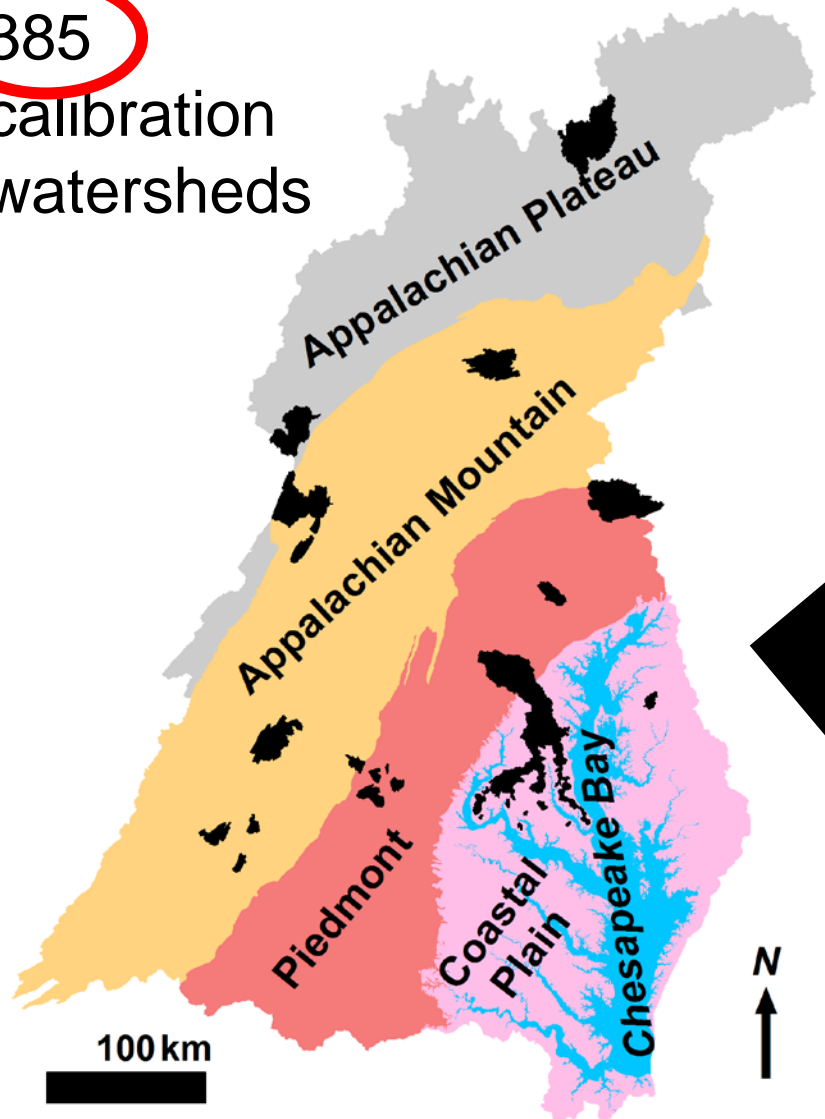
Buffer effect quantified!



Extrapolating to predict watershed-wide effects on cropland nitrate

385

calibration
watersheds



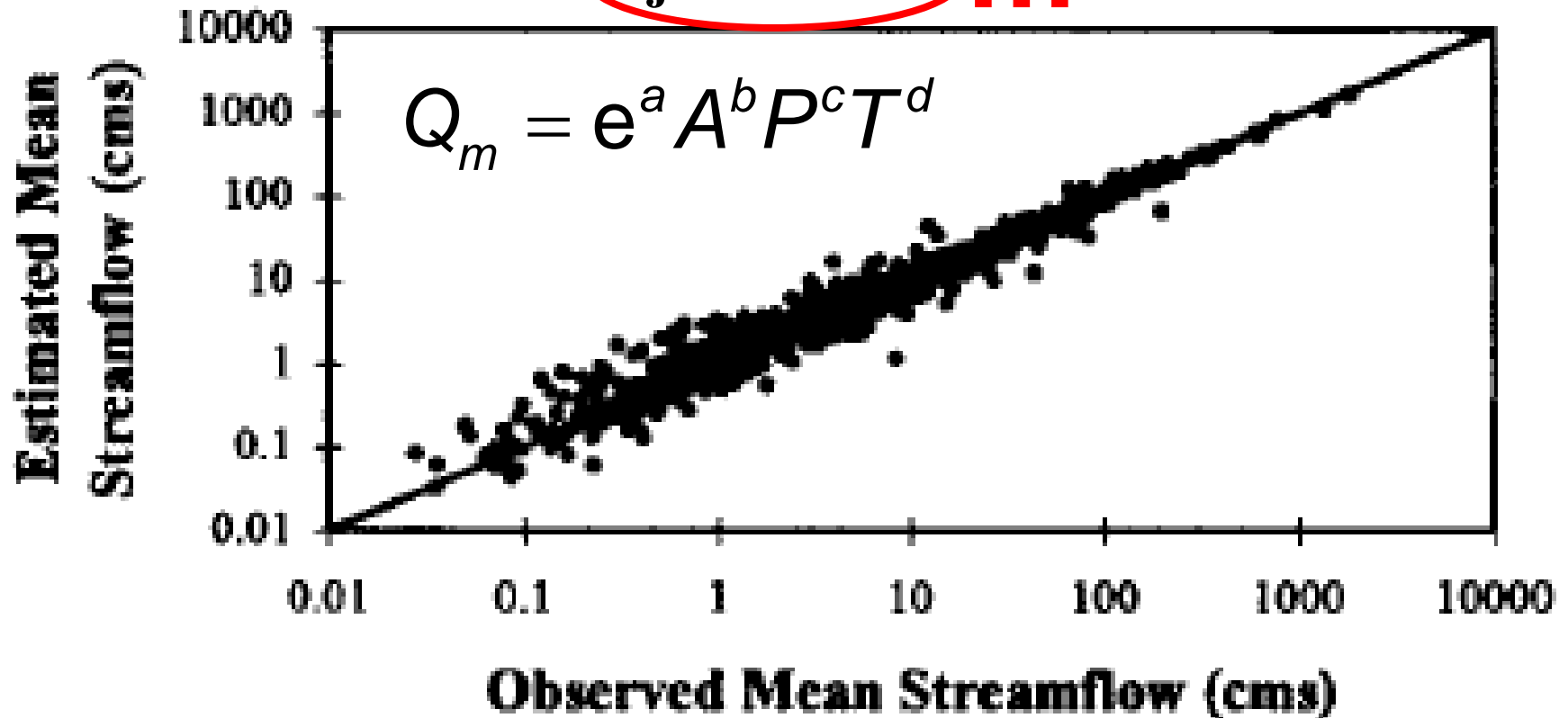
1964 HUCs



Mean annual stream flow model

(b) Area, Precipitation and Temperature

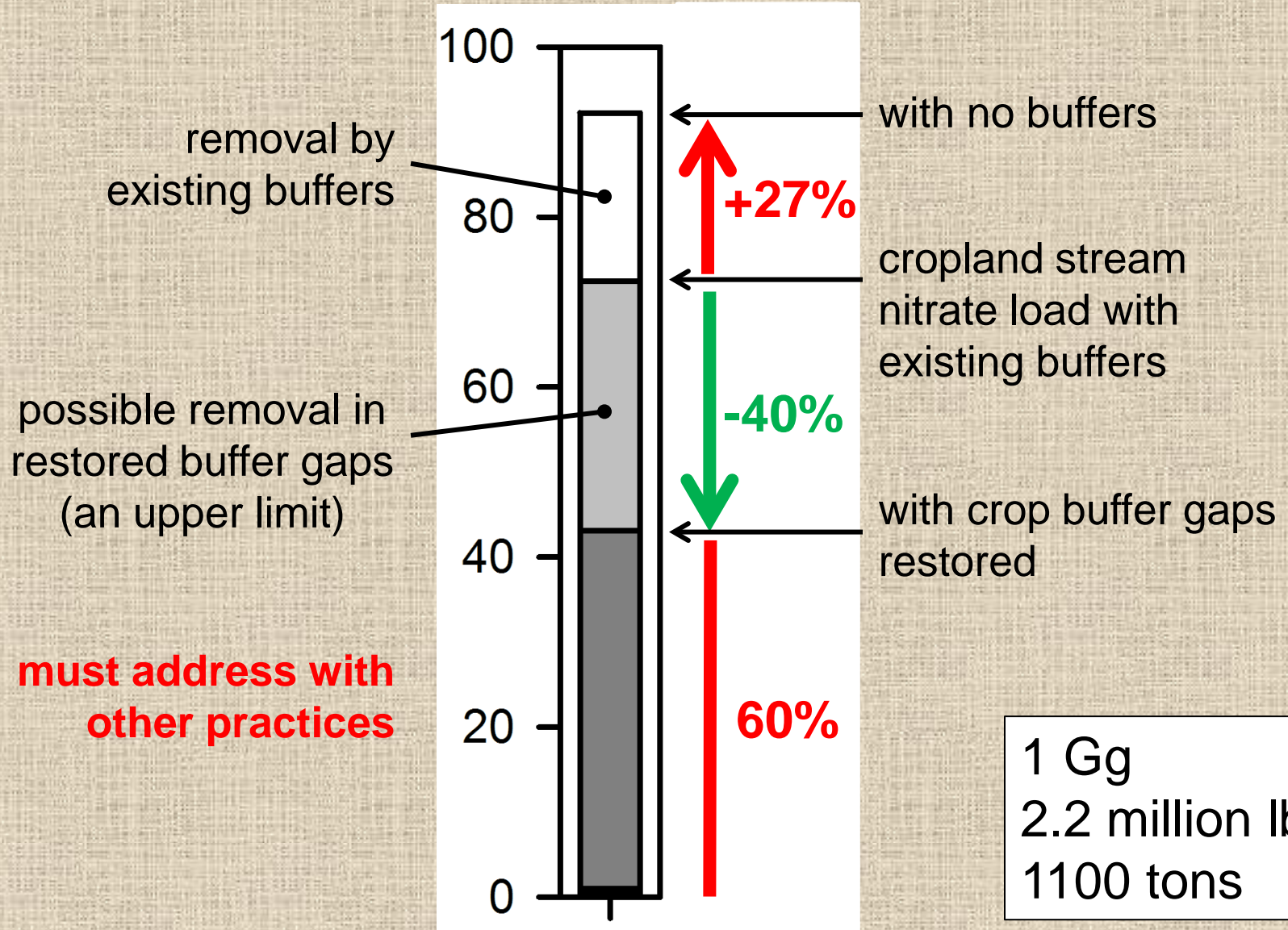
Adj R² = 0.994 !!!



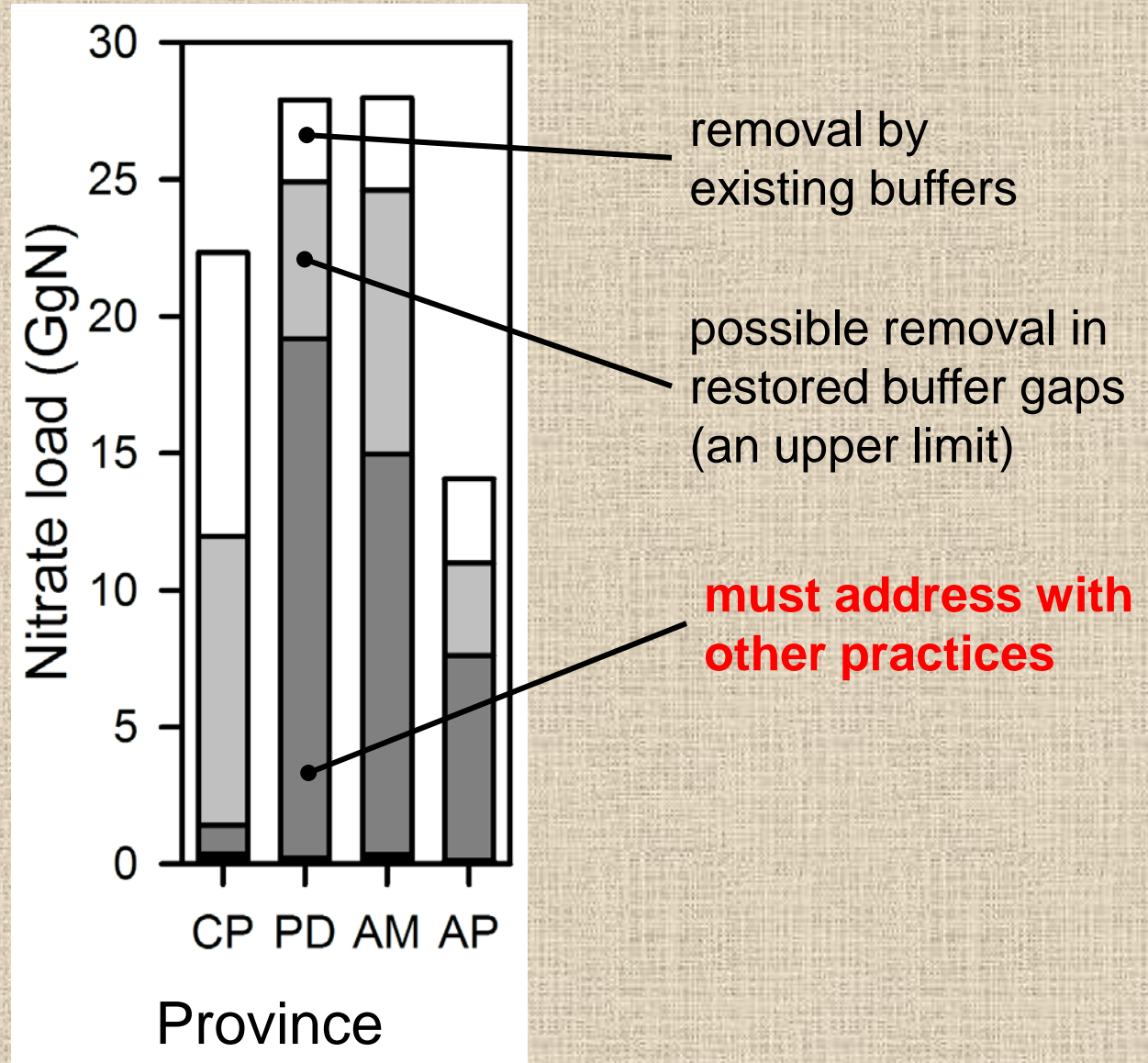
Vogel et al. 1999 *J. Irrig. Drainage Engin.* 125:148-157

Daly et al. 2002. *Climate Research* 22:99-113 (PRISM 1971-2000)

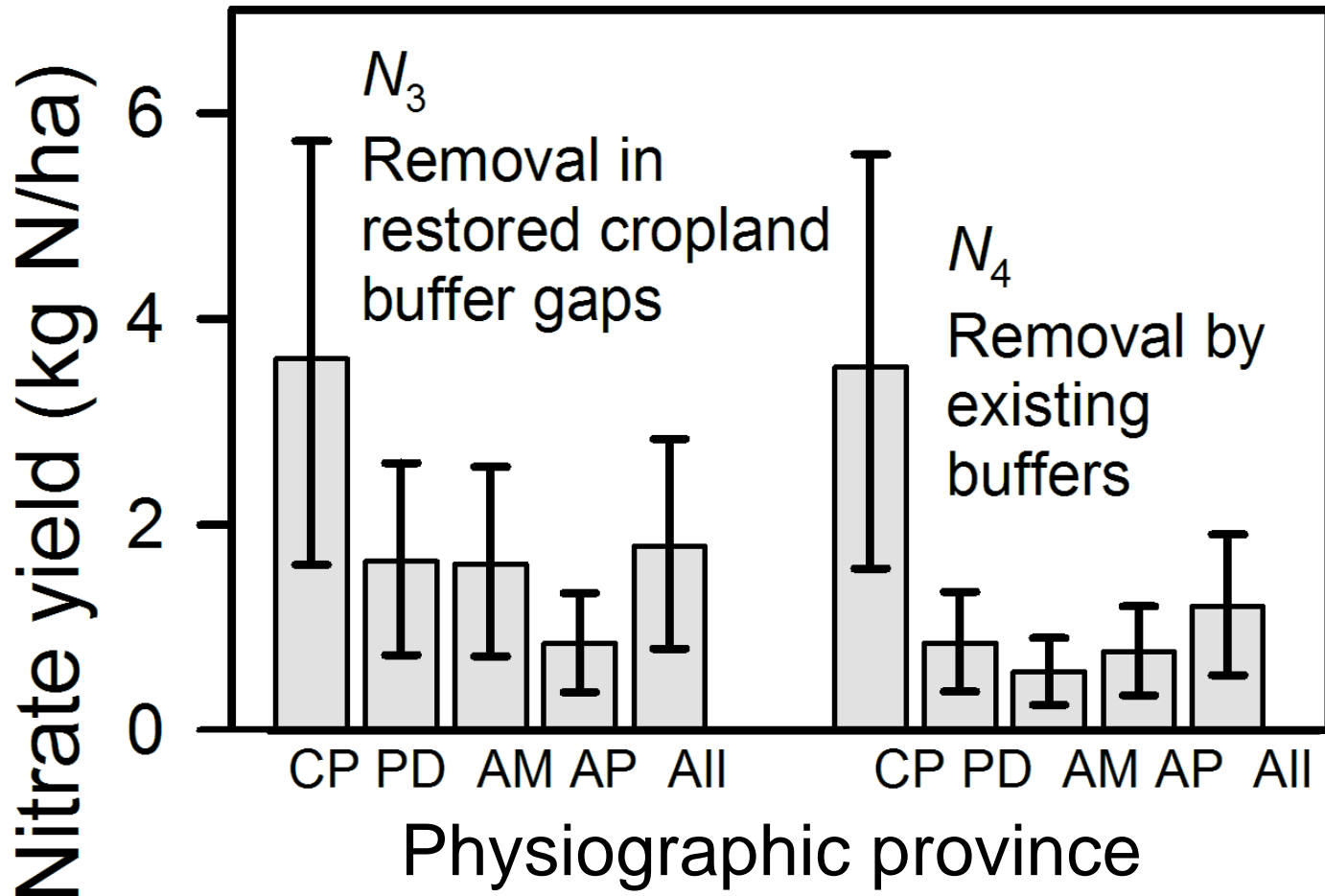
Bay-wide buffer effects on nitrate load *to streams* (Gg N/yr)



Differences among provinces



Analysis provides confidence limits



Summary – first example

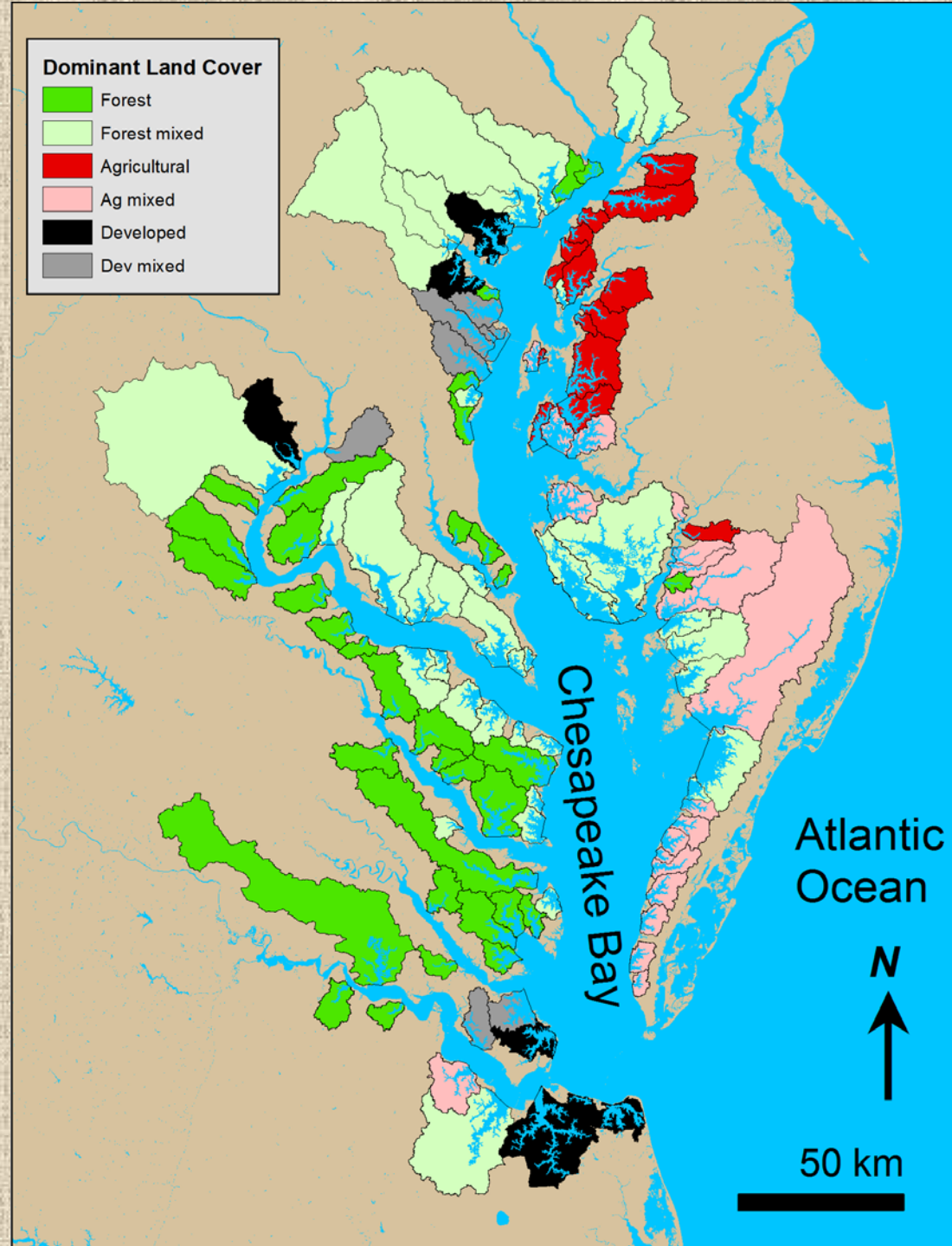
- Good news
 - Related a source (cropland) and management practice (buffers) to water quality
 - Accounted for environmental setting
 - Demonstrated buffer effect
 - Quantified buffer effect
 - Extrapolated to whole Bay watershed
- Bad news
 - Not the buffers the CBP tracks as a BMP
 - Need higher resolution land cover and buffer BMP locations

Example 2 -- subestuary studies document effects of land cover and shoreline armoring on SAV abundance

- Important habitat and ecosystem component
- Integrating indicator of water quality
- Water quality standard

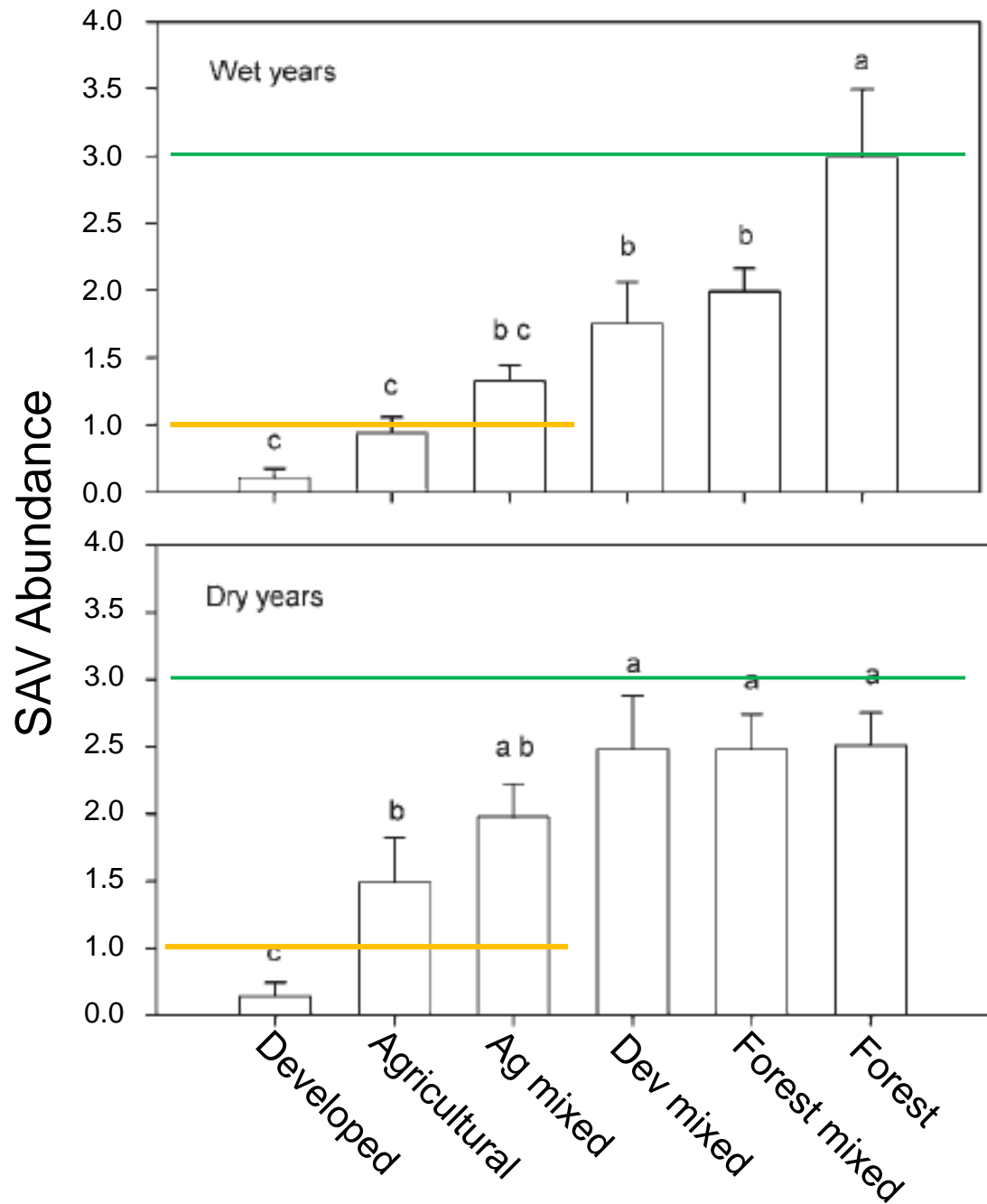
~100 study subestuaries

- Shallow hot spots
- Contrasting local watersheds (*a priori* categories)
- Replicates



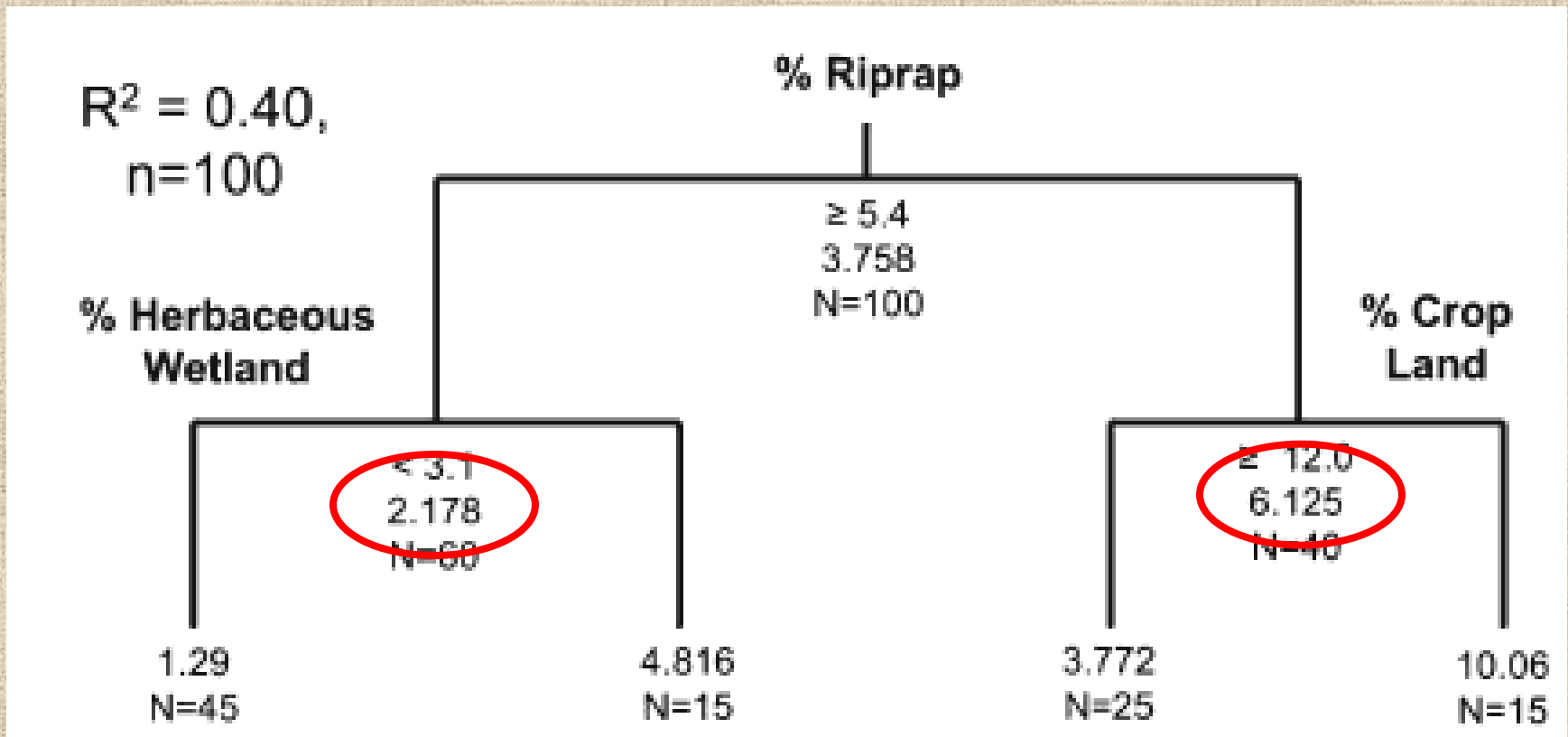
Interacting effects of land cover and weather

- SAV area normalized to habitat area & density weighted
- RM ANOVA
- Dev always low
- Ag better in dry years
- Forest better in wet years

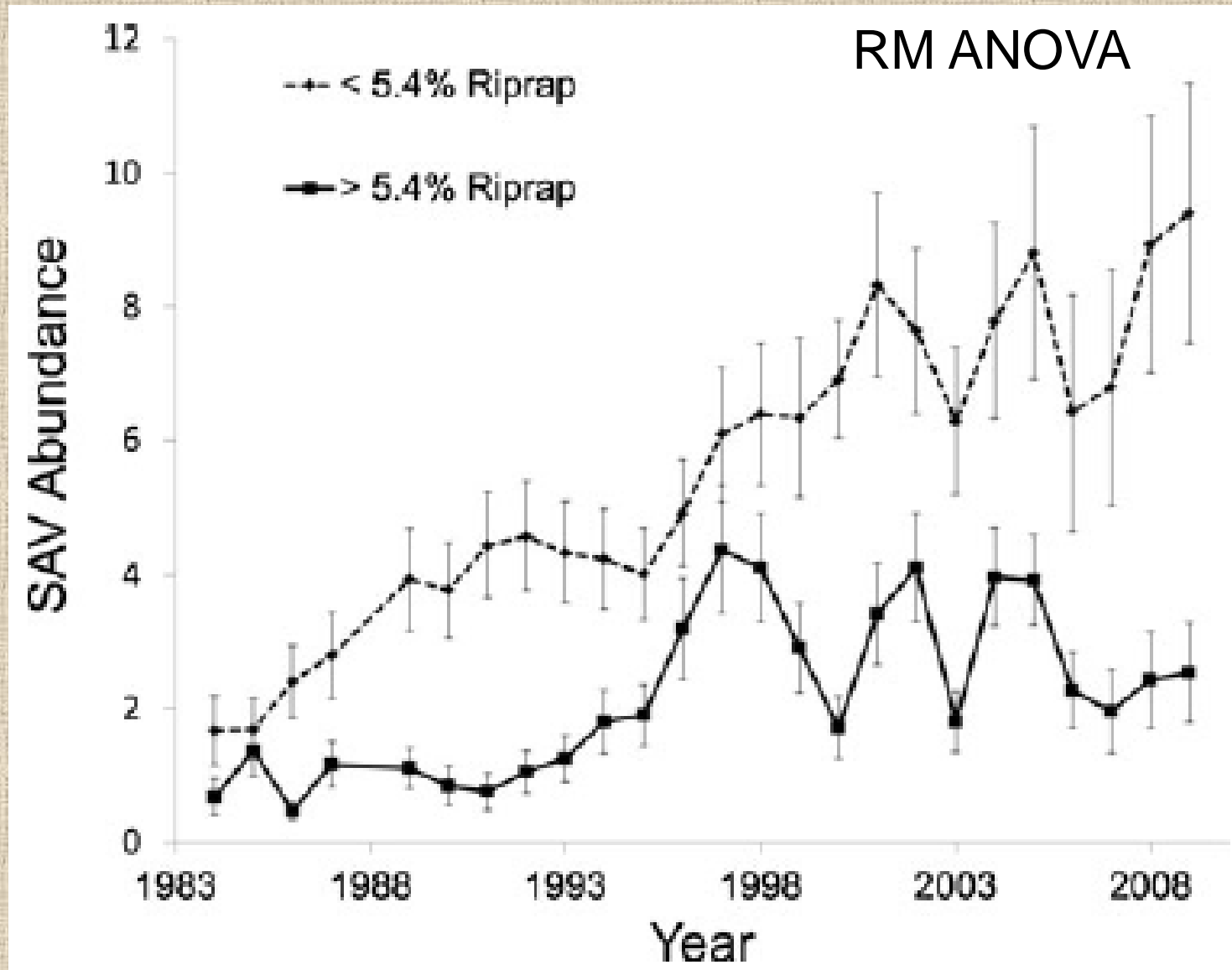


Shoreline armoring predicts abundance

CART analysis of normalized abundance vs. watershed and estuary characteristics



Recovery trends differ with armoring



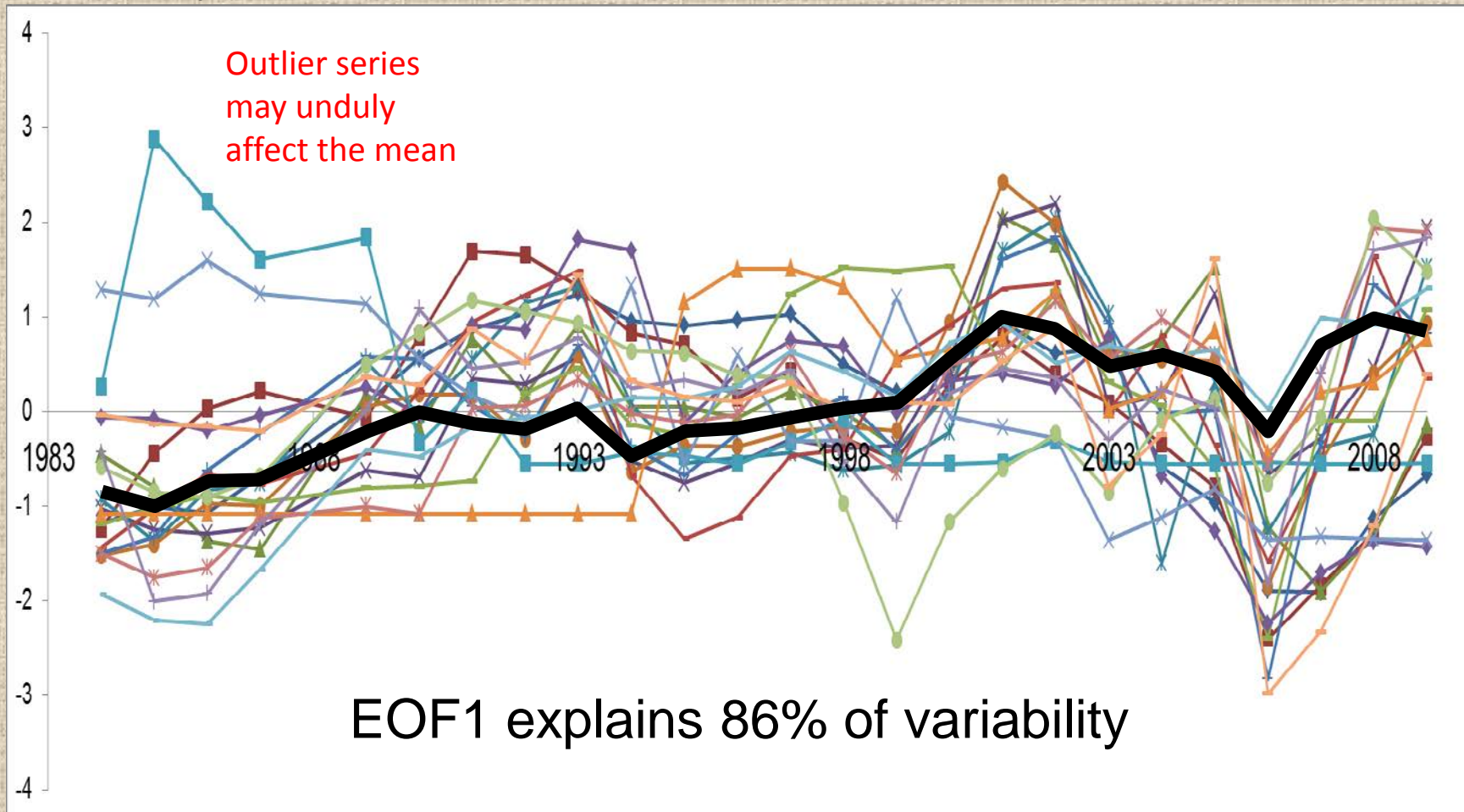
Time series analysis of SAV abundance

Empirical Orthogonal Function Analysis

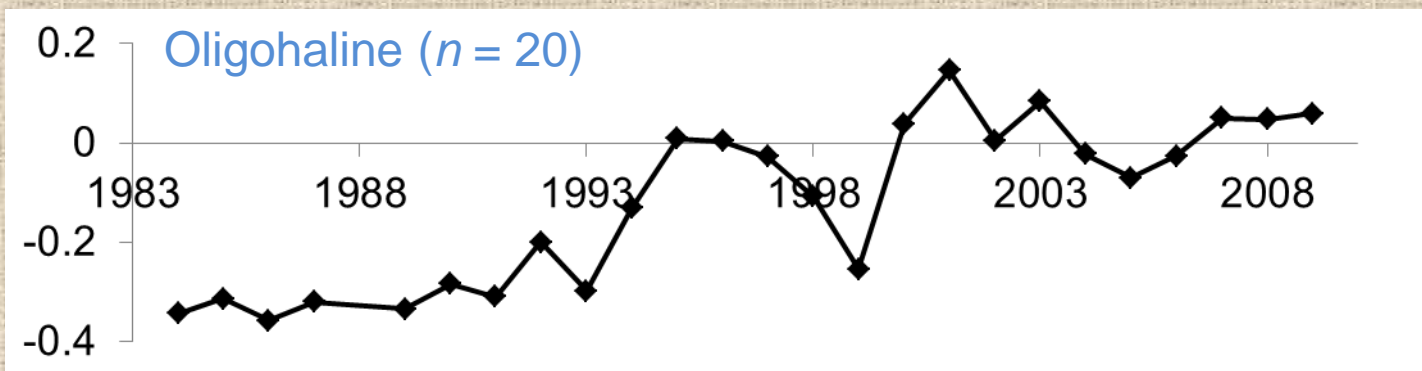
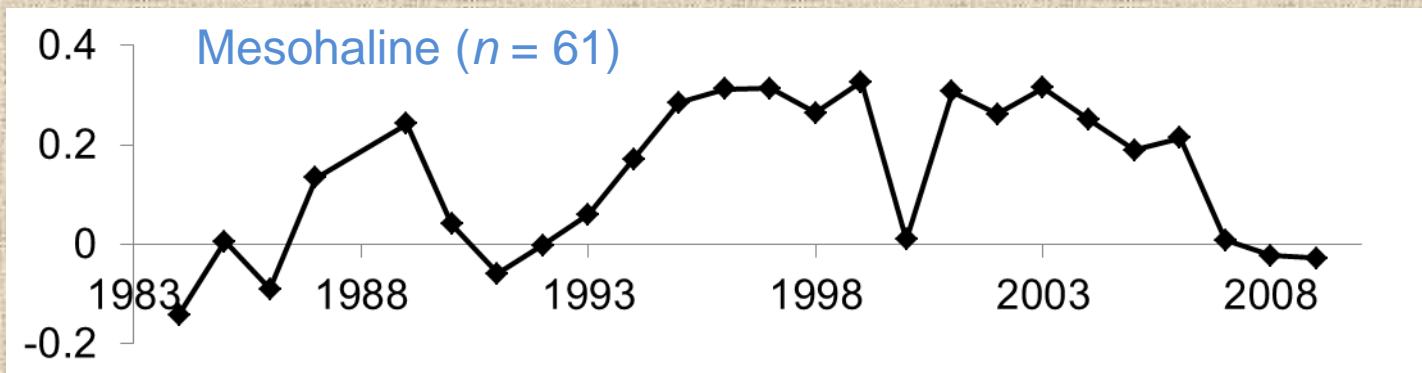
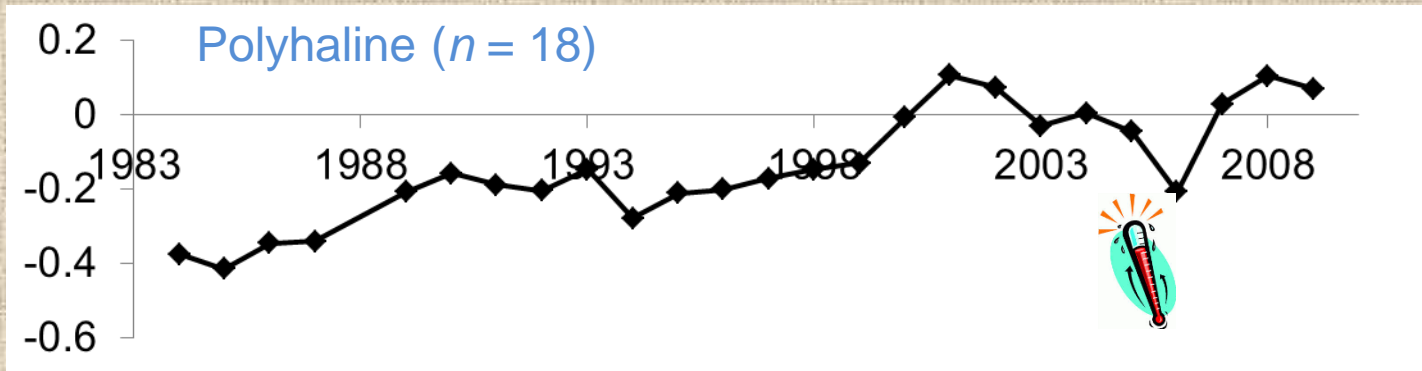
Reduces the dimensionality of a set of time series (like PCA)

Polyhaline subestuaries ($n = 18$) 1983-2009

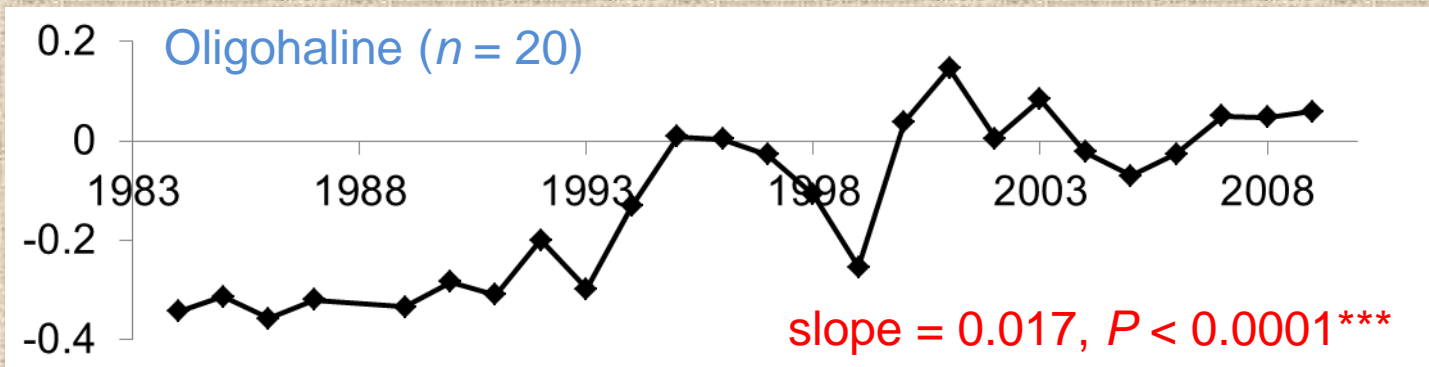
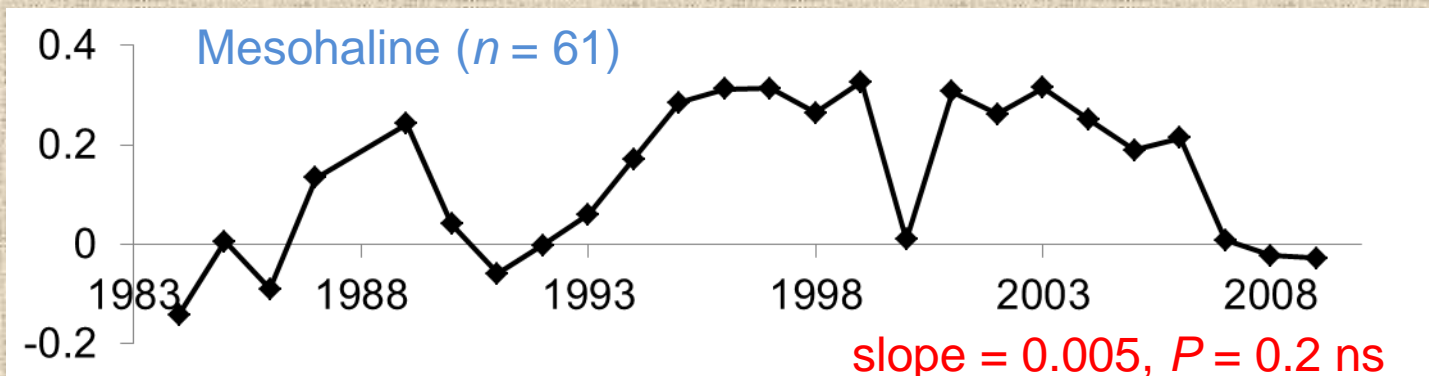
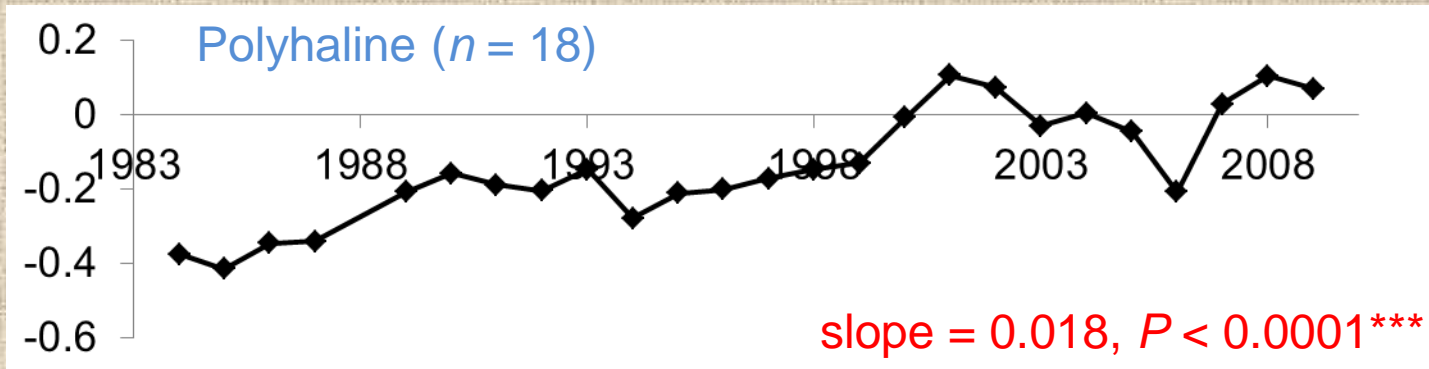
Standard normalized SAV abundance



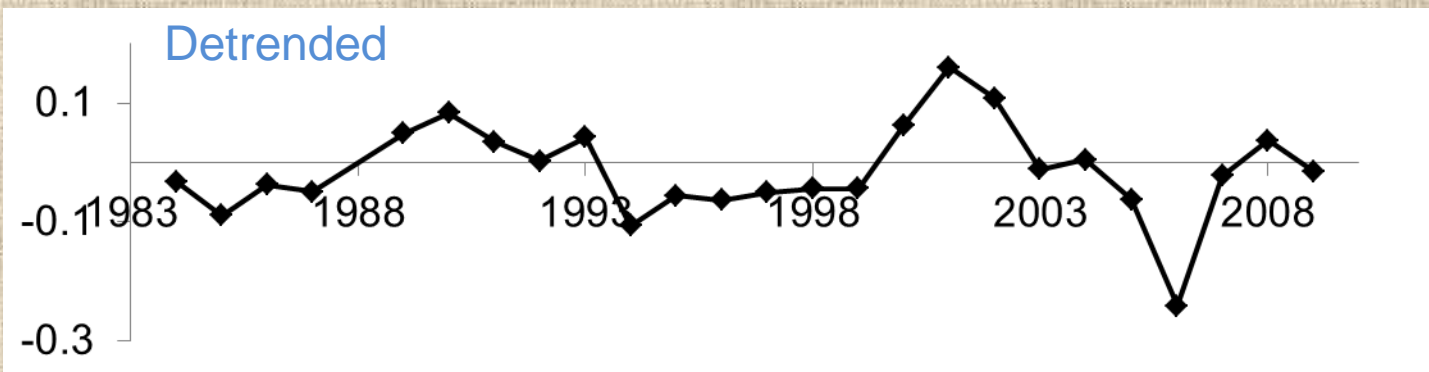
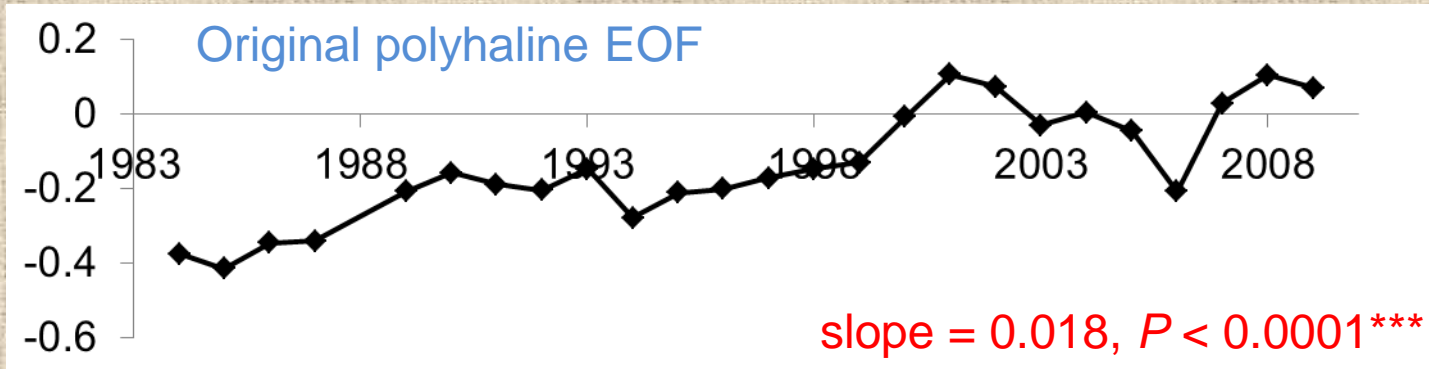
EOF results



Kendall trend tests

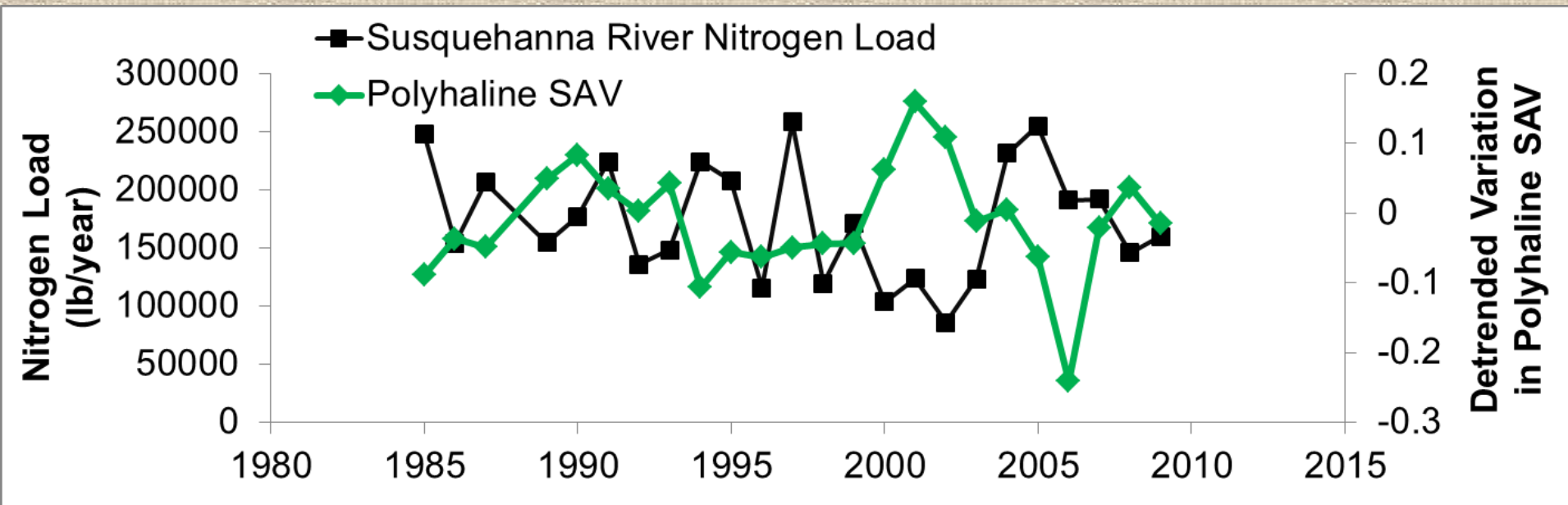


Detrending for cross correlation analysis with water quality



Significant cross correlates of interannual variability

	Same year	Last year	Two years ago
Susquehanna River N load	ns	-0.46	-0.44
March chlorophyll <i>a</i>	ns	-0.45	



Significant correlates differ among salinity zones

Summary – SAV example

- Good news
 - Documented effects of natural factor (precipitation) and human stressors (land use, shoreline armoring) on SAV response
 - Considered environmental setting (salinity)
 - Illustrated (yet another) time series method
 - Identified trends
 - Cross correlated year-to-year variations
- Bad news
 - Didn't document effects of BMPs
 - Need data on living shoreline installations

Take me home

- Study lots of small systems
- Maximize contrast in important factors
- Compare to stressor or management gradient for early feedback

Recent sponsors



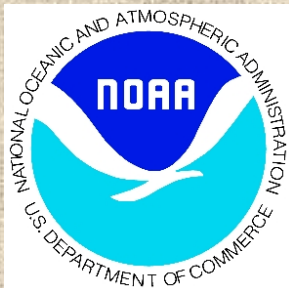
Atlantic Slope Consortium
EPA Estuarine & Great Lakes Indicators Program



EPA Watershed
Classification Program



The Cooperative Institute for Coastal and
Estuarine Environmental Technology



NOAA Coastal Oceans
Program