

Lake Erie “re-Eutrophication”

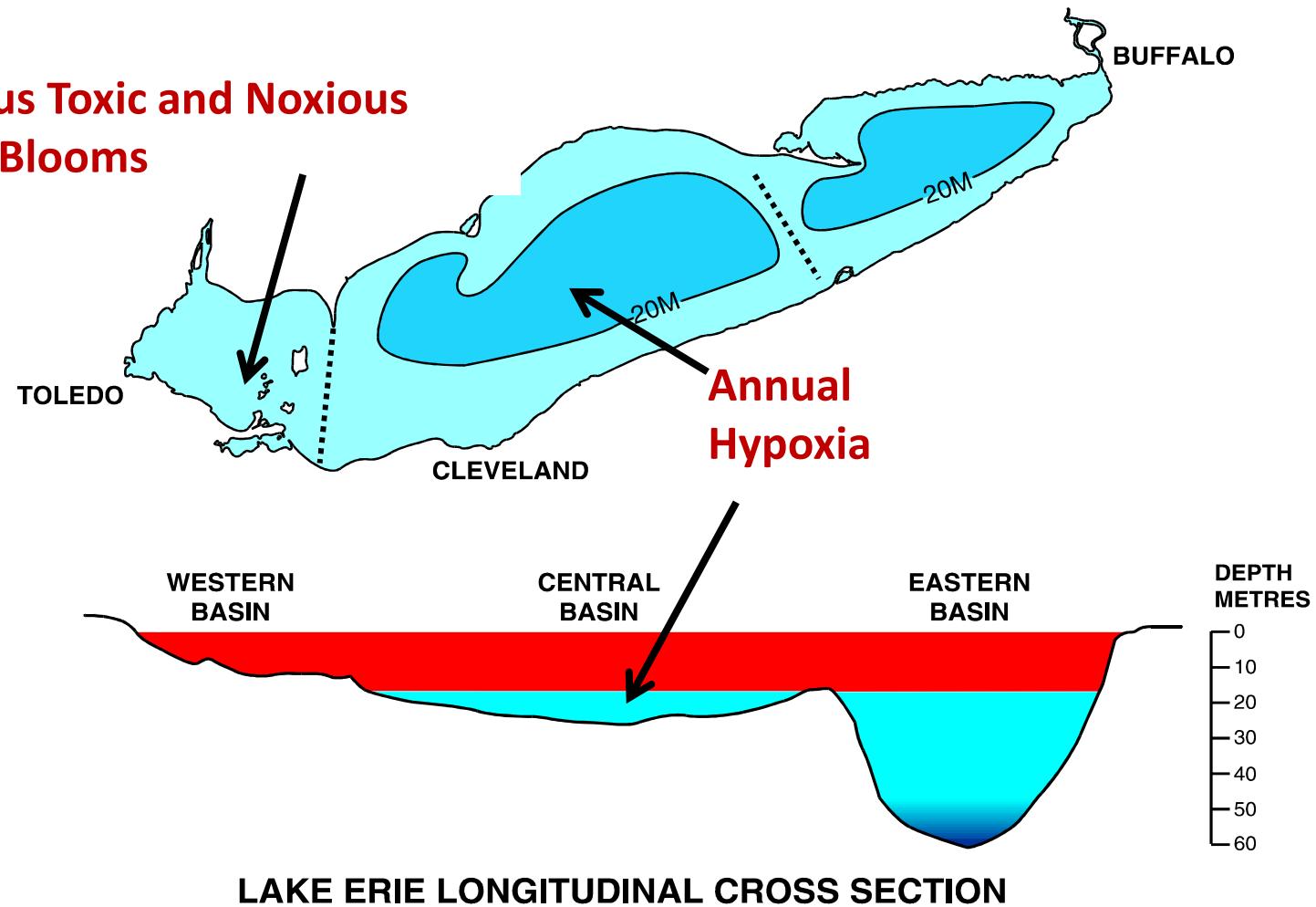


Don Scavia
Graham Sustainability Institute
University of Michigan



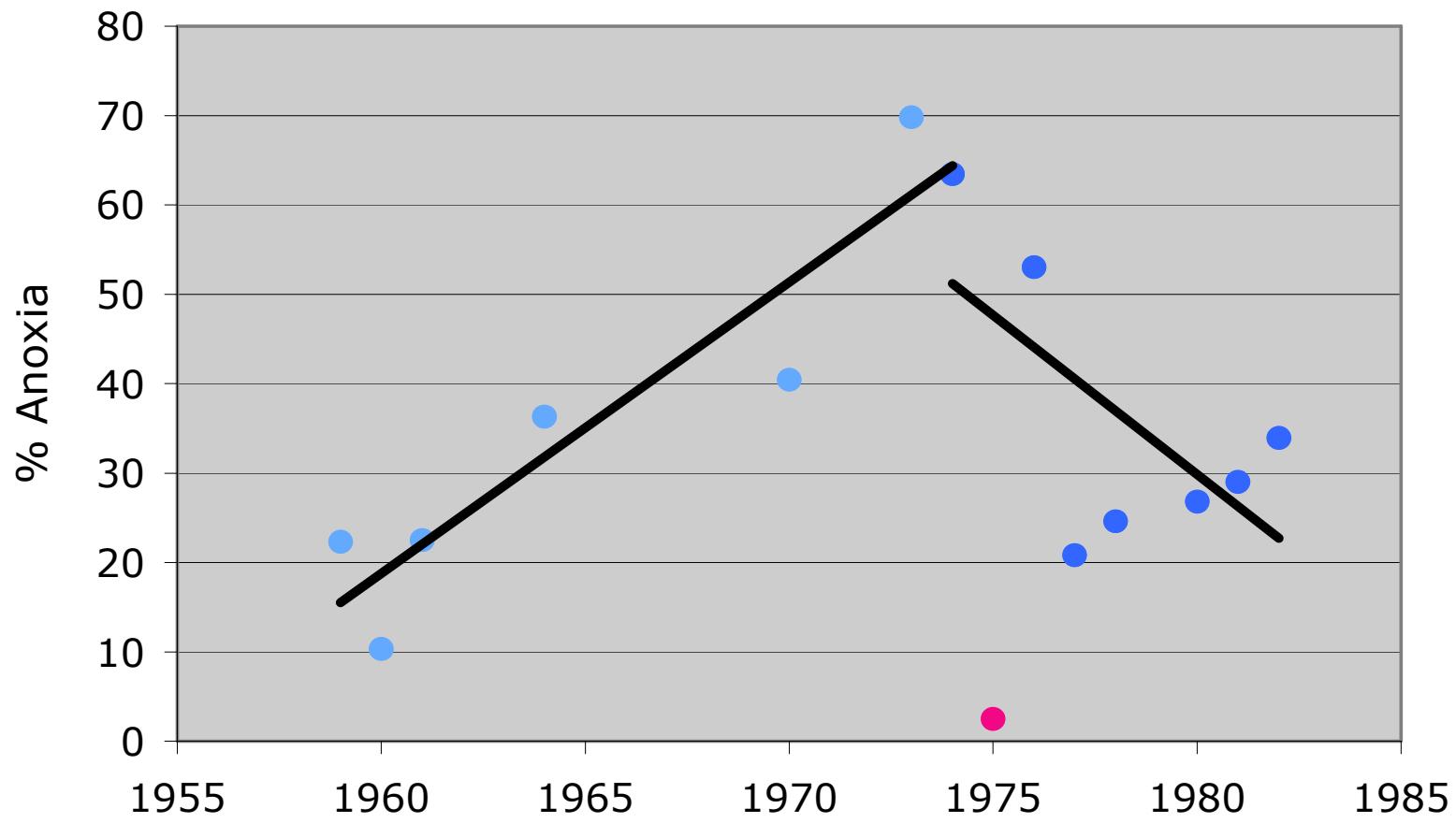
Lake Erie Eutrophication

Serious Toxic and Noxious
Algal Blooms

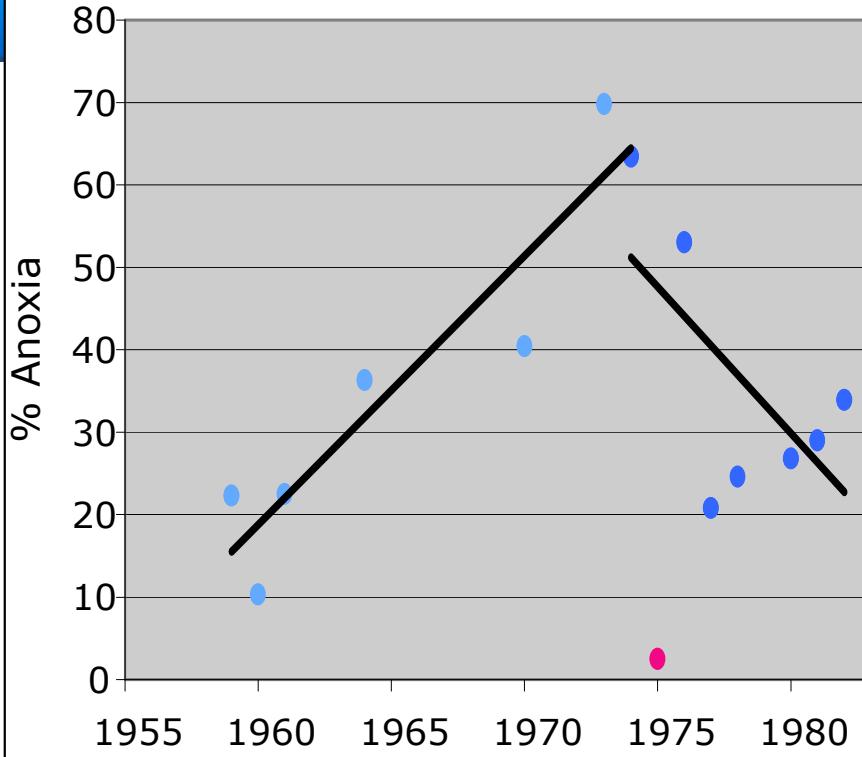


**History: Increased with increasing TP load
Decreased with decreasing load**

Central Basin Anoxia

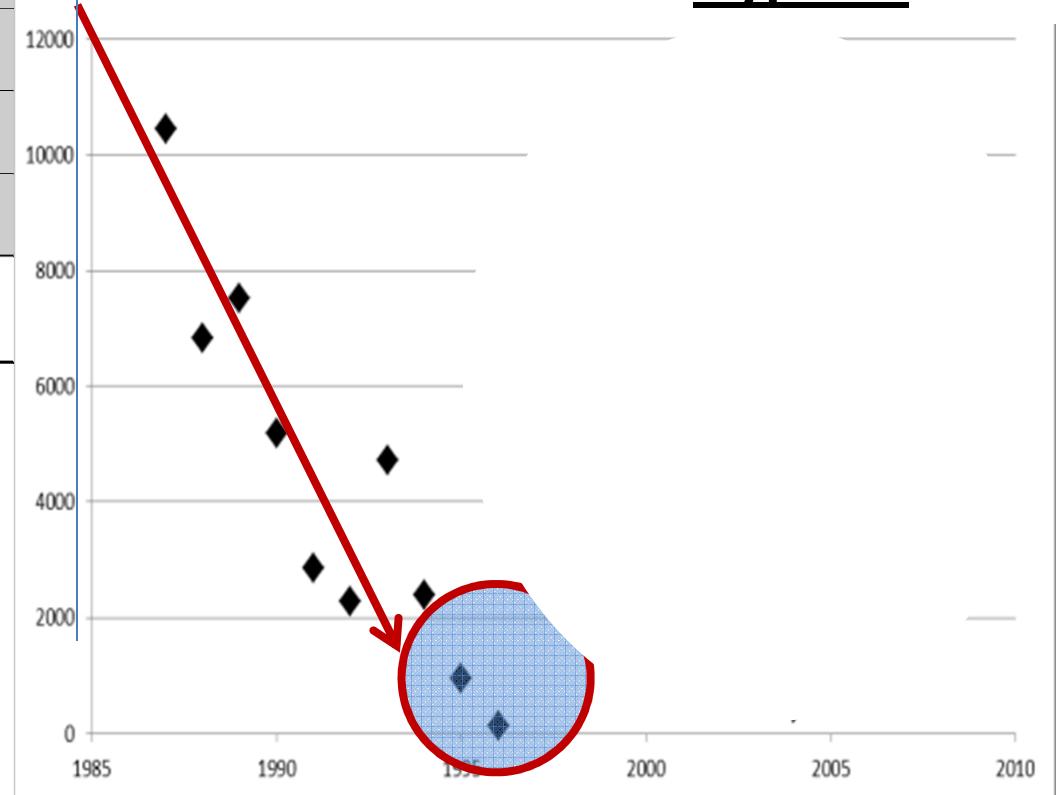


Central Basin Anoxia



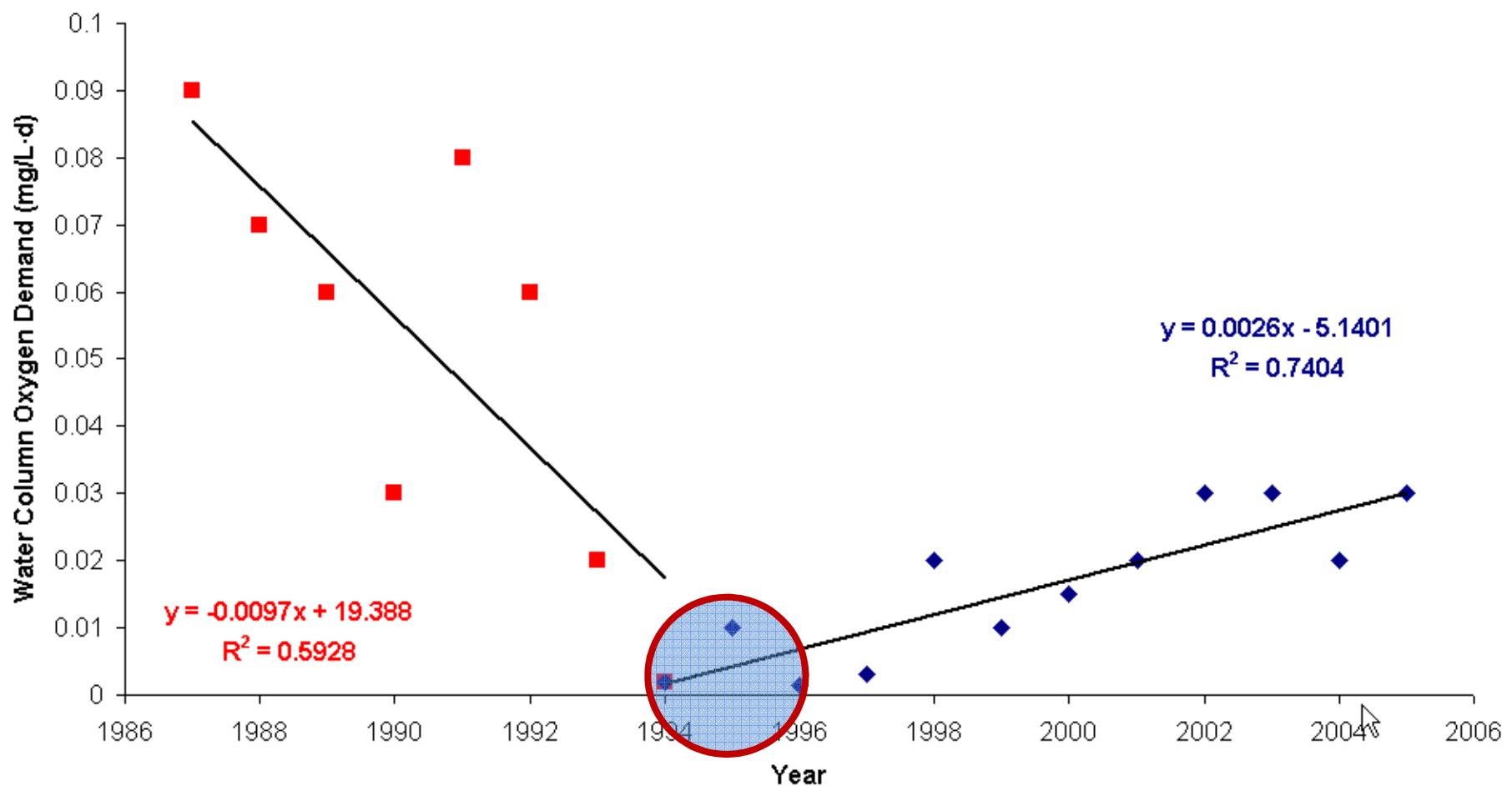
Y. Zhou

Central Basin Hypoxia



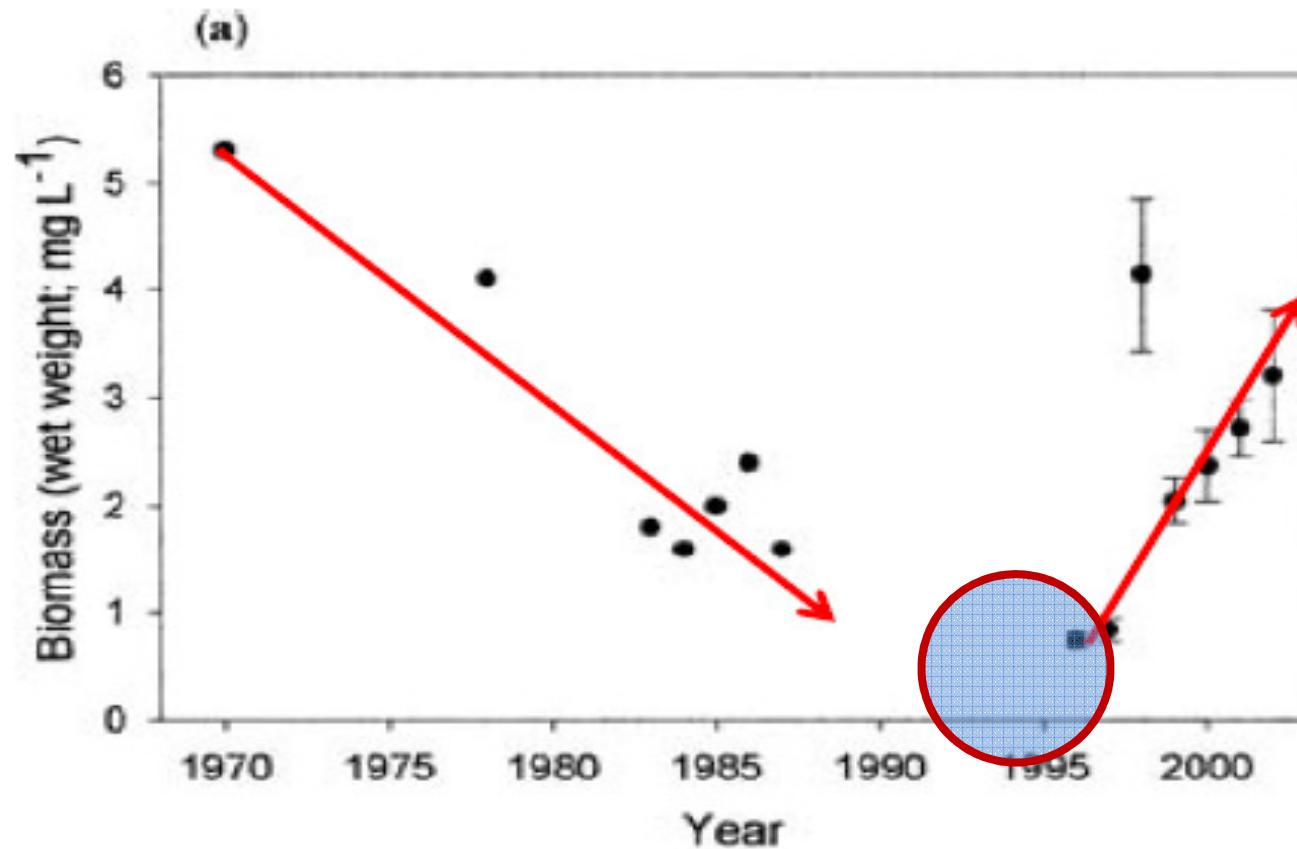
Water Column Oxygen Depletion Rate

Rucinski, et al 2010



Similar Trends in Algal Biomass

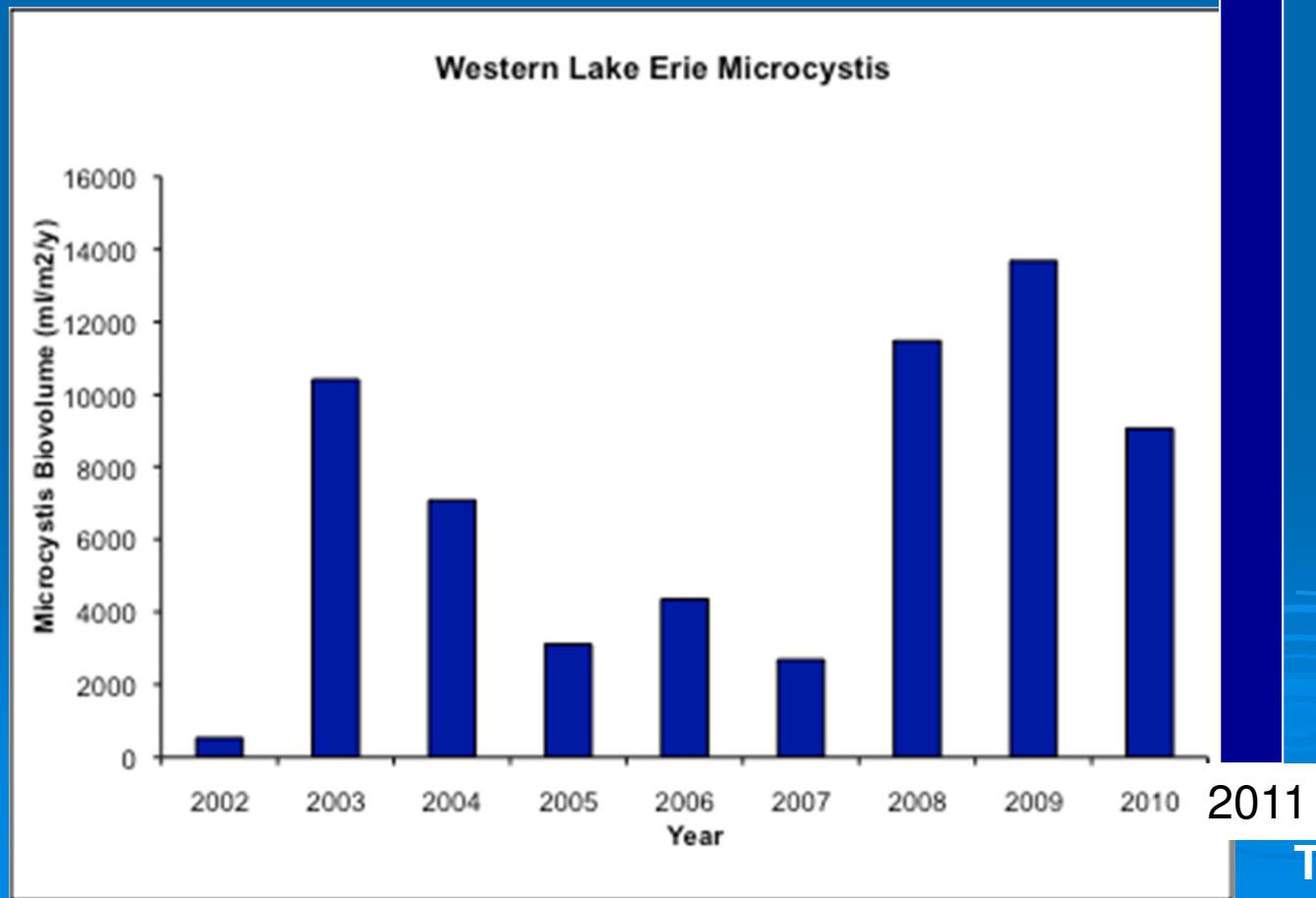
- plus return of cyanobacteria



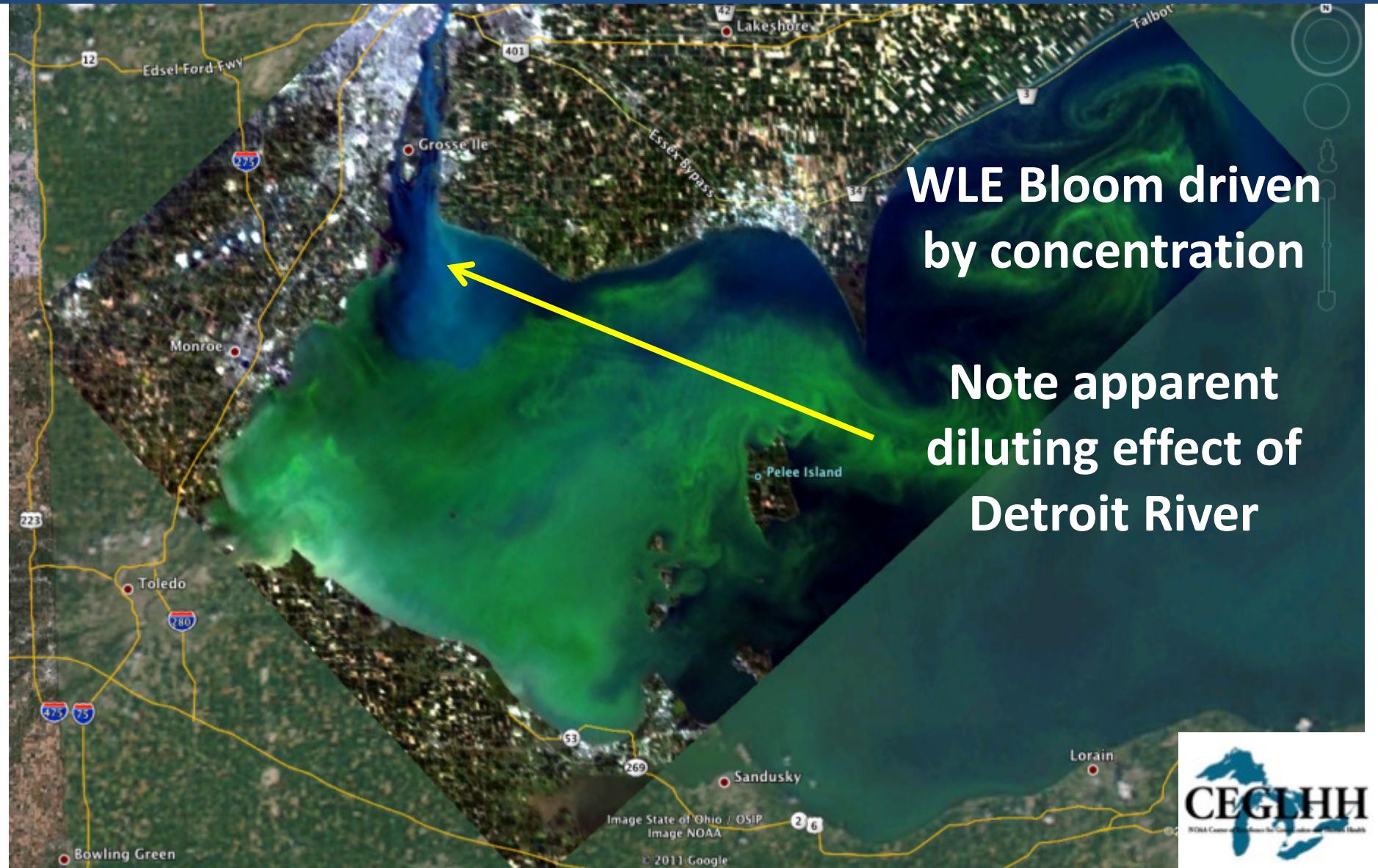
Conroy & Culver 2005

Microcystis in Lake Erie

- The *Microcystis-Anabaena* bloom of 2009 was the largest in recent years in our sampling region
- ...until 2011



Extent of 2011 Bloom



What Matters to Hypoxia?

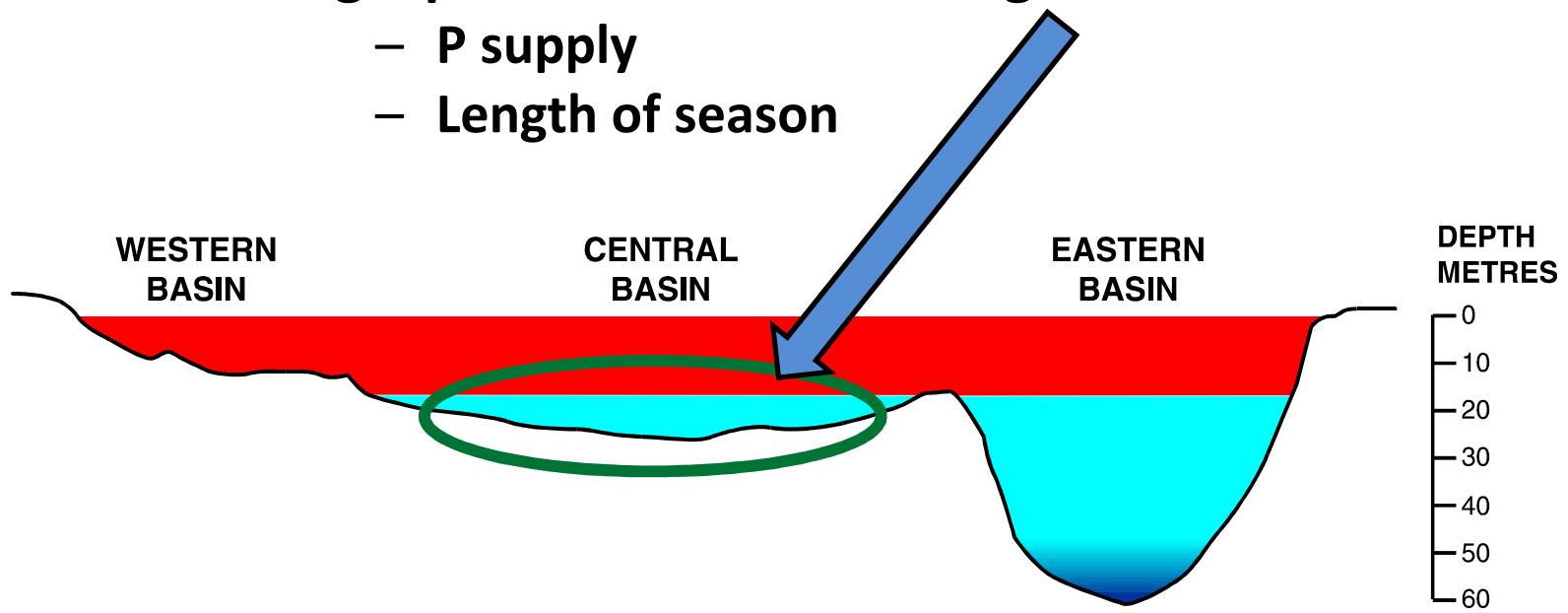
Thickness of Central Basin Bottom Layer

Air temperature, winds, length of season

Organic Matter Flux to the Bottom

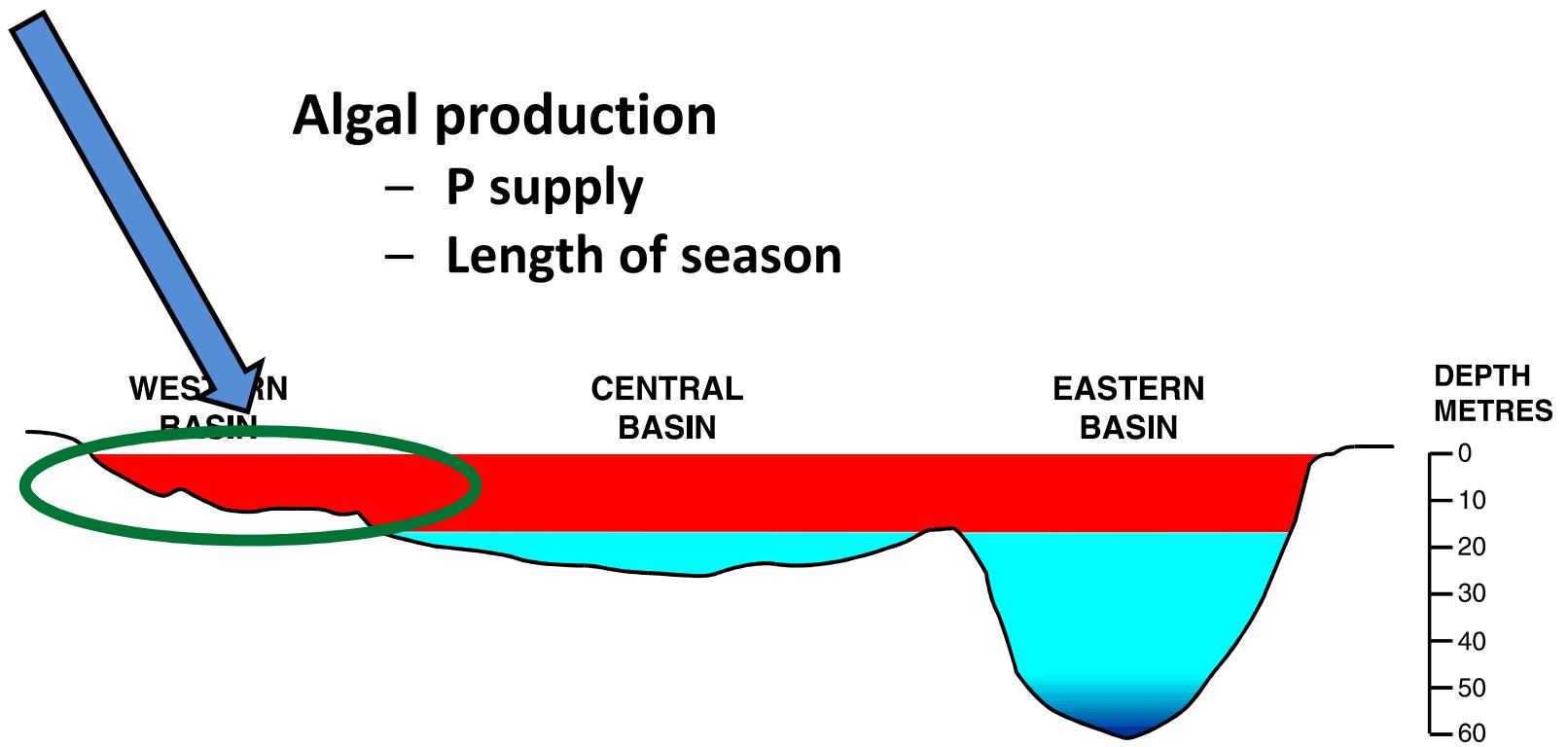
Algal production and settling

- P supply
- Length of season



What Matters to Algal Blooms?

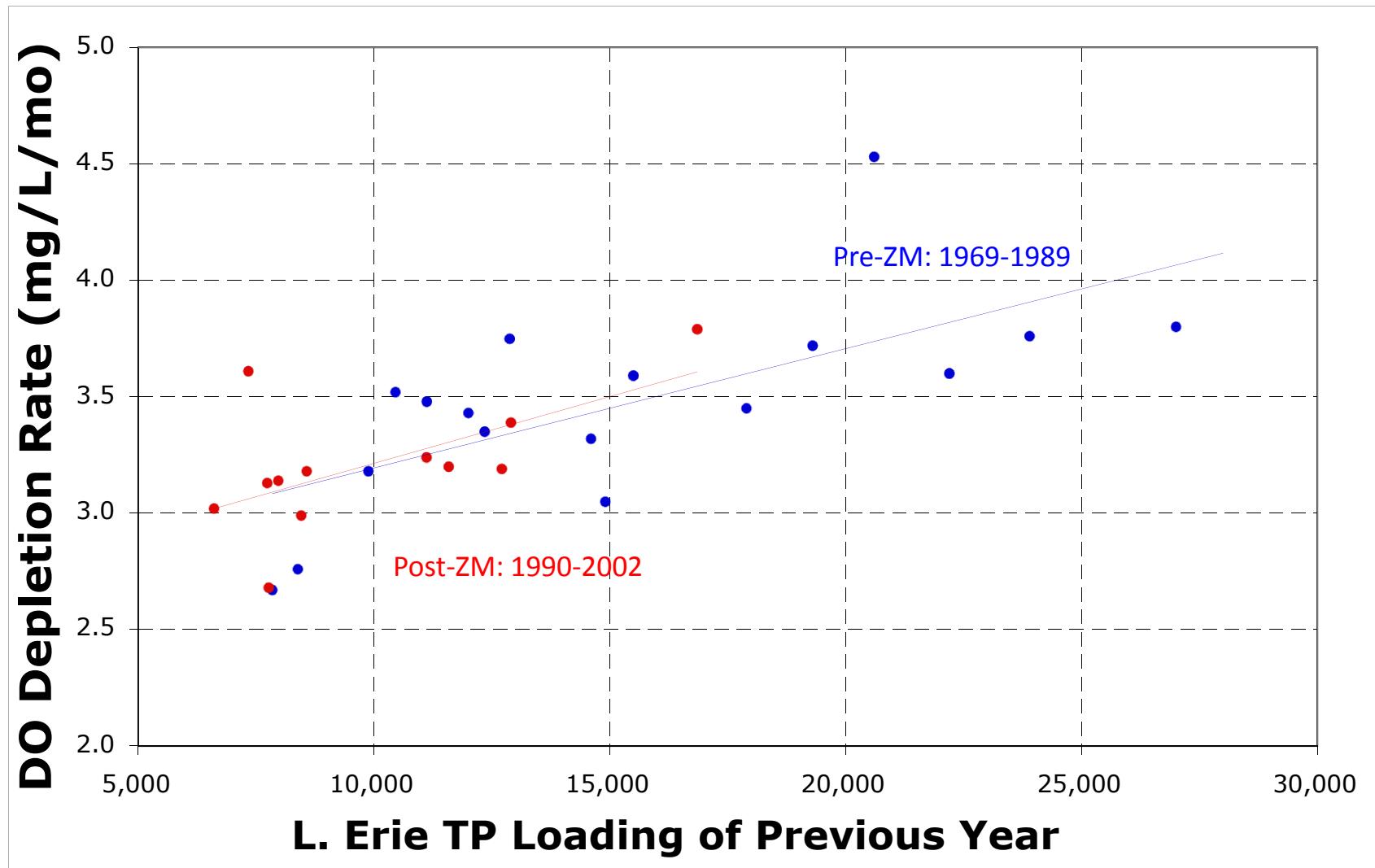
Air temperature, winds, length of season





**So What's Been Going
On?**

Mussel Impact on Hypoxia Not Obvious



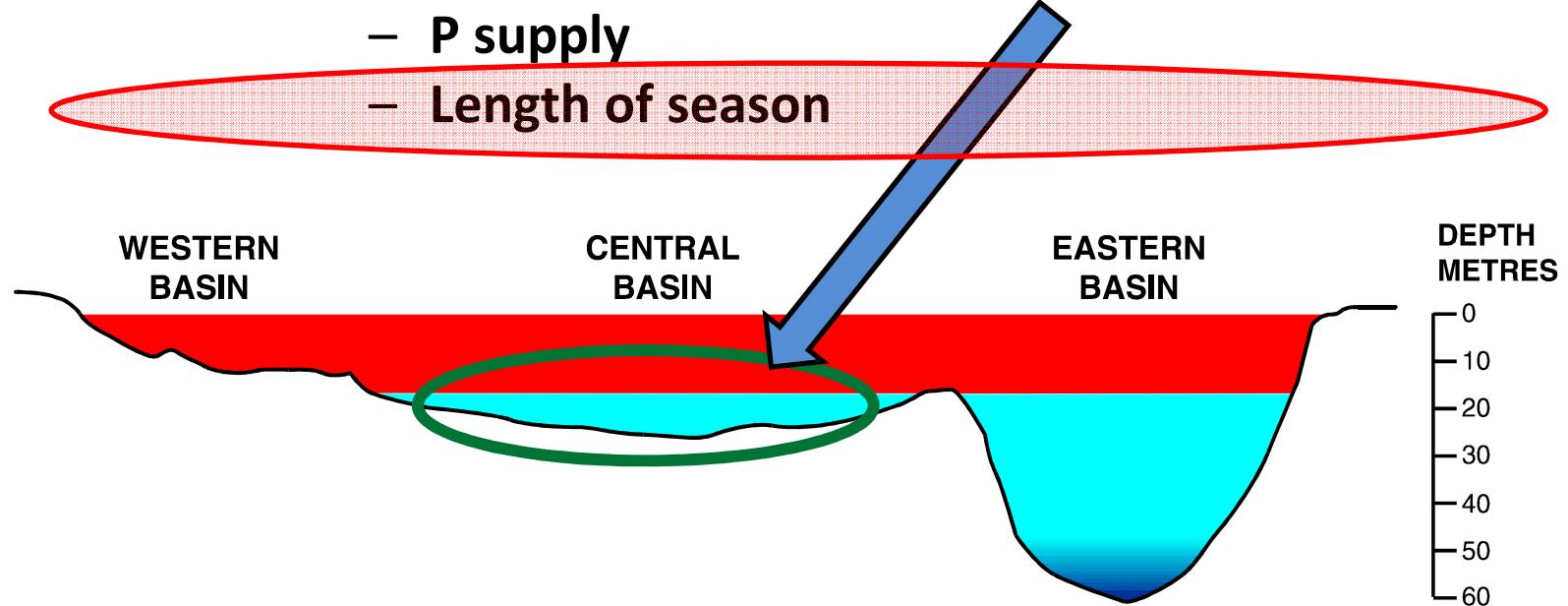
What Matters to Hypoxia?

Thickness of Central Basin Bottom Layer
Air temperature, winds, length of season

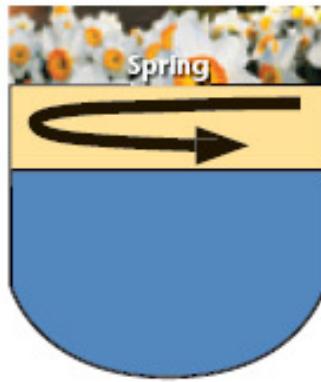
Organic Matter Flux to the Bottom

Algal production and settling

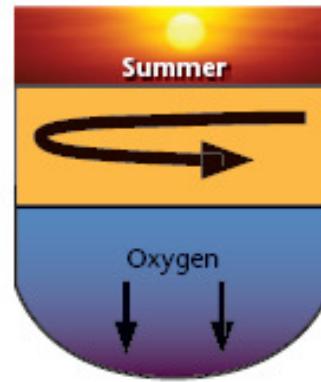
- P supply
- Length of season



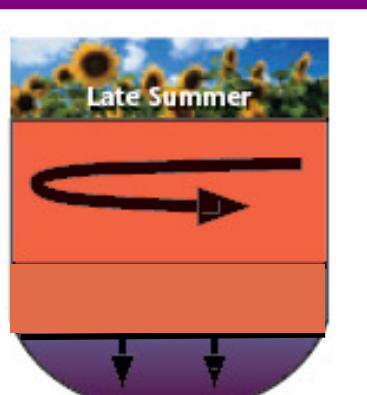
Thinner Bottom Layer?



Stratification begins: A warm surface layer of water develops over cooler, deeper waters; surface currents are cut off from the deeper waters and cannot supply them with atmospheric oxygen



Stratification Intensifies: The surface layer continues to warm while, in the deepest water, the oxygen level drops as it is absorbed by the bottom sediments



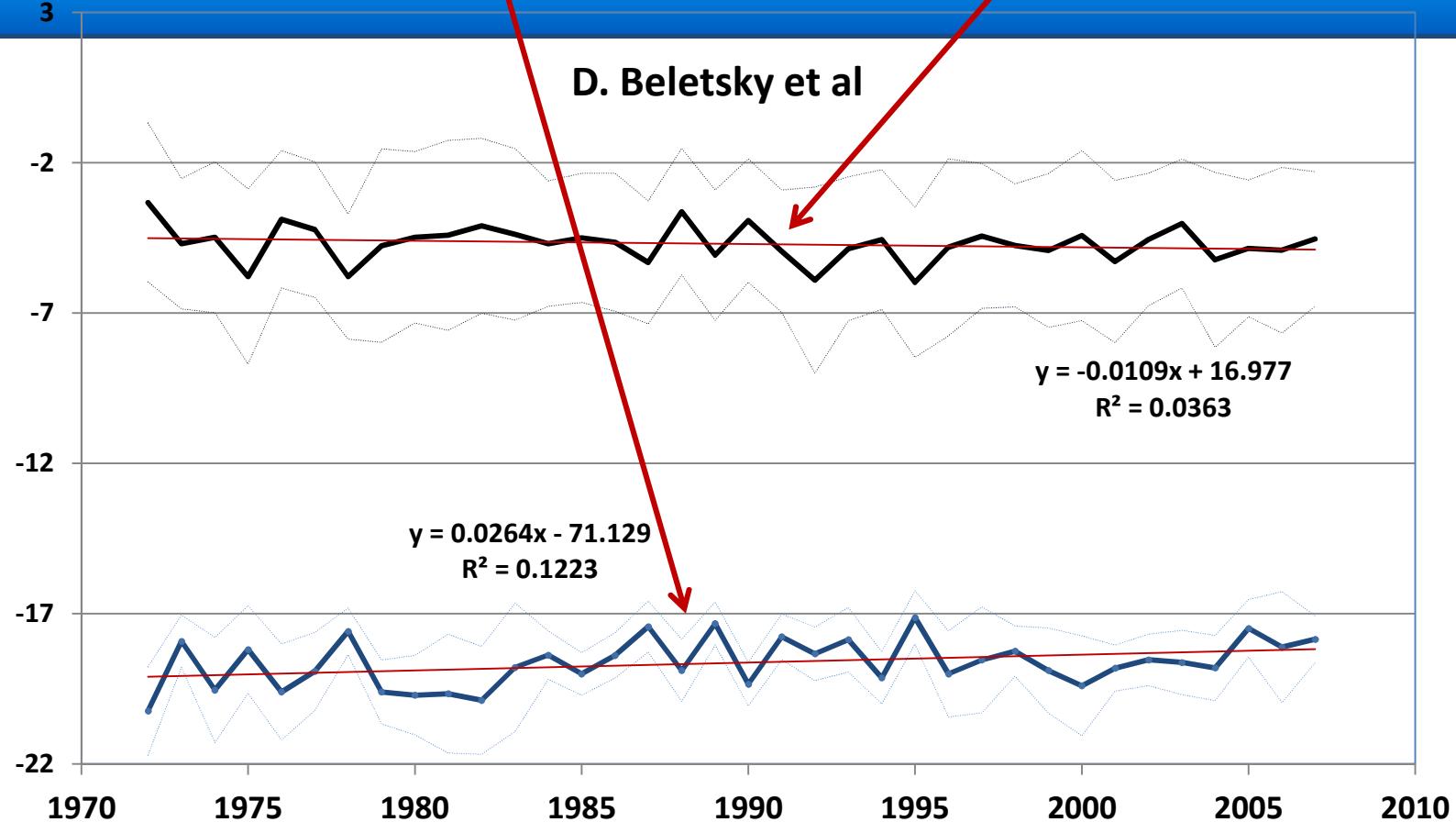
Stratification peaks: 'Dead zone' forms as low oxygen levels spread throughout the deep waters



Turnover: As the surface layer cools, fall winds generate currents that are strong enough to carry oxygen to the bottom waters and return their

=> Less O₂
Available

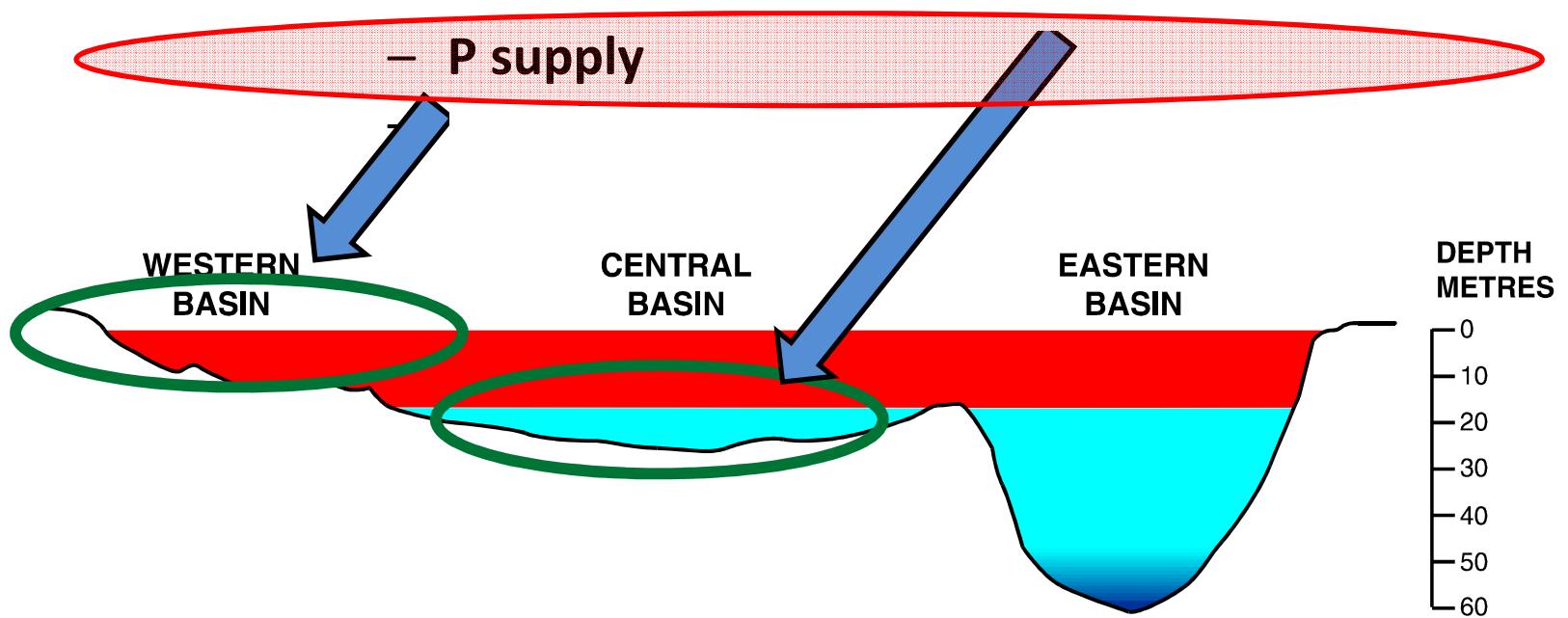
Thermocline Depth and Stratification Strength



No clear evidence yet

Rucinski et al. 2010

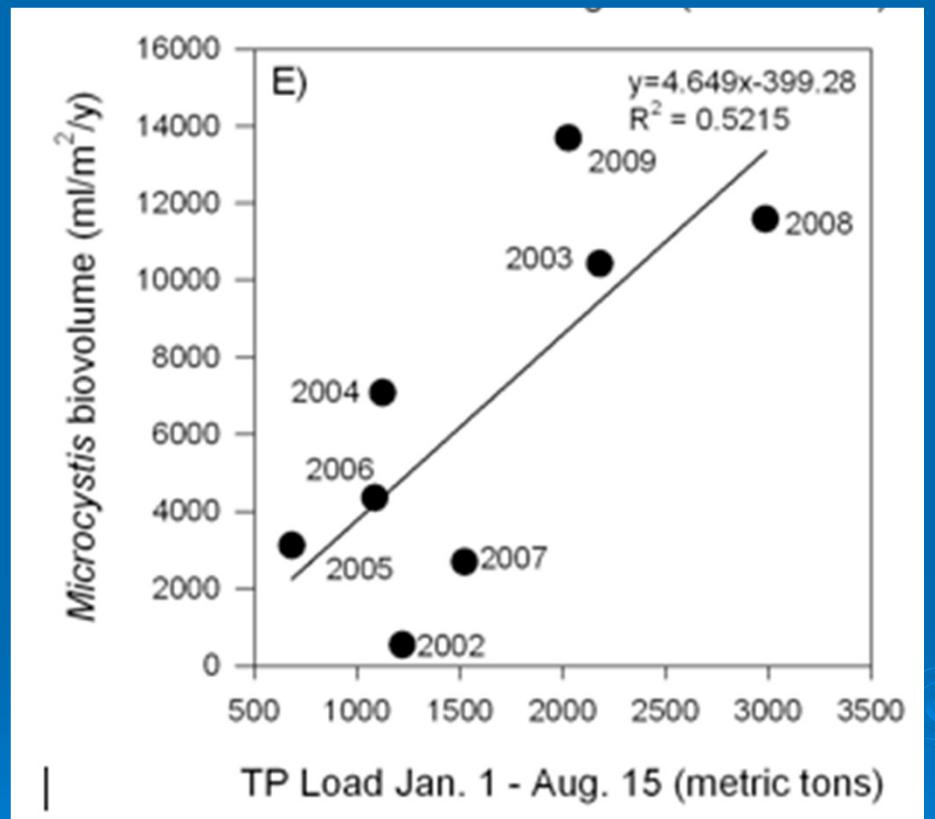
What Matters to HAB and Hypoxia?



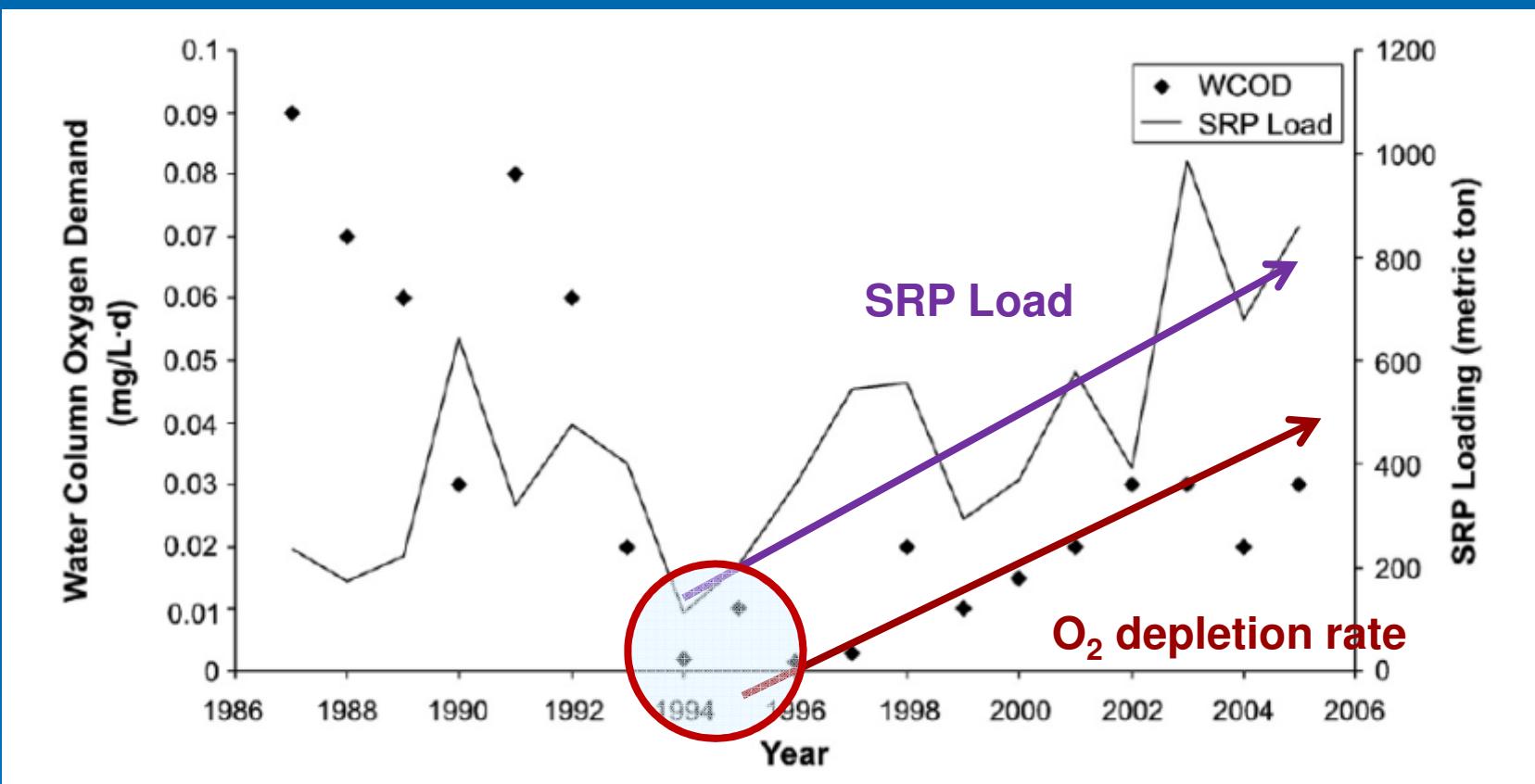
What accounts for the large interannual variation in *Microcystis* blooms?

-What is the effect of Maumee River P loading?

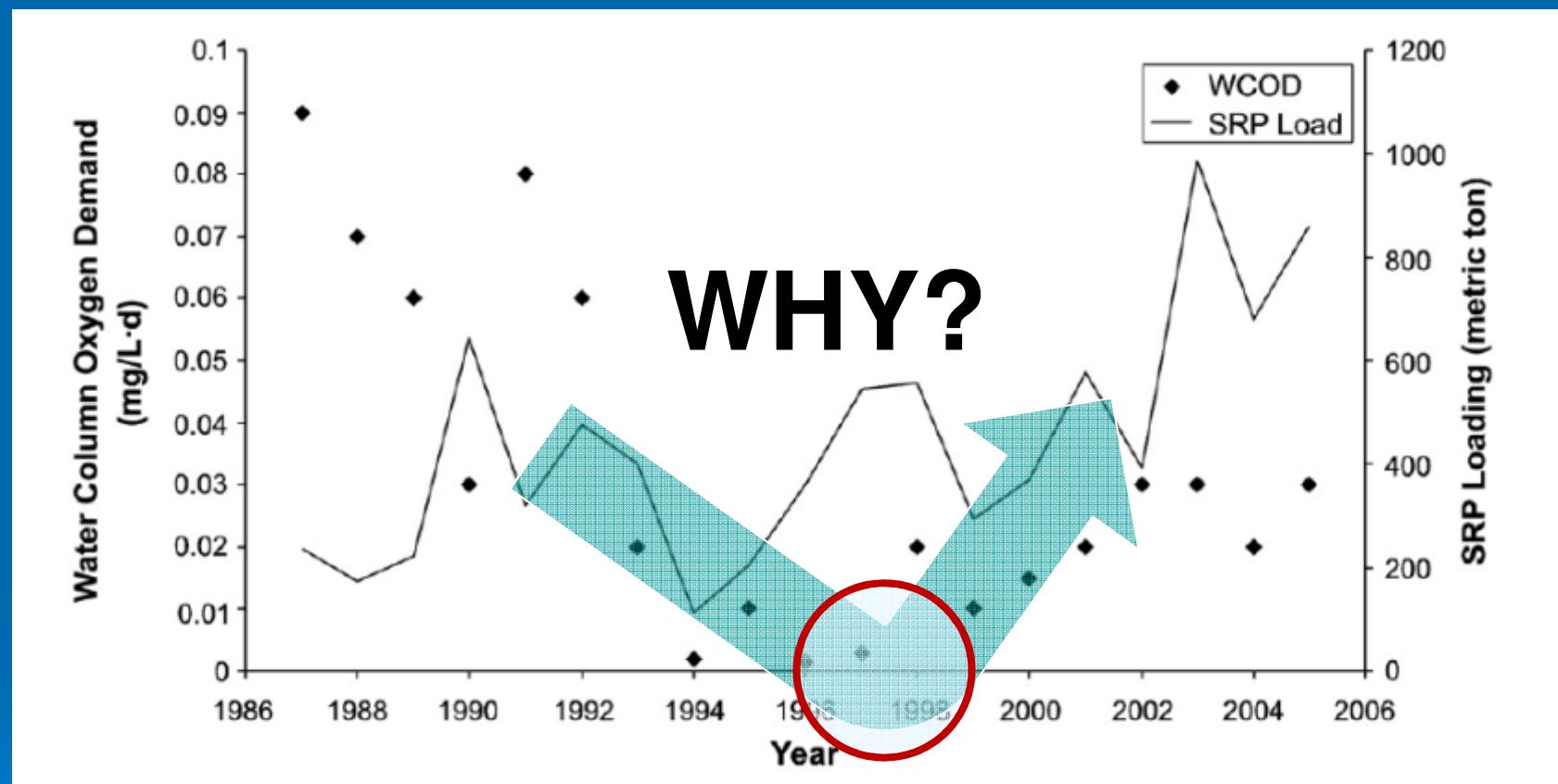
The best predictor of *Microcystis* annual crop is the cumulative TP load from the Maumee River from January to August.



T. Bridgeman



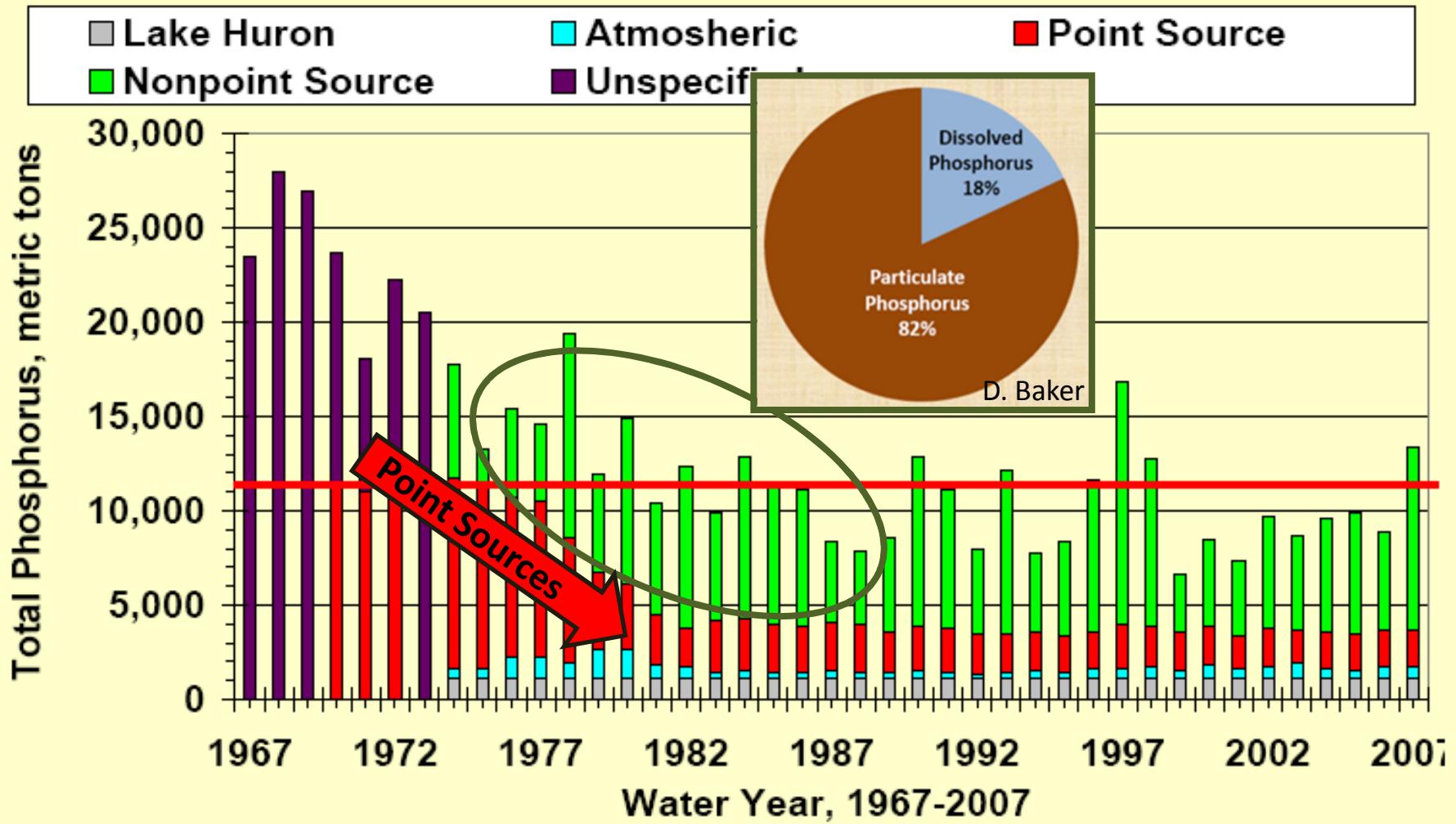
Rucinski et al 2010



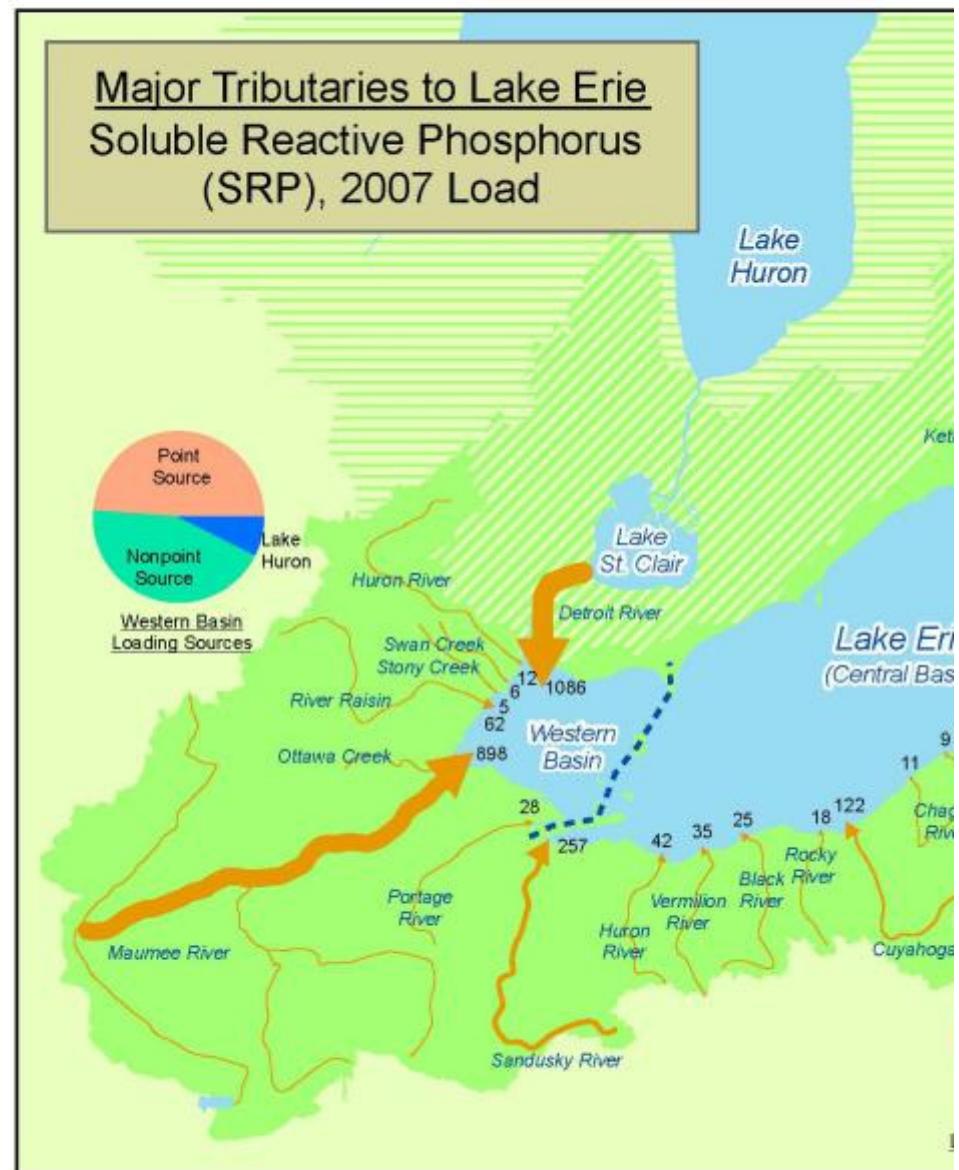
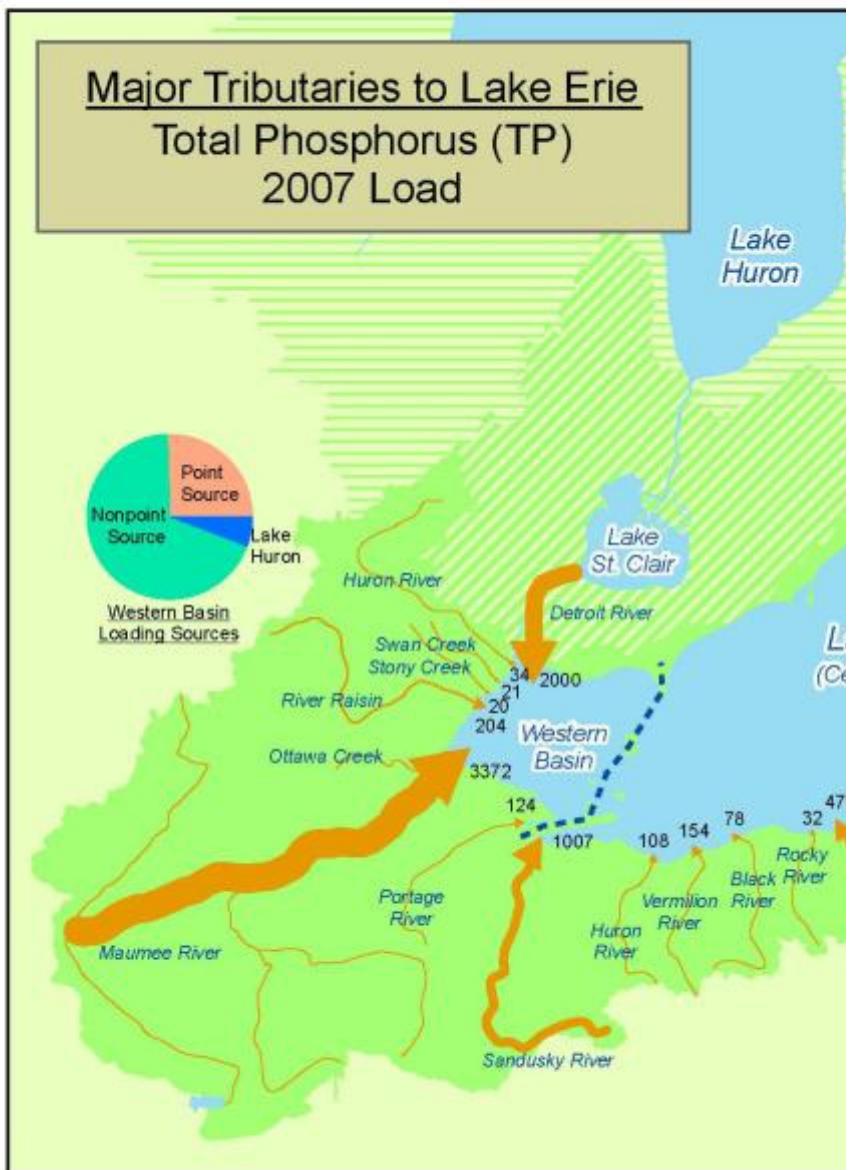
Rucinski et al 2010

An overview of phosphorus loading to Lake Erie

Lake Erie Total Phosphorus Loading by Major Source

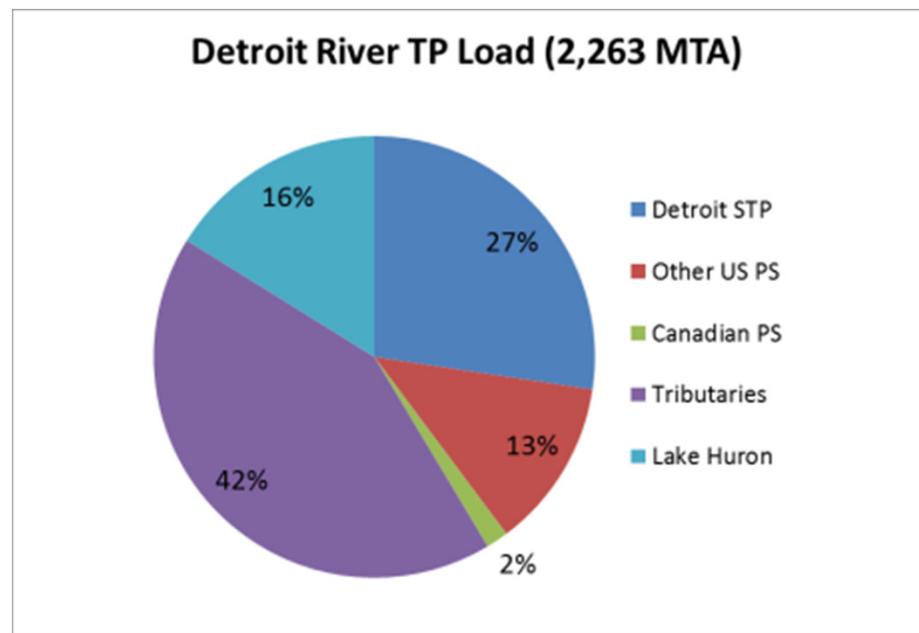
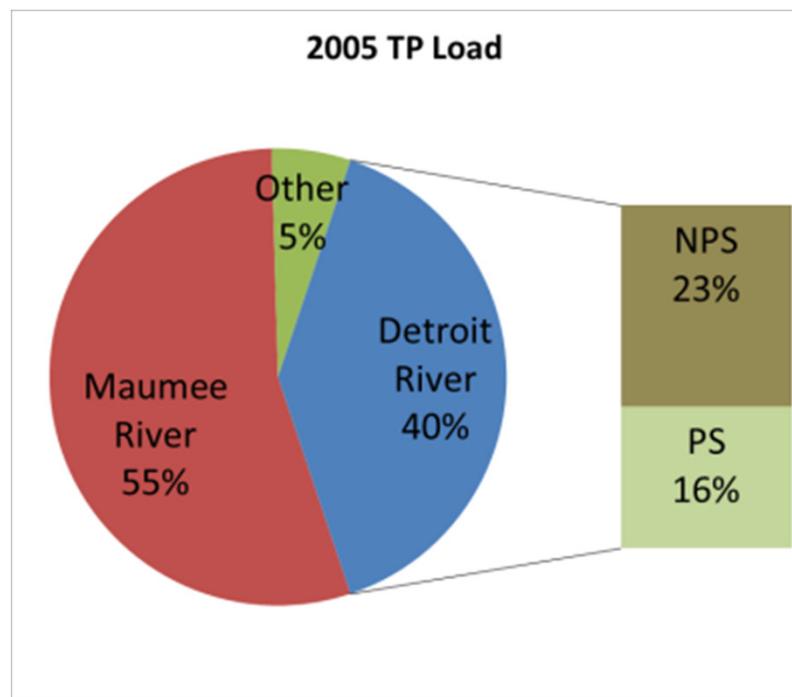


Data from Rockwell and Dolan



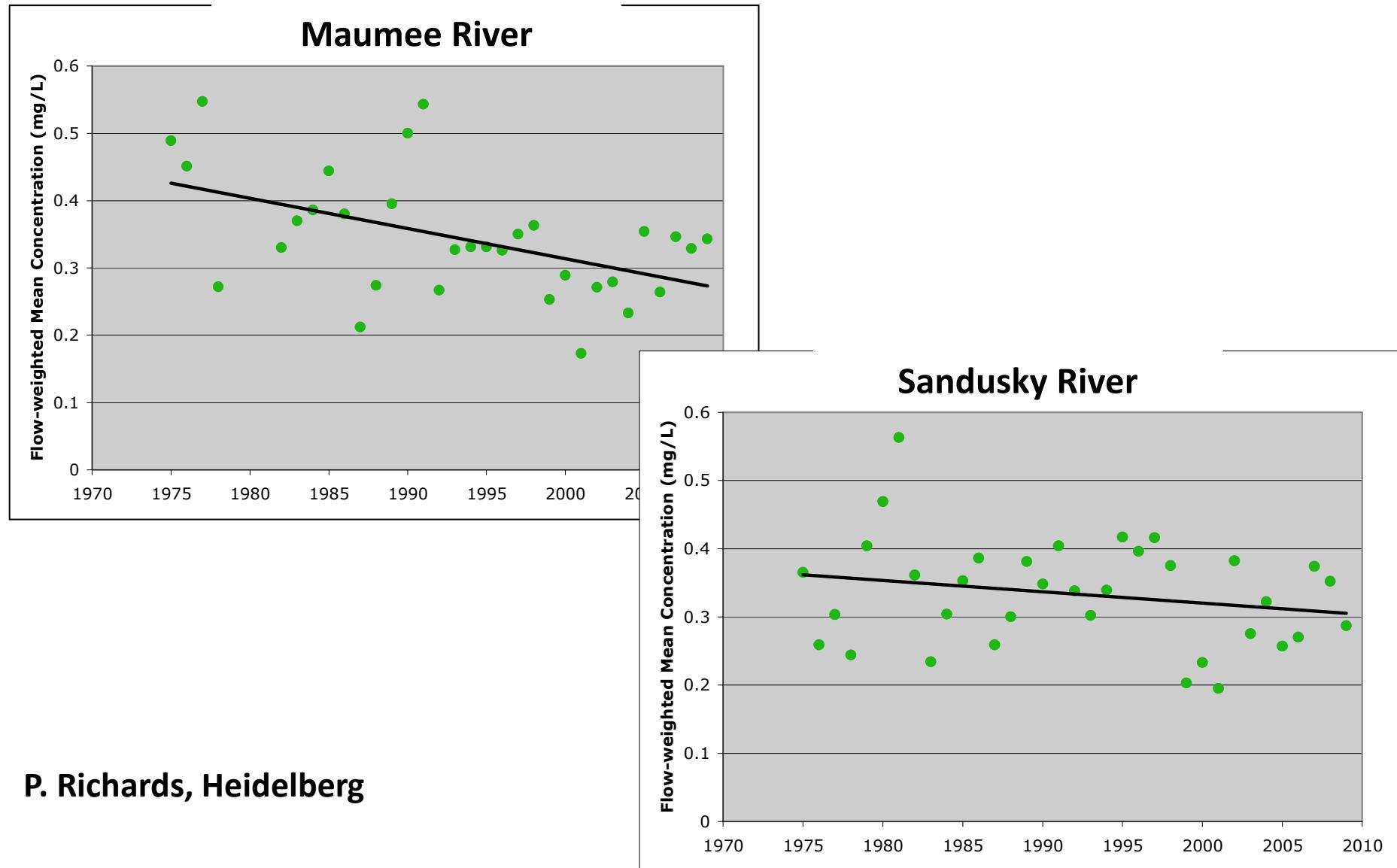
Phosphorus Loads to Western Basin - 2005

5,697 Metric Tonnes/year

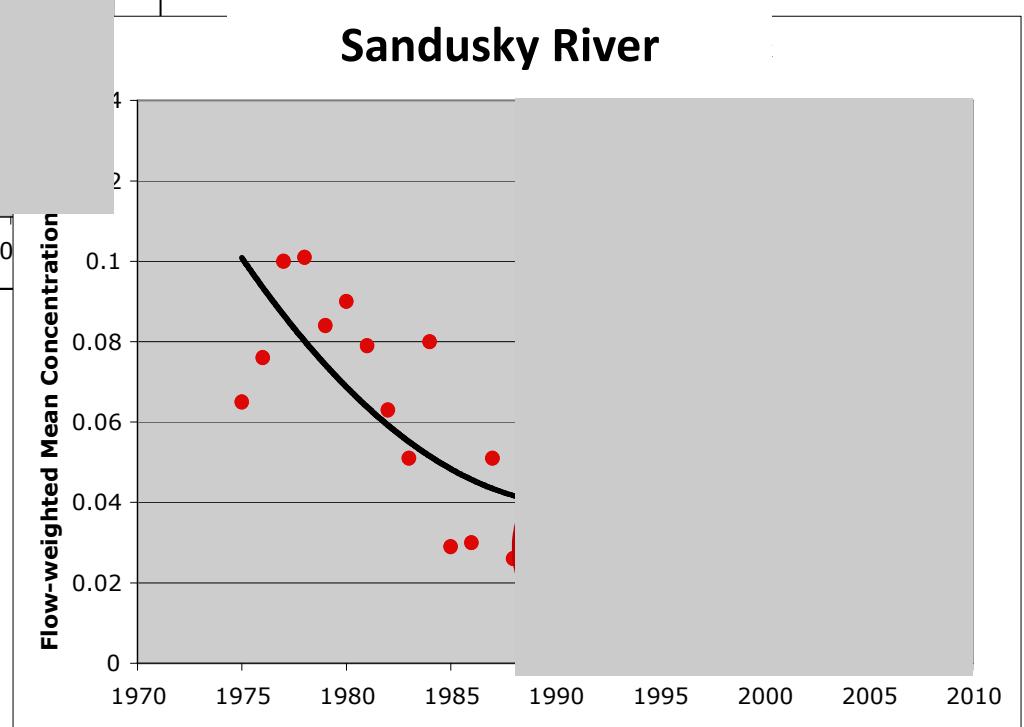
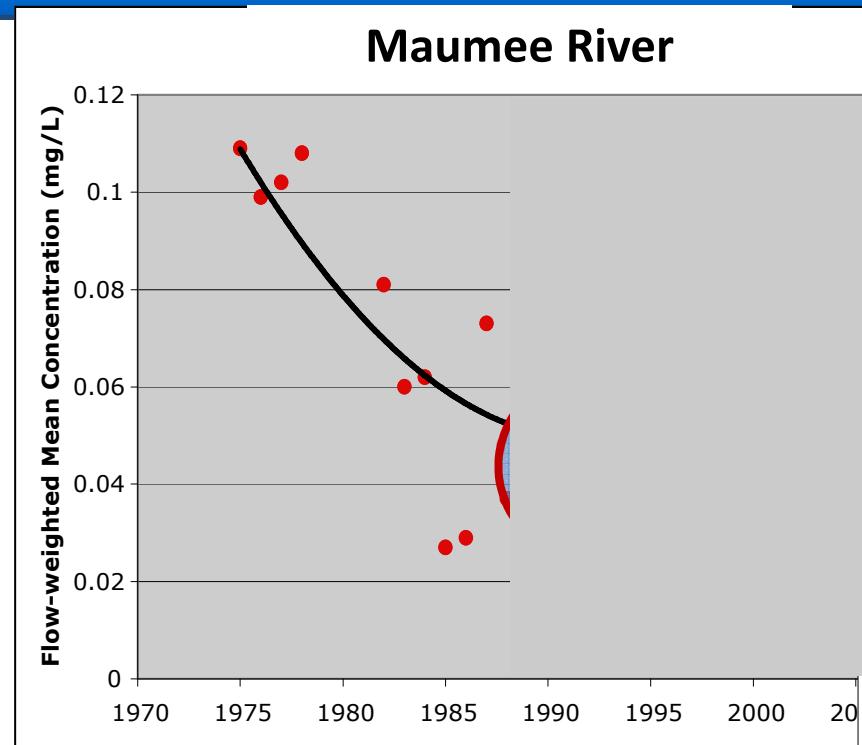


Data compiled by Dave Dolan, UW-Green Bay
Maumee data from Heidelberg University

The Trends Particulate Phosphorus

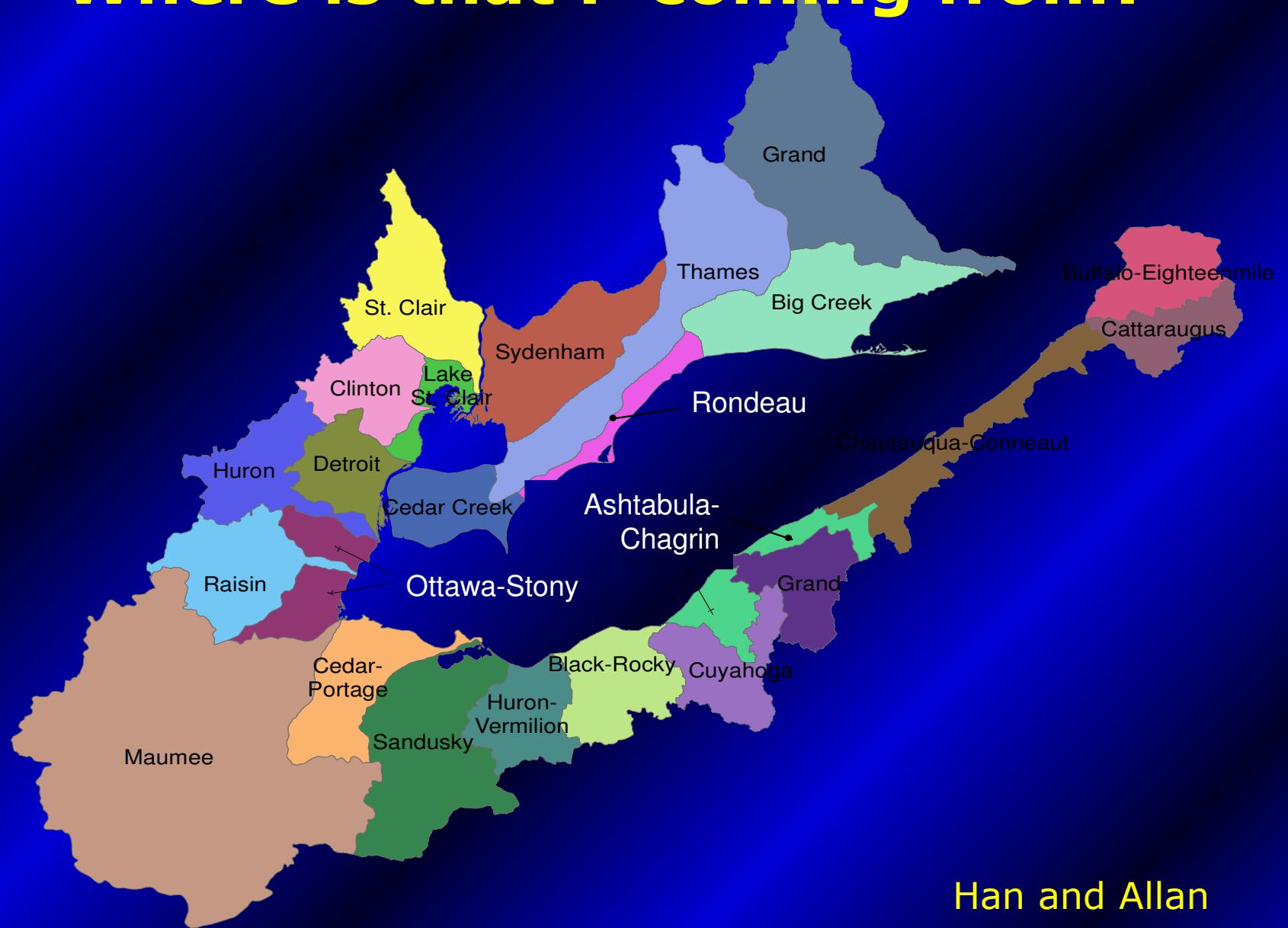


The Trends in Dissolved Reactive P



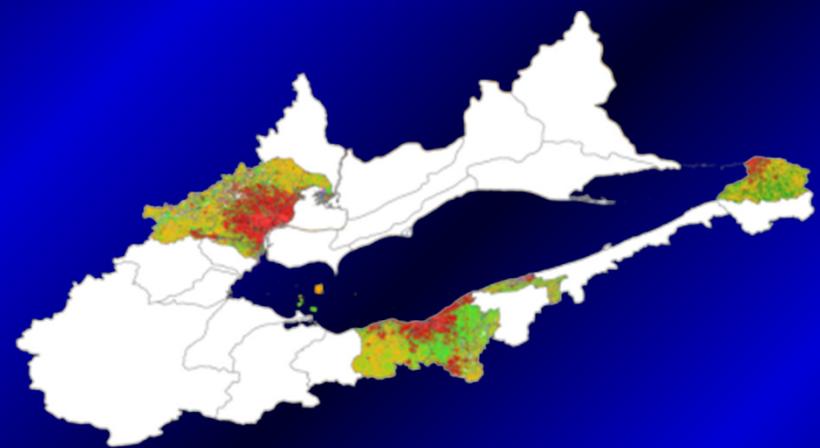
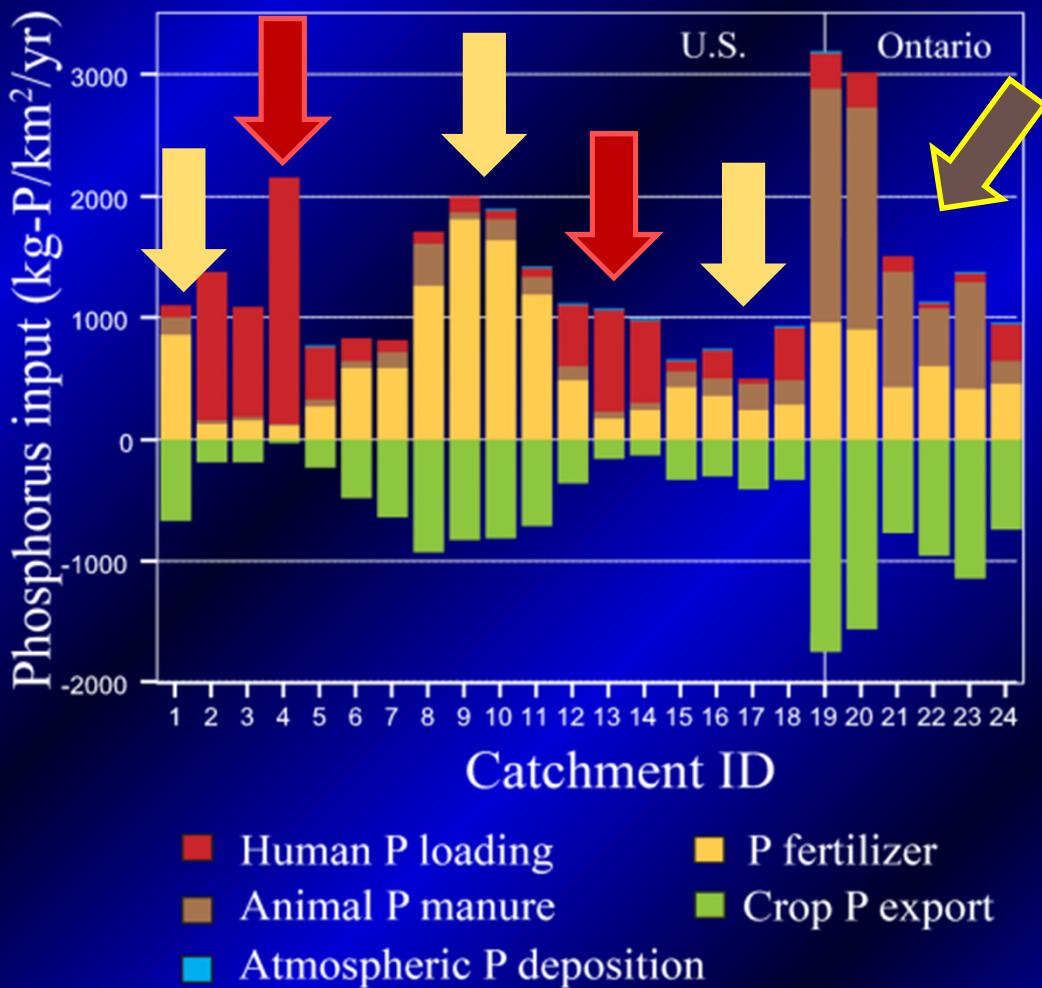
P. Richards, Heidelberg

Where is that P coming from?



Han and Allan

Relative importance of individual P sources

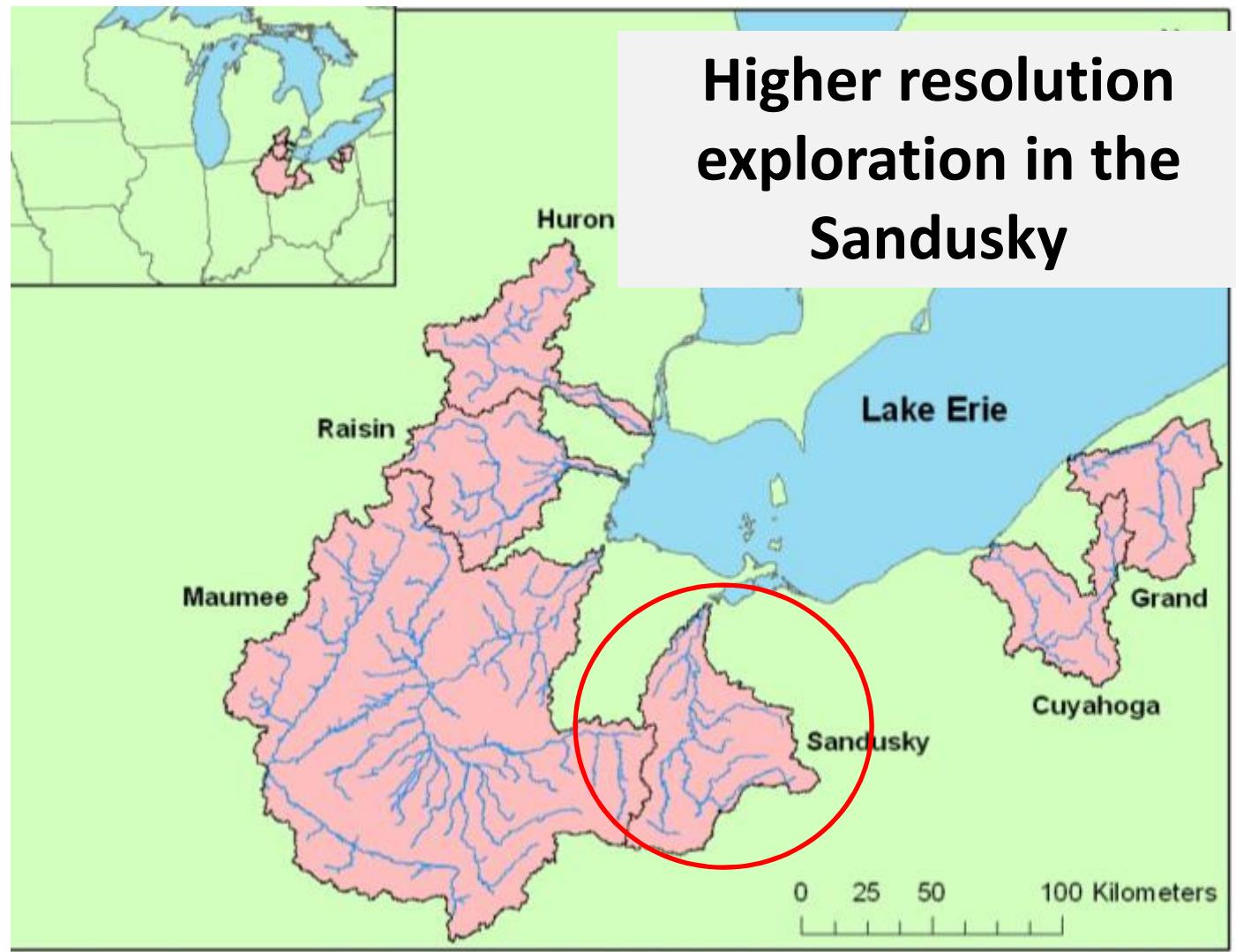


Fertilizer is the largest P input to the agricultural agrosheds of Ontario

Human loading is the largest P input for urbanized watersheds

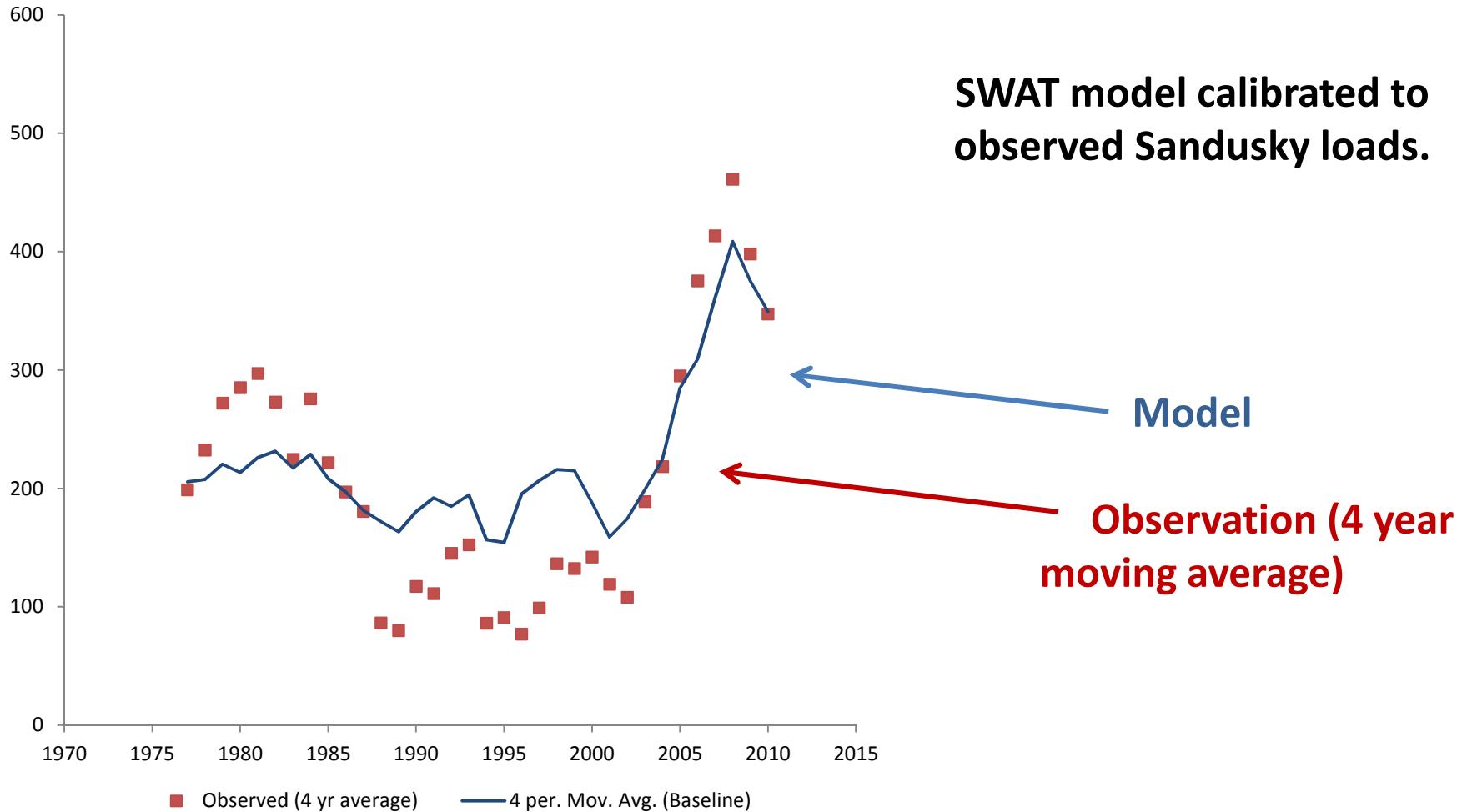
Han and Allan

Calibrated Soil & Water Assessment Tool (SWAT) models for Major Watersheds

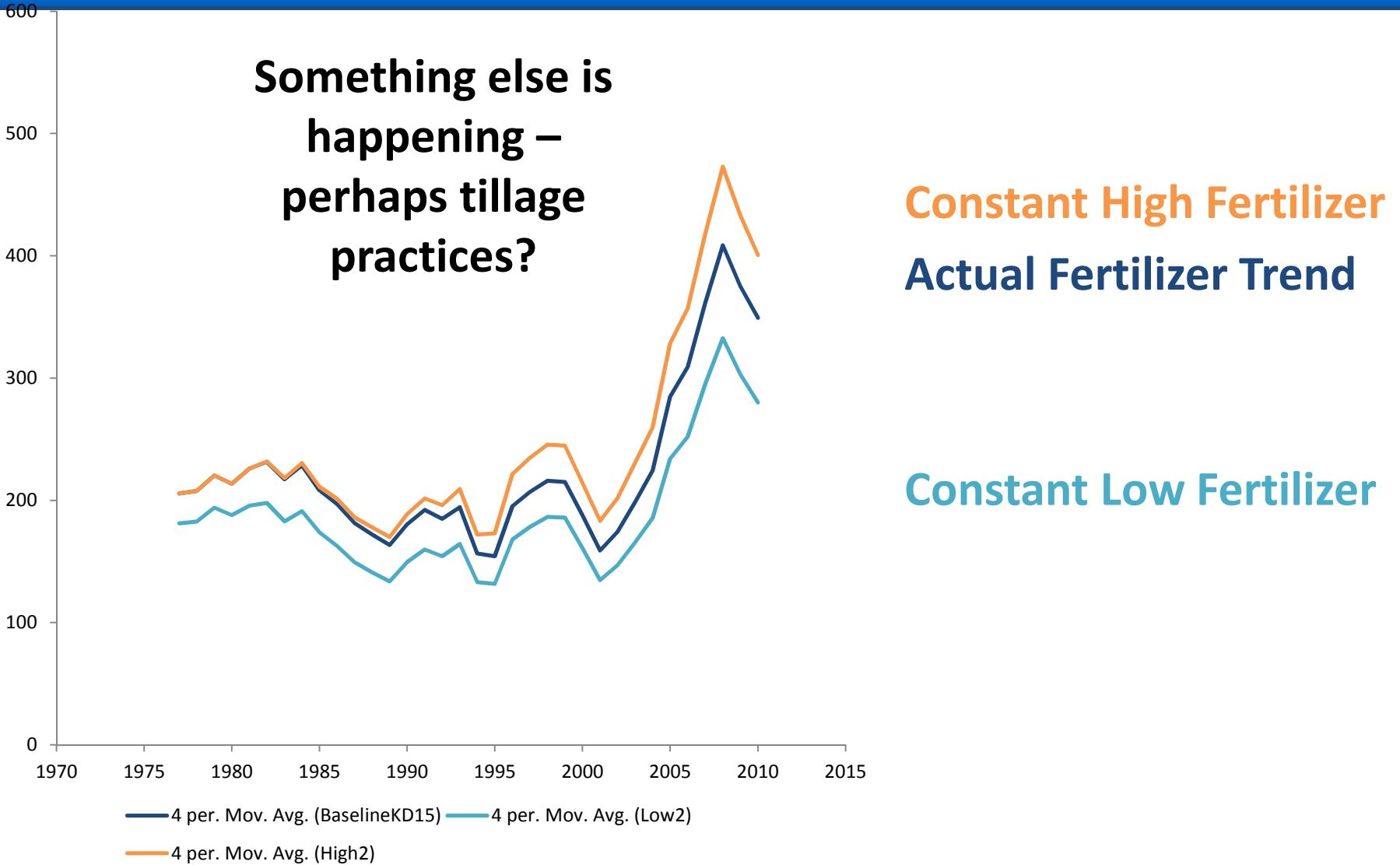


I. Daloglu

Simulated DRP Load

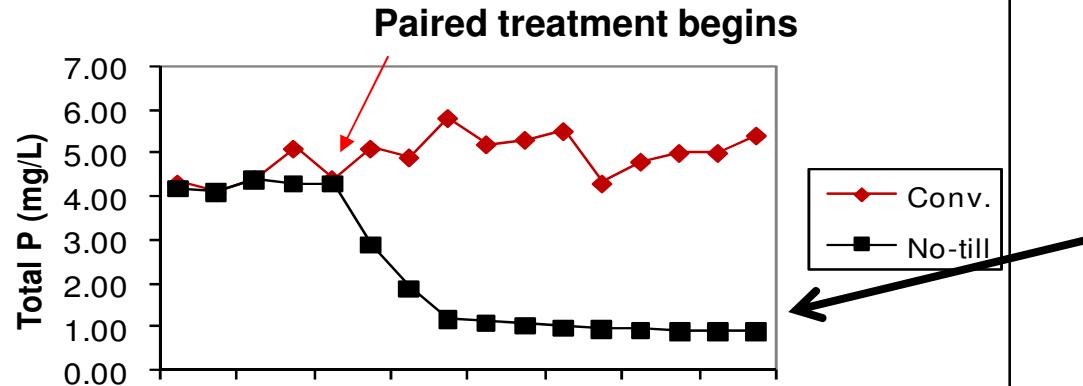


Simulated DRP Load



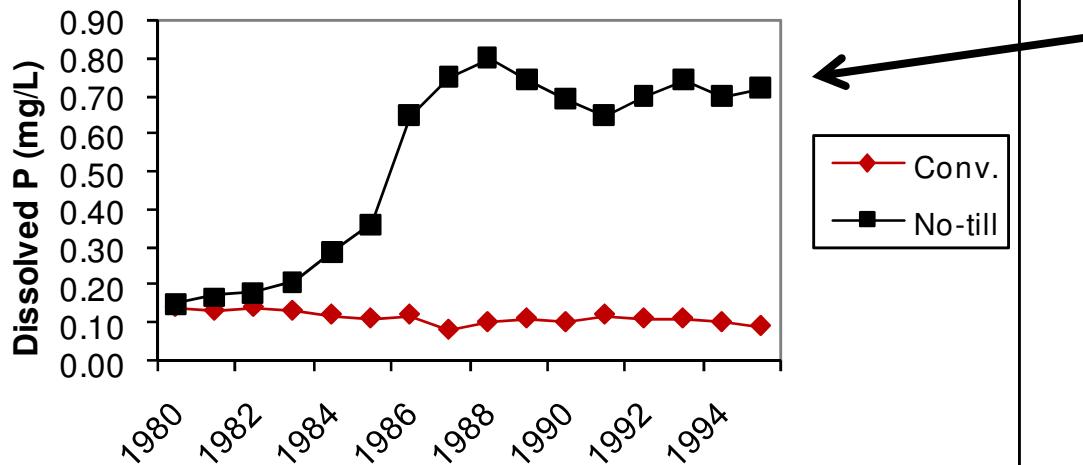
Perhaps a “no-till impact”?

Mean Annual TP in Runoff as a Function of Tillage Management



No-till decreases TP in runoff ...

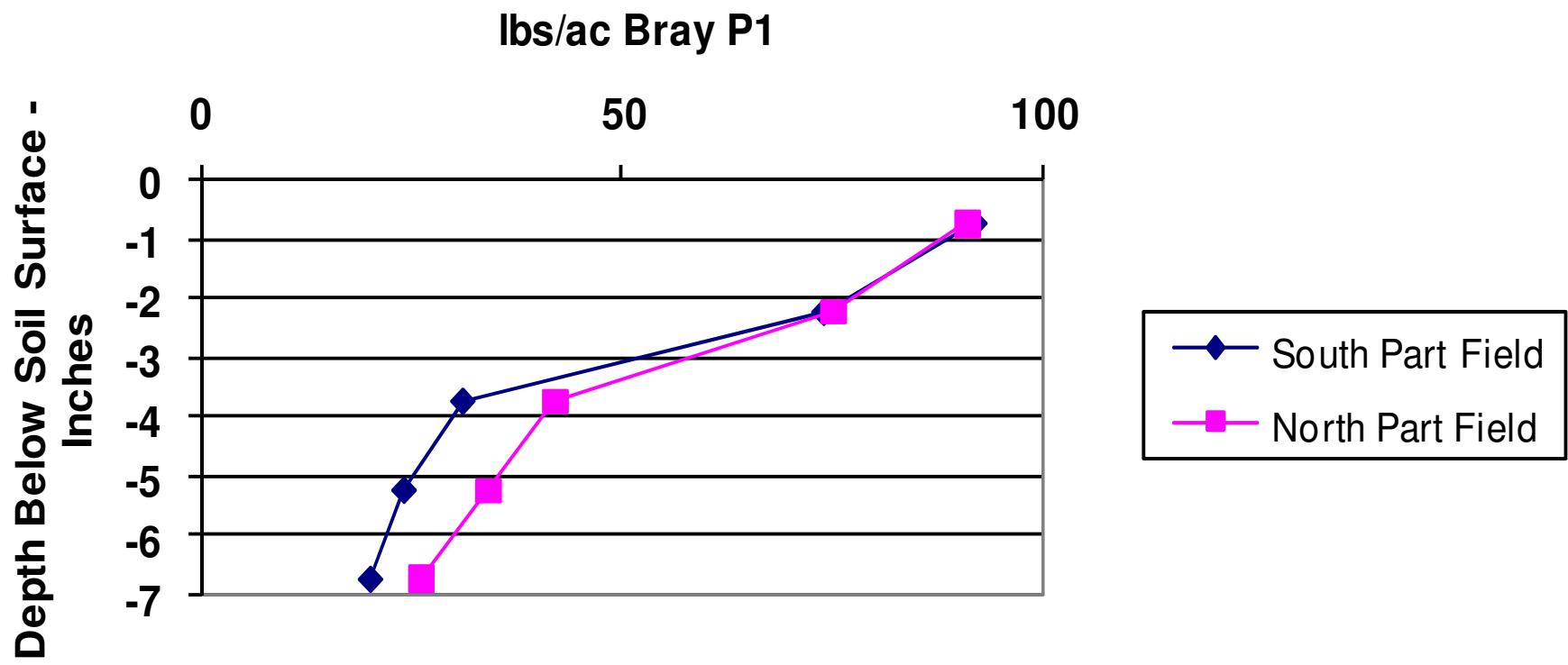
Mean Annual DP in Runoff as a Function of Tillage Management



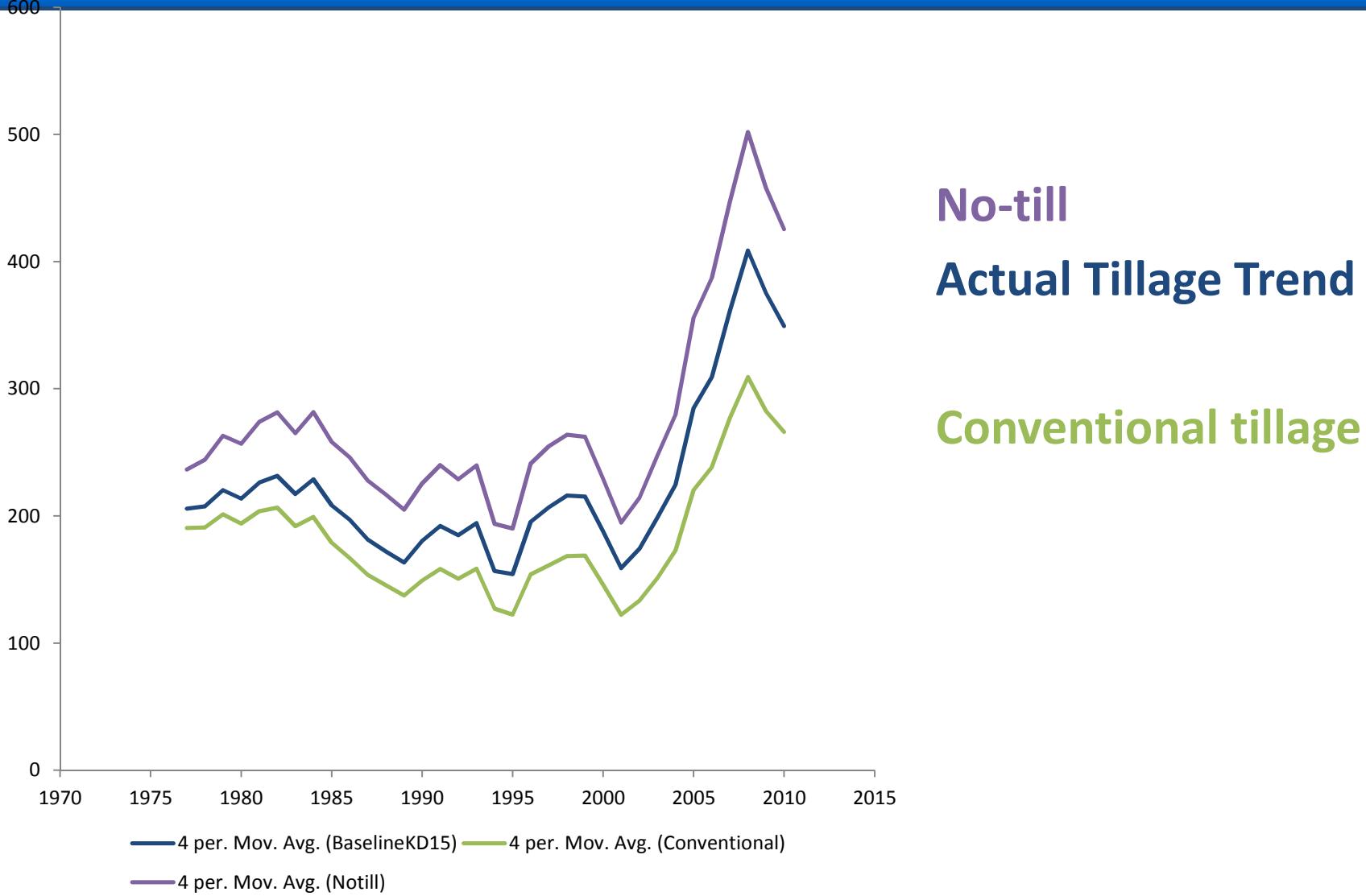
...but increases DP in runoff.

Enriched soil P near surface

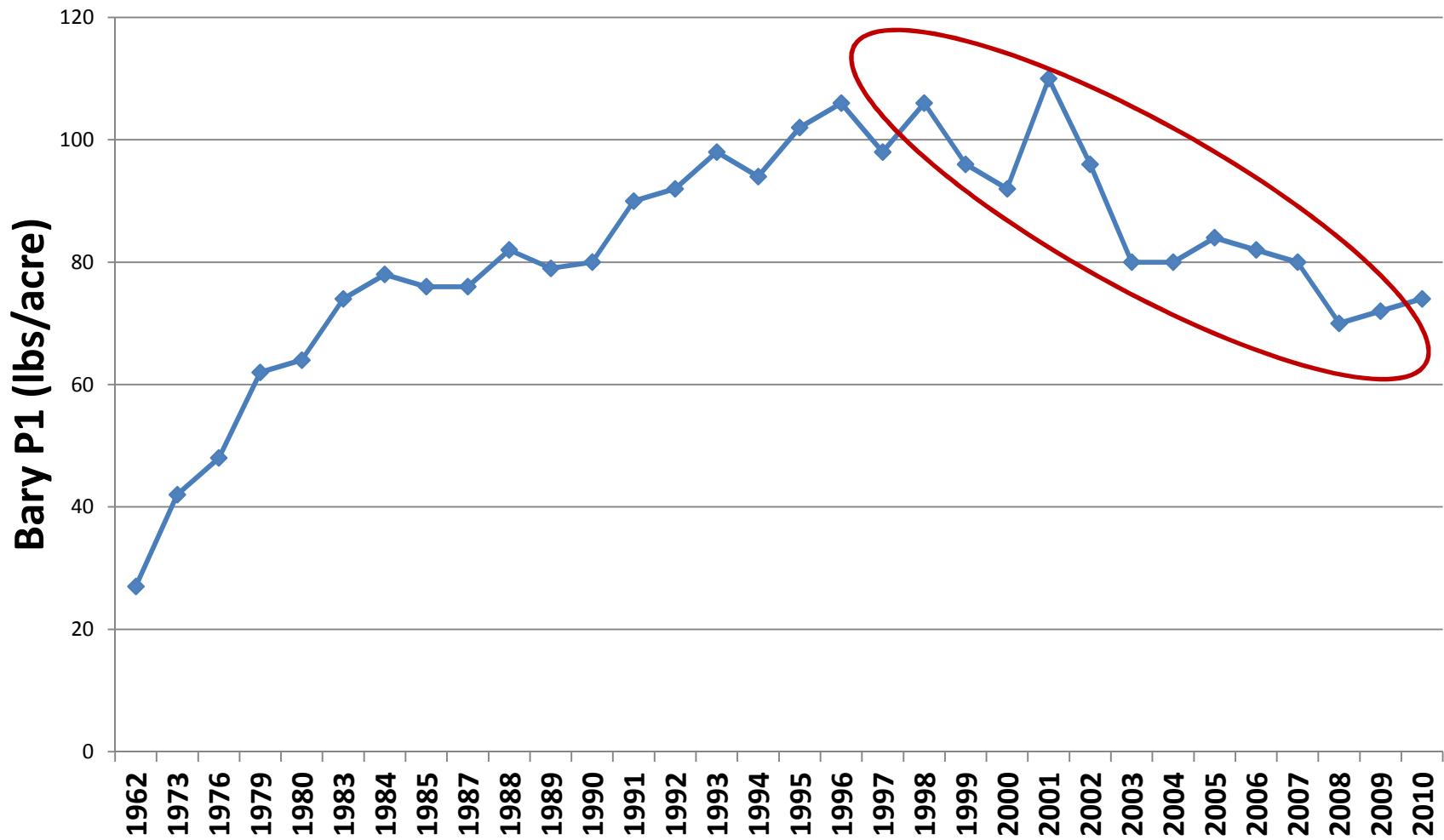
Phosphorus Stratification After 20 Years of No-till on
a Blount silt loam, Seneca County, OH



Simulated DRP Load

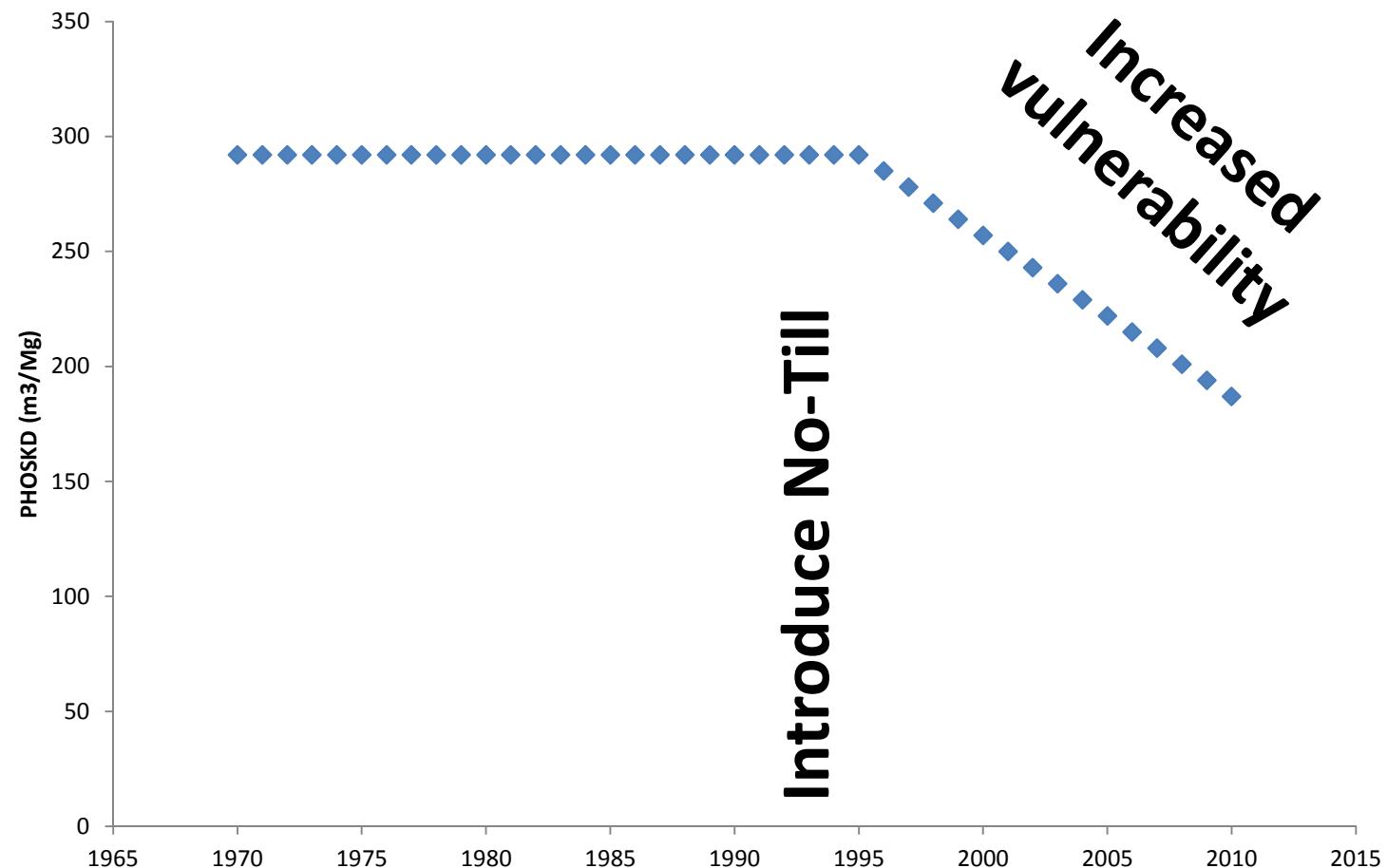


Long-Term Soil P for NW Ohio

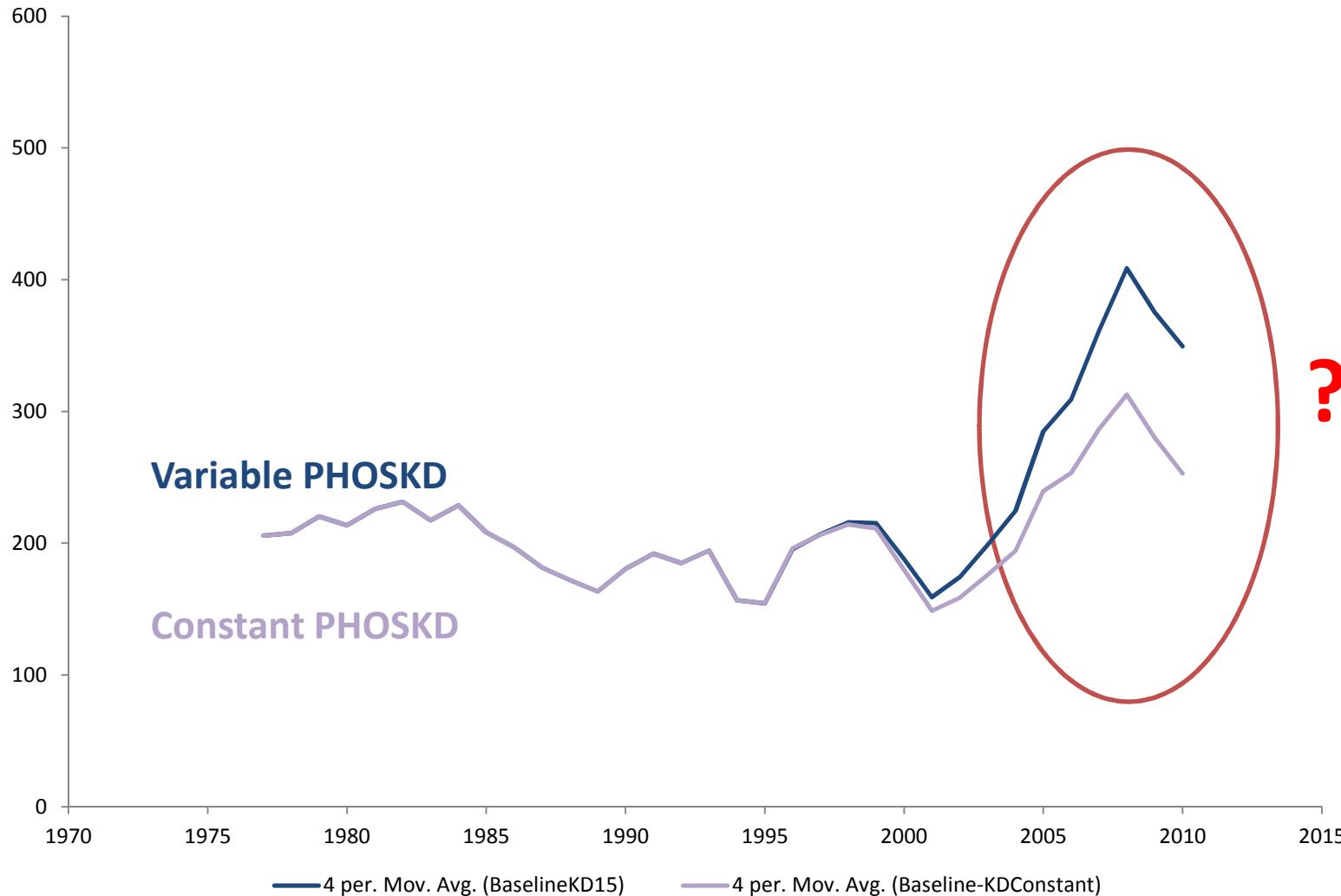


From A&L Laboratory, Ohio

PHOSKD values (Soil P/Runoff P)

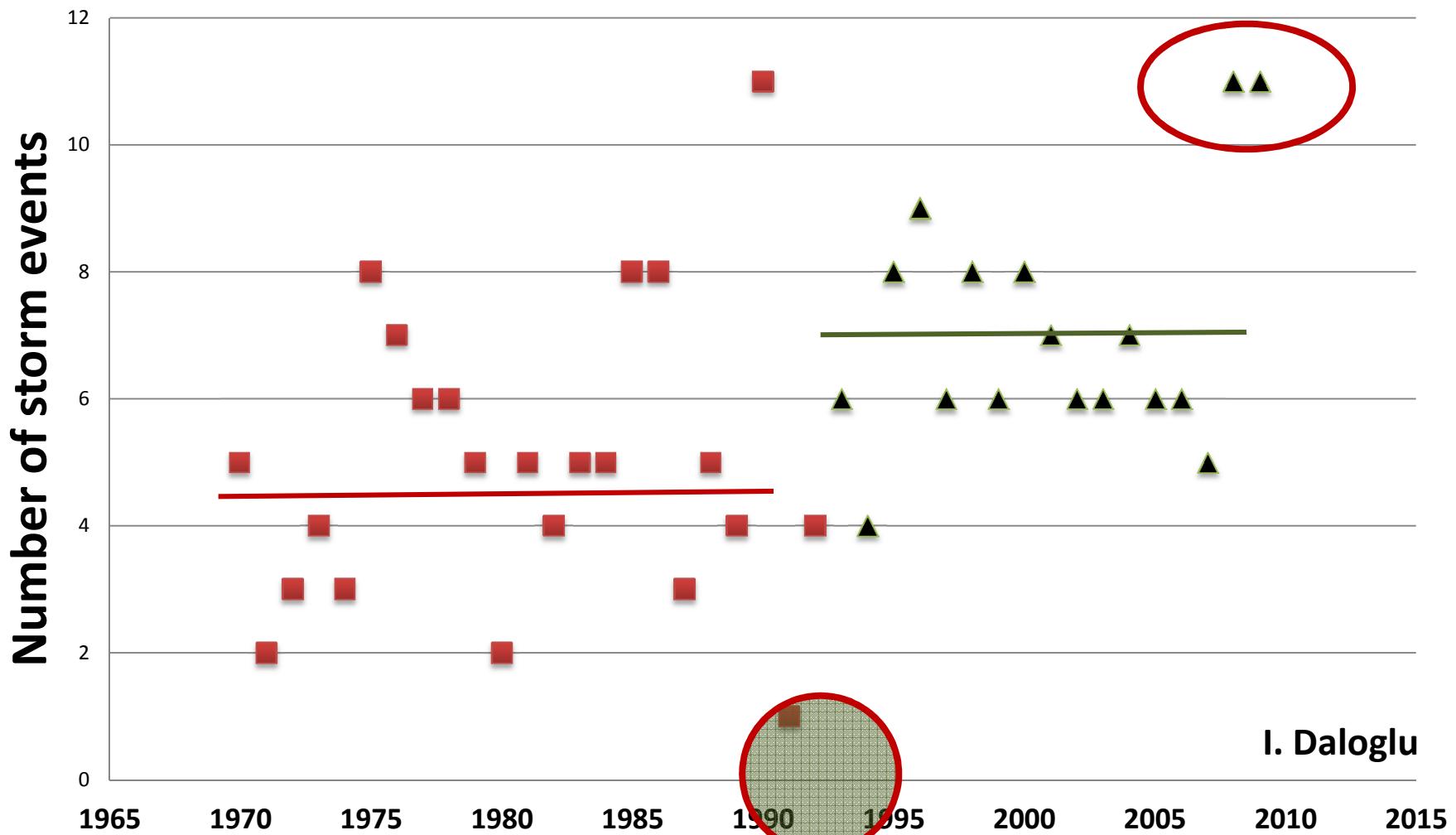


Simulated DRP Load



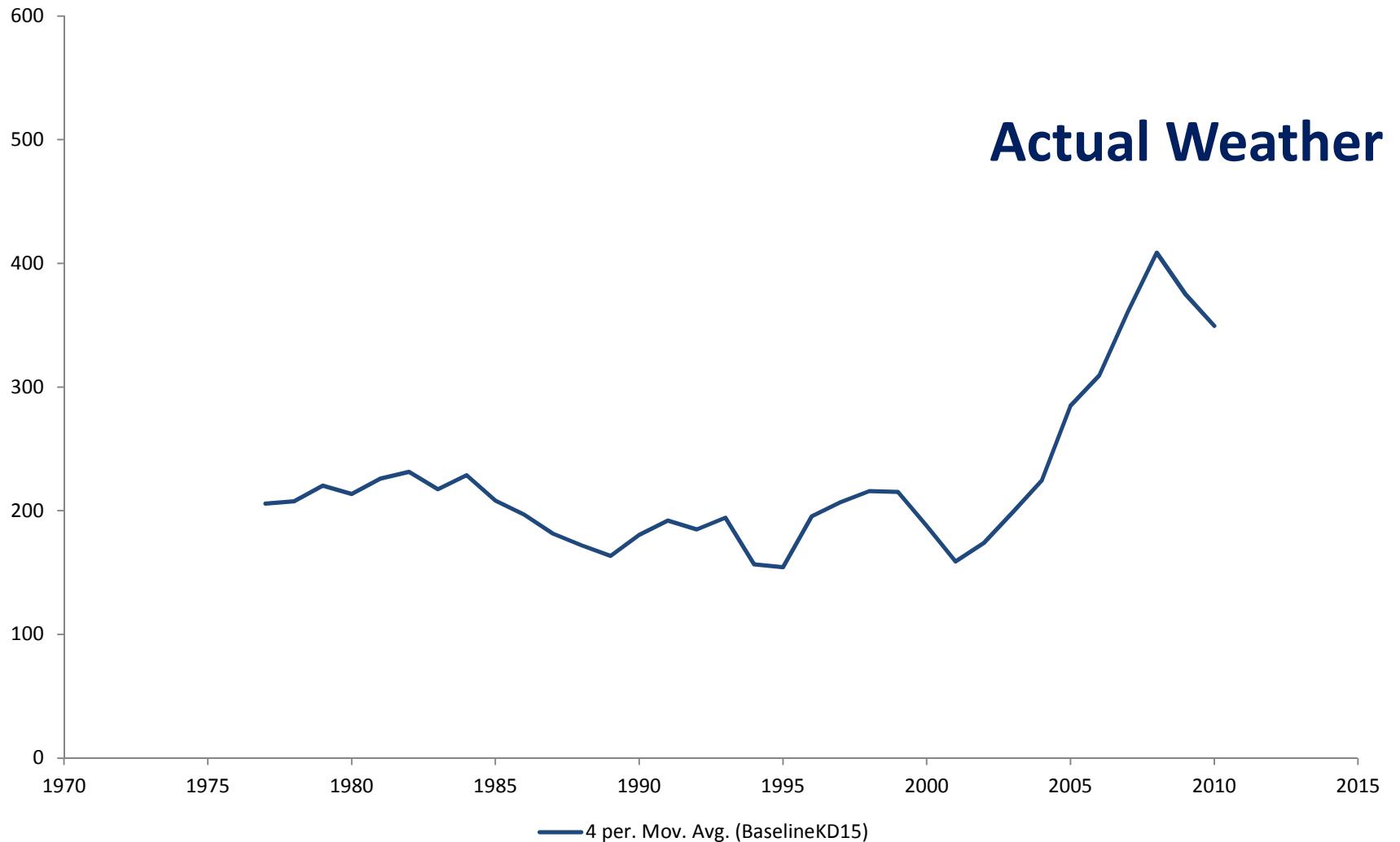
Lake Erie Extreme Precipitation

Sandusky Watershed

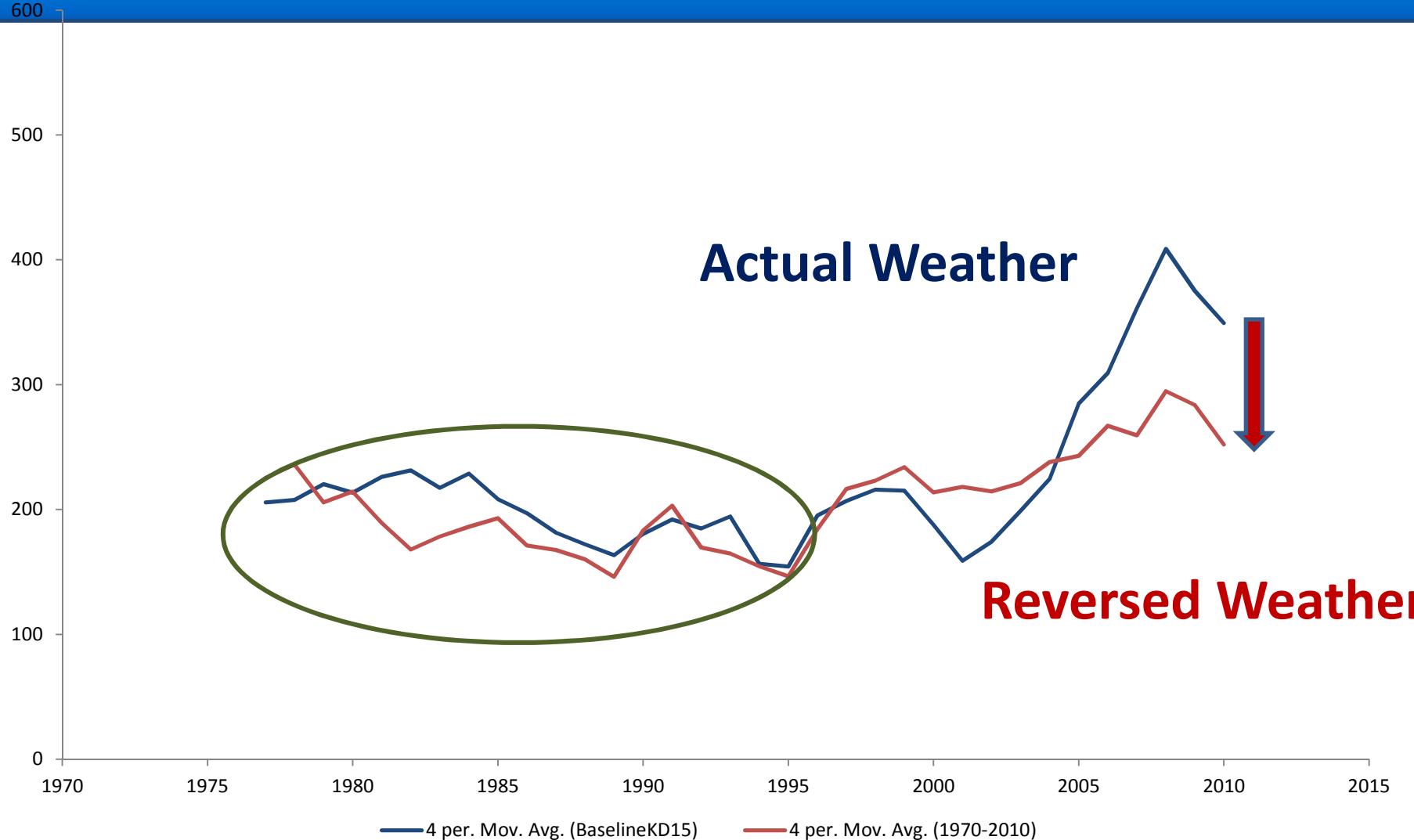


I. Daloglu

Simulated DRP Load



Simulated DRP Load

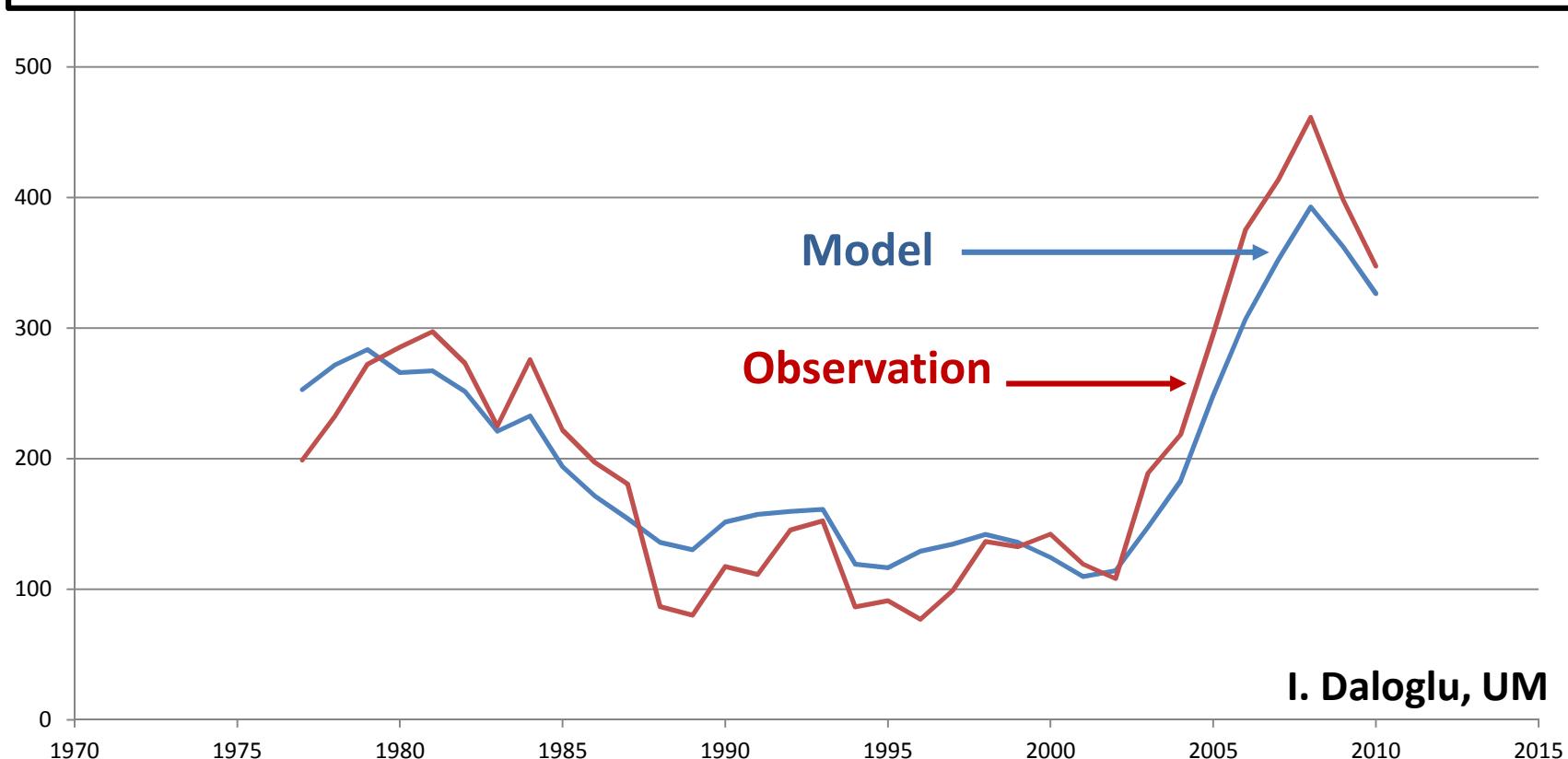


Trend appears to be function of:

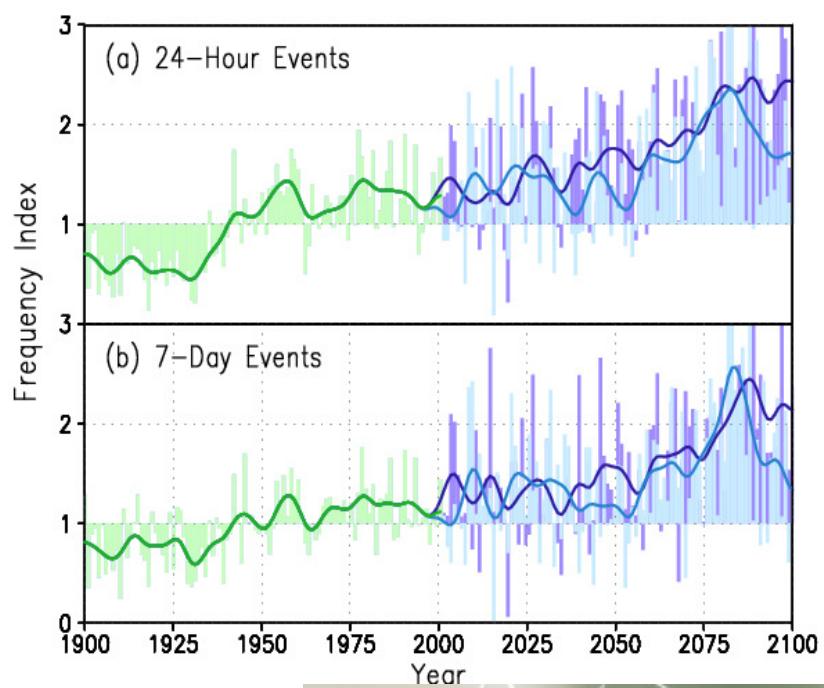
- Soil P build up through early 1990s
- no-Till or other practices making DRP loss more vulnerable after mid 1990s
- Exacerbated by recent extreme storm intensity

Still testing:

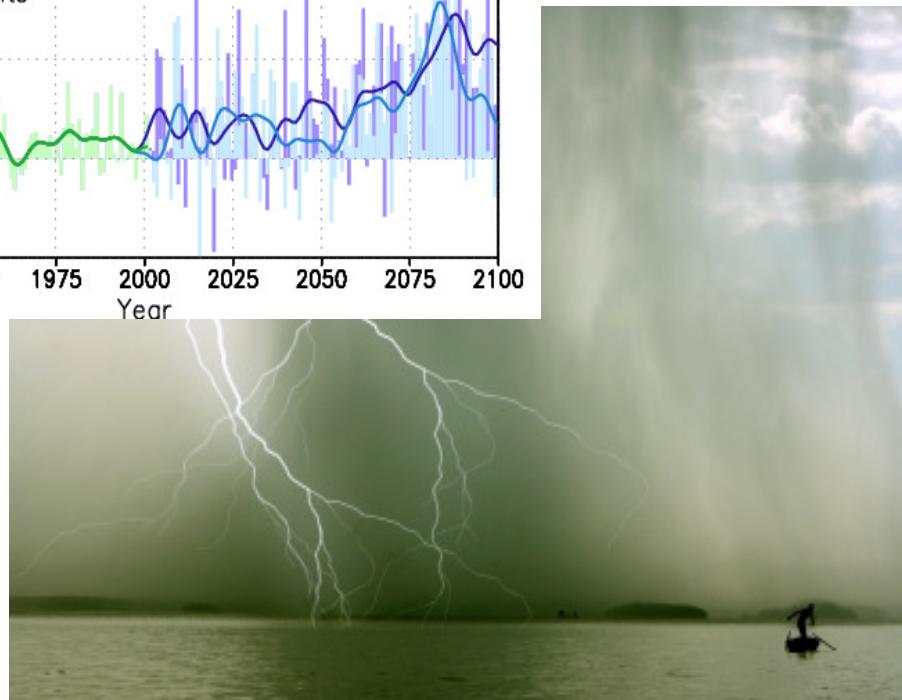
Spring vs. Fall Application



If weather patterns matter ...



... where are we heading?



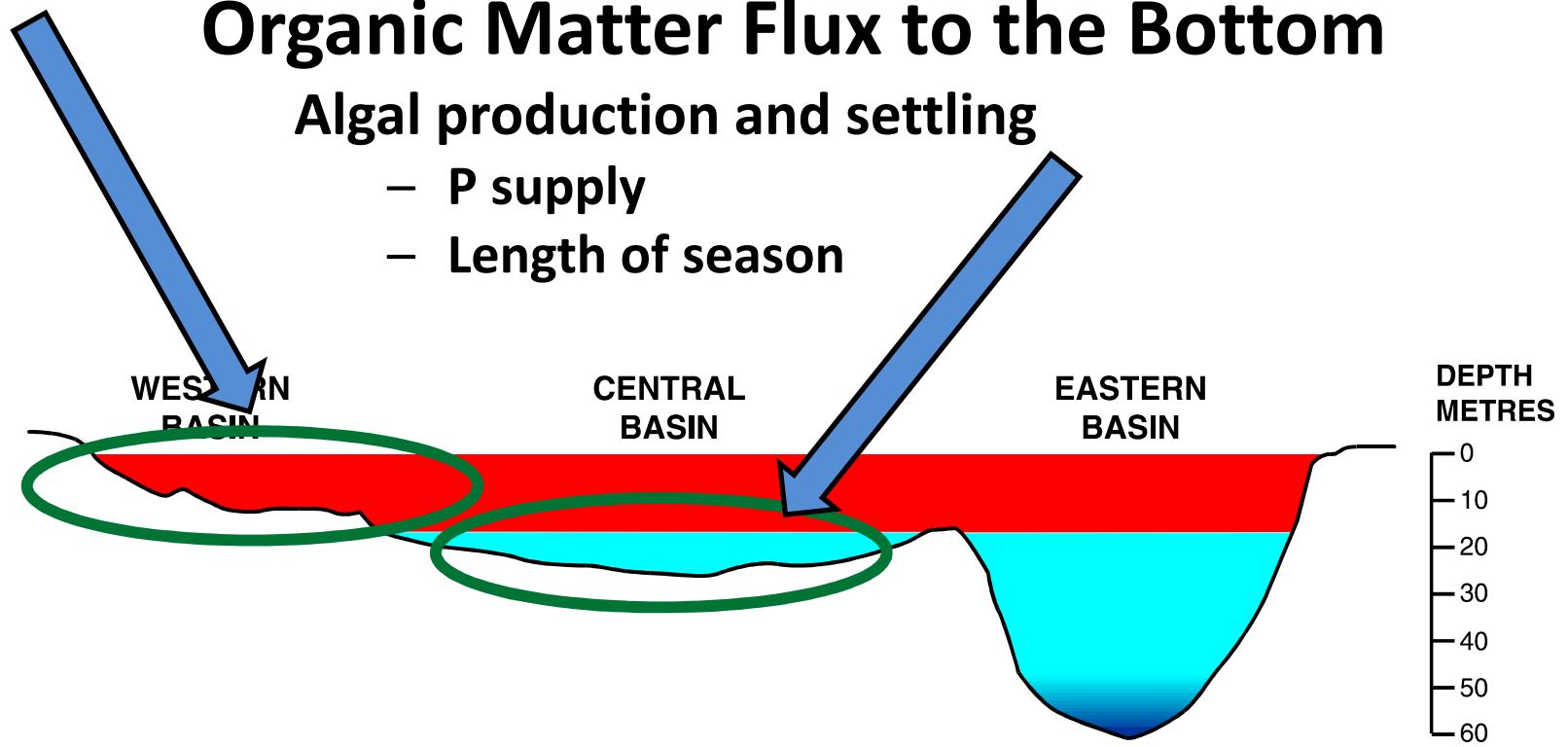
Why Climate Matters

Thickness of Central Basin Bottom Layer
Air temperature, winds, length of season

Organic Matter Flux to the Bottom

Algal production and settling

- P supply
- Length of season



Why Climate Matters

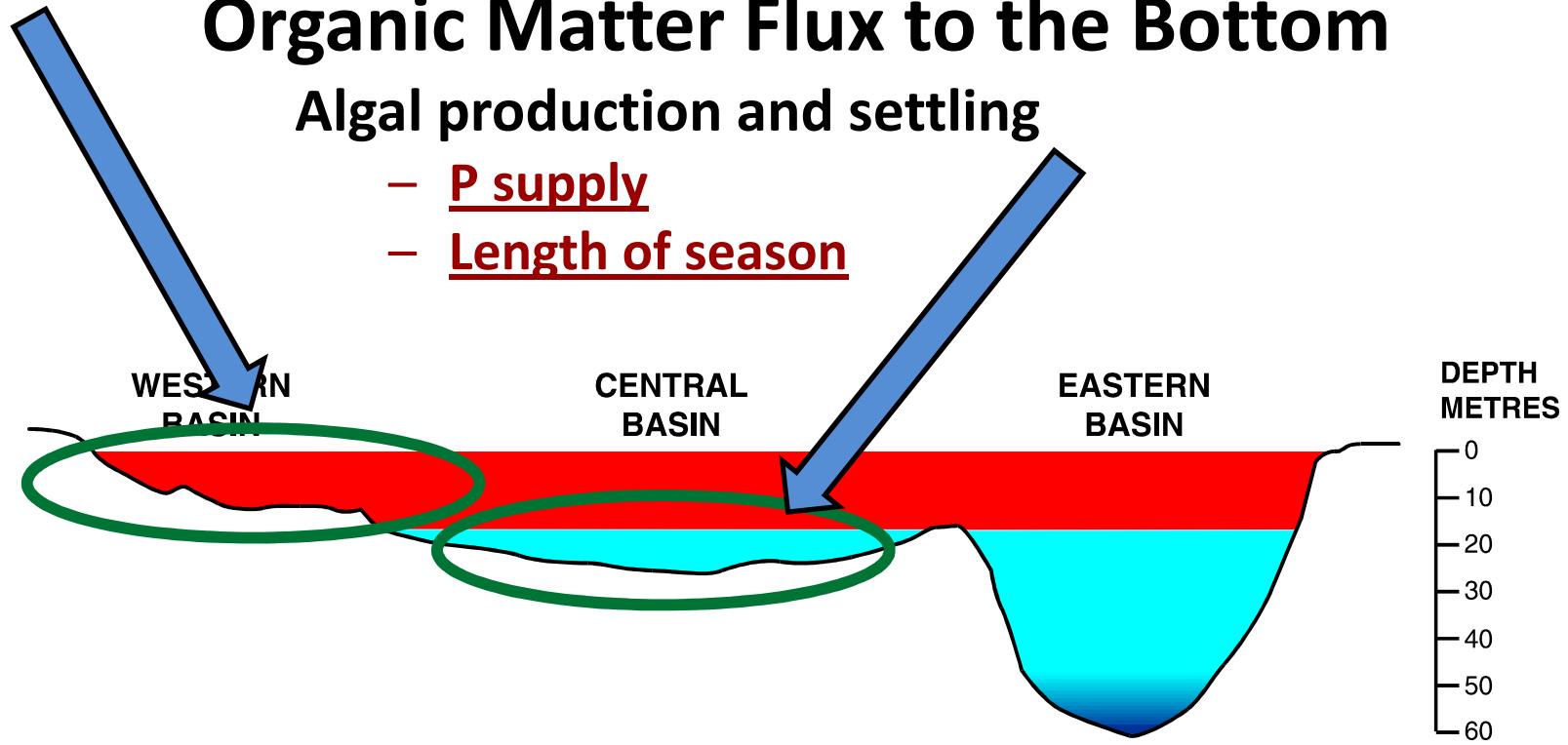
Processes exacerbated by future climate

Thickness of Central Basin Bottom Layer
Air temperature, winds, length of season

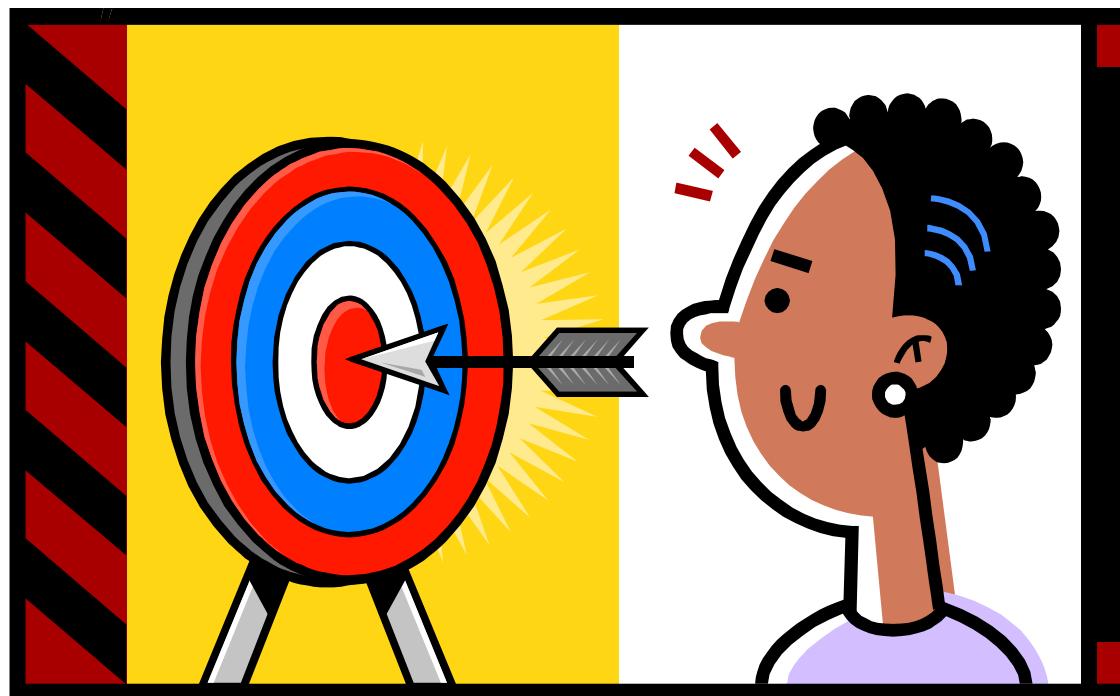
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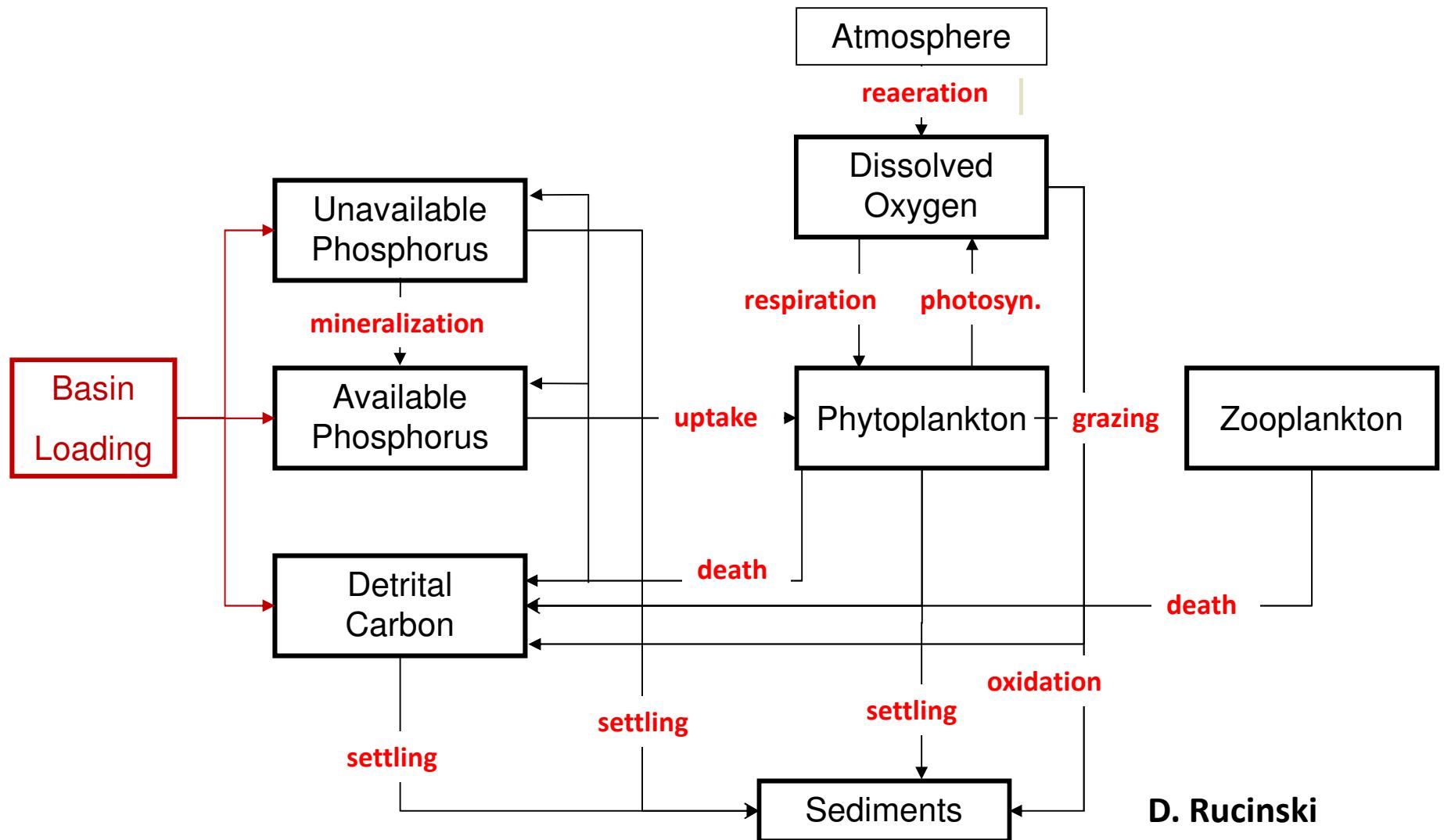
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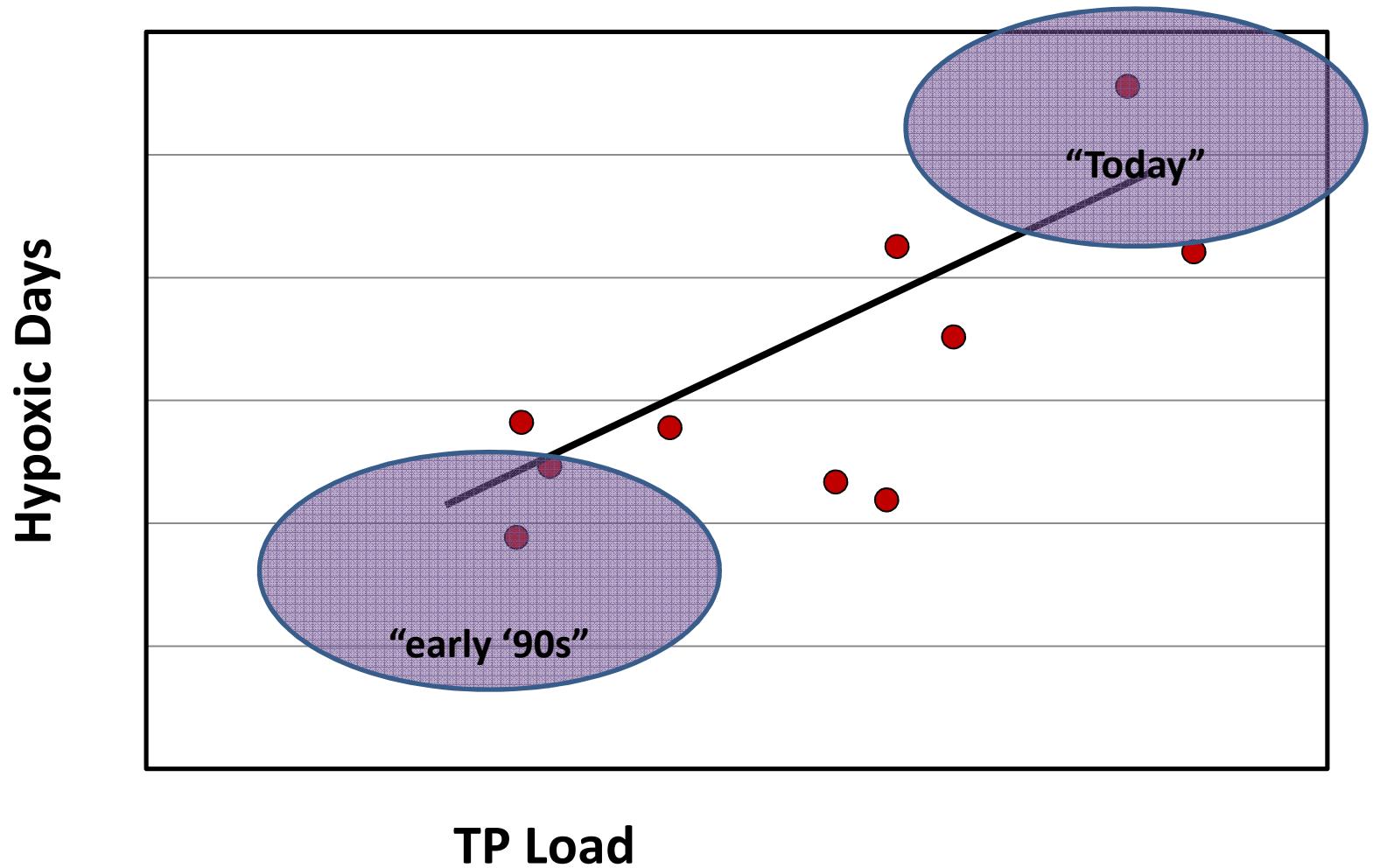
Can We Set New Load Targets?



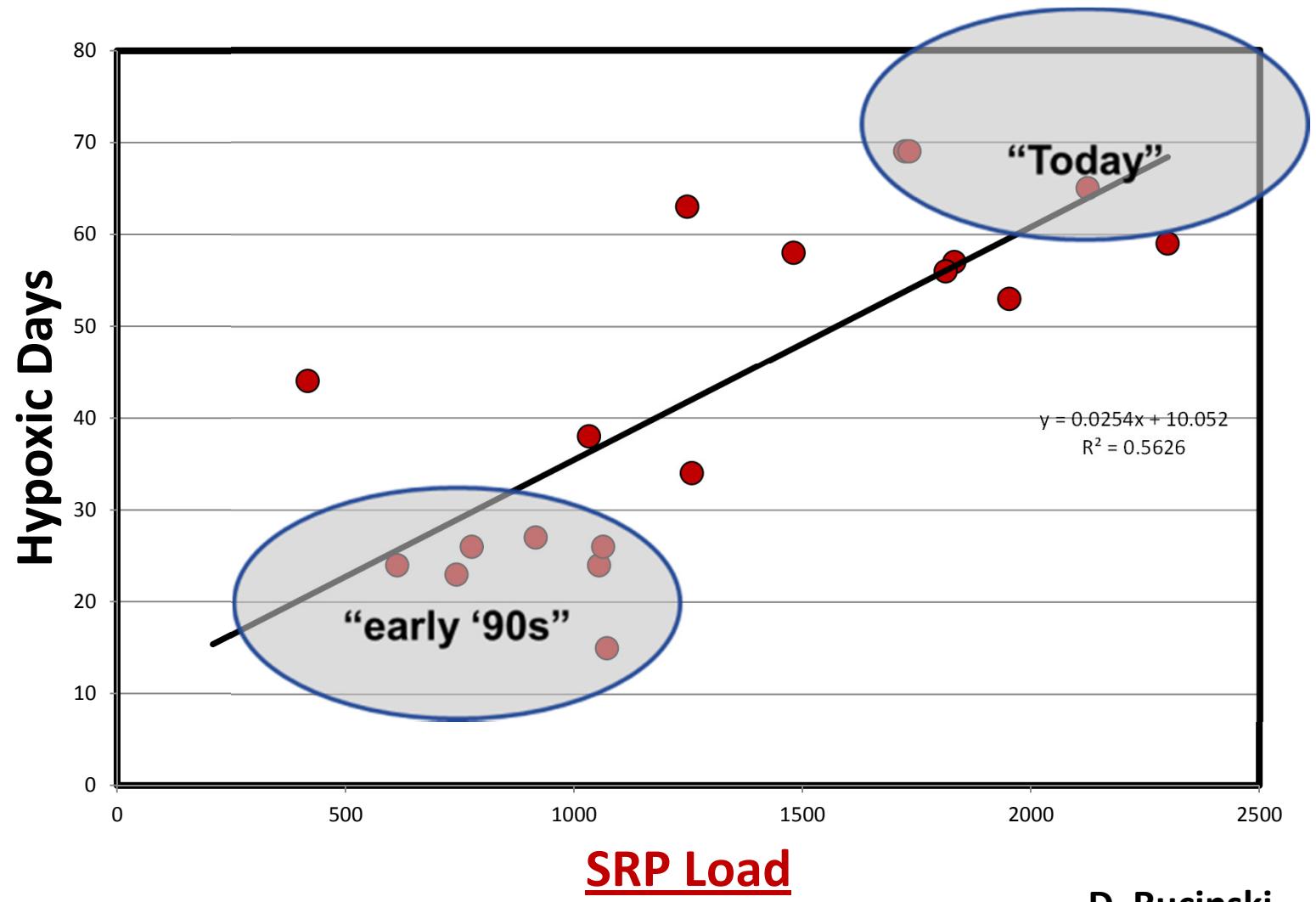
Lower Food Web Model



Getting Close!



Rucinski, et al.



D. Rucinski

Microcystis Response Curve

Workin' on it!

NSF Water Sustainability and Climate Project:
Assessing the effects of climate-change-induced extreme events on
water quality and ecology in the Great Lakes

<http://miseagrant.umich.edu/nsfclimate>



**With new targets,
where to do we focus?**

Potential Solutions to Agriculture Contribution:

Apply fertilizer in spring & incorporate

Don't apply before precipitation

Apply only to replace crop removal

Don't apply if soil P>2x agronomic need

Limit manure to P replacement amounts

Precision apply based on yield maps

Develop BMPs specifically for DRP

Closing Arguments:

- Hypoxia/HABs increased since the 1990s
- It matters to fish
- Increased hypoxia likely reflects increased SRP load
- Increased SRP load appears driven by increased storm intensity and agricultural practices (no-till?)
- Current suite and use of BMPs may not be sufficient
- Climate change will make reductions more difficult

We may need a whole new set of BMPs to control dissolved phosphorus runoff under this new climate regime!

Are we preparing?

