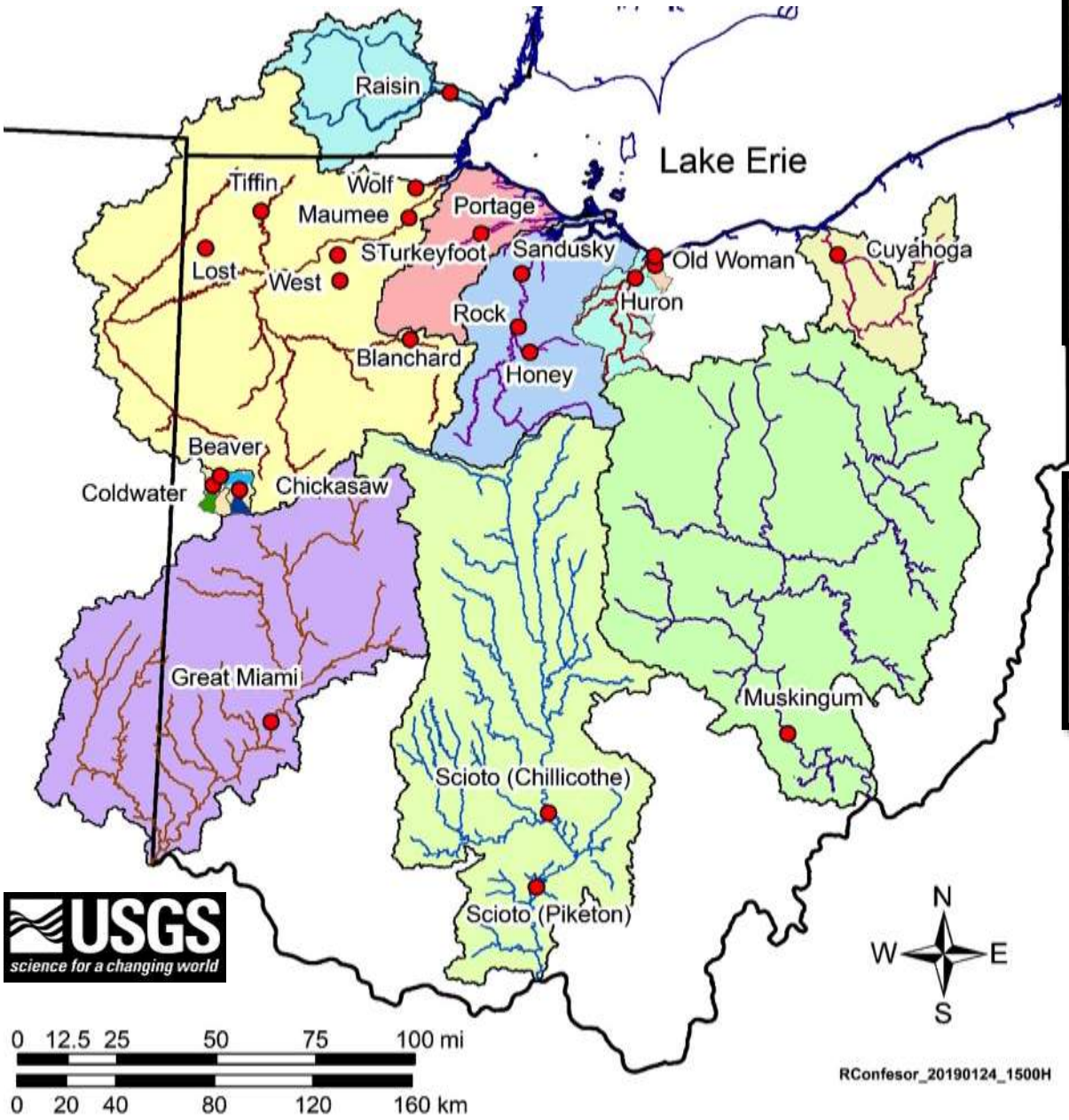
Trends in phosphorus loads from agricultural watersheds in Lake Erie and the prevalence of soil P stratification

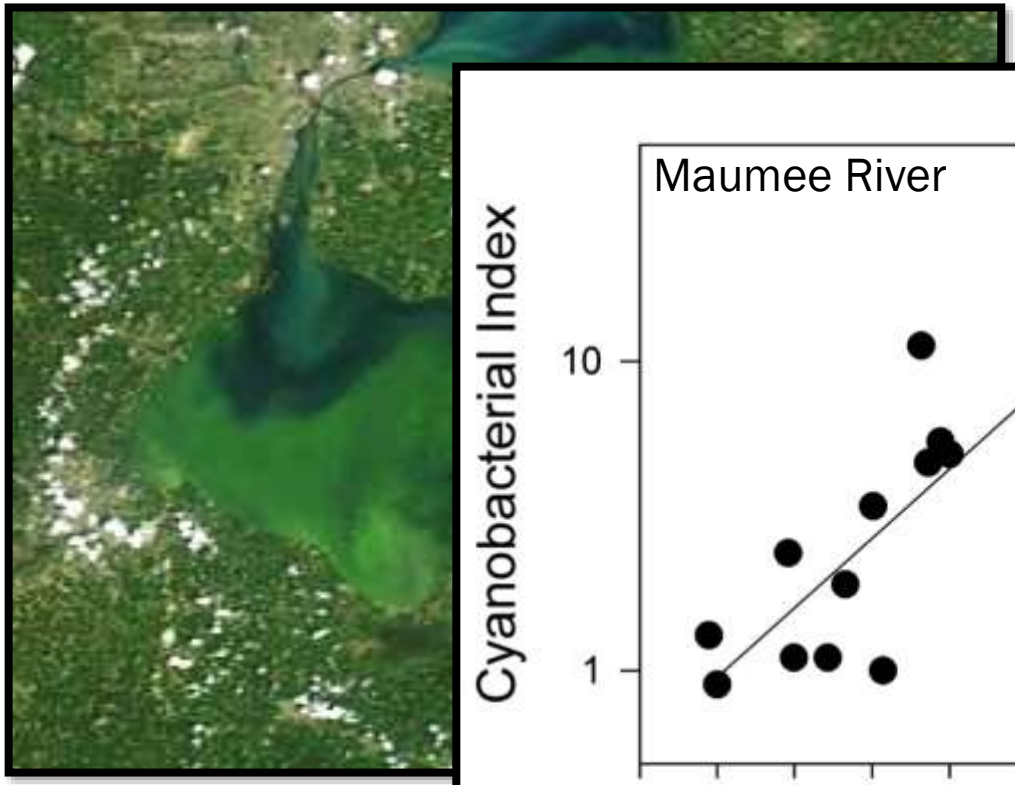
Laura Johnson

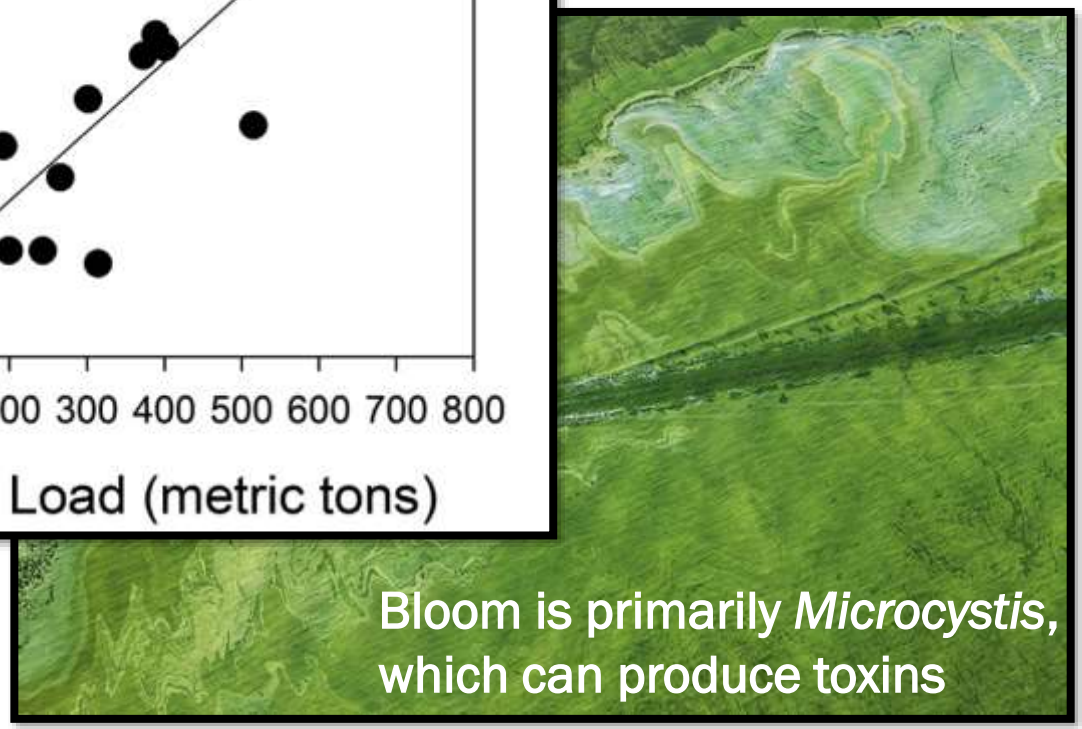
National Center for Water Quality Research
HEIDELBERG UNIVERSITY

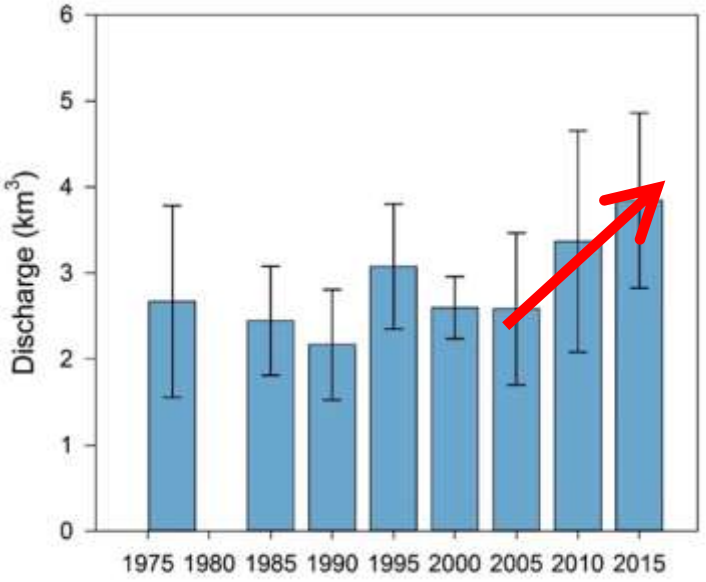
Heidelberg Tributary Loading Program



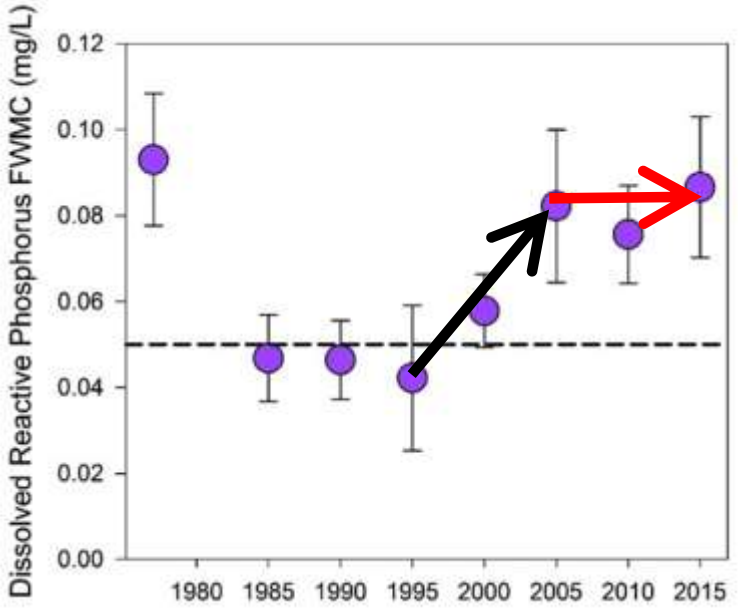
Algal blooms returned to Lake Erie in the early 2000s and their size is correlated to phosphorus loads from the Maumee River from March – July





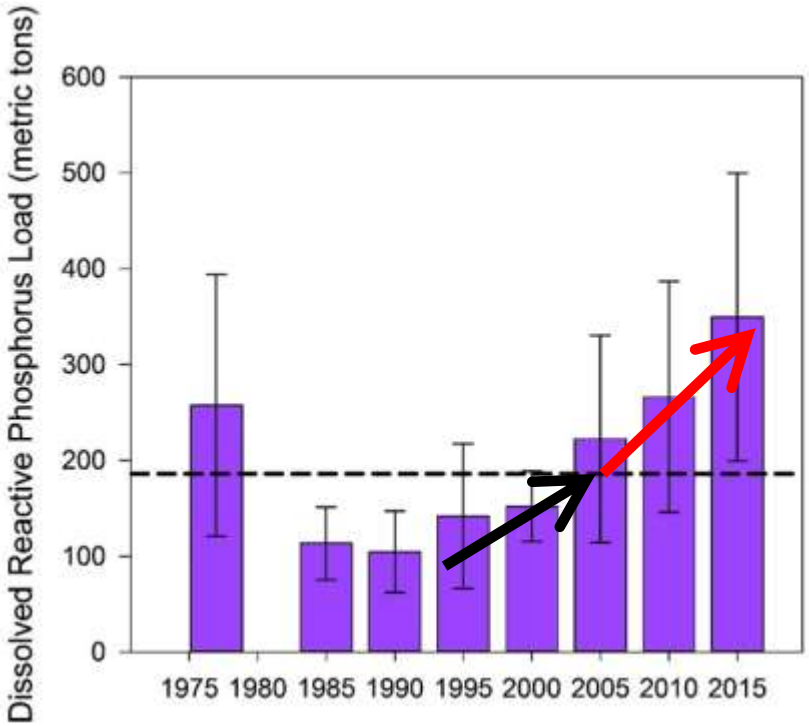


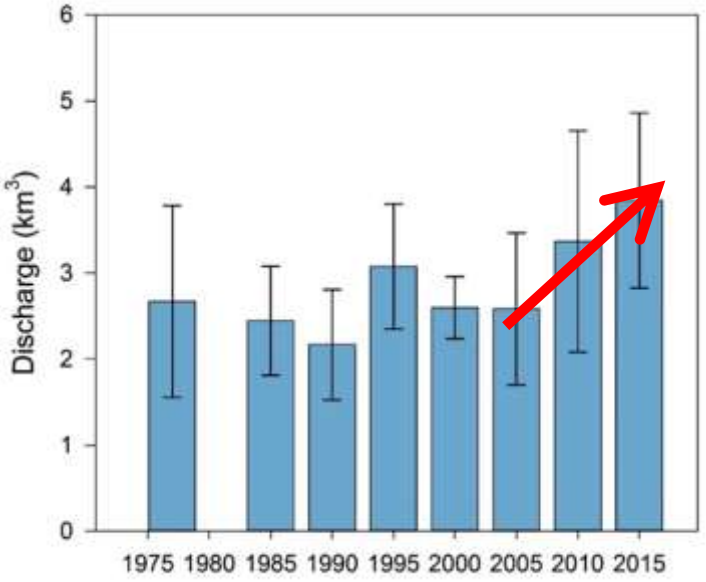
X



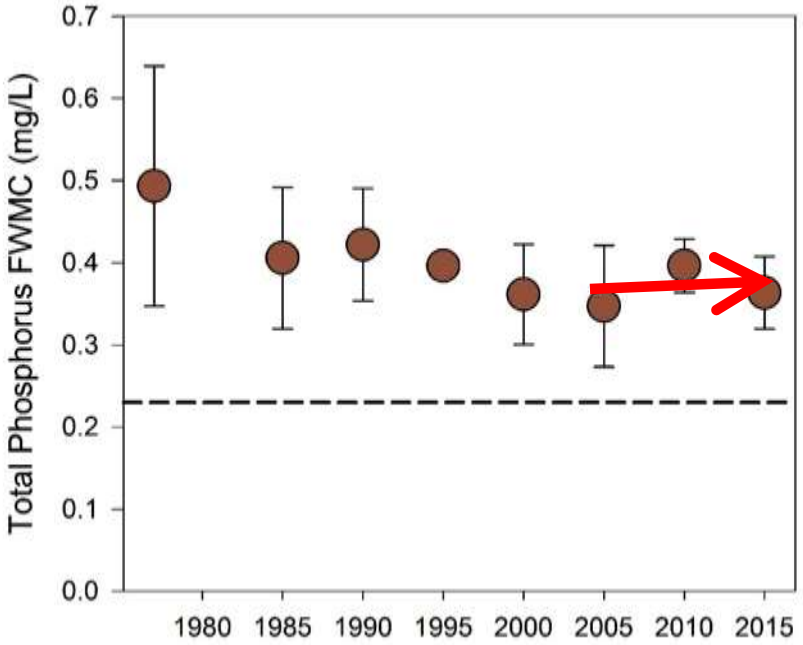
Higher runoff volume accounts for ~35% of the increased load

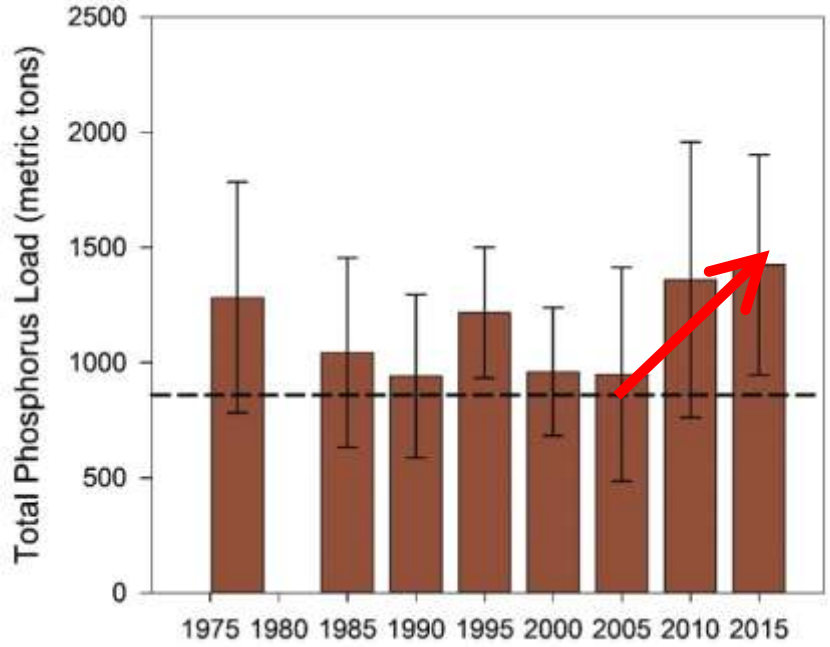
Jarvie et al. 2017, JEQ



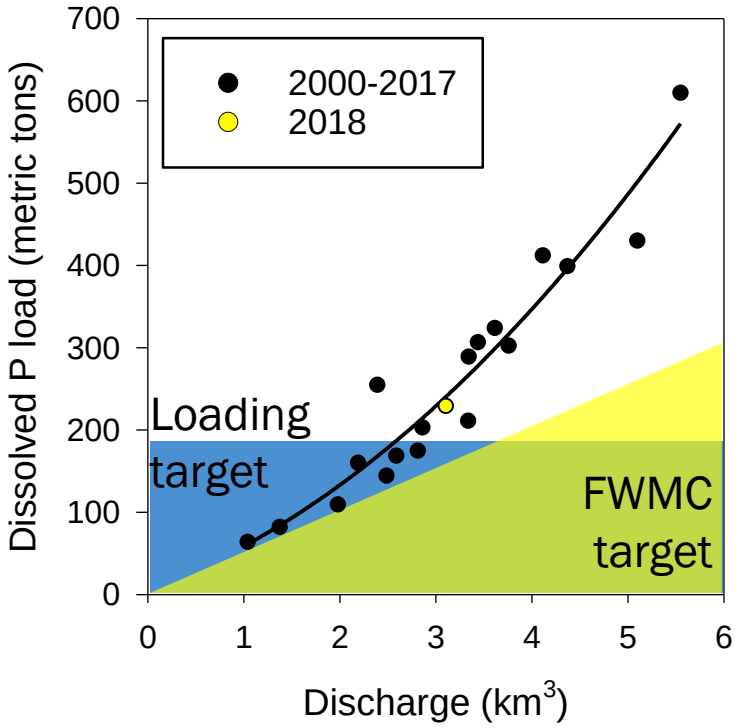

Discharge (km3)
0
1
2
3
4
5
6
1975 1980 1985 1990 1995 2000 2005 2010 2015

X


Total Phosphorus FWMC (mg/L)
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1980 1985 1990 1995 2000 2005 2010 2015


Total Phosphorus Load (metric tons)
0
500
1000
1500
2000
2500
1975 1980 1985 1990 1995 2000 2005 2010 2015

Tracking change in loads and flow-weighted mean concentrations



The 2018 load is where we would expect based on discharge

Load = Discharge x FWMC

FWMC = Load / Discharge

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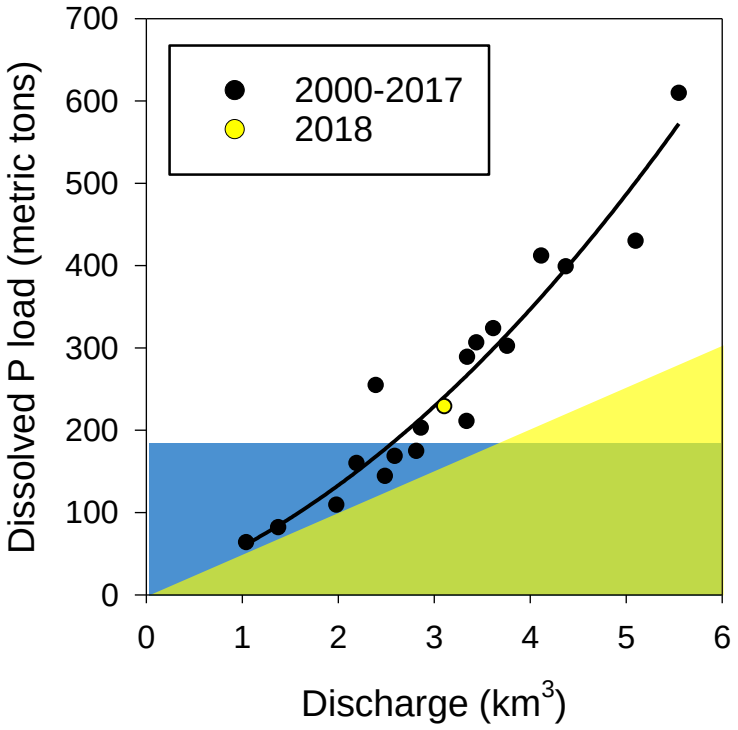
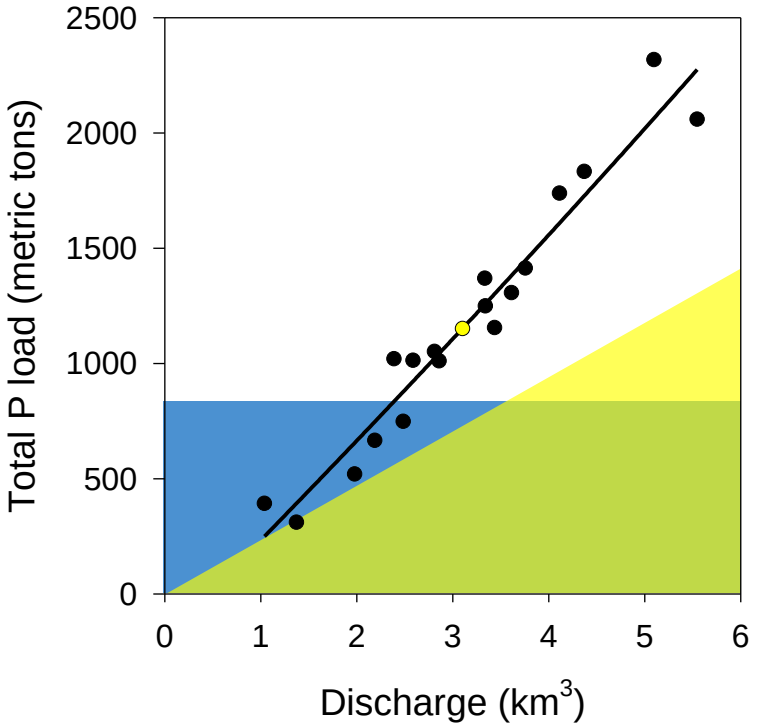
Tracking change in loads and flow-weighted mean concentrations





The 2018 load is where we would expect based on discharge

Load = Discharge x FWMC

FWMC = Load / Discharge

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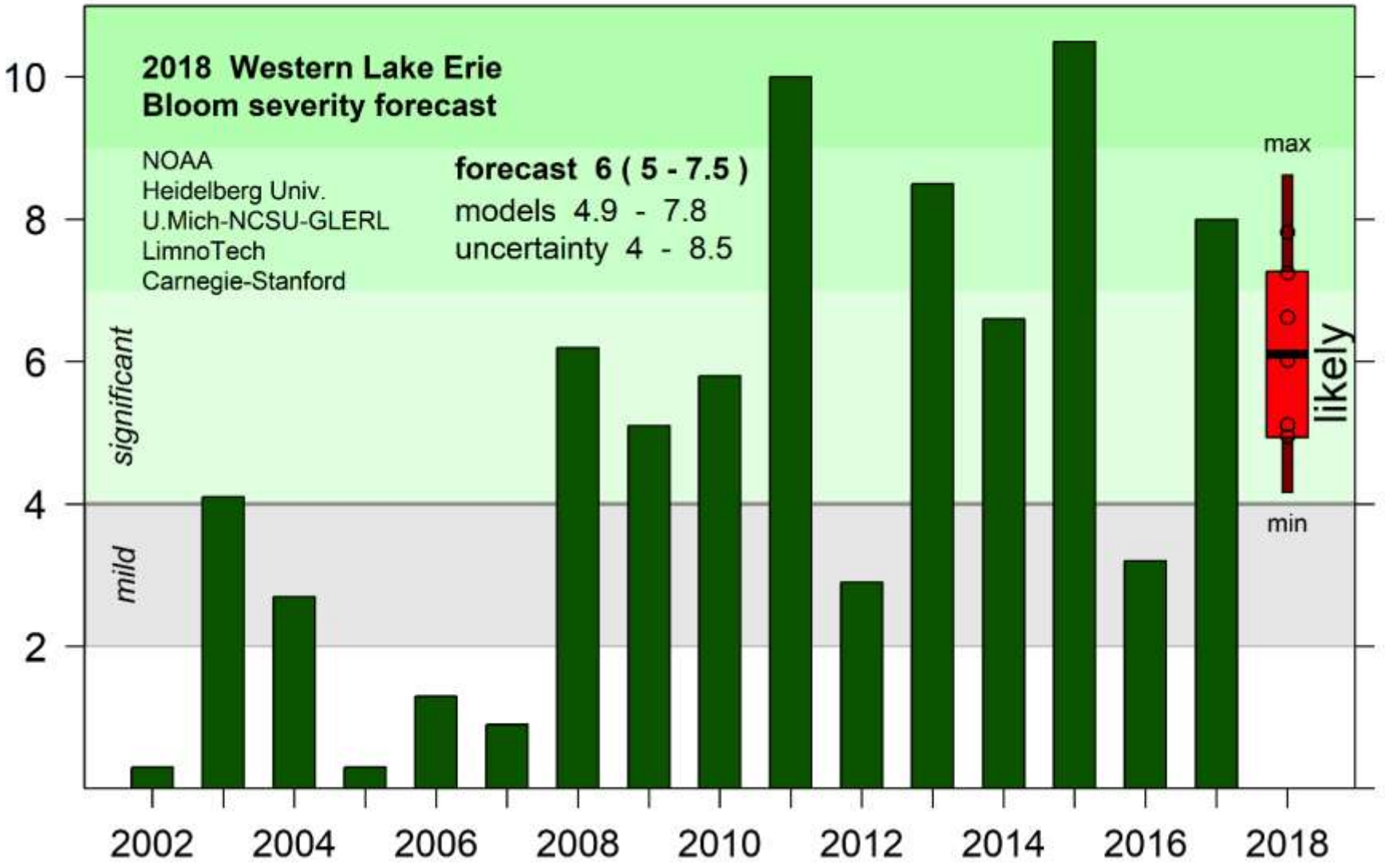
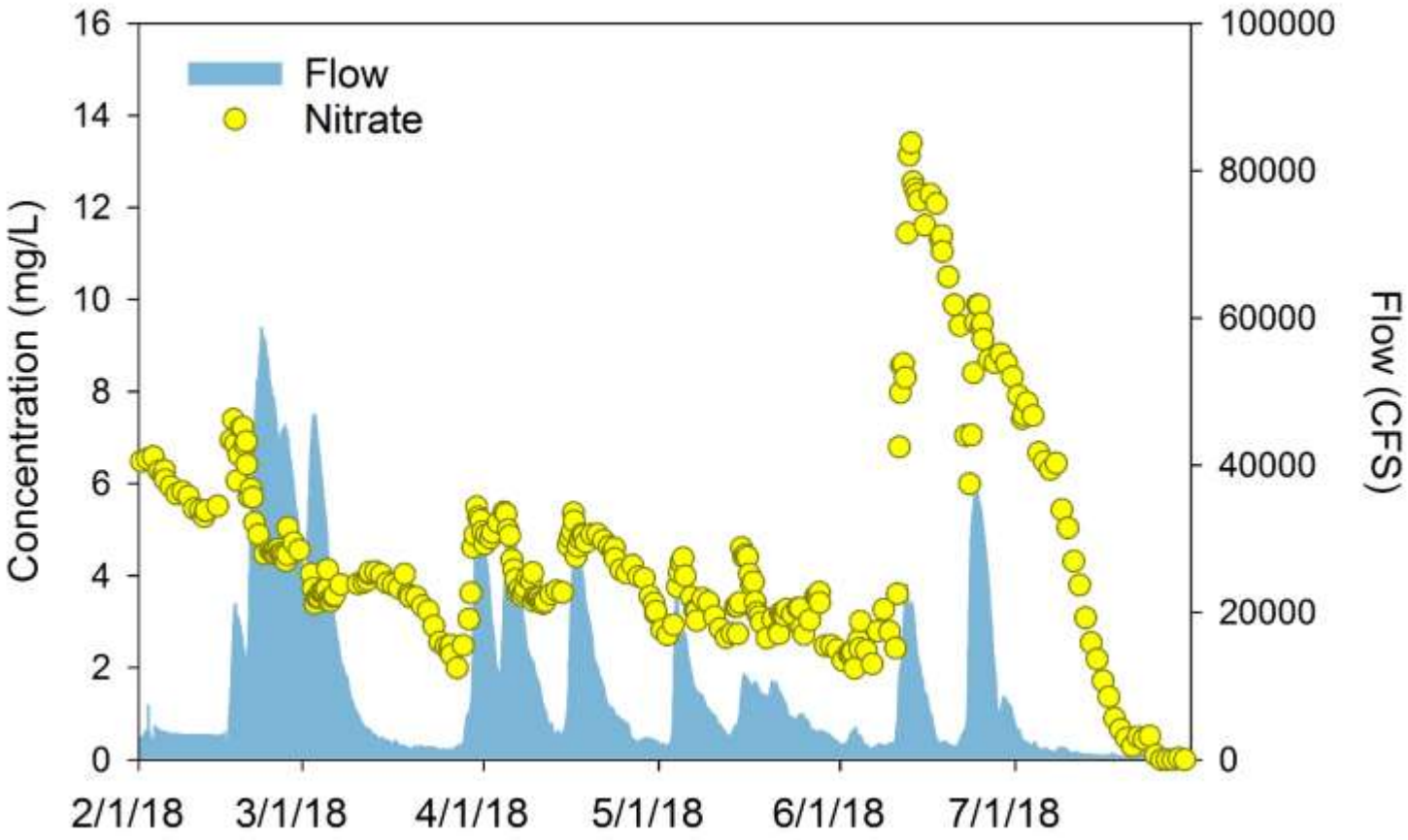
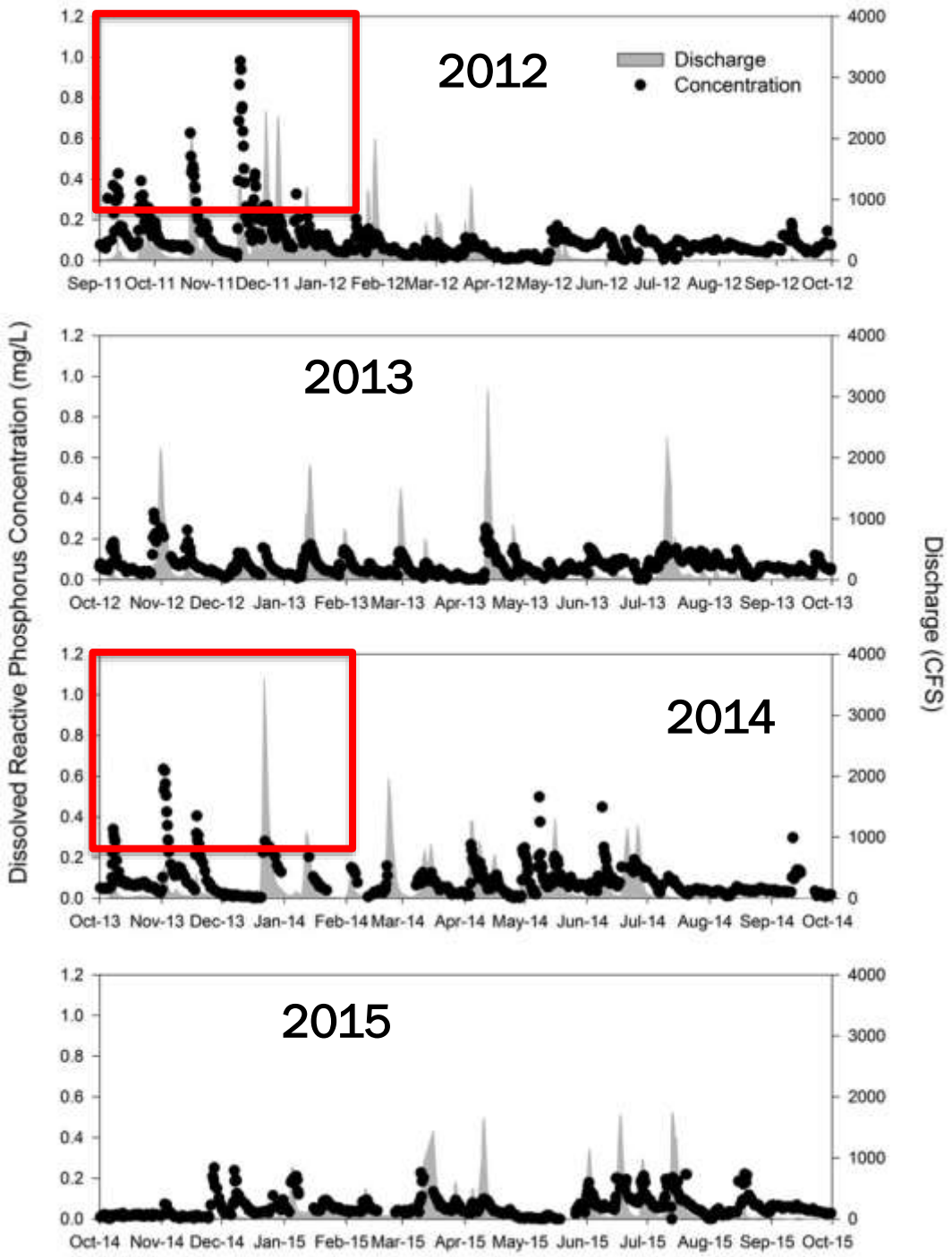
2018 Western Lake Erie Bloom Severity Forecast



Maumee Spring hydrograph and nutrient concentrations





Hydrology
(Water movement)
drives P losses

Honey Creek
2012-2015

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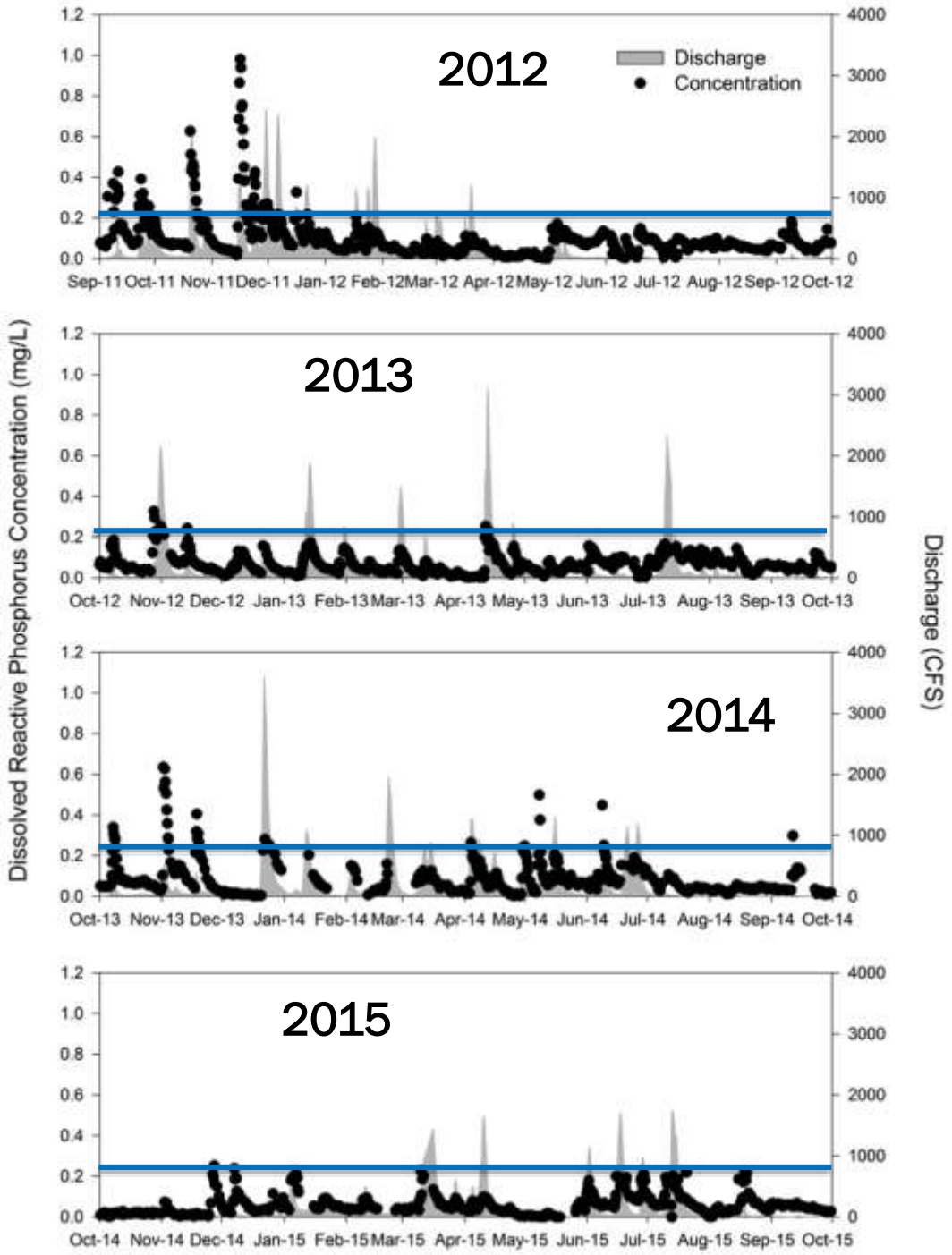

Hydrology
(Water movement)
drives P losses

Honey Creek
2012-2015

Large source of P in soils

Why?

~~High soil test P?~~

Soil P stratification?

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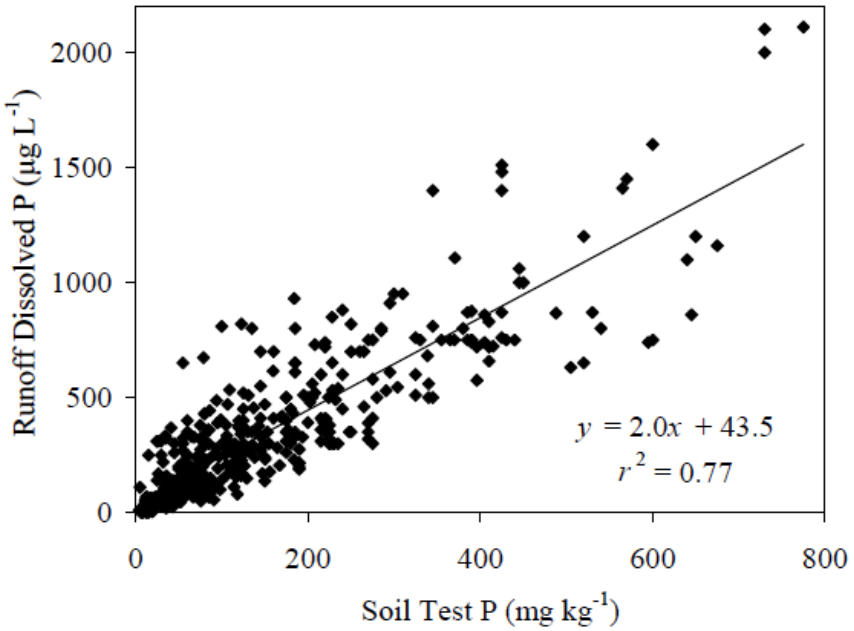
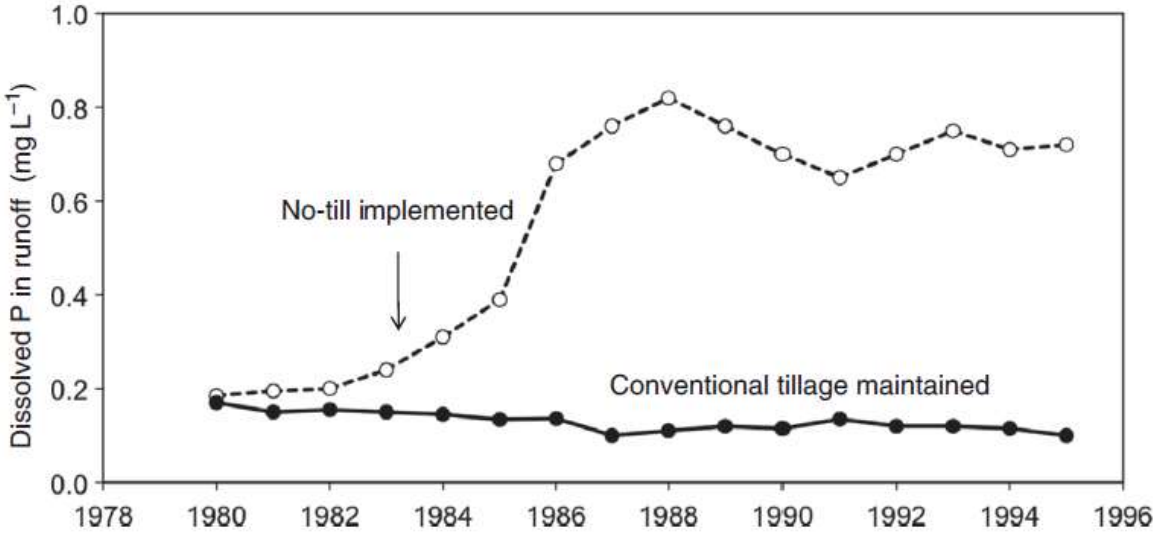
From Vadas et al. 2005



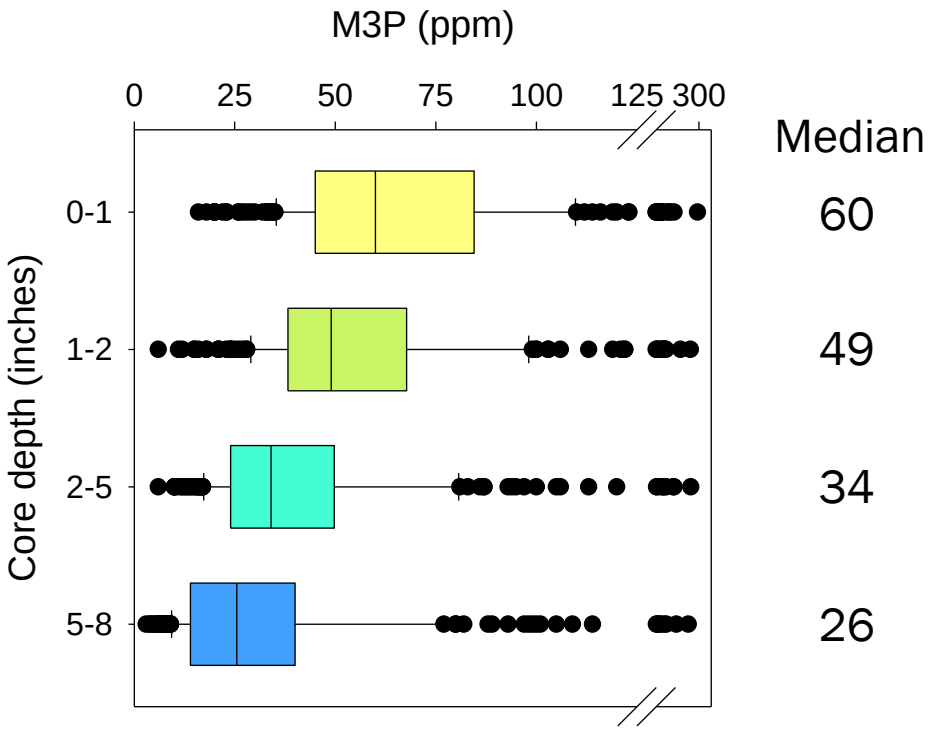
Potential for soil P stratification

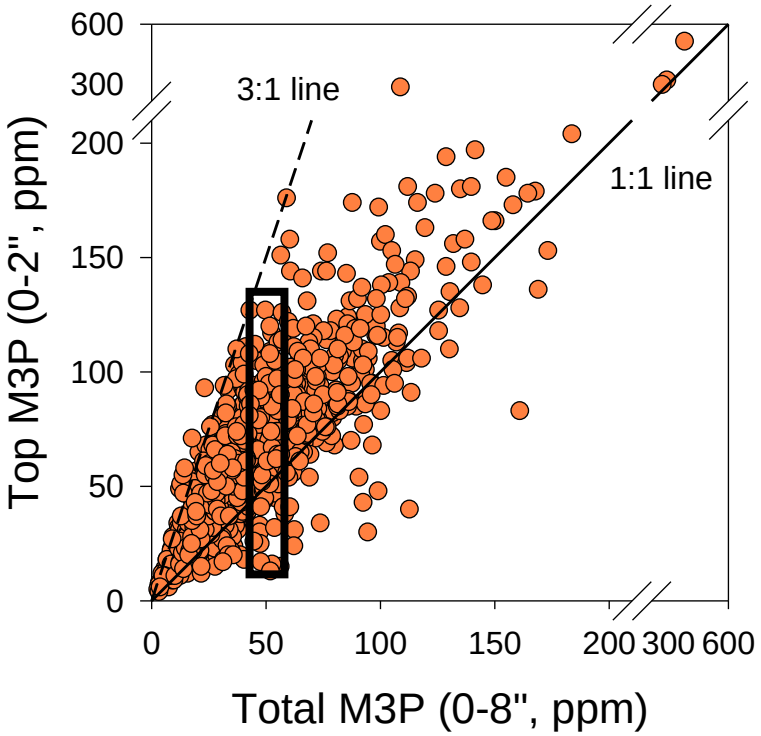
- Will stratification develop under rotational no-till with commercial fertilizer use?
- Sampled 1500+ farms in Sandusky River Watershed



From Kleinman et al. 2011

The extent of P stratification





- Most soils within agronomic recommendations (median=35ppm M3P)
- Stratification evident even in the top 1” of soil (ANOVA, P<0.001, n=232)

- High variation in 0-2” at any given 0-8” STP level
- Can’t predict stratification

Baker et al. 2017, JEQ

Does P stratification matter??

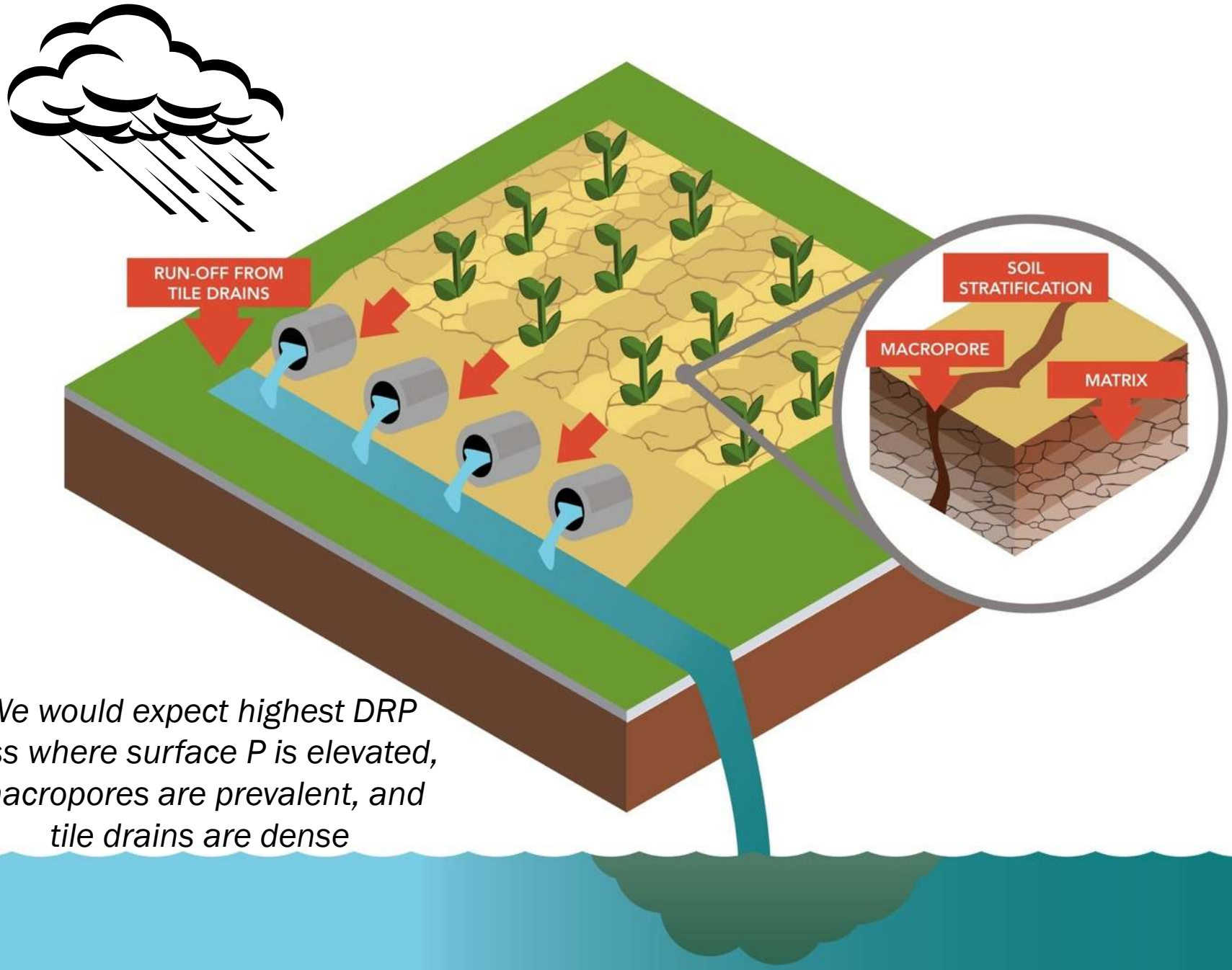
- Compared the cumulative distributions of the 0-2” STP (E-STP) and the 0-8” STP (A-STP) relative to the 0-8” STP as a way to compare BMP targeting and the risk for DRP runoff
- Assumes linear relationship between STP and DRP runoff, each unit of STP is a unit of DRP runoff risk

- The risk of DRP runoff is 55% higher estimated from E-STP compared to A-STP

- What if we reduced all fields over 40ppm down to 40ppm?
  - 15.3% reduction in risk of DRP runoff and targets 40% of fields
- What if we reduced all fields where the top 2” (E-STP) is at least 20 ppm higher than the 0-8” STP (A-STP) to be equal to that 0-8” STP?
  - 28.5% reduction in risk of DRP runoff and targets 51.3% of fields

Ignores preferential flow and incidental losses

Baker et al. 2017, JEQ



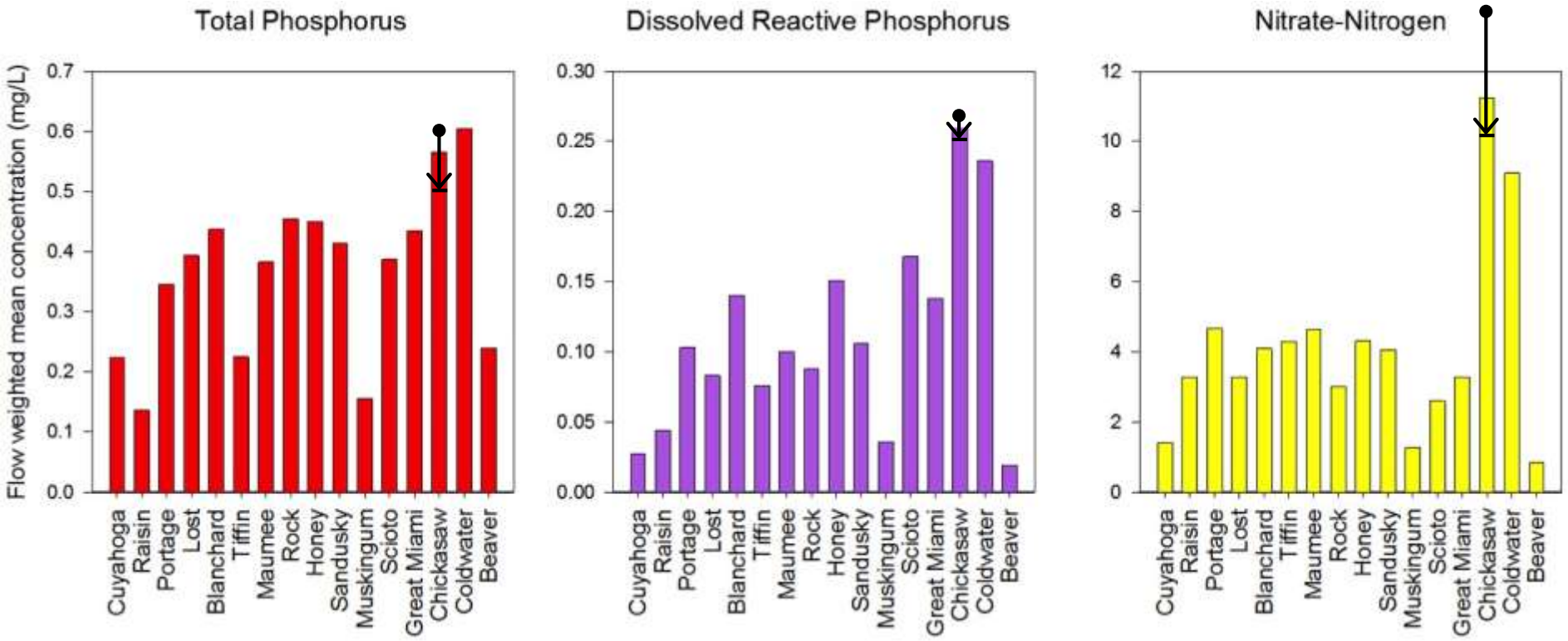
We would expect highest DRP loss where surface P is elevated, macropores are prevalent, and tile drains are dense

Thanks!

Laura T. Johnson
Director
National Center for Water Quality Research
Heidelberg University
310 E. Market Street
Tiffin, OH 44883
ljohnson@heidelberg.edu
419.448.2056
http://www.ncwqr.org

https://www.facebook.com/ncwqr
http://www.LakeErieAlgae.com
http://data.glos.us/maumee/

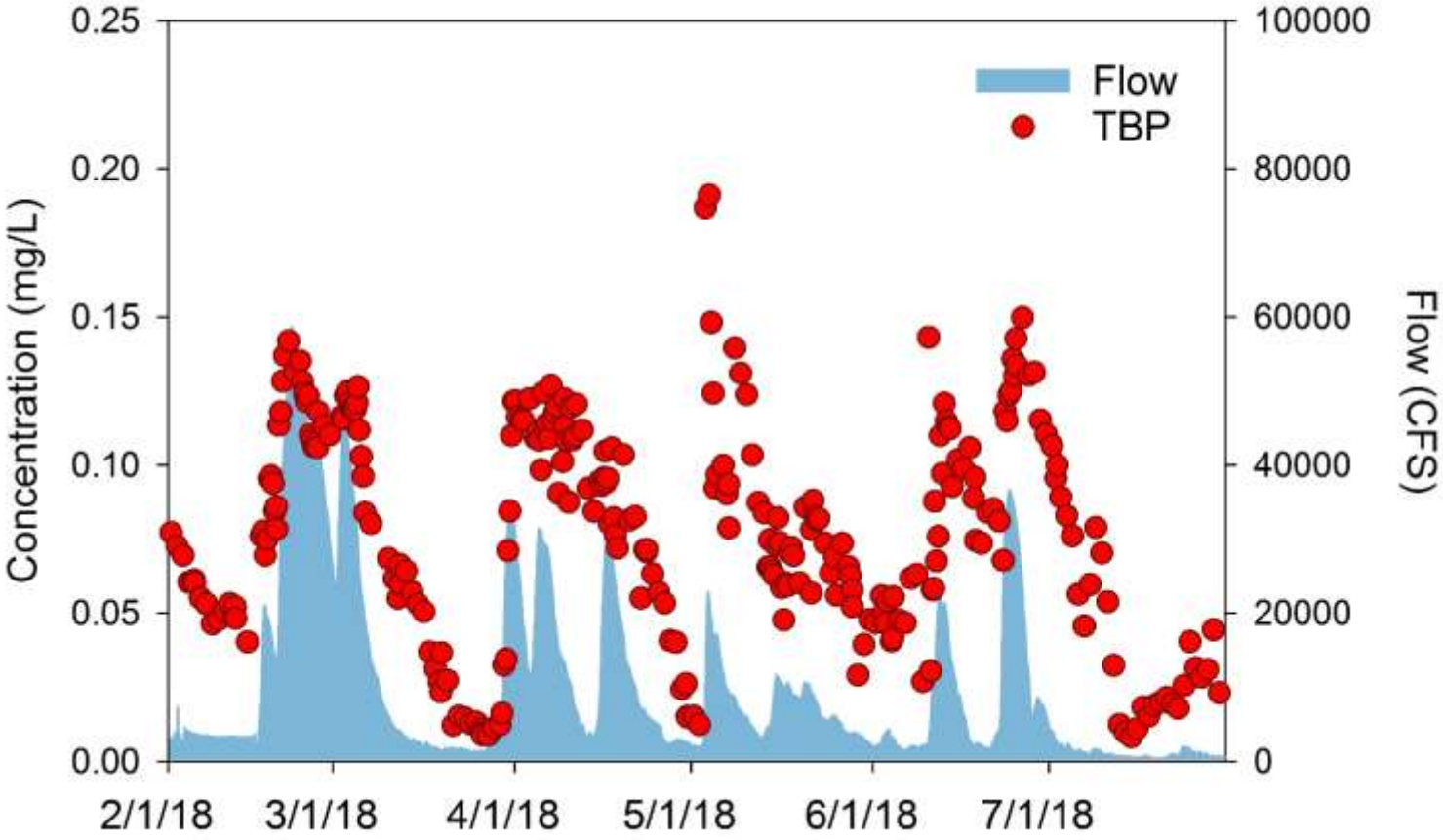
Five year average annual FWMC and unit area loads



- Grand Lake St Marys tributaries have decreased, but are still quite high

Total bioavailable phosphorus at the Maumee River in Waterville

March 1 – July 31, 2018



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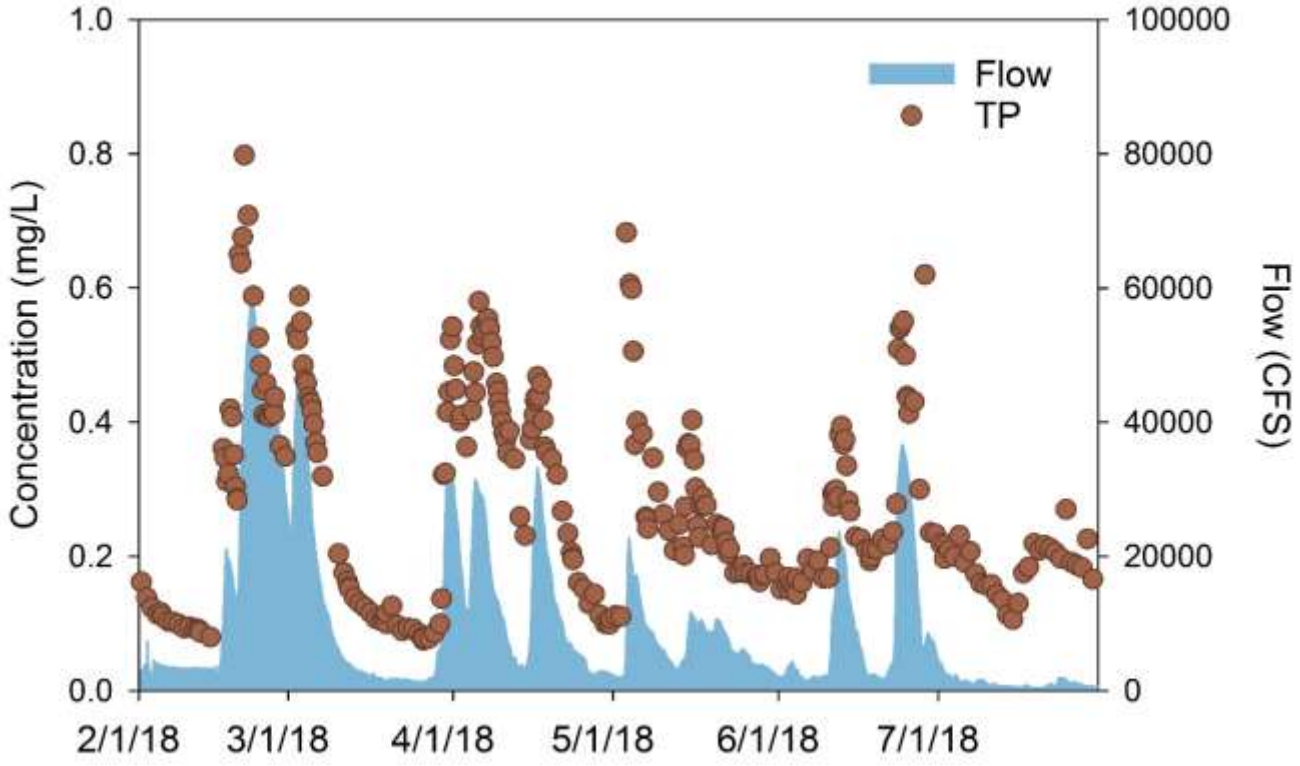
Total Phosphorus
Maumee River in Waterville
March 1 – July 31, 2018



Most P and N comes from nonpoint sources

Maumee River

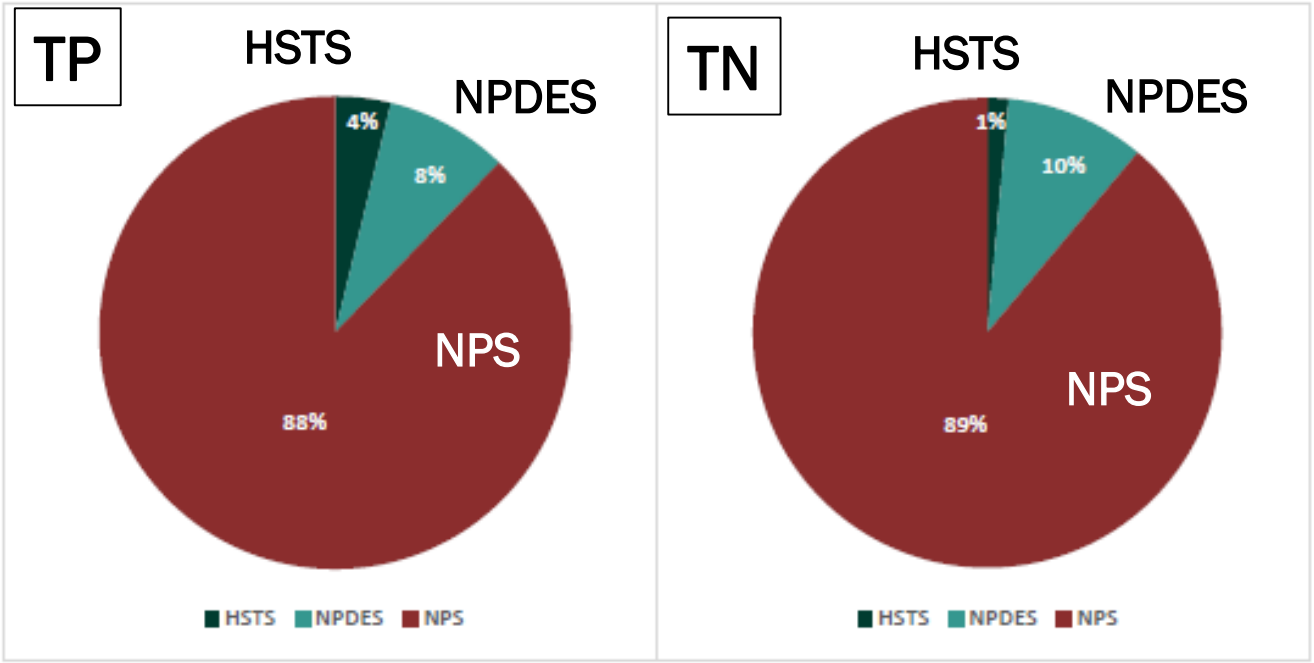
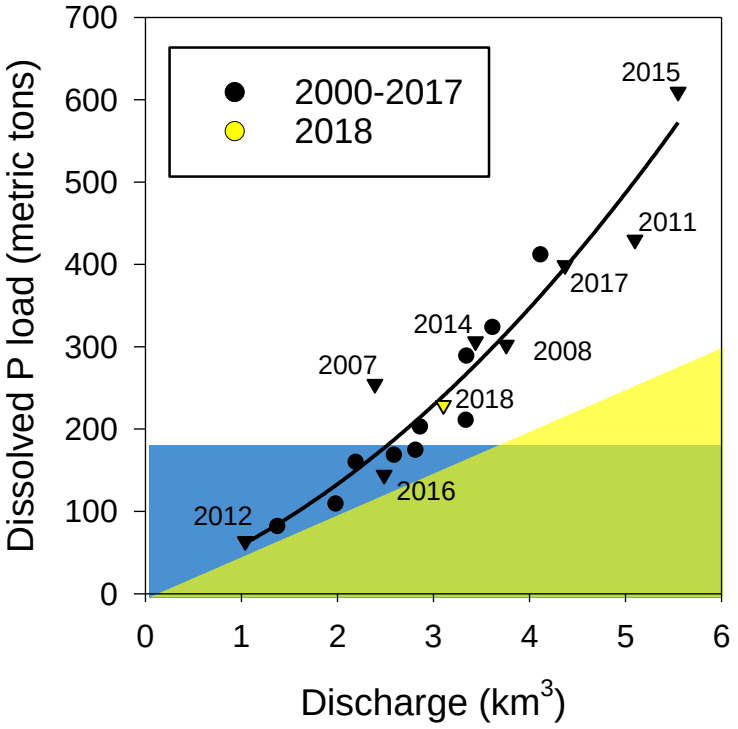
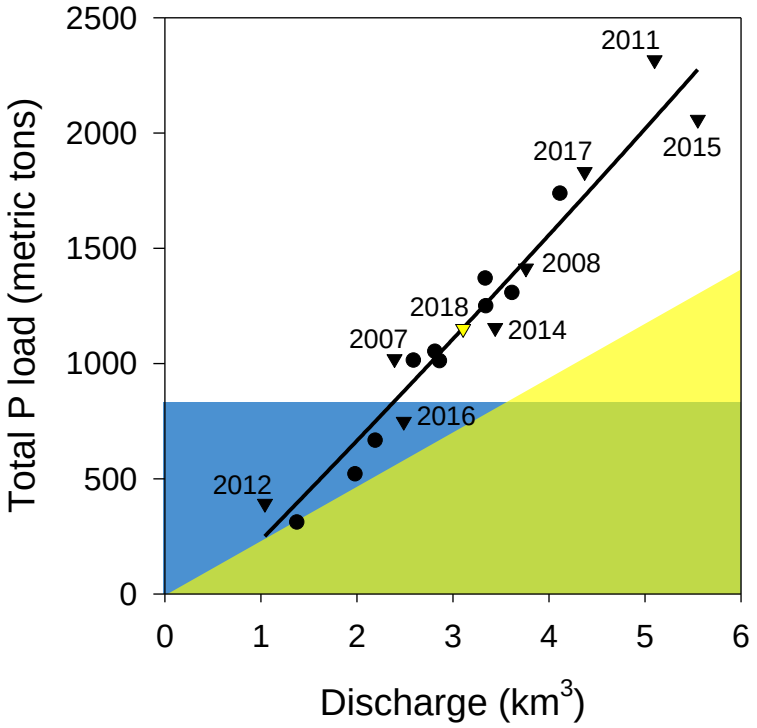


Figure 10 — Proportion of total phosphorus and nitrogen load from different sources for the Maumee watershed, average of 5-years (wy13-wy17).

OEPA report 2018

Tracking change in loads and flow-weighted mean concentrations





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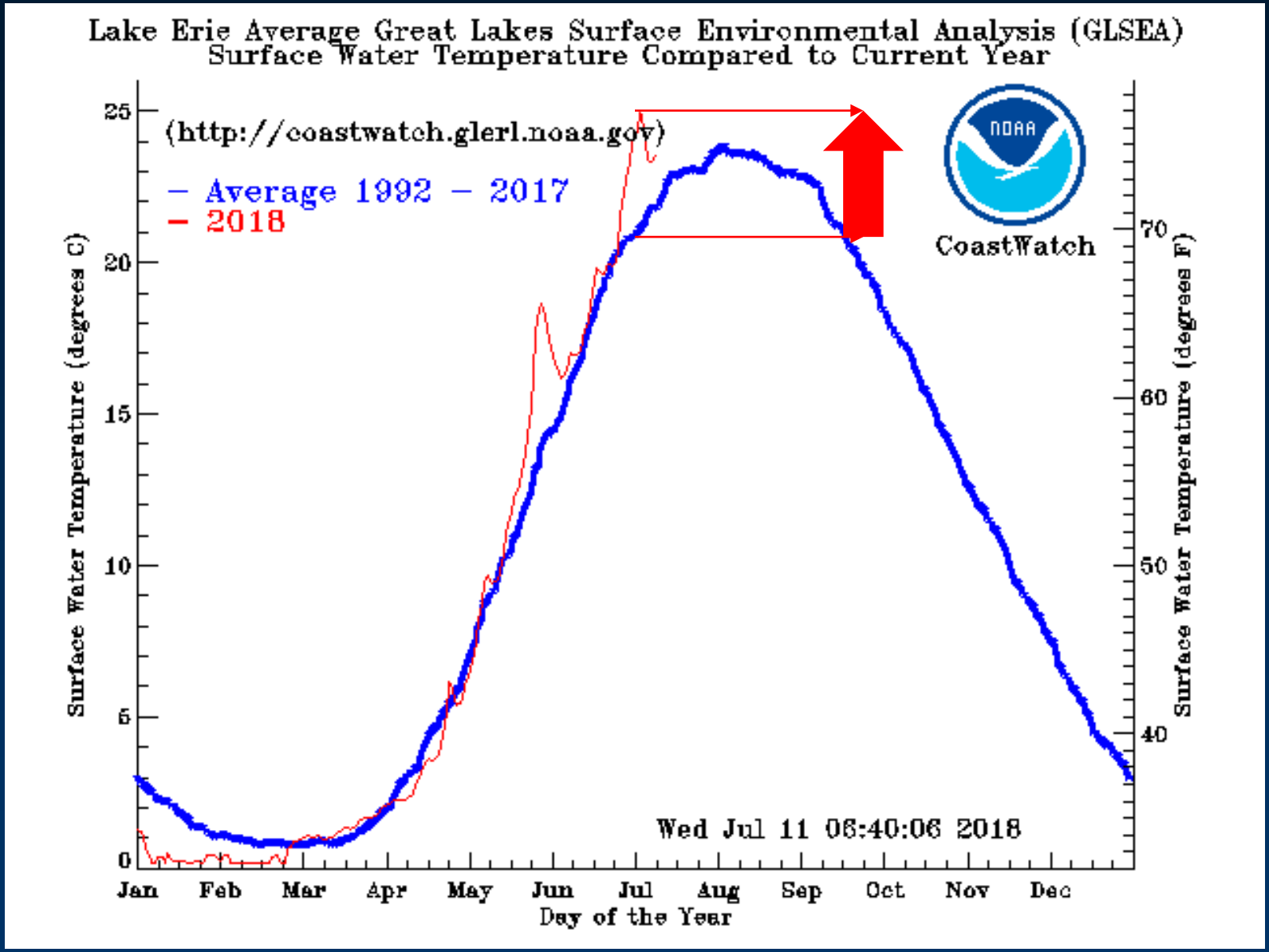
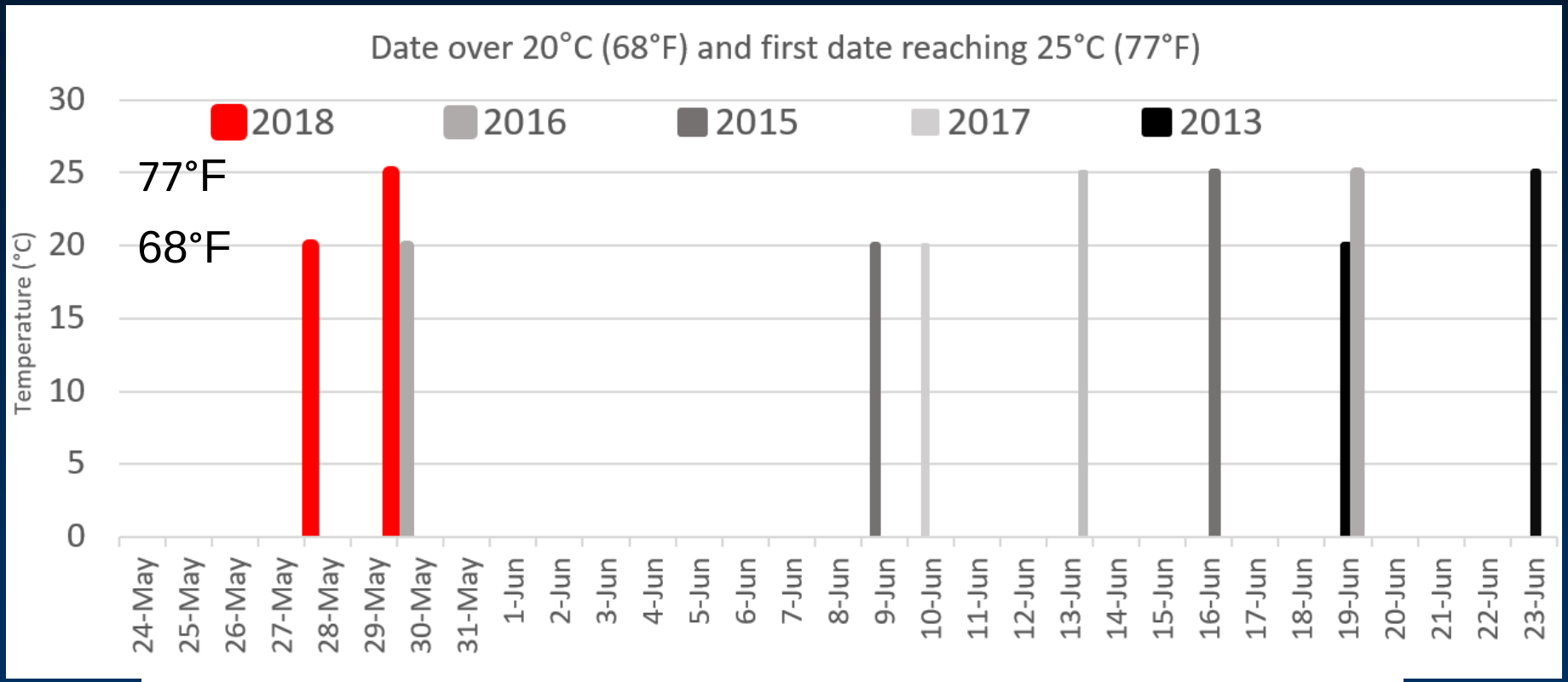
Lake Erie is warmer this year



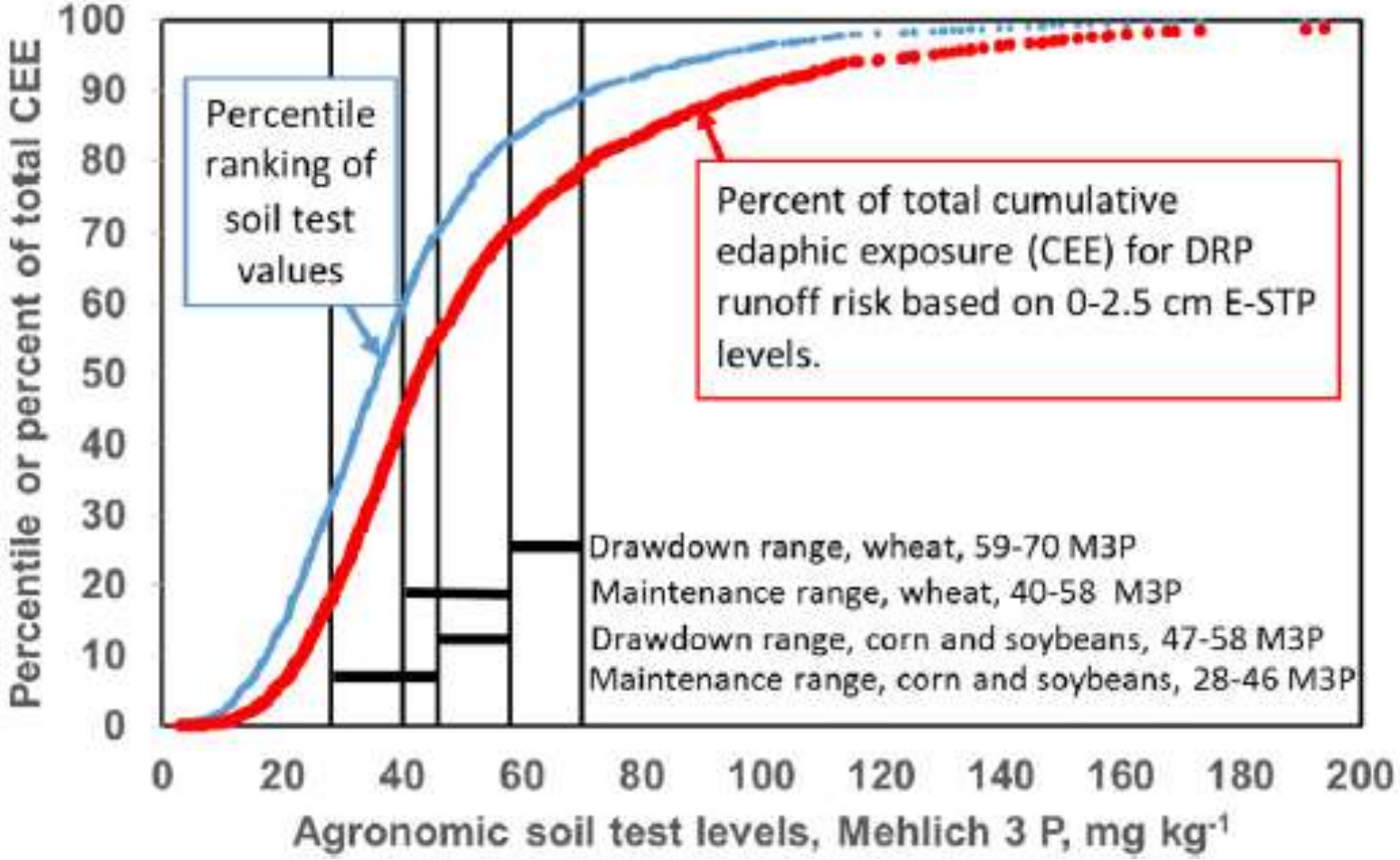
Early warming, may start bloom early but does not mean a worse bloom

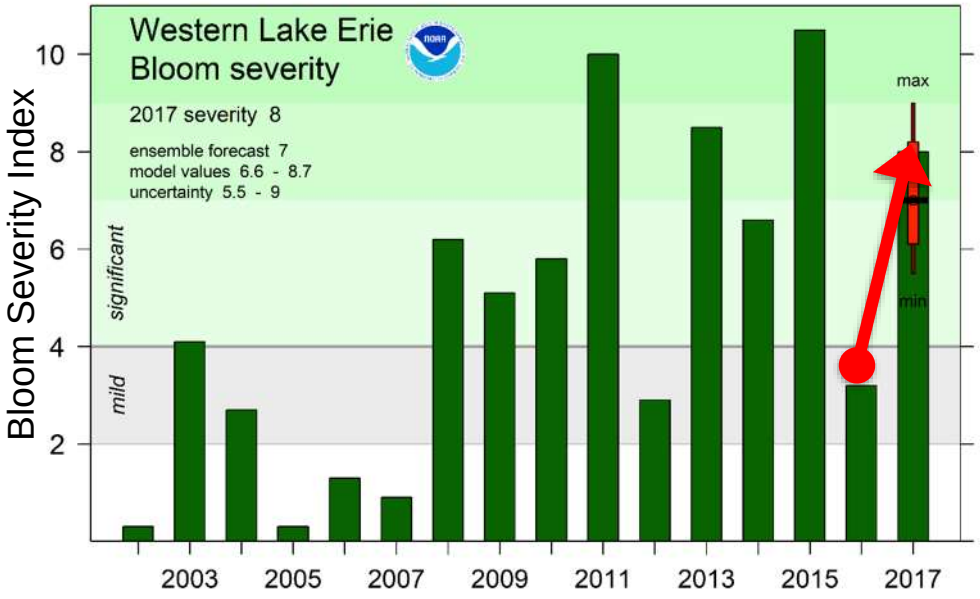


LimnoTech buoy, data from NOAA NDBC and GLOS

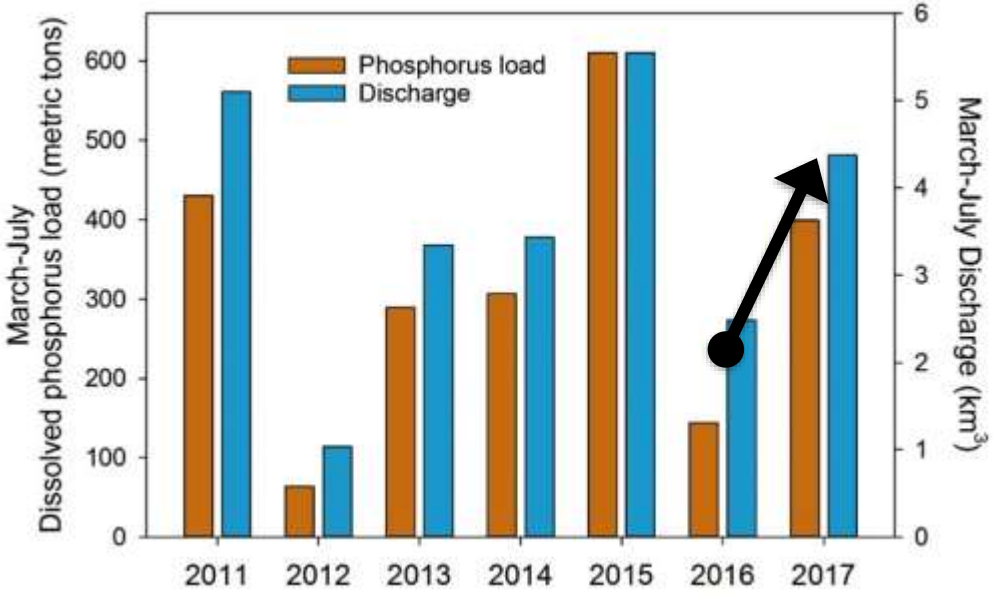
Microcystis (cyanobacteria) grows in warm water, but is limited by the amount of phosphorus

Does P stratification matter??

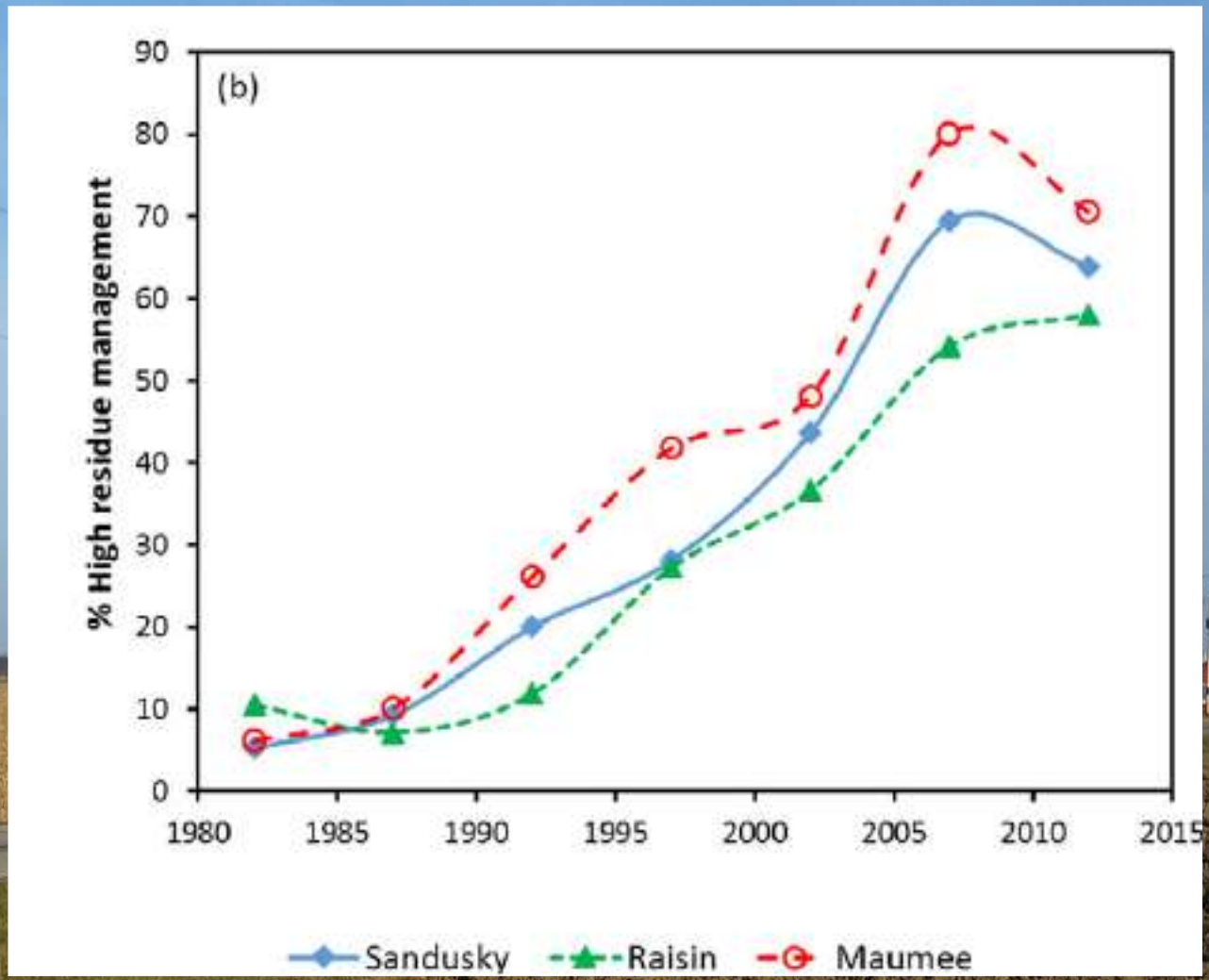



Western Lake Erie
Bloom severity
2017 severity 8
ensemble forecast 7
model values 6.6 - 8.7
uncertainty 5.5 - 9
significant
mild
max
min
Bloom Severity Index
10
8
6
4
2
2003
2005
2007
2009
2011
2013
2015
2017


2011

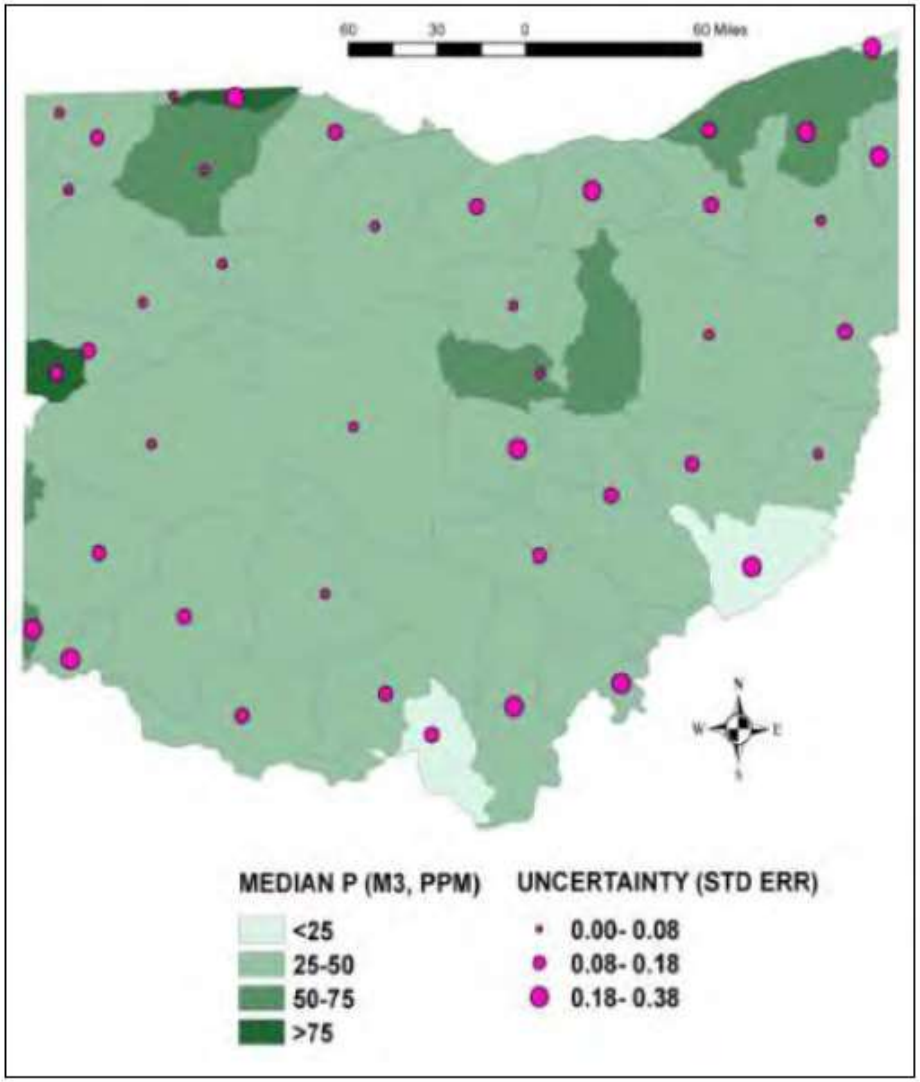

Phosphorus load
Discharge
March-July
Dissolved phosphorus load (metric tons)
March-July Discharge (km3)
600
500
400
300
200
100
0
6
5
4
3
2
1
0
2011
2012
2013
2014
2015
2016
2017


2012

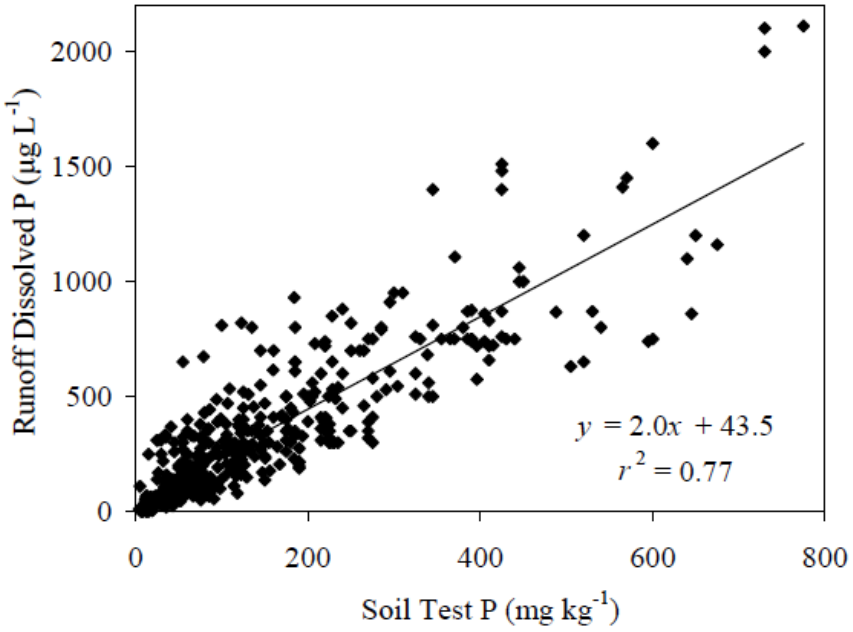


Jarvie et al. 2017, JEQ

Is soil P high indicating over application of fertilizer or manure?



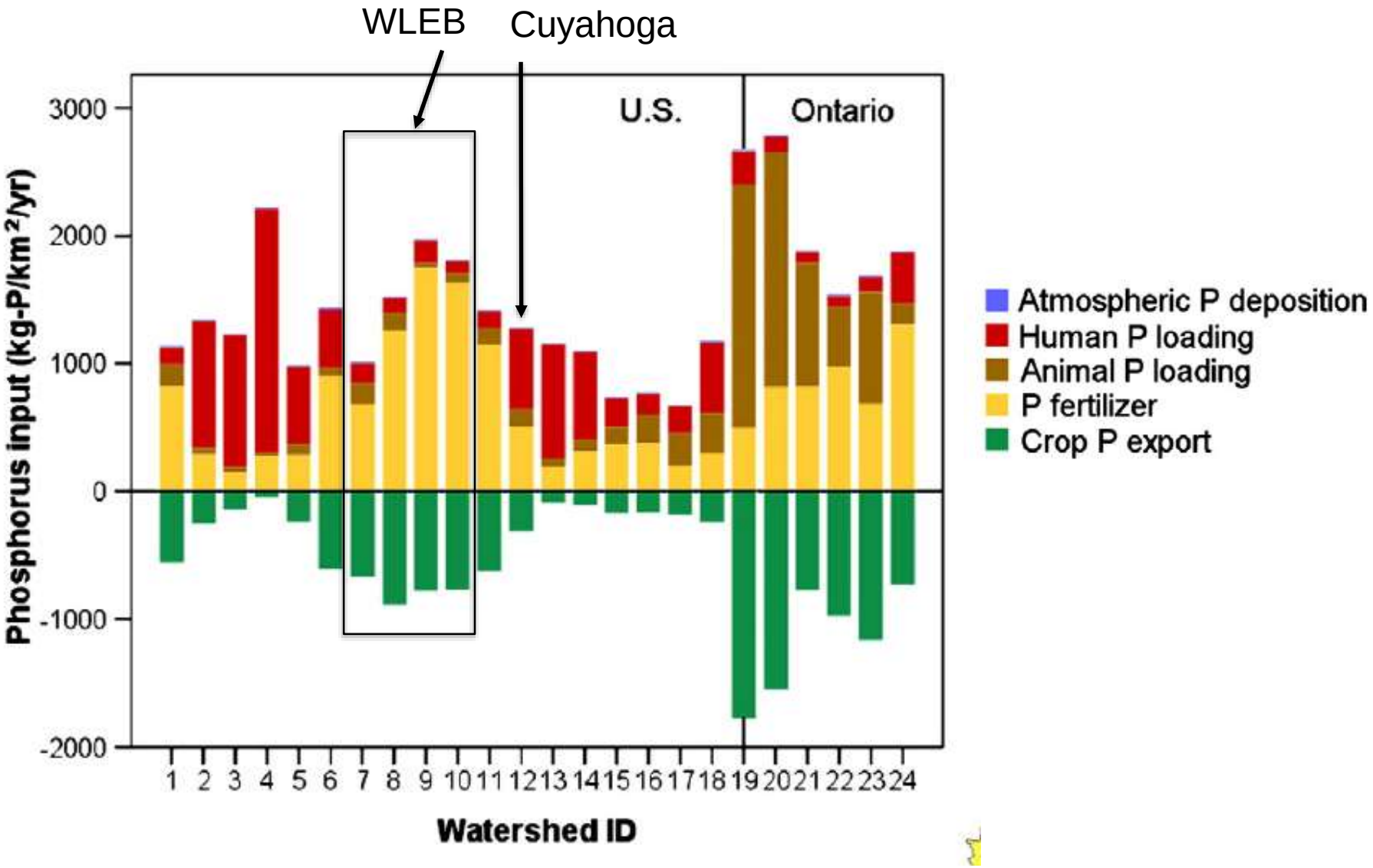
Ohio Phosphorus Taskforce II report

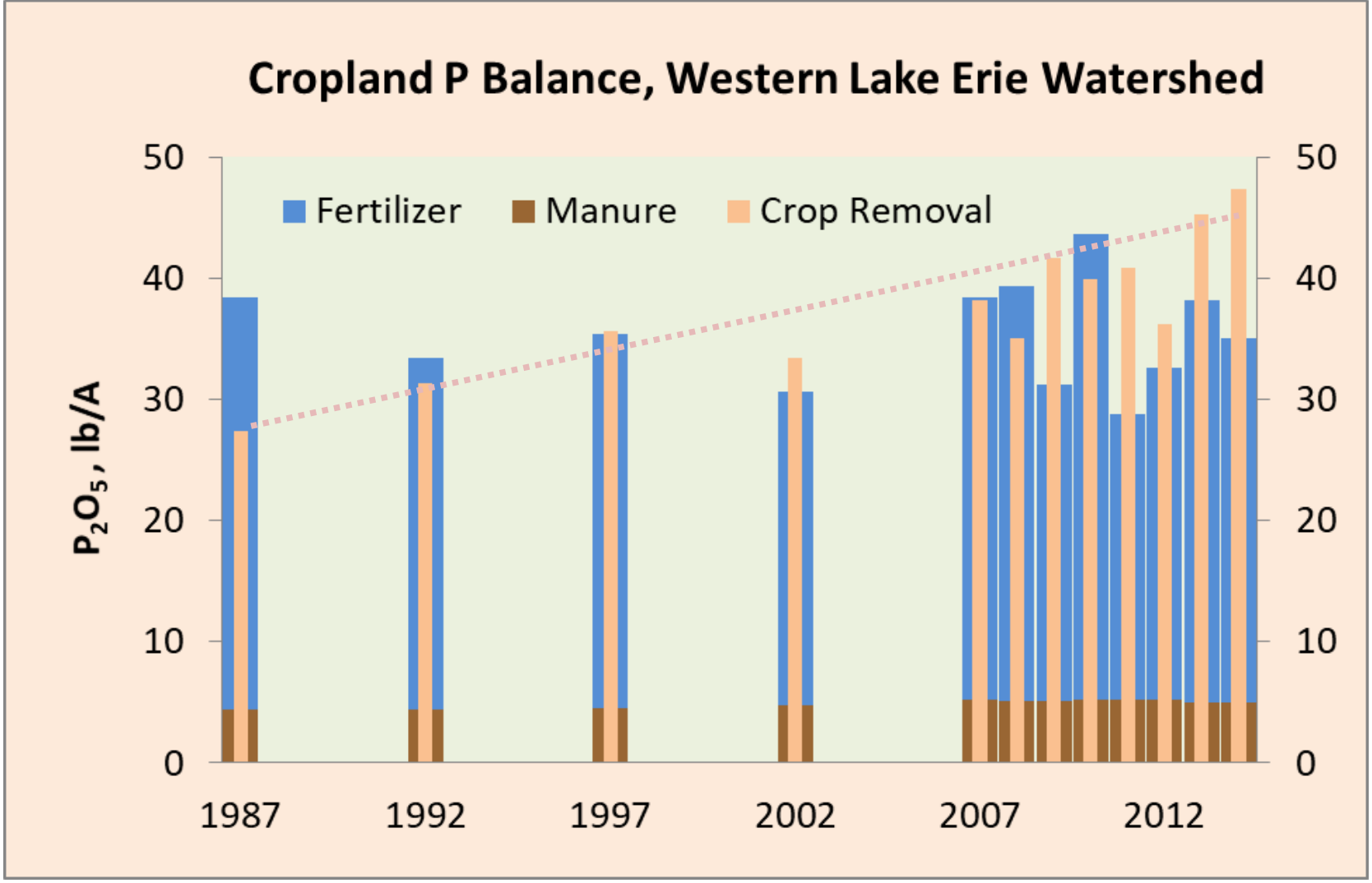


From Vadas et al. 2005

Phosphorus input budget

Scavia et al. 2014





- **Yield and P removal increased 50% over 27 years.**
- **P surplus changed to P deficit.**

NuGIS
Nutrient Use Geographic Information System

IPNI. 2018. http://nugis.ipni.net.

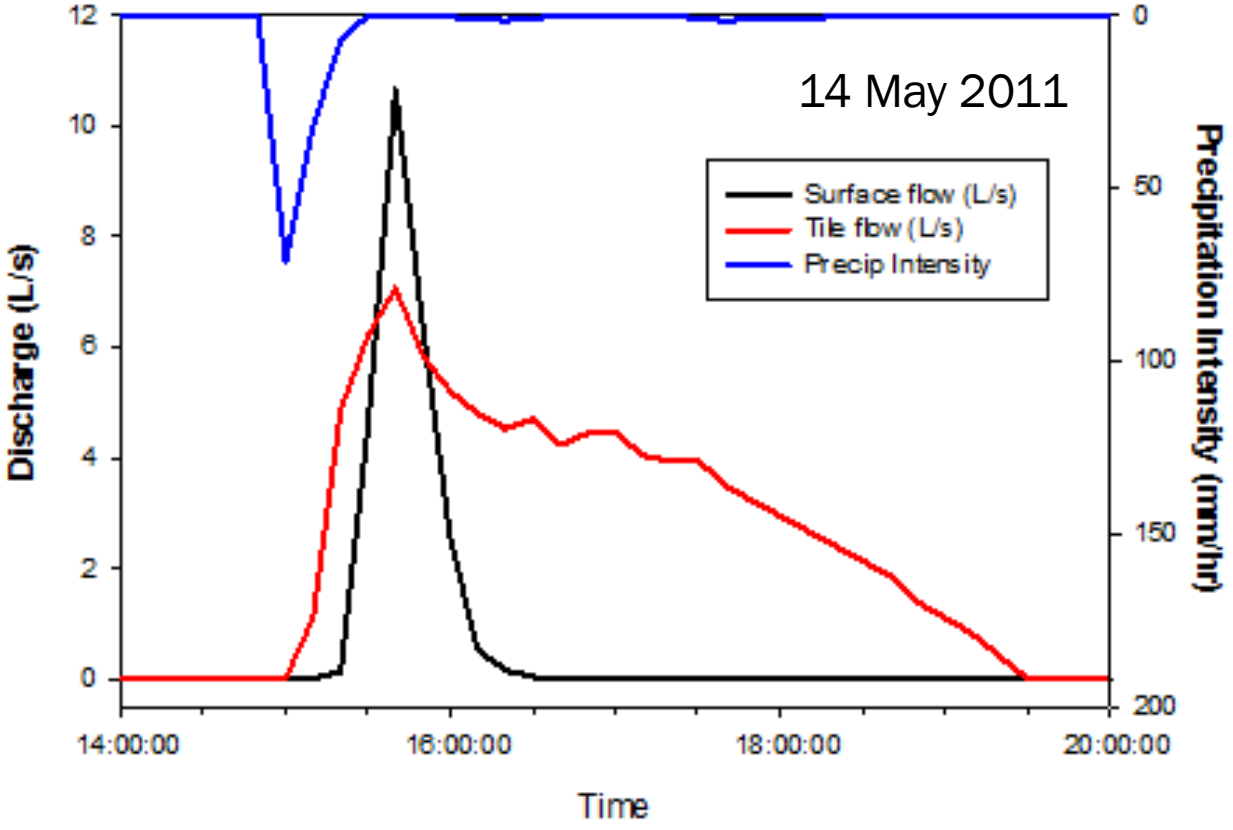
IPNI

Evidence of macropore tile drain flow

Data from Doug Smith, USDA-ARS

St. Joseph River watershed

- Tile drain flow peaked with surface flow at in a May 2011 storm



Smith et al. 2014, JEQ