Trends in water quality across Ohio watersheds

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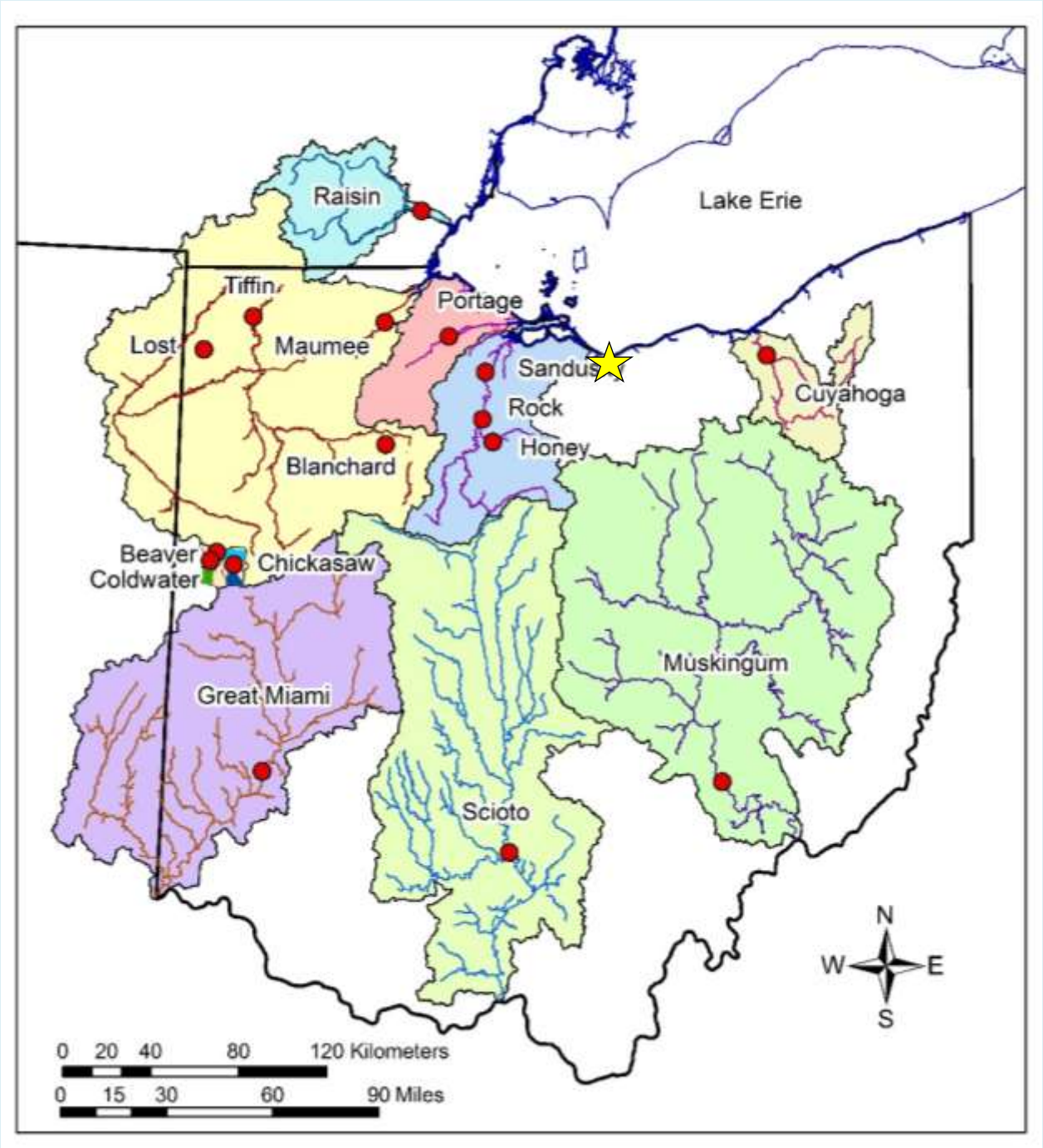
Ohio Water Resources Council

Workgroup for Water Resources Monitoring

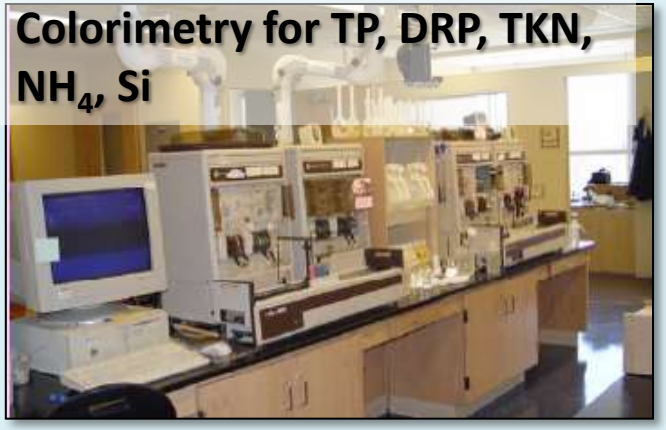
21 March 2014

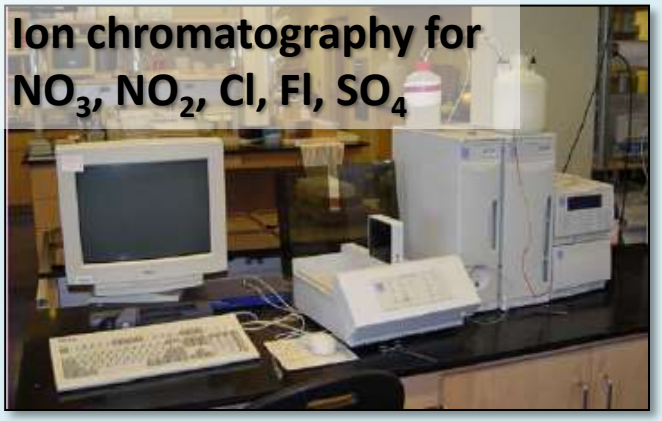
National Center for Water Quality Research
Heidelberg University



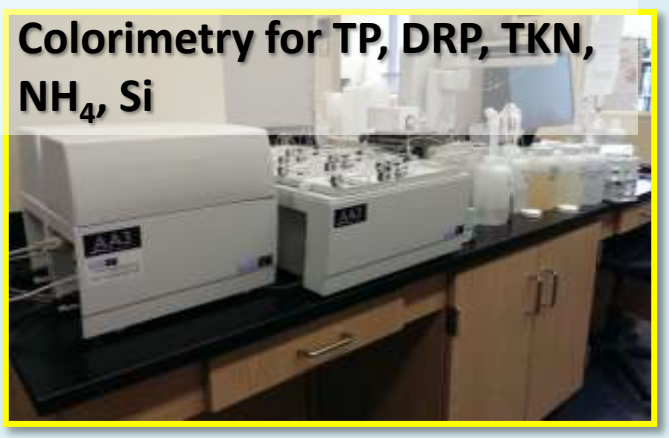
Heidelberg Tributary Loading Program

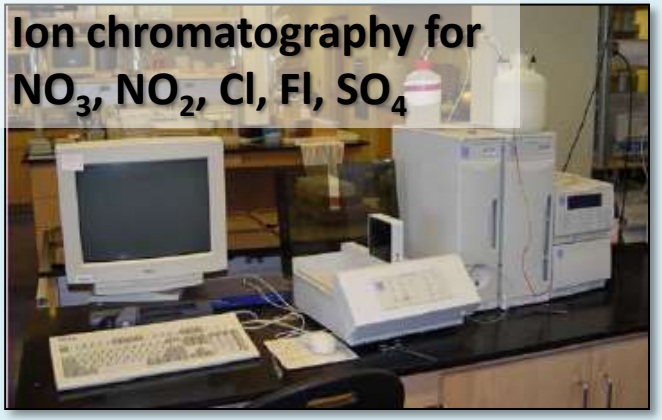
- 16 stations
- Started in 1975 with the Sandusky and Maumee
- Old Woman Creek probable new addition
  - Up and down of the wetland





- Samples collected 3x a day
- Analyzed for all major nutrients and suspended sediments



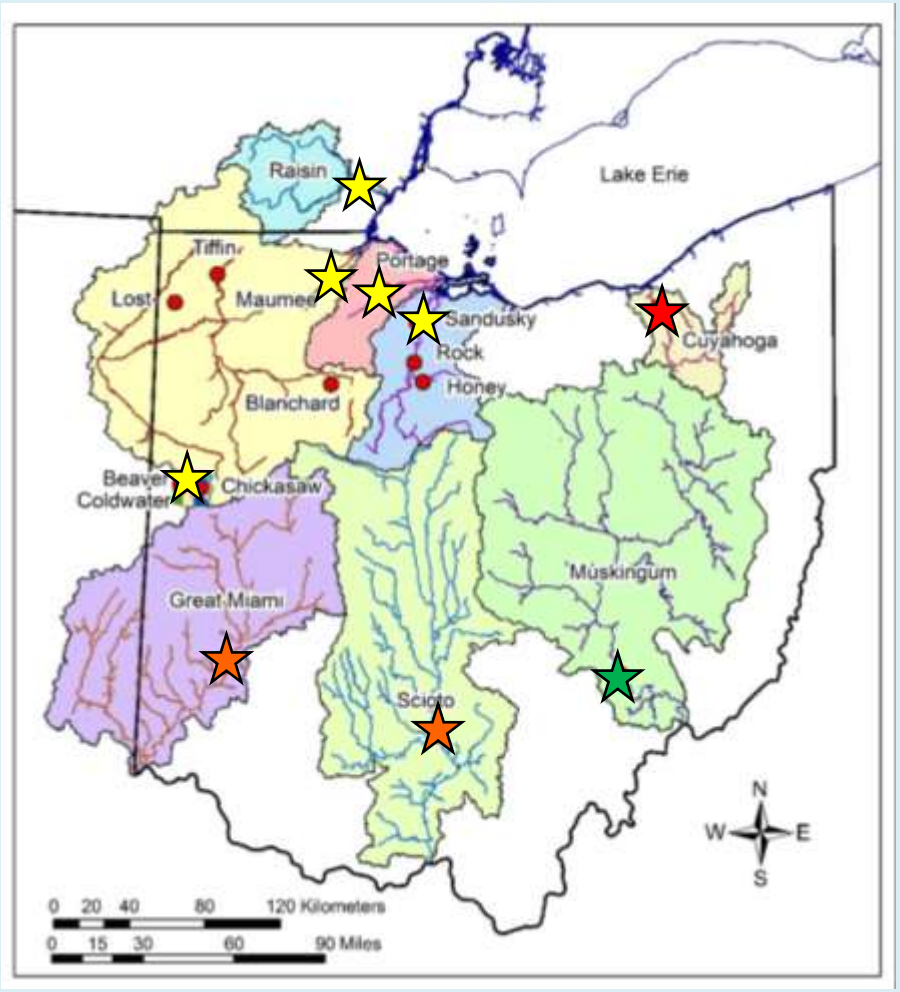


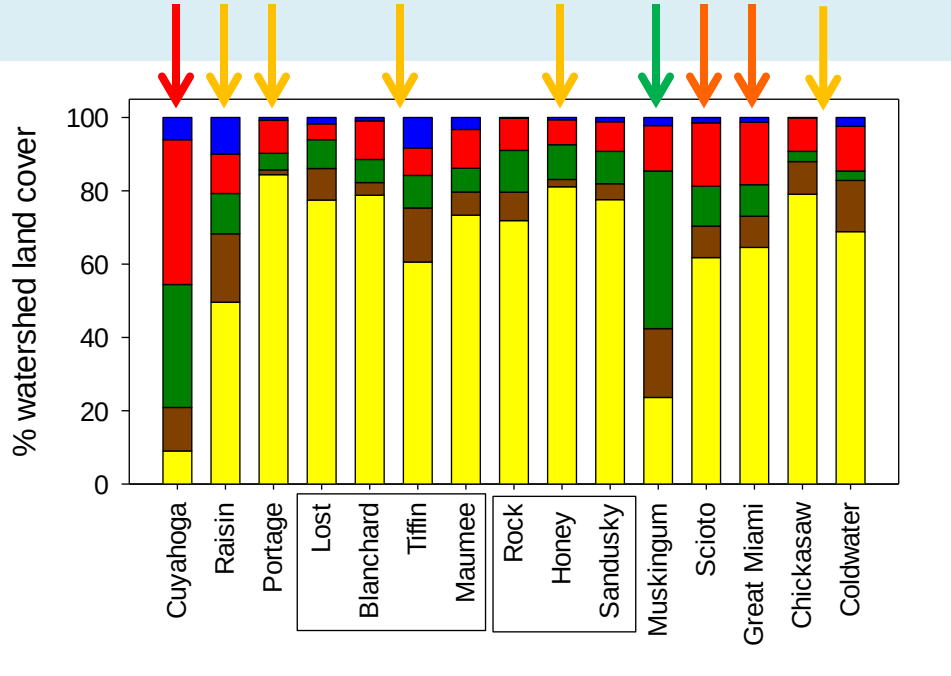
- Samples collected 3x a day
- Analyzed for all major nutrients and suspended sediments

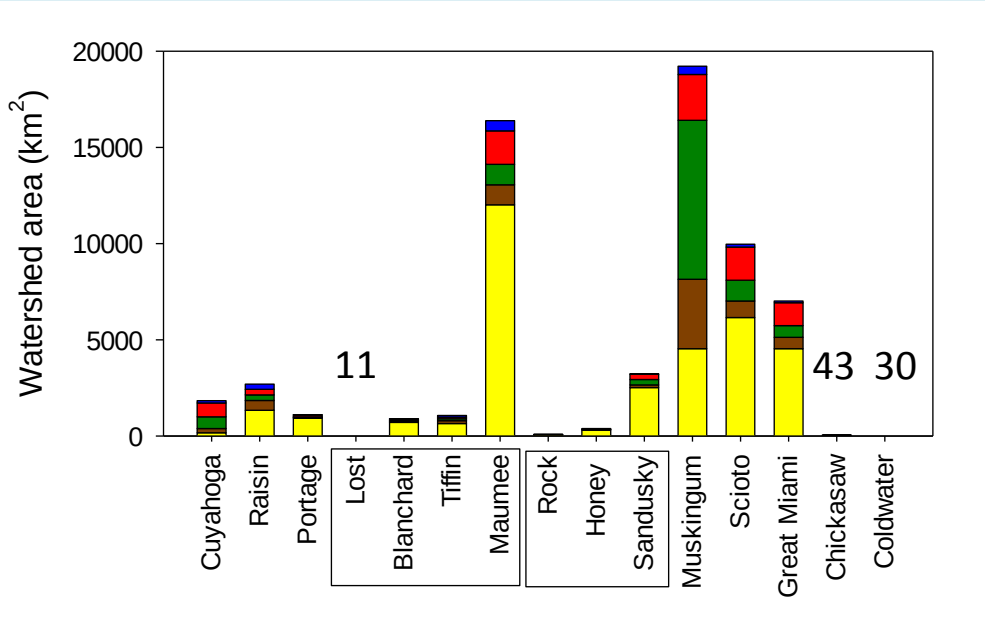
Objectives

- Explore patterns in nutrient export from watersheds in Ohio and Michigan
  - Watershed yield or unit area loads (kg/ha) to correct for differences in watershed size
  - Focus on WY 2013 and past 5 years of data

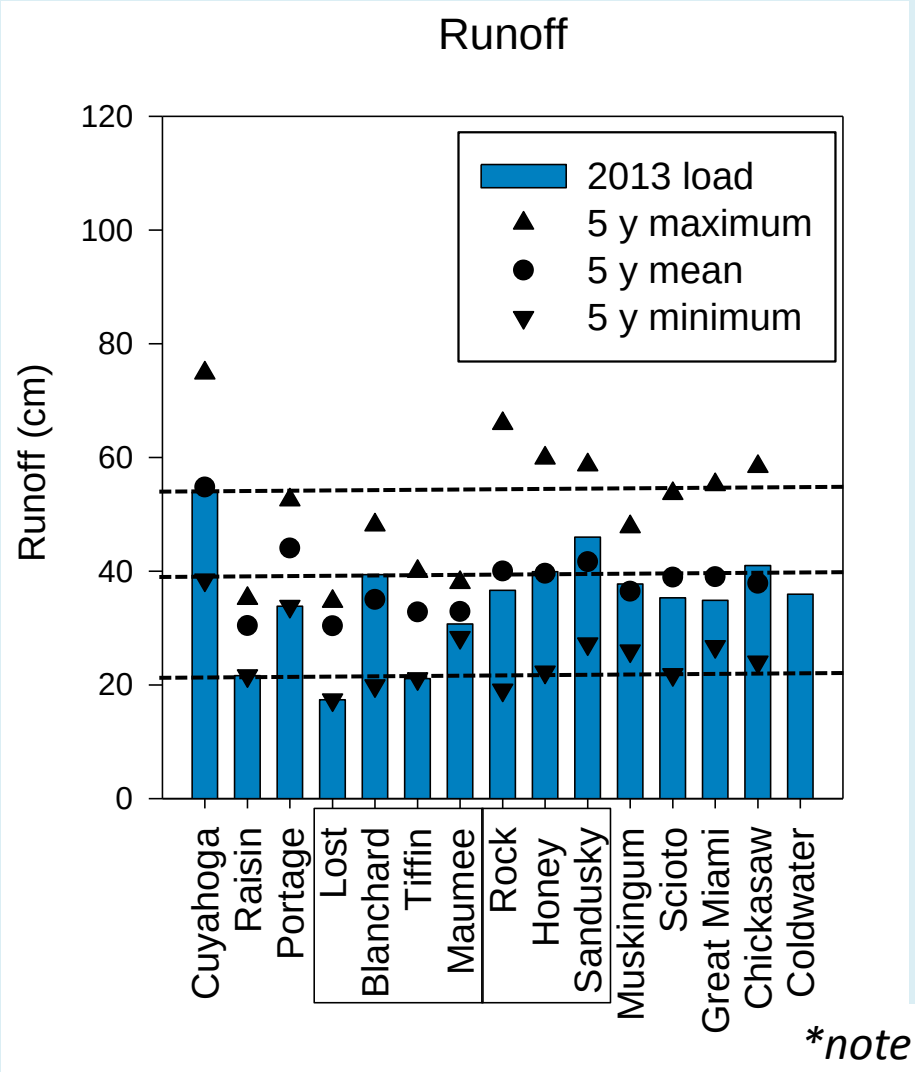
- Quantify the potential importance of hydrology alongside watershed area and land use


Agriculture
Hay-Pasture
Forest
Urban
Other
Raisin
Lake Erie
Tiffin
Portage
Lost
Maumee
Sandusky
Rock
Honey
Cuyahoga
Blanchard
Beaver
Coldwater
Chickasaw
Muskingum
Great Miami
Scioto
N
W
E
S
0 20 40 80 120 Kilometers
0 15 30 60 90 Miles


% watershed land cover
0
20
40
60
80
100
Cuyahoga
Raisin
Portage
Lost
Blanchard
Tiffin
Maumee
Rock
Honey
Sandusky
Muskingum
Scioto
Great Miami
Chickasaw
Coldwater


Watershed area (km2)
0
5000
10000
15000
20000
11
43
30
Cuyahoga
Raisin
Portage
Lost
Blanchard
Tiffin
Maumee
Rock
Honey
Sandusky
Muskingum
Scioto
Great Miami
Chickasaw
Coldwater

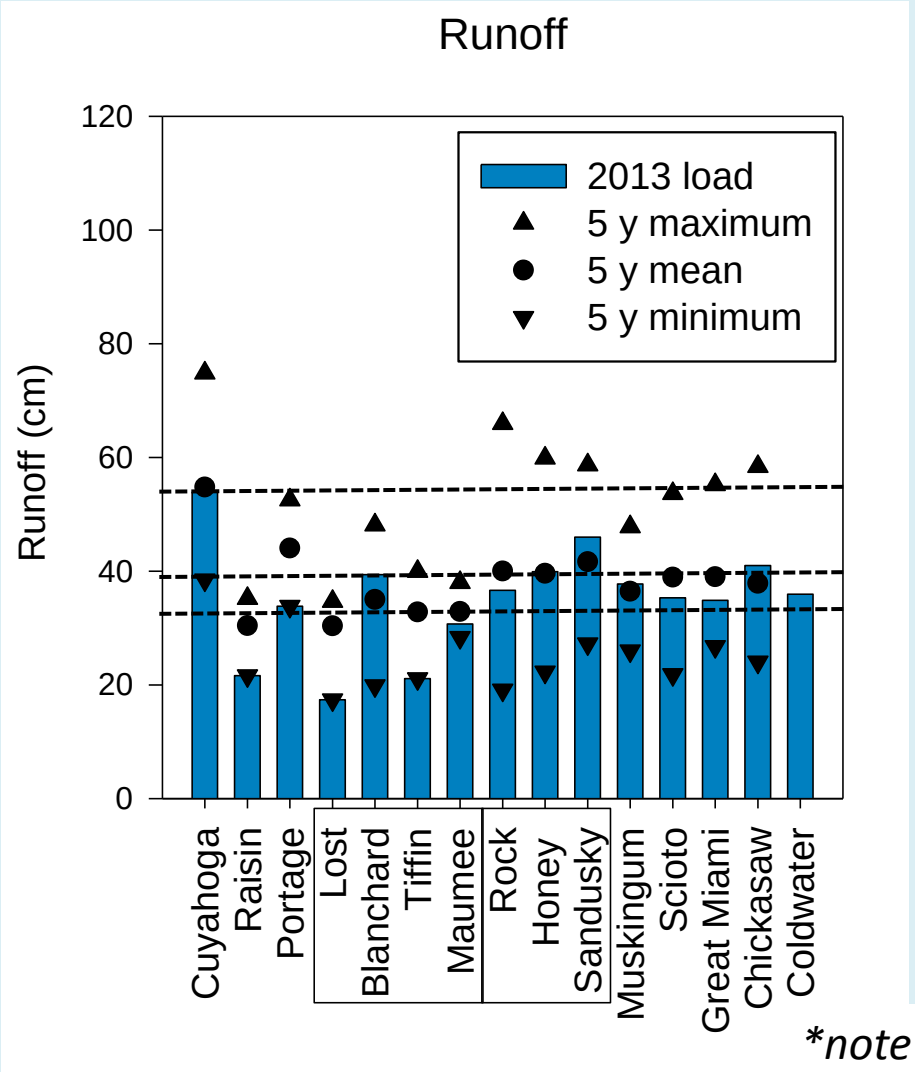
Comparisons across watersheds



**note only 1y of data for Coldwater*

- Runoff is similar across watersheds
  - Particularly low in Raisin, Lost, and Tiffin

Comparisons across watersheds



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- Runoff is similar across watersheds
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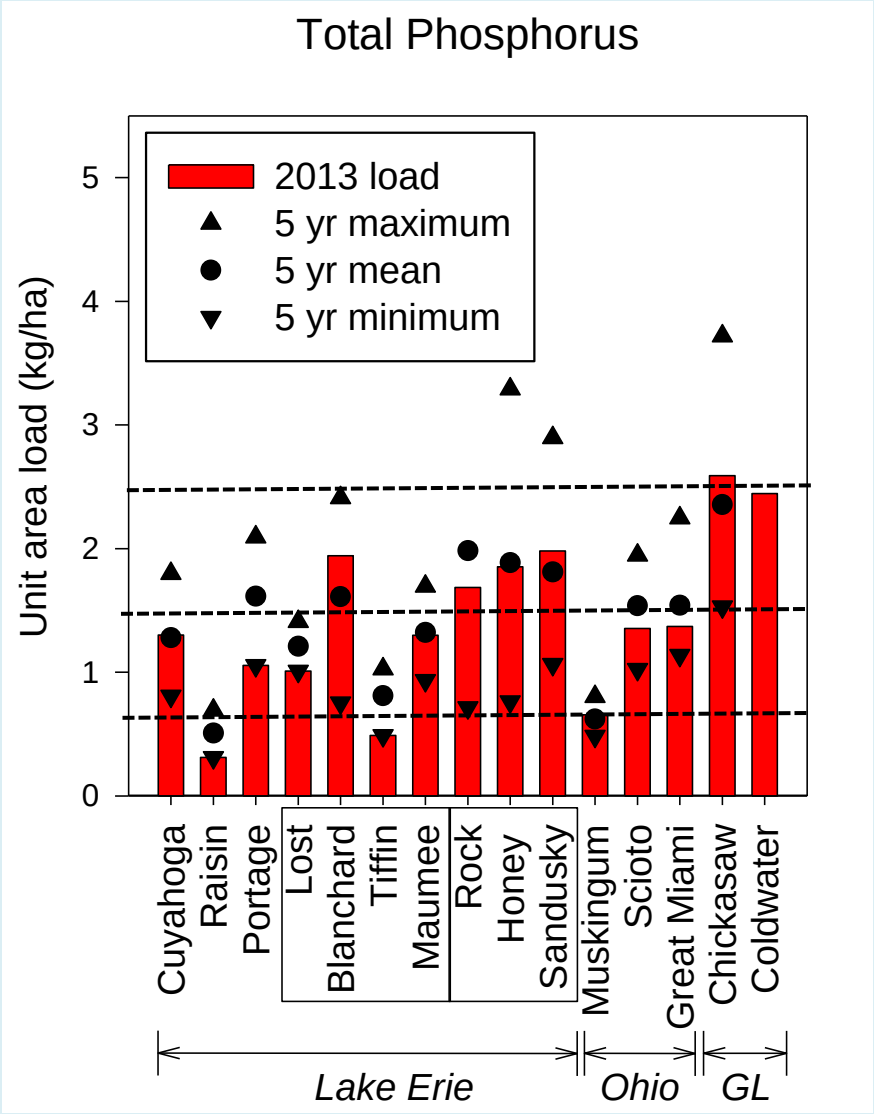
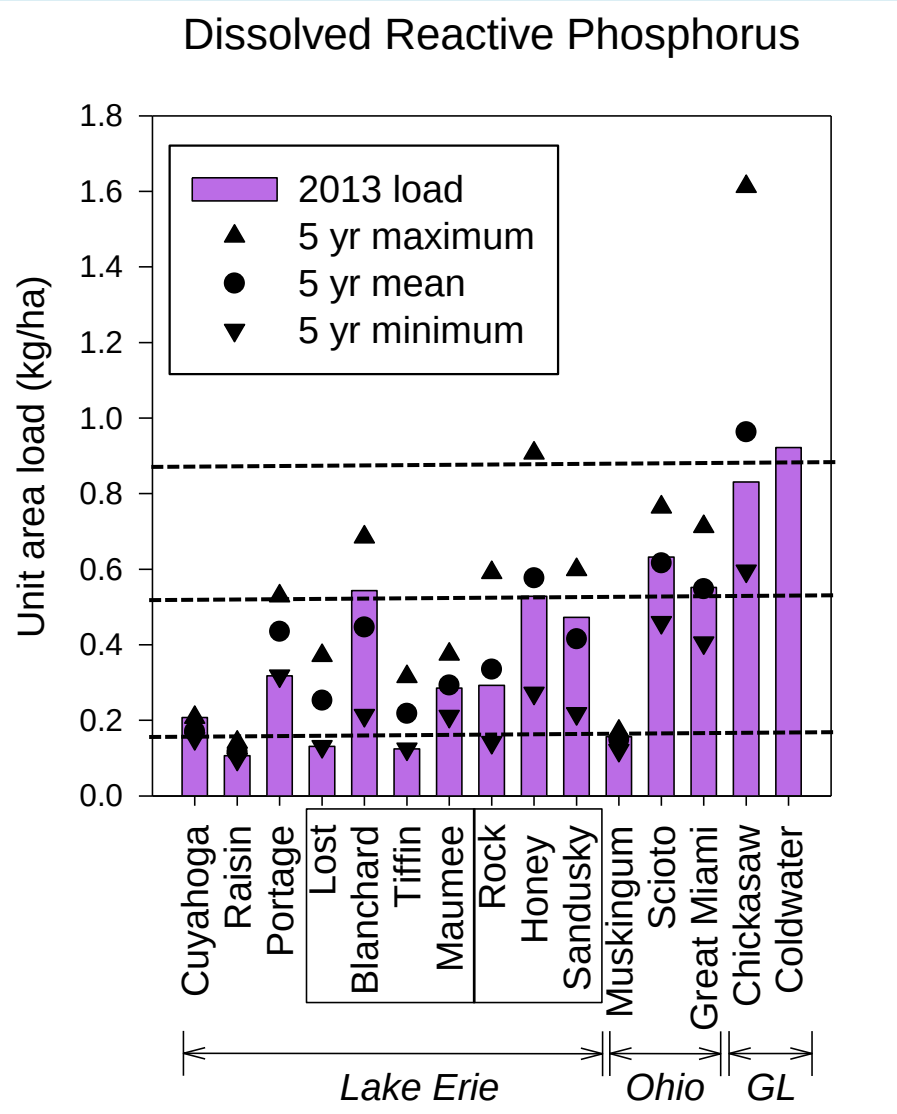
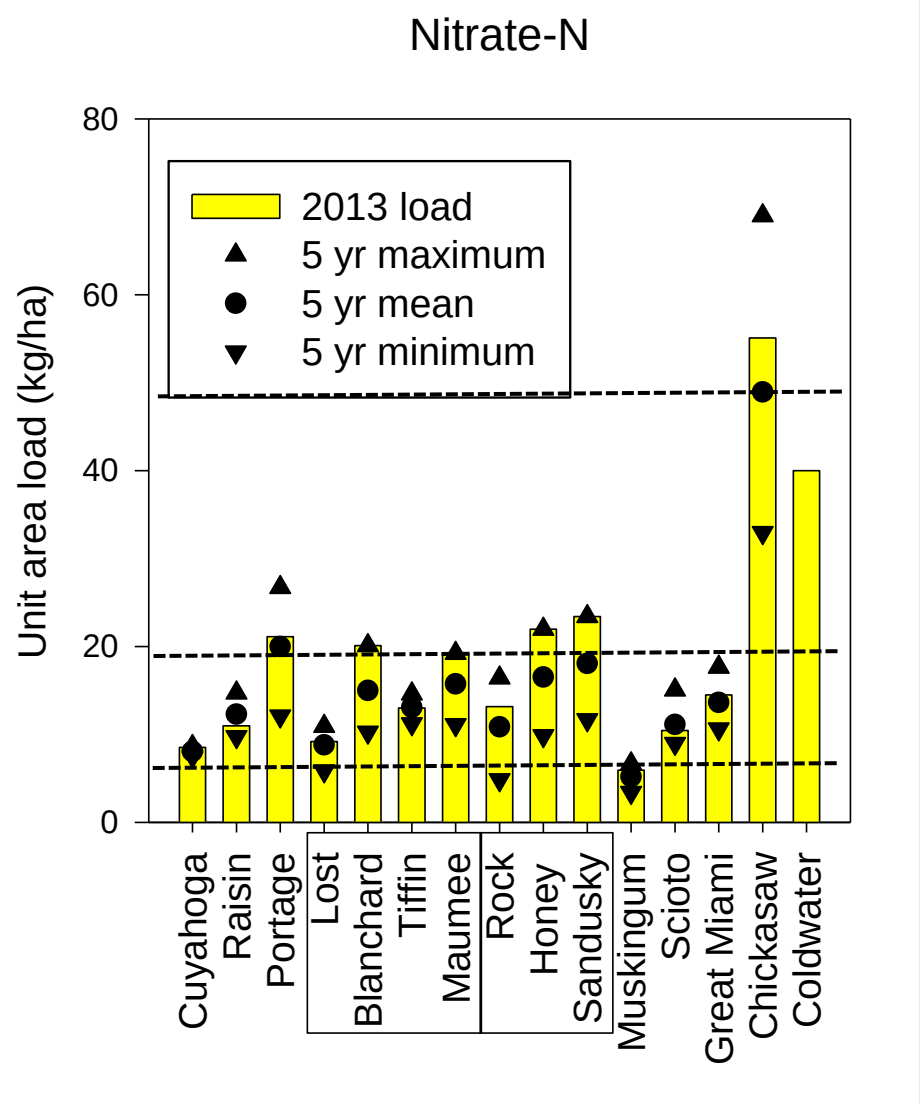




- Both TP and DRP are particularly low in Raisin and Tiffin

Comparisons across watersheds

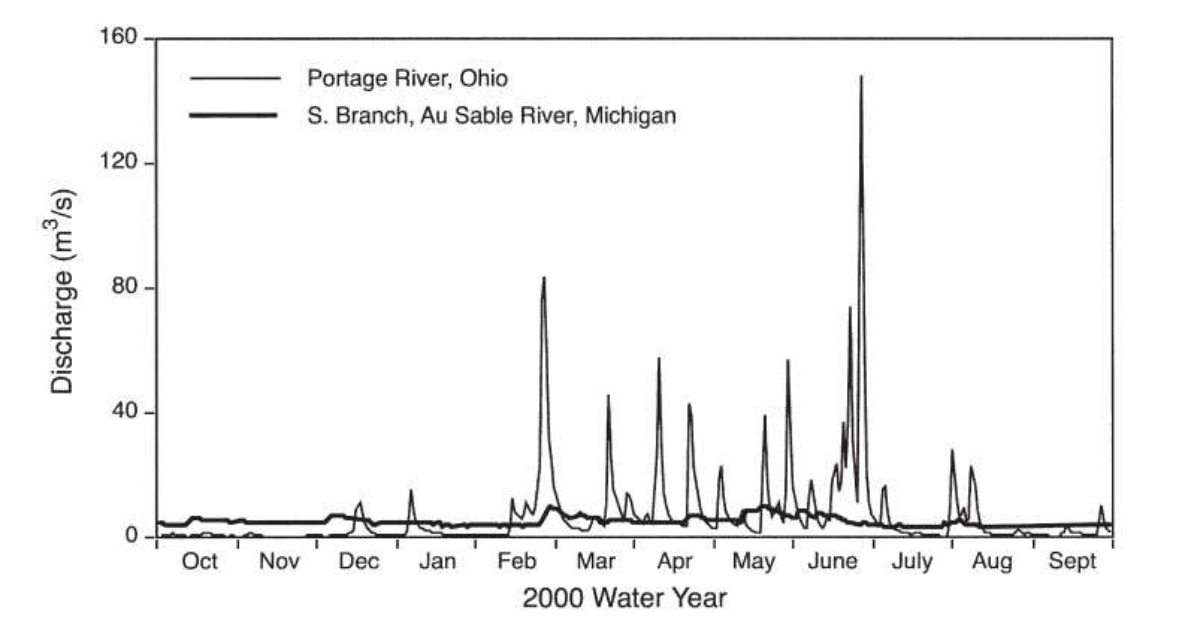


- Nitrate yield is high in Chickasaw and Coldwater
- Next highest in Portage, Blanchard, Maumee, Honey and Sandusky

Why such variation in unit area loads across watersheds?

- In part due to land use:
  - Agricultural watersheds tended to have higher loads
  - Chickasaw and Coldwater (GLSM) watersheds had consistently high loads, especially nitrate
- What about influence of “flashiness”?

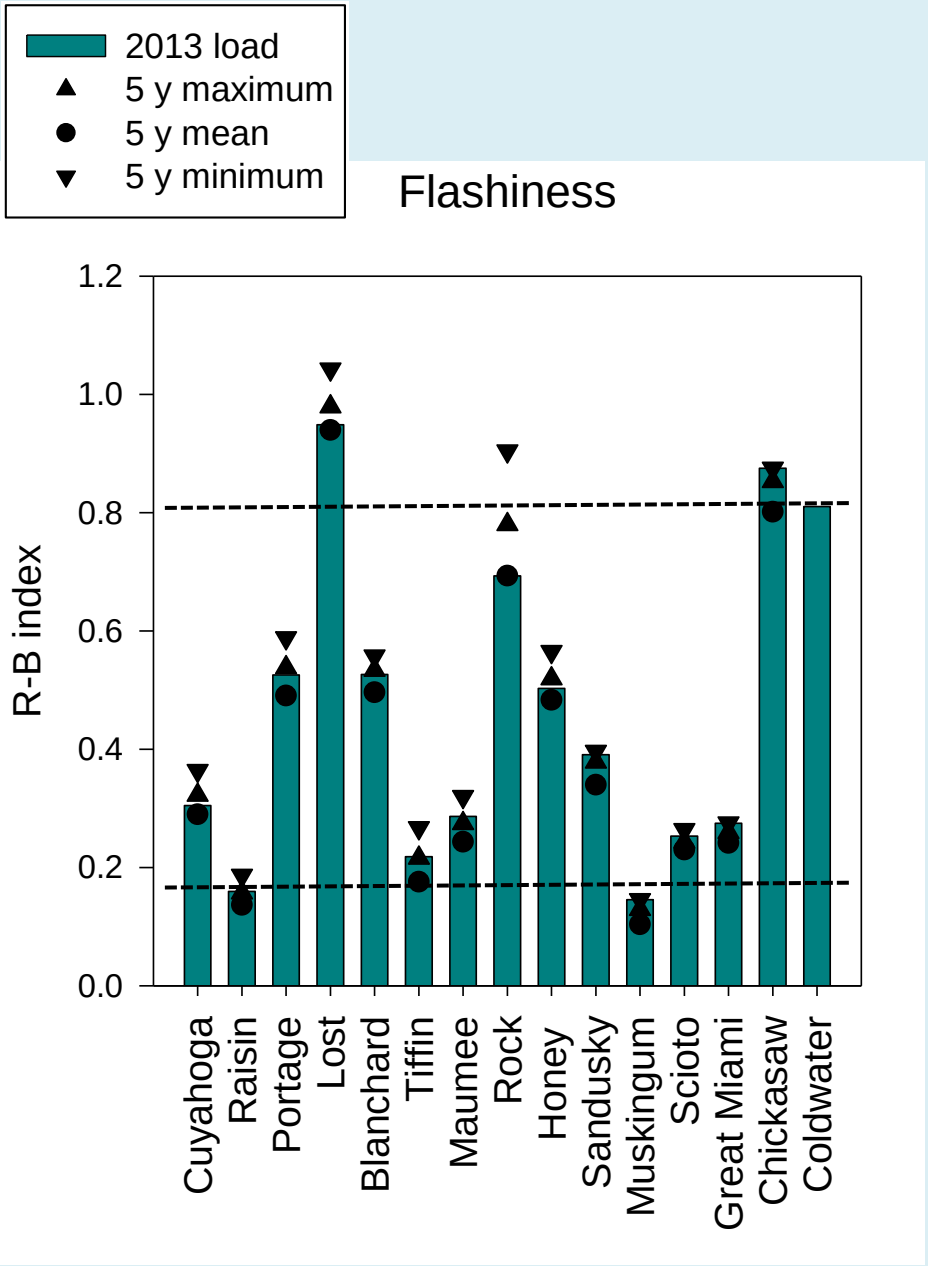
R-B flashiness index



$$R-B\ Index = \frac{\sum_{i=1}^{n} |q_i - q_{i-1}|}{\sum_{i=1}^{n} q_i}$$

- Flashiness = the frequency and rapidity of short-term changes in discharge
- Incorporates the day-to-day changes in discharge relative to total discharge over the time interval

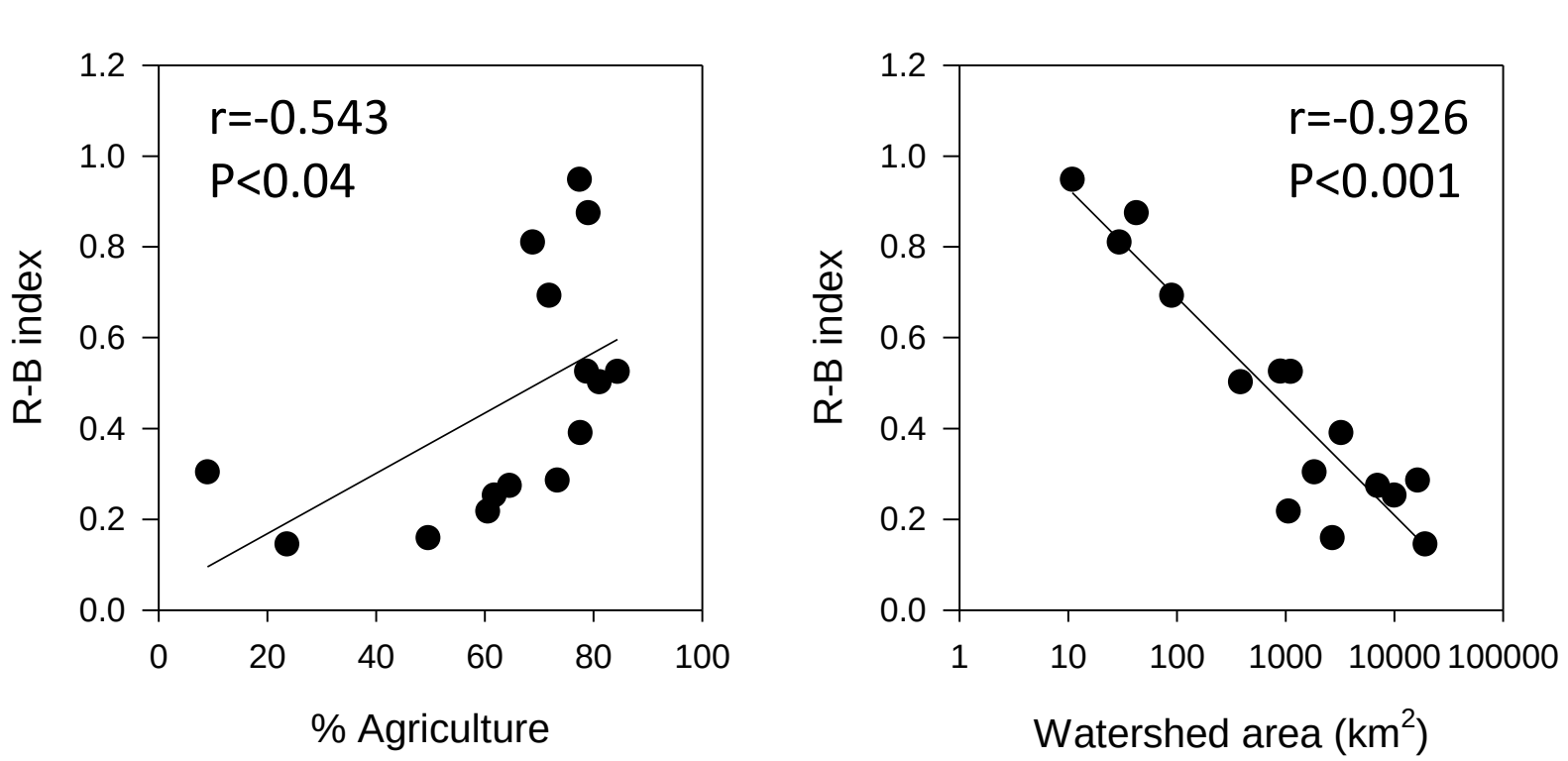
From Baker et al. 2004, JAWRA



Comparisons across watersheds

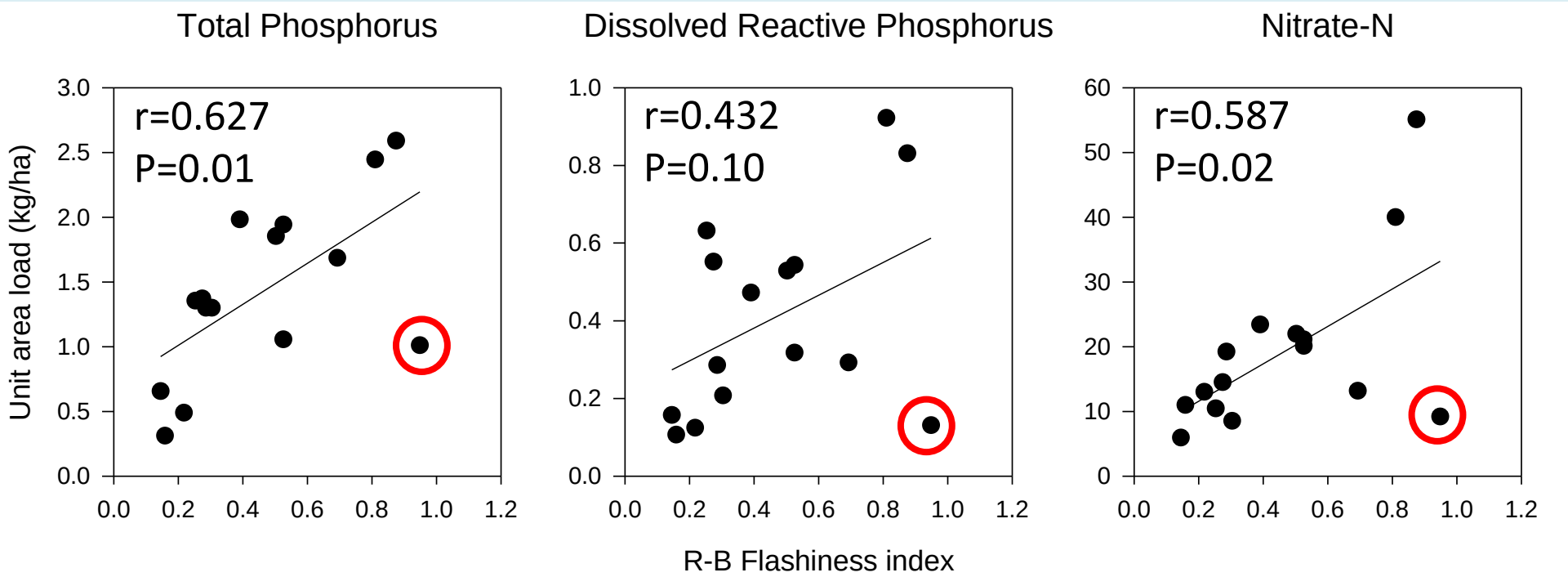
- Smaller watersheds most flashy
- Agricultural watersheds as well
- Raisin and Tiffin have low indices

Influence of agriculture and watershed area on flashiness



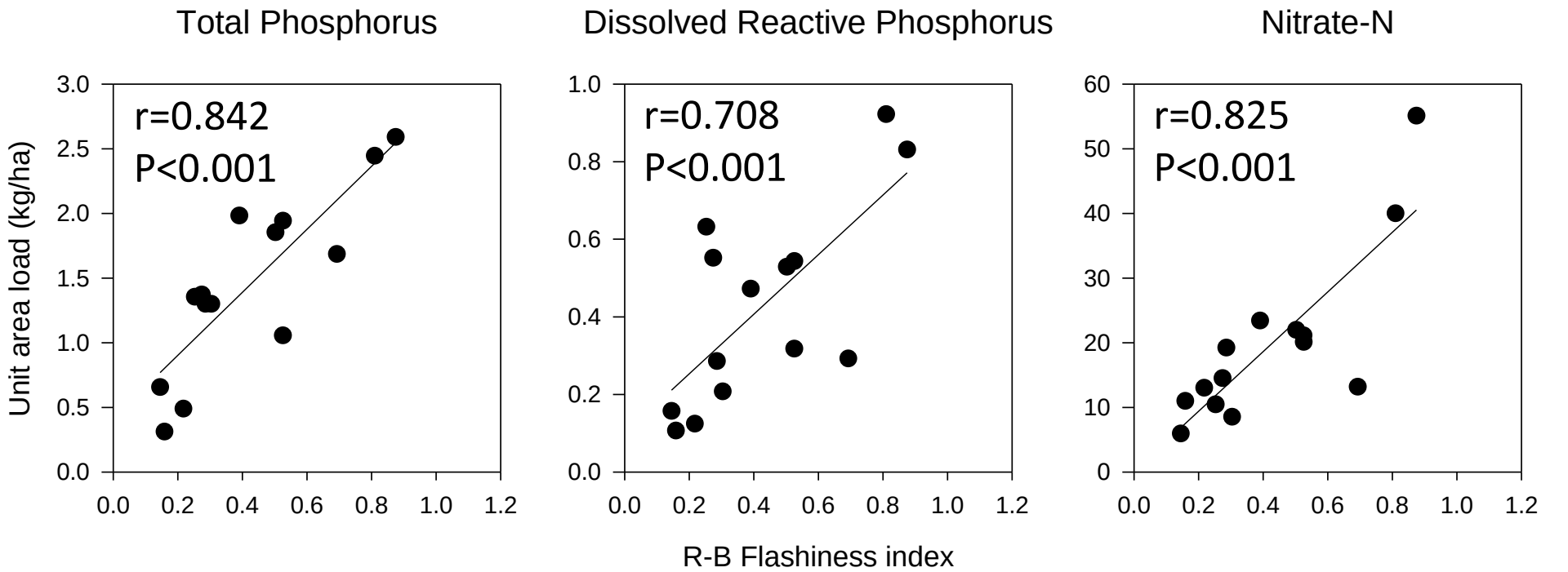
*note log scale

Influence of flashiness on unit area loads



- TP and nitrate are significantly related to flashiness
- The tributary to Lost Creek has lower loads than expected

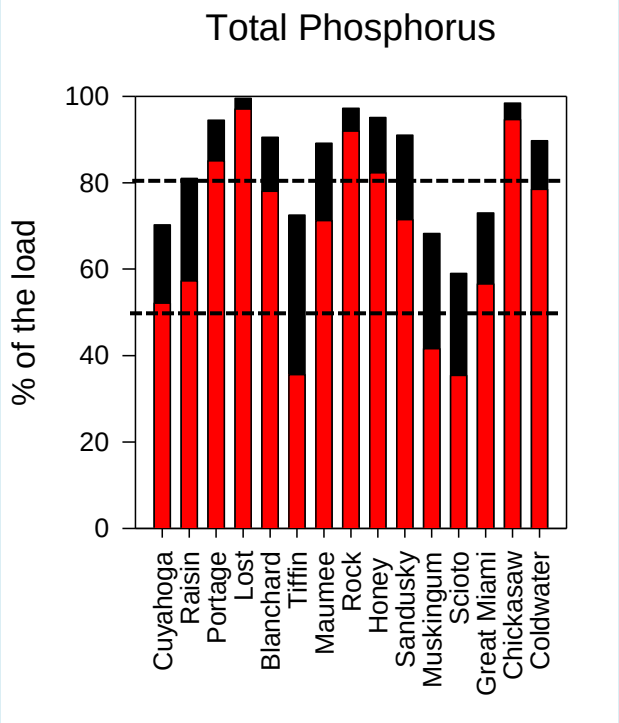
Influence of flashiness on unit area loads

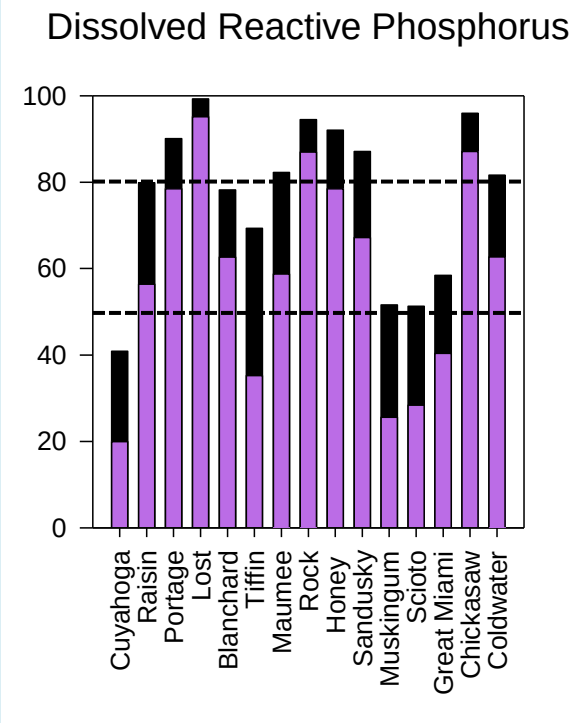


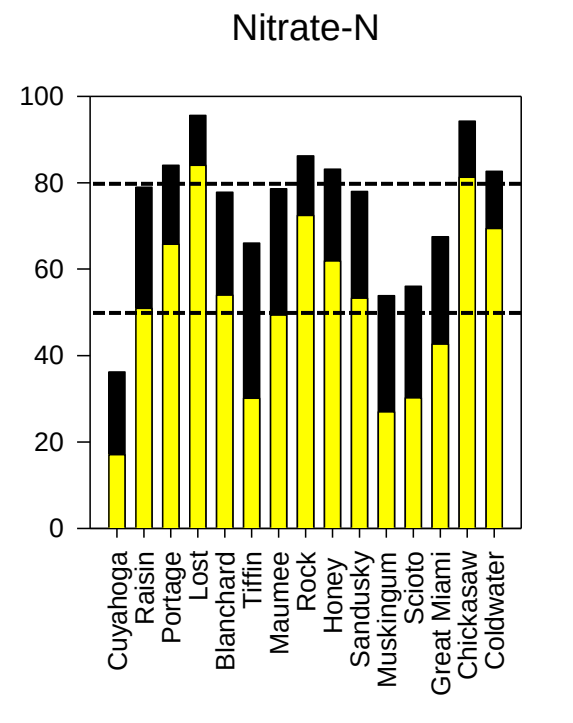
- Relationships much stronger without Lost Cr tributary
- Yet, in part driven by Chickasaw and Coldwater, that have high loads because of land management, small watersheds, and high % agriculture

Load exported in top 10 and 25% of flows

Colored bar *Total bar*

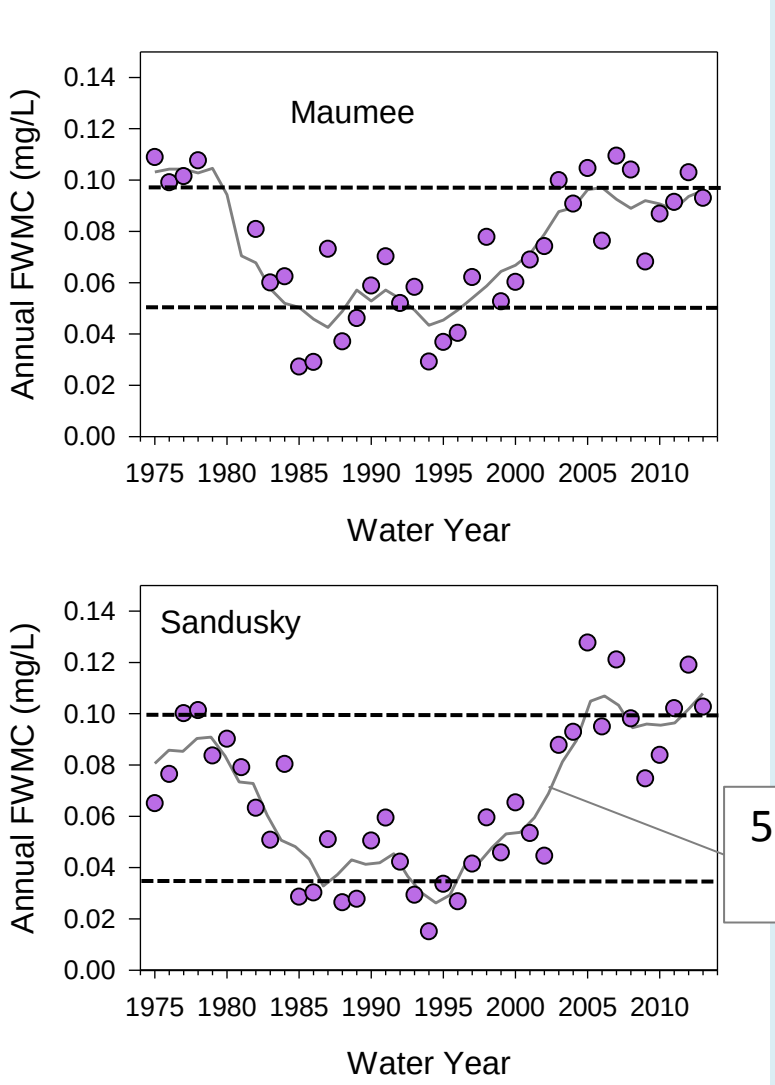






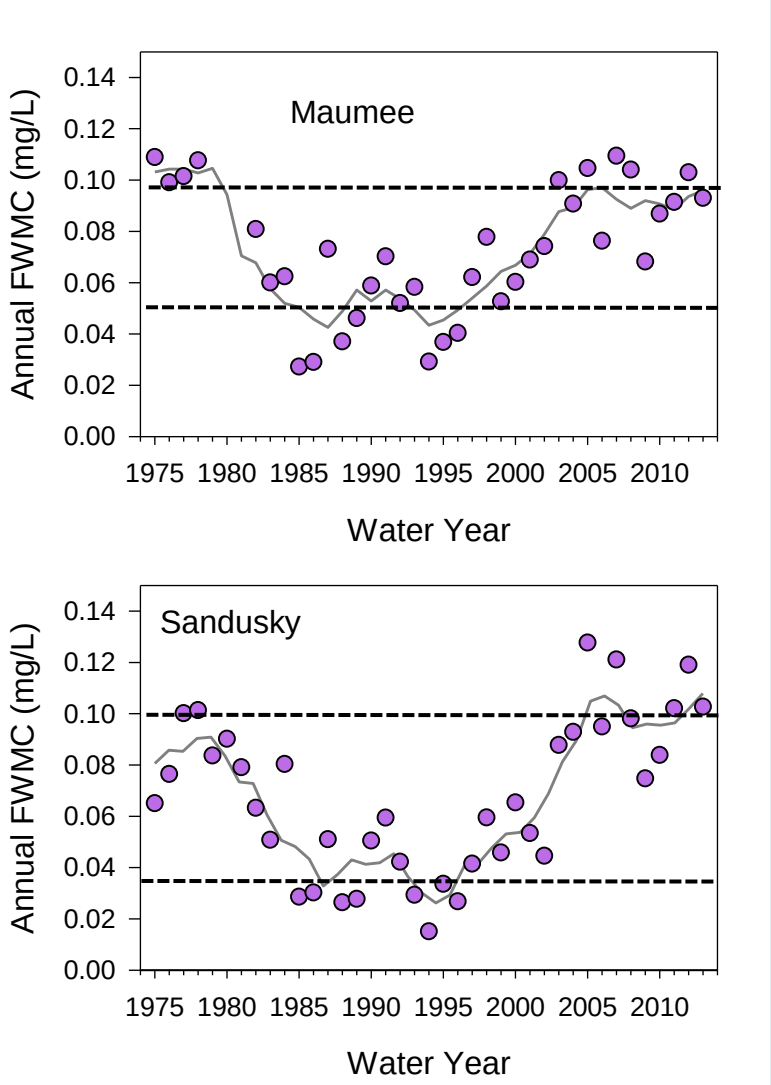
- For all nutrients, most of the load occurs in the top 25% of flow
  - Except the Cuyahoga
- Small watersheds have higher % exports
- Point source dominated exports are lower

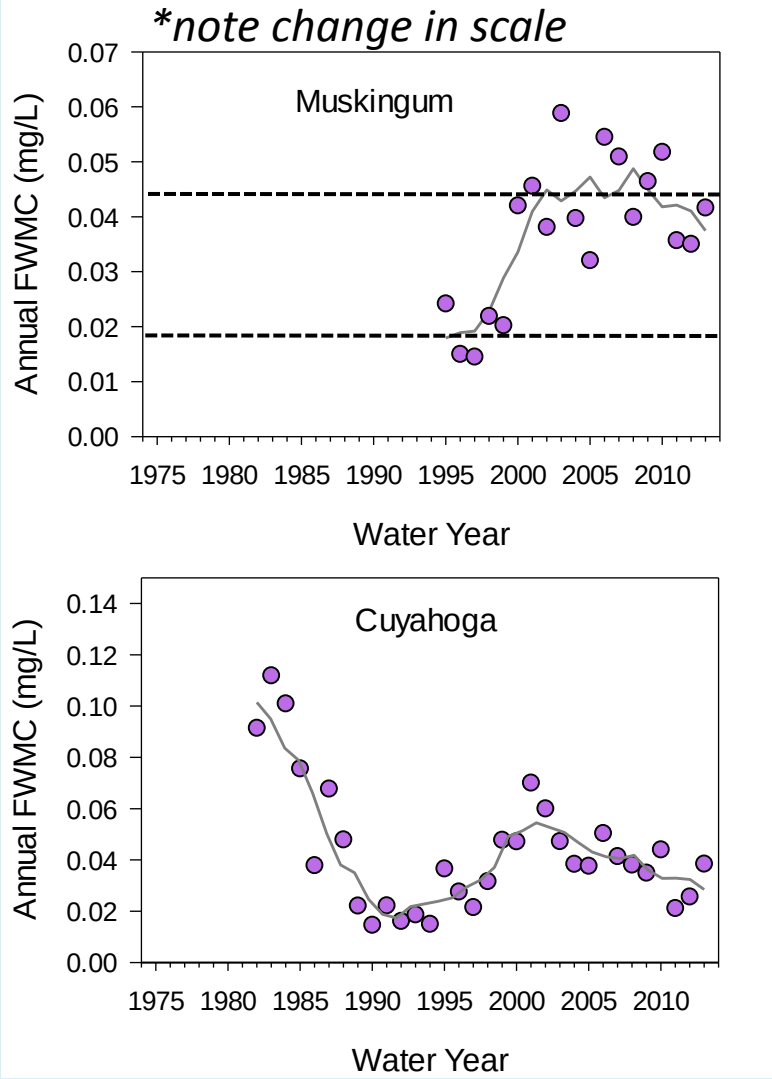
Long-term trends in DRP concentrations



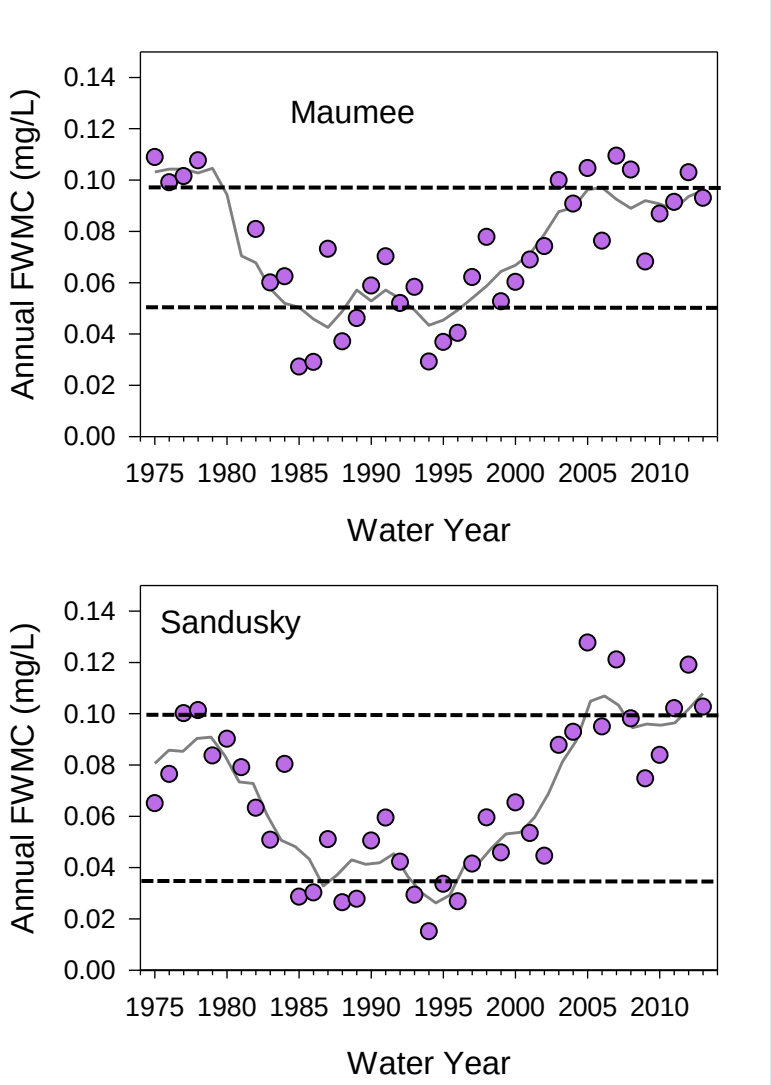
- FWMC have been increasing in the Maumee and Sandusky Rivers since the mid-1990's

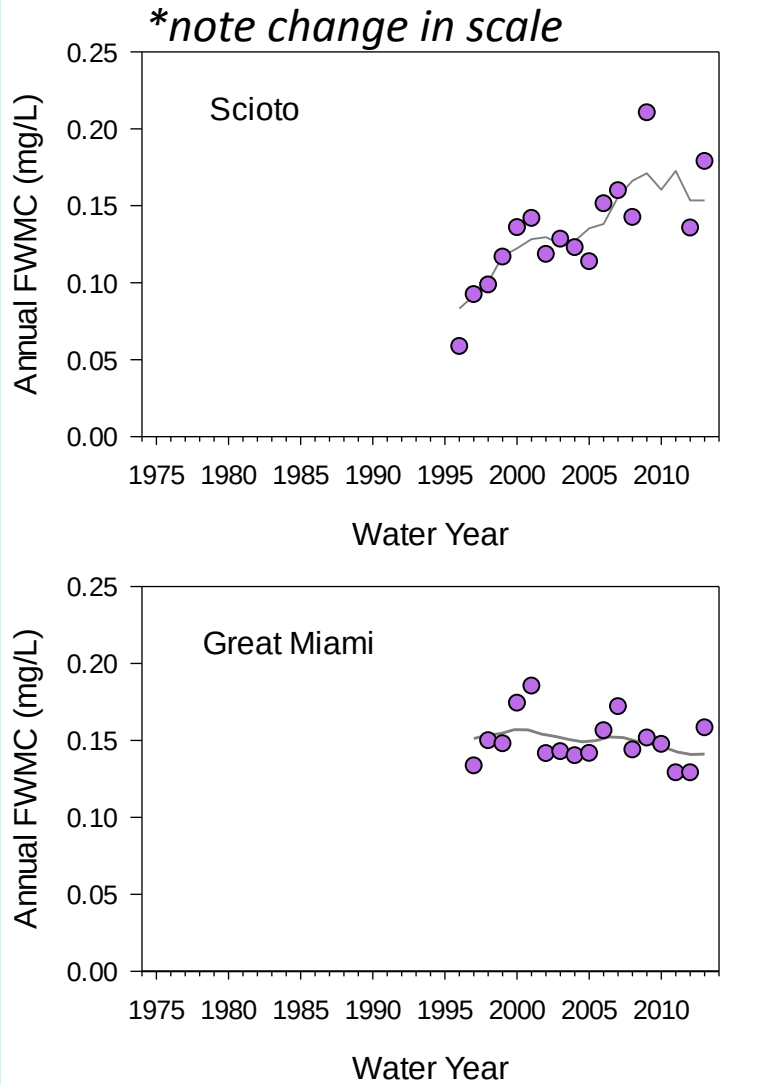
Long-term trends in DRP concentrations



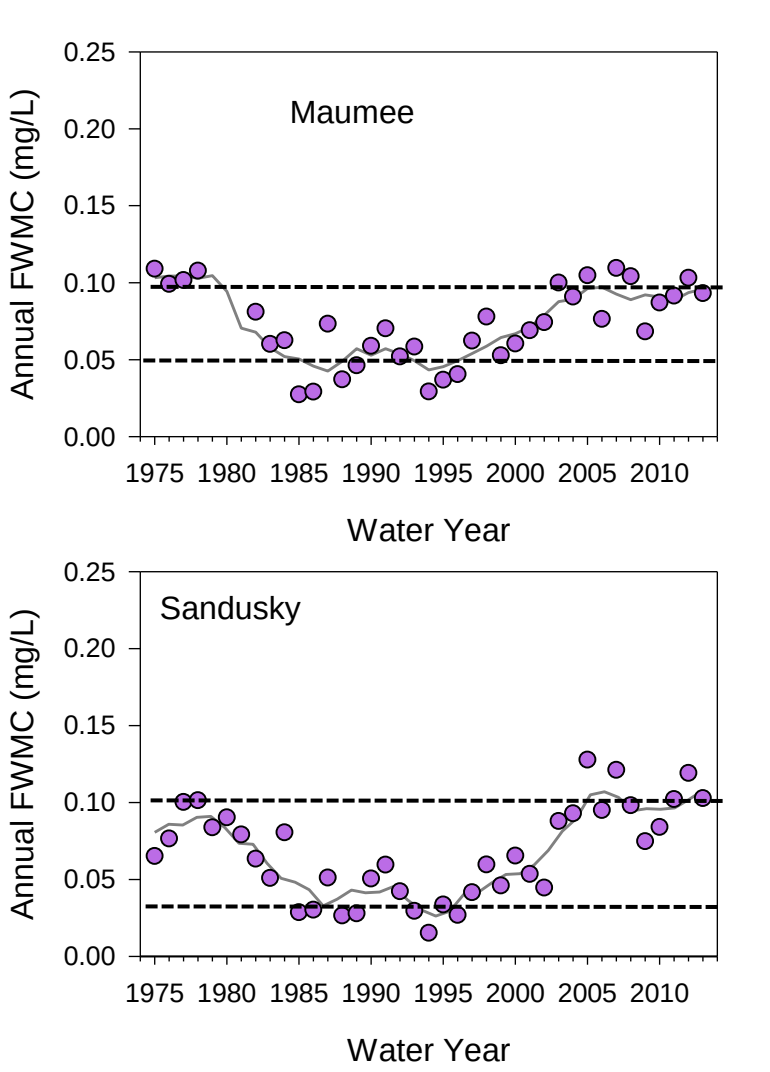


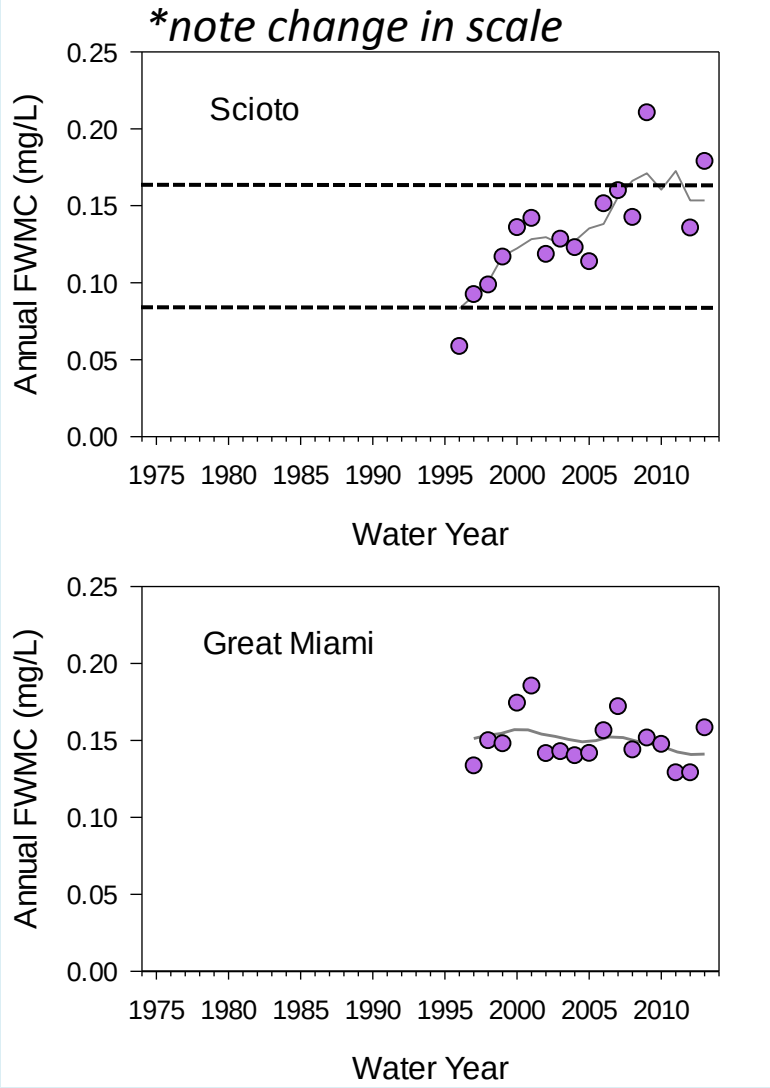
Long-term trends in DRP concentrations



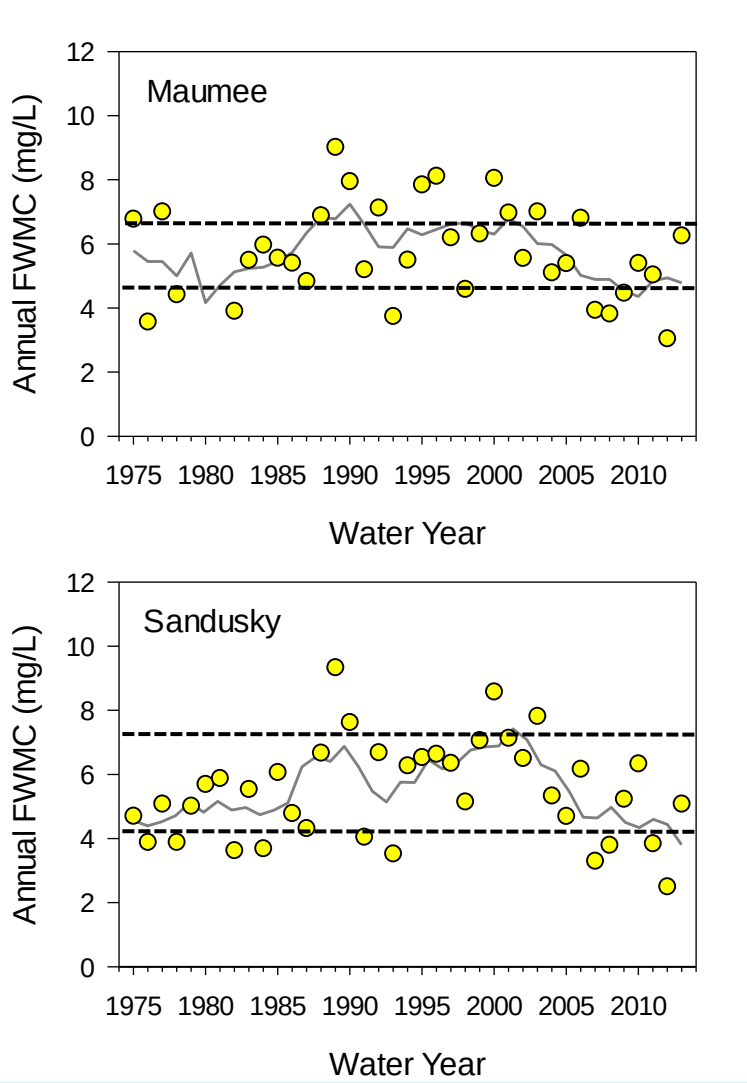


Long-term trends in DRP concentrations



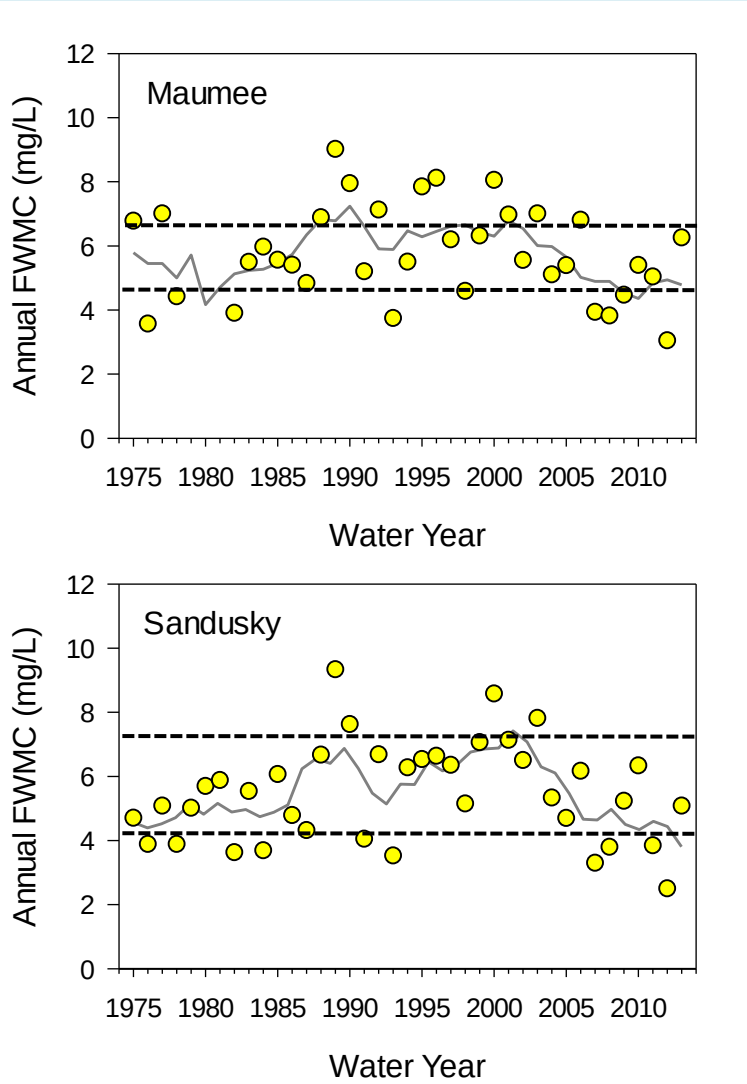


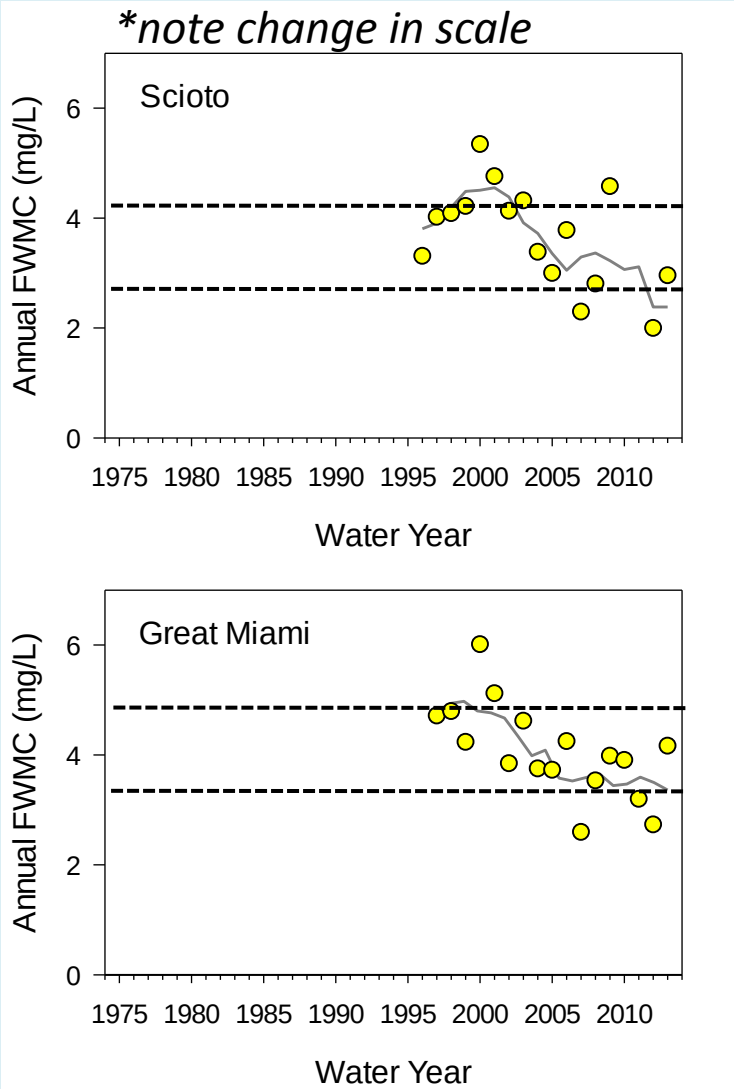
Long-term trends in nitrate concentrations



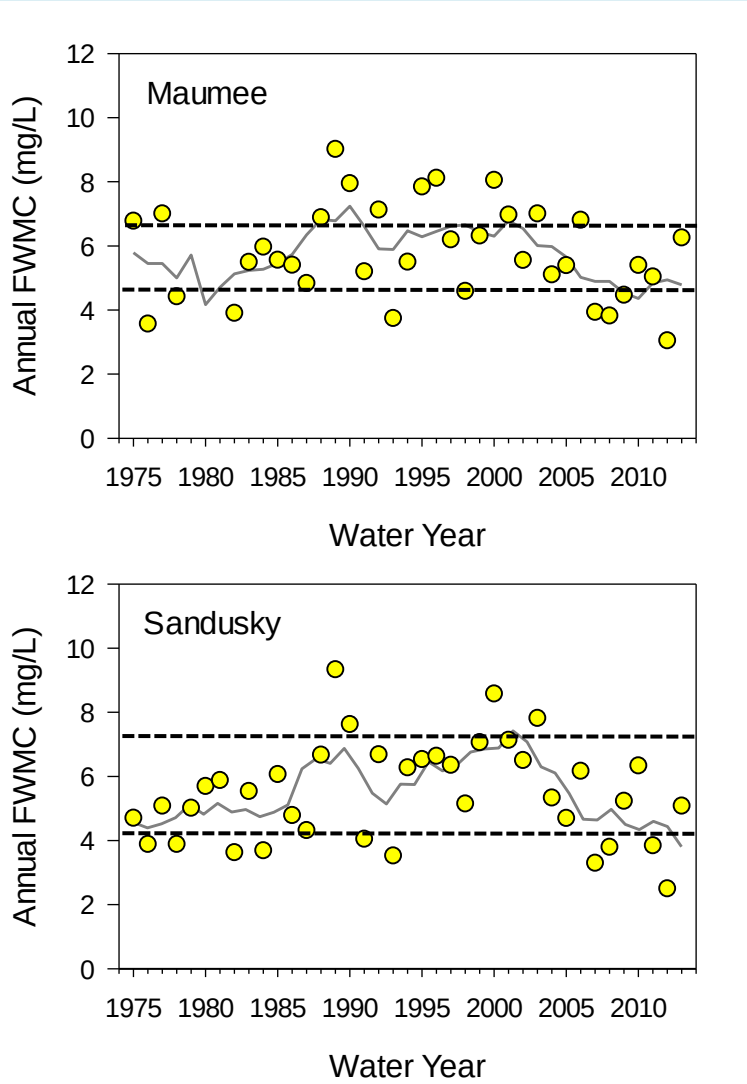
- FWMC has declined in the Maumee and Sandusky Rivers since the early 2000's

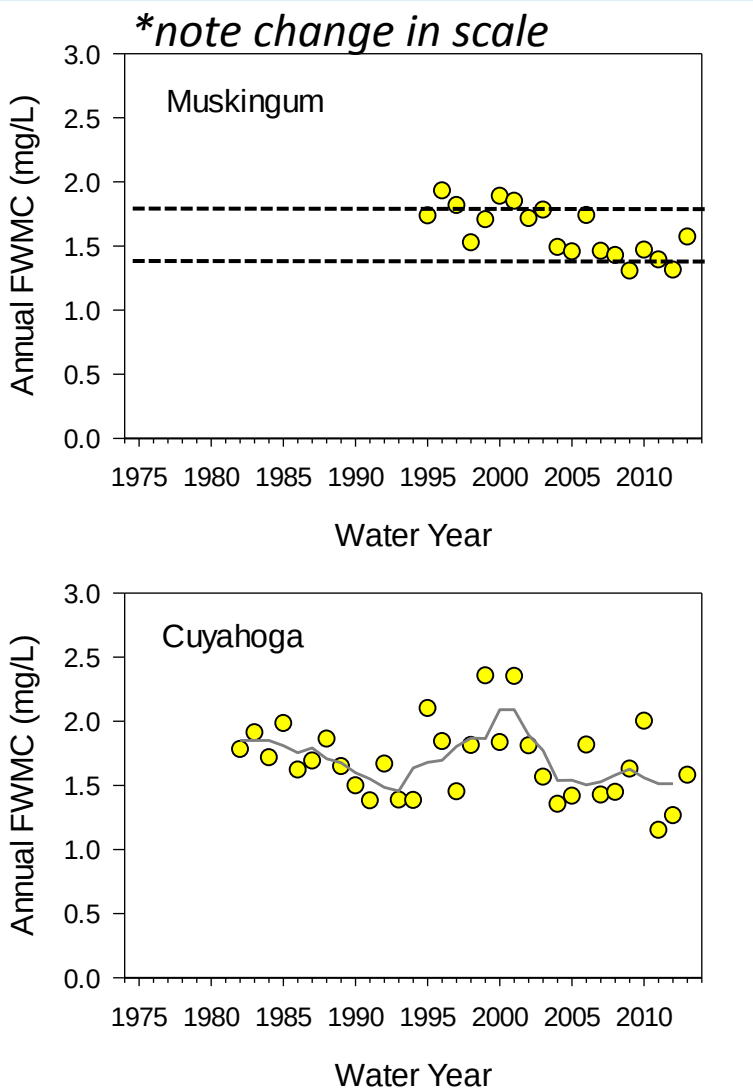
Long-term trends in nitrate concentrations



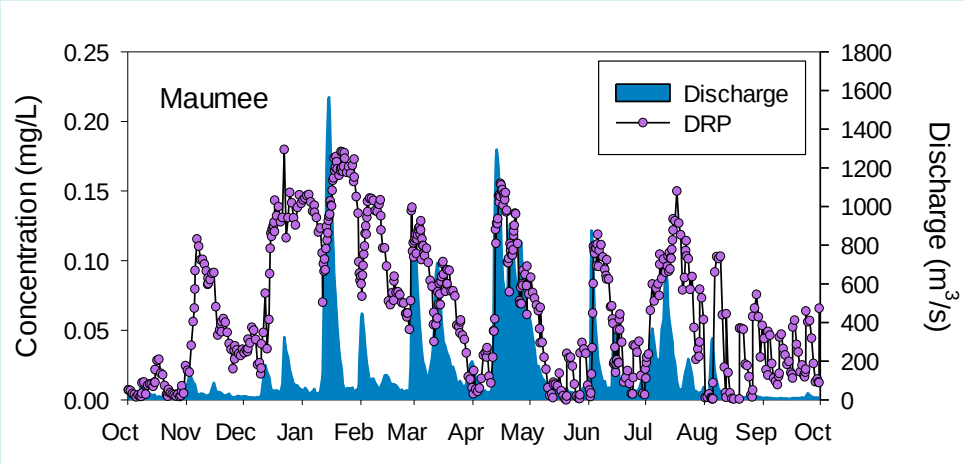


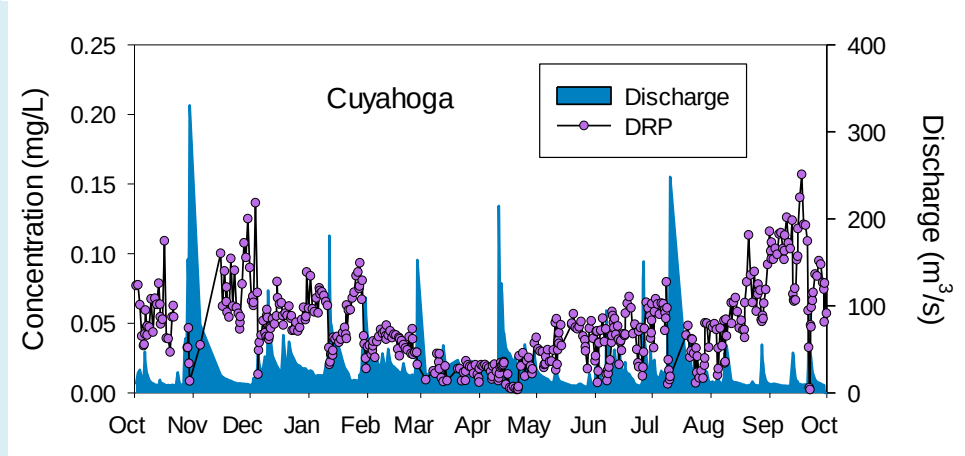
Long-term trends in nitrate concentrations

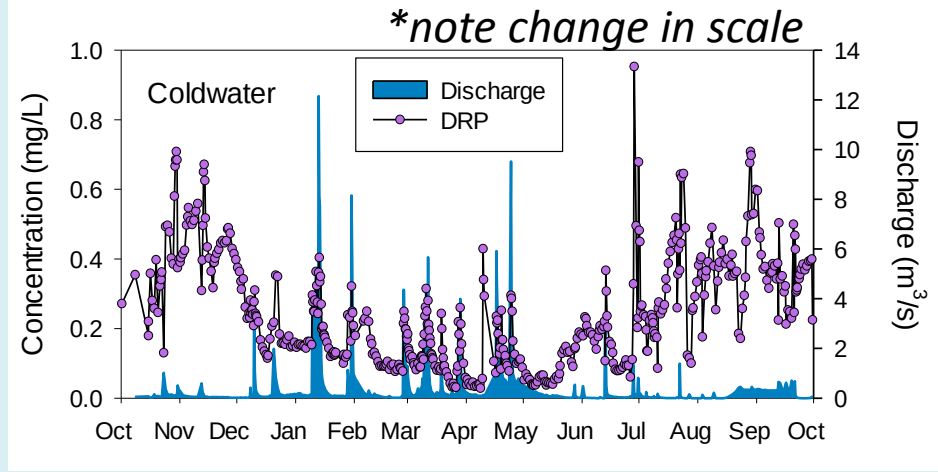




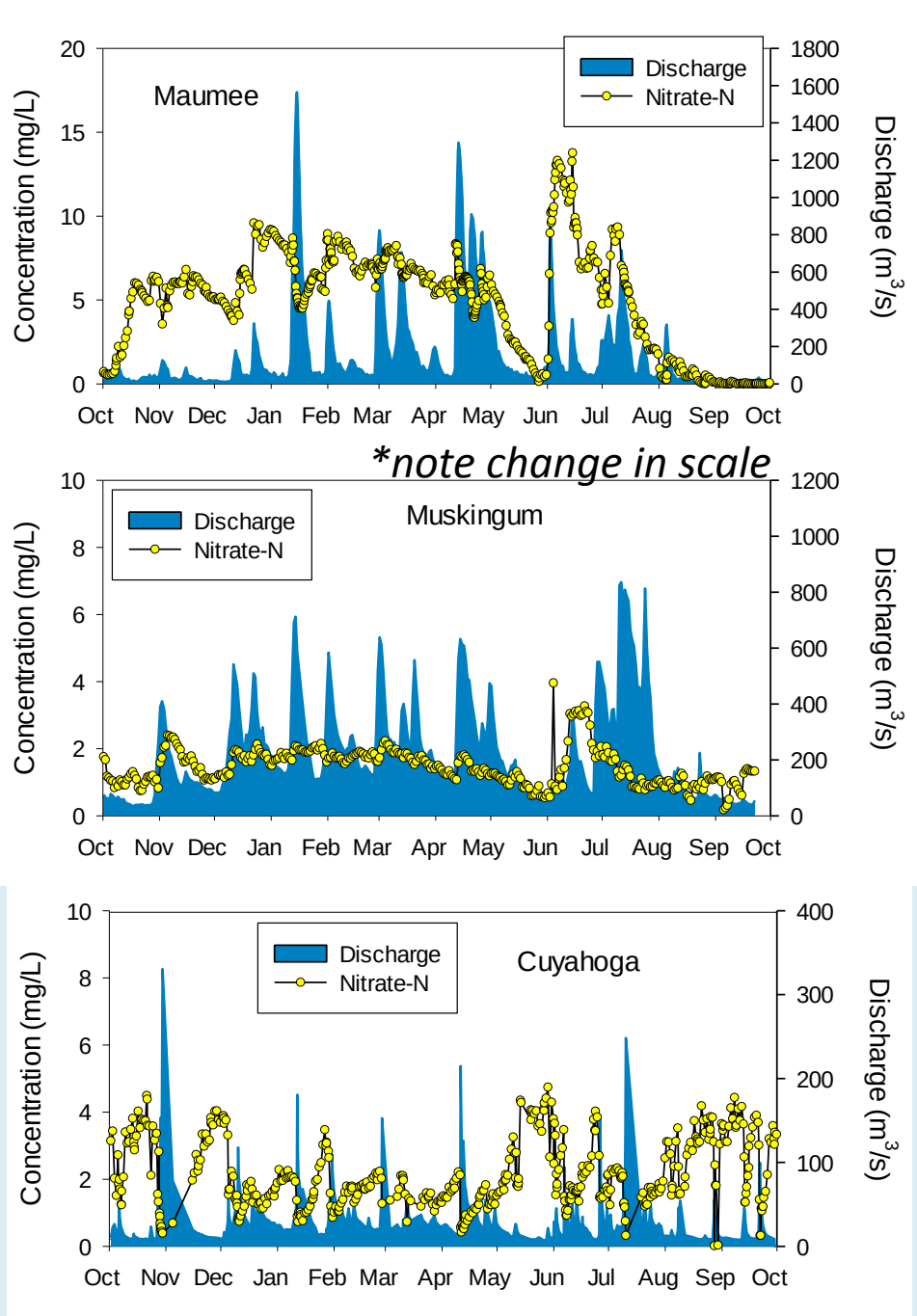
DRP chemograph







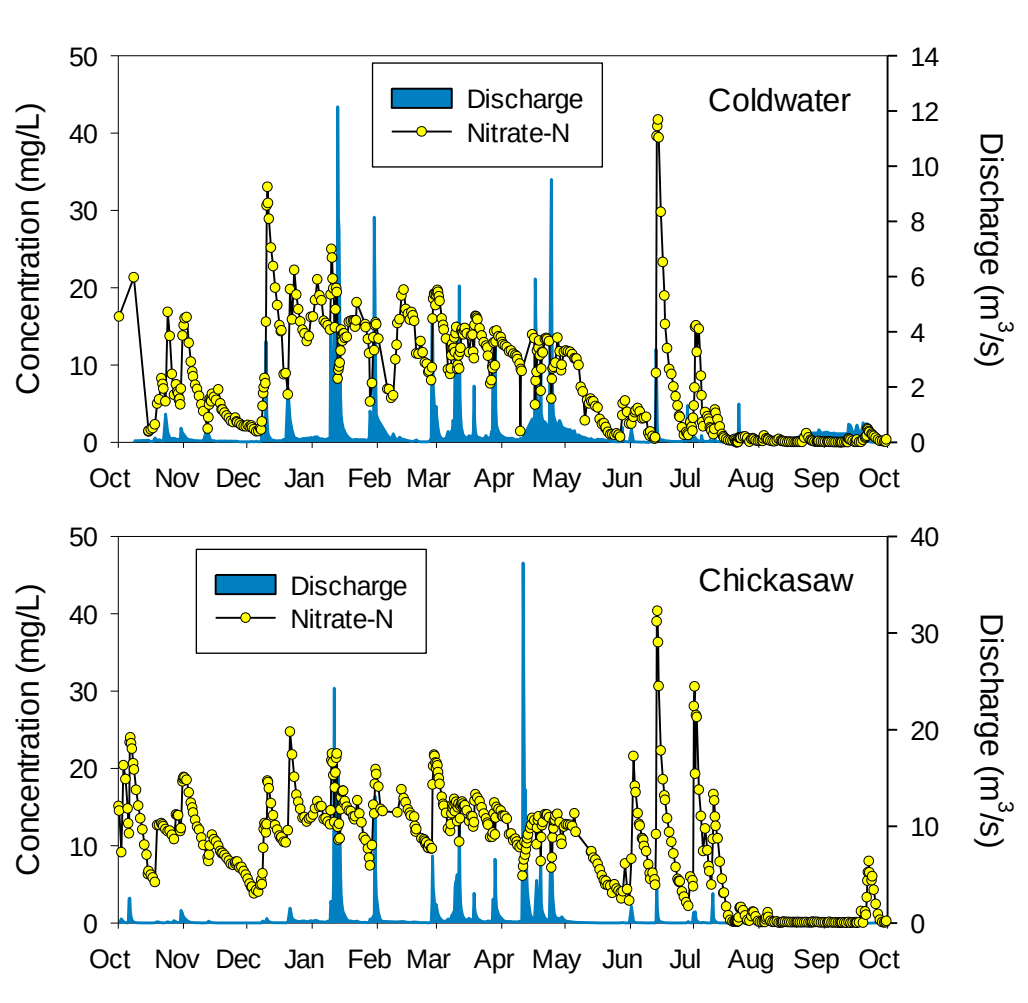
- Most agricultural rivers are similar to the Maumee
- Cuyahoga reflects point source inputs
  - As do Great Miami and Scioto
- Coldwater and Chickasaw have the highest concentrations
  - Pattern in Portage is similar but lower magnitude



Nitrate chemograph

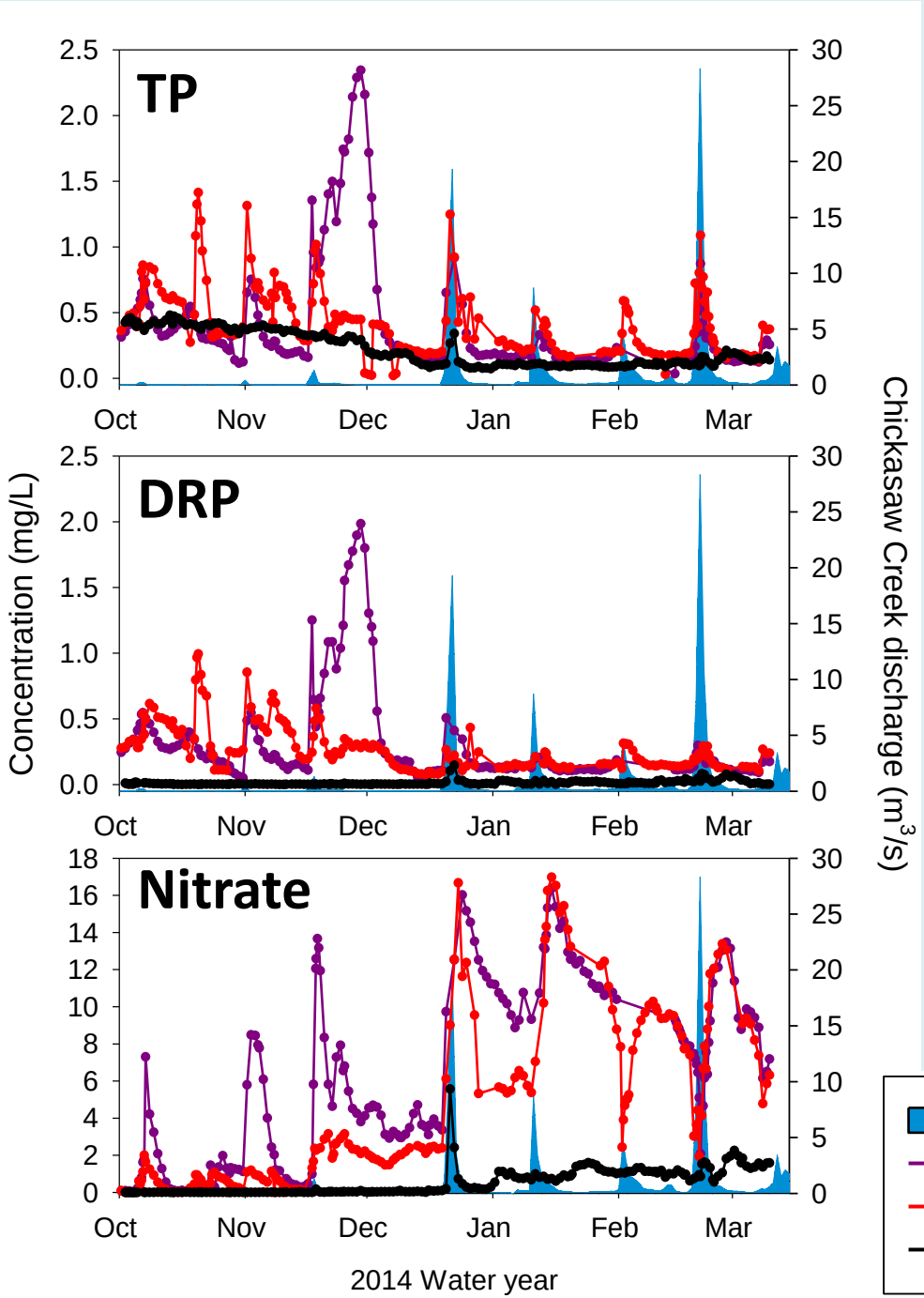
- June peaks in nitrate across all watersheds, except the Cuyahoga
- Great Miami and Scioto exhibit similar peaks reflecting mixed sources of nutrients

Nitrate chemograph



- Coldwater and Chickasaw peaks are particularly pronounced

GLSM tributaries



- Added Beaver Creek, outfall of Grand Lake St Marys in October 2013
- Thus far in WY 2014, Chickasaw and Coldwater have much higher DRP and nitrate concentrations than Beaver, TP is similar
  - Indicates substantial processing in the lake

Conclusions

- Unit area loads vary across watersheds based on specific land management practices as well as hydrology
  - Tributaries to GLSM have high loads, especially of nitrate
- Recent increases in DRP may also be occurring in watersheds outside Lake Erie, though hard to discern from point sources
- Nitrate may be decreasing across many watersheds, but patterns are still variable
  - Concentrations peak in June even in watersheds with very little agriculture

For more information visit:

http://www.heidelberg.edu/NCWQR

Or contact me at ljohnso1@heidelberg.edu

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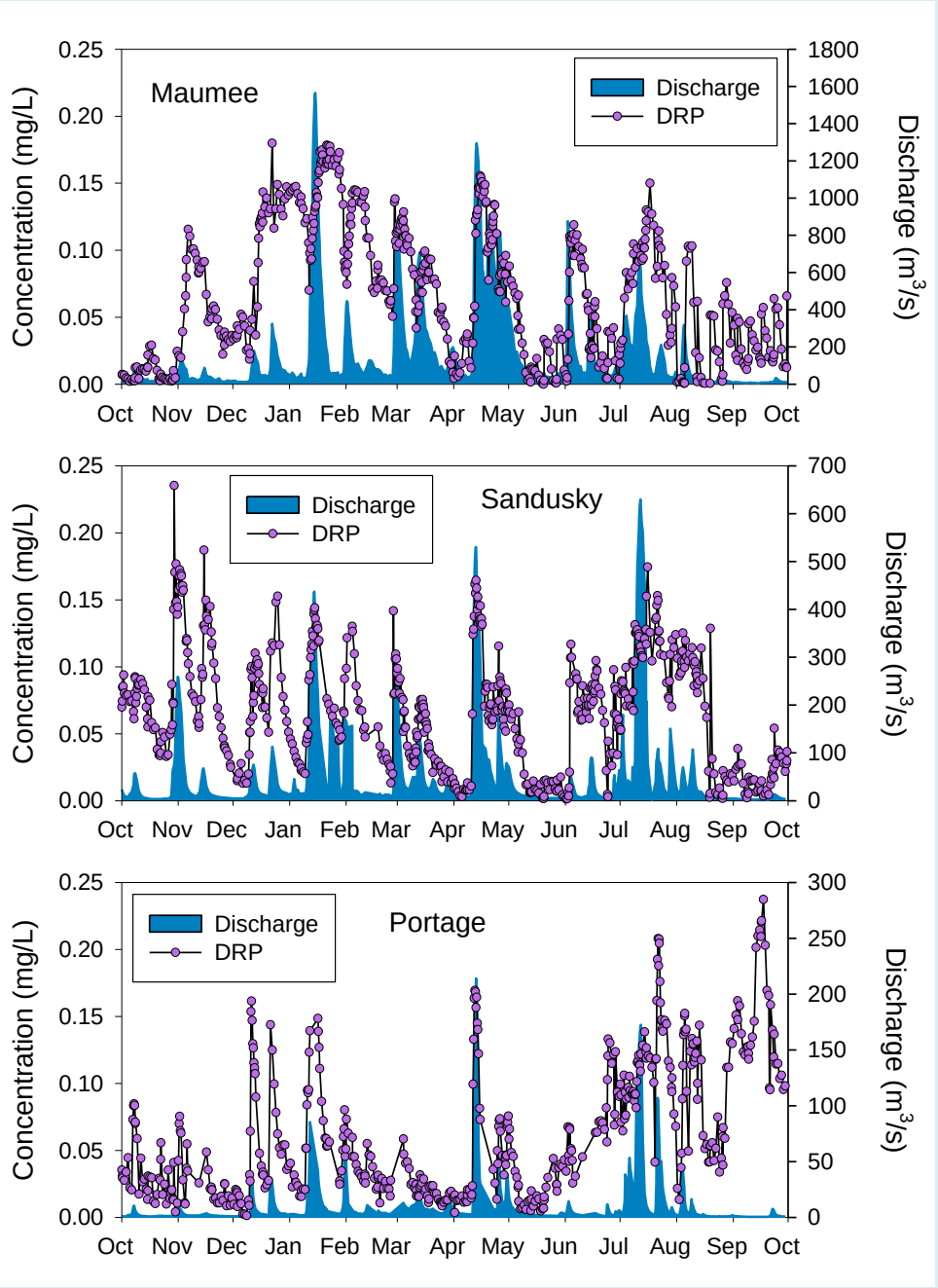
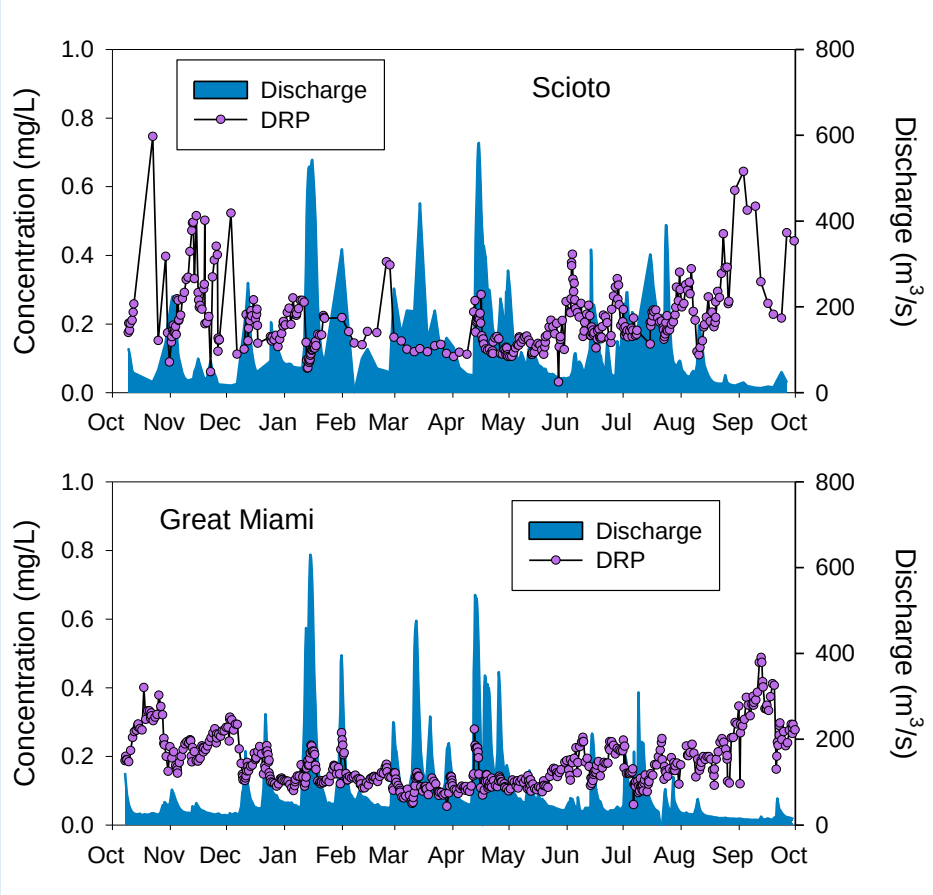
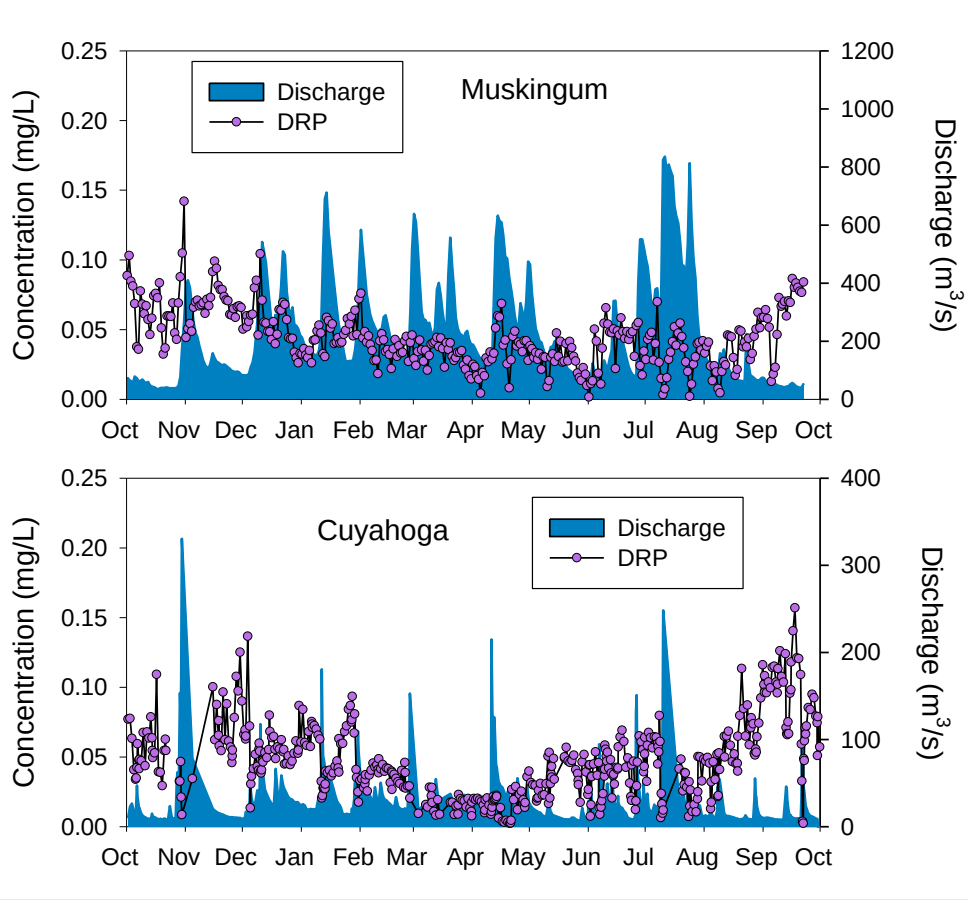
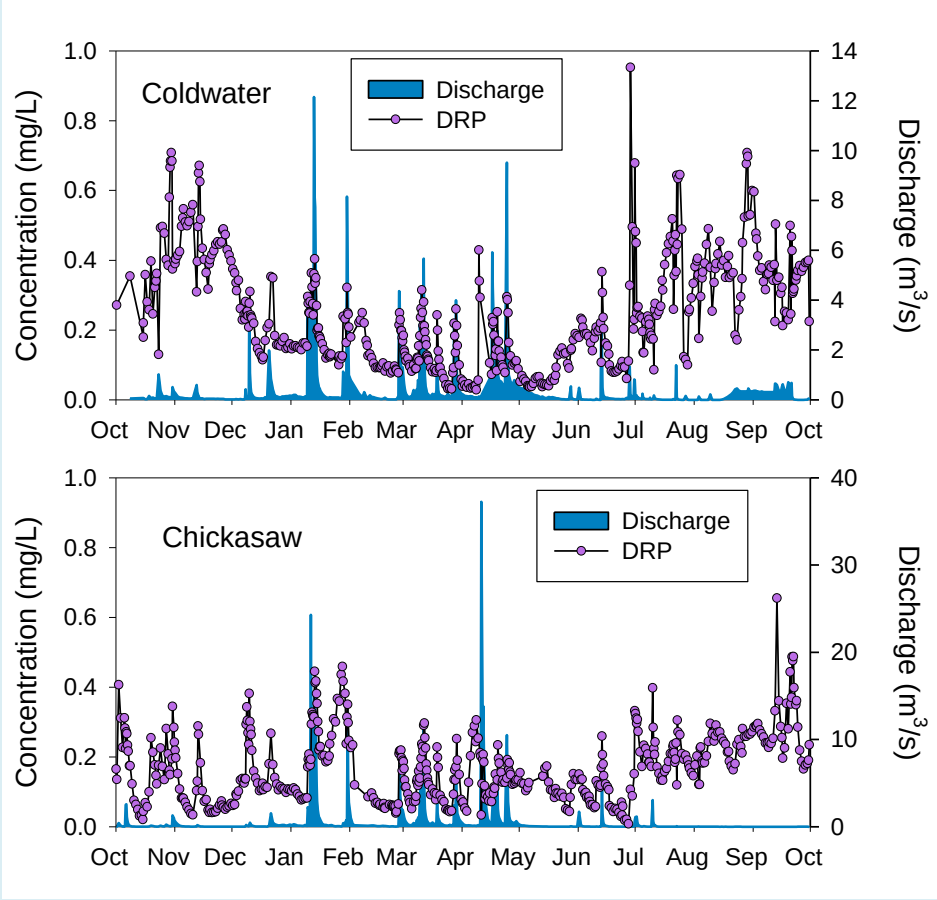
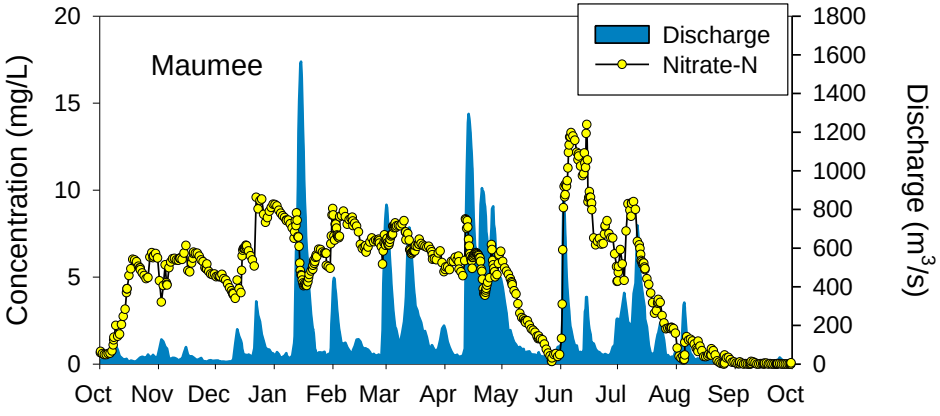
Questions?

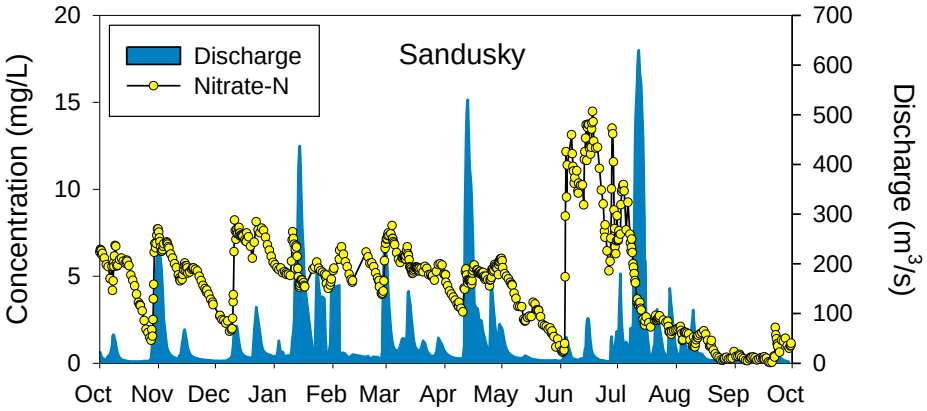

Maumee
Sandusky
Portage
Discharge
DRP
Concentration (mg/L)
Discharge (m3/s)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct

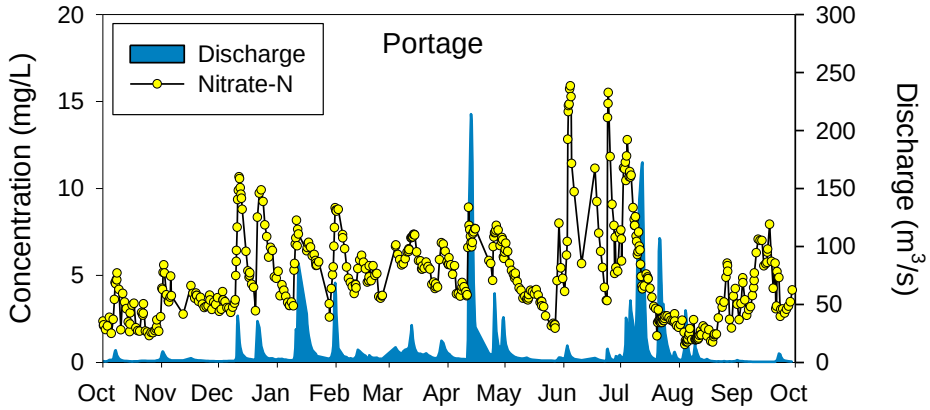

Scioto
Great Miami
Discharge
DRP
Concentration (mg/L)
Discharge (m3/s)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct

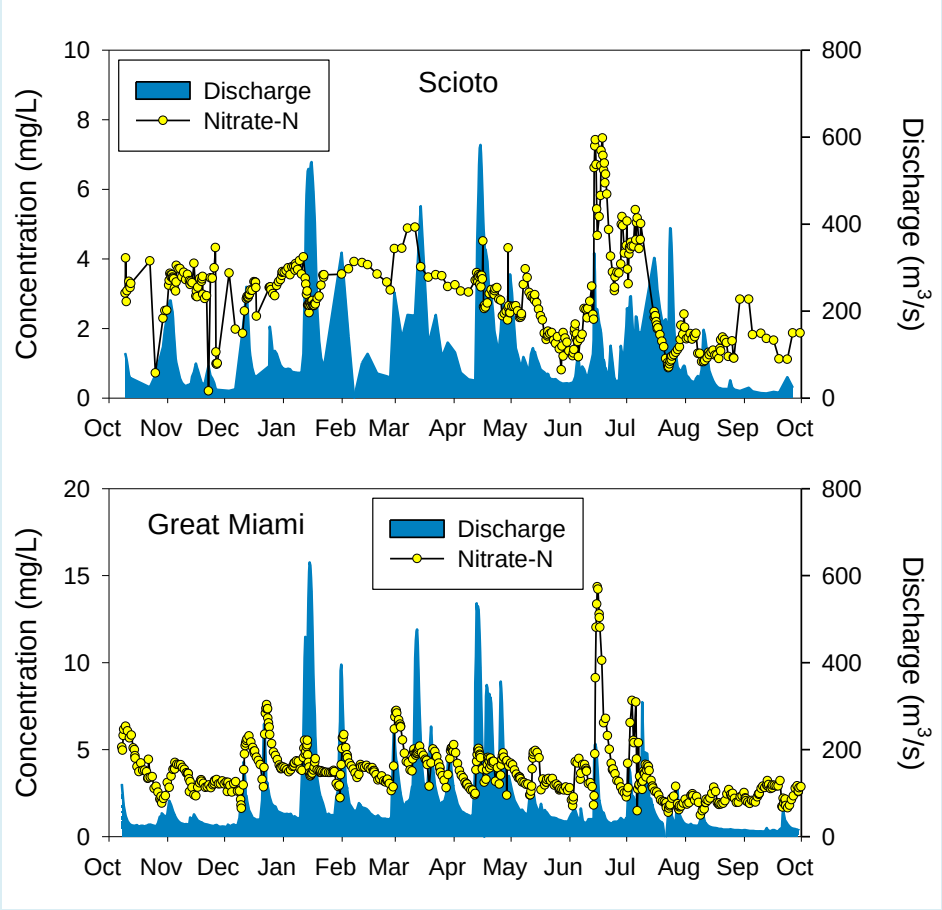

Muskingum
Discharge
DRP
Concentration (mg/L)
Discharge (m3/s)
0.25
0.20
0.15
0.10
0.05
0.00
1200
1000
800
600
400
200
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
Cuyahoga
Discharge
DRP
Concentration (mg/L)
Discharge (m3/s)
0.25
0.20
0.15
0.10
0.05
0.00
400
300
200
100
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct

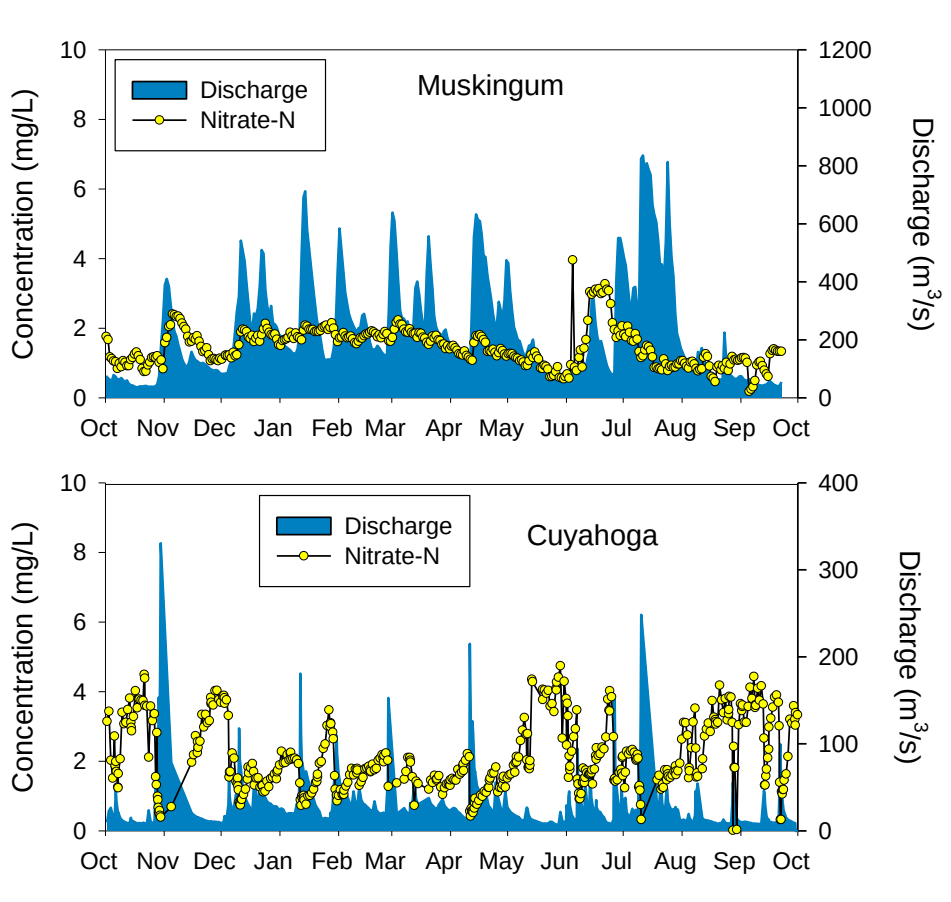

Coldwater
Discharge
DRP
Concentration (mg/L)
Discharge (m3/s)
1.0
0.8
0.6
0.4
0.2
0.0
14
12
10
8
6
4
2
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
Chickasaw
Discharge
DRP
Concentration (mg/L)
Discharge (m3/s)
1.0
0.8
0.6
0.4
0.2
0.0
40
30
20
10
0
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct

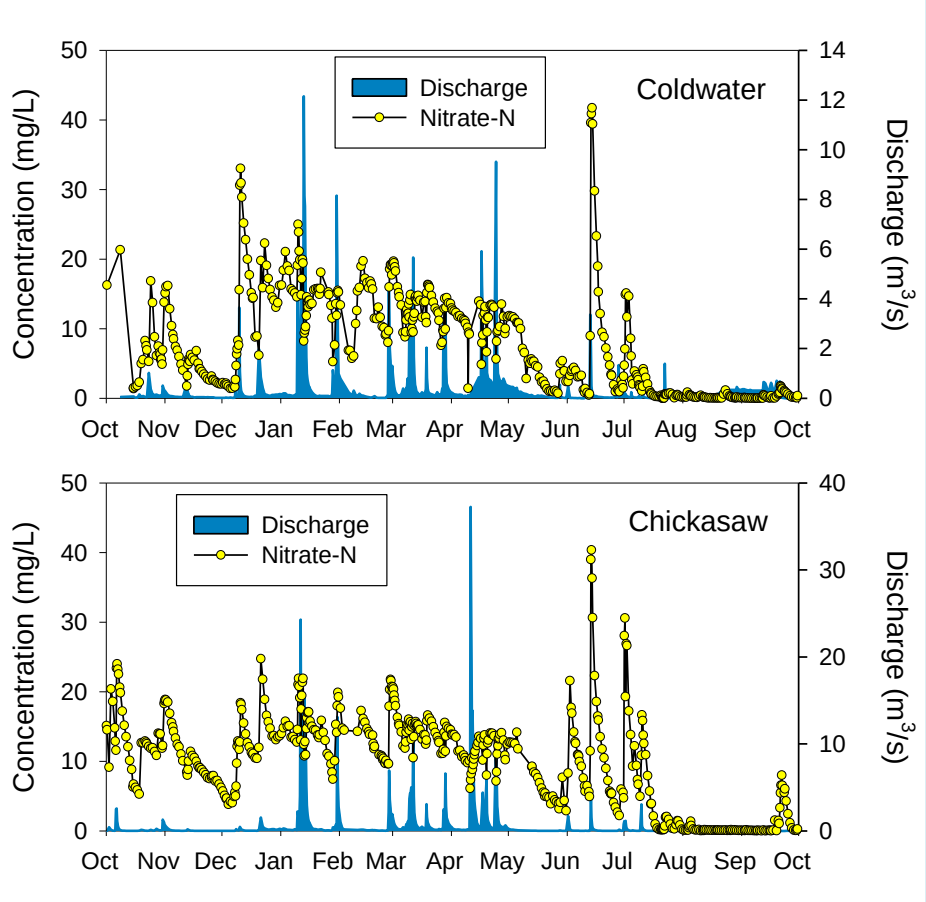

Maumee
Discharge
Nitrate-N
Concentration (mg/L)
Discharge (m3/s)
0
5
10
15
20
0
200
400
600
800
1000
1200
1400
1600
1800
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct


Sandusky
Discharge
Nitrate-N
Concentration (mg/L)
Discharge (m3/s)
0
5
10
15
20
0
100
200
300
400
500
600
700
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct


Portage
Discharge
Nitrate-N
Concentration (mg/L)
Discharge (m3/s)
0
5
10
15
20
0
50
100
150
200
250
300
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct


Scioto
Discharge
Nitrate-N
Concentration (mg/L)
Discharge (m3/s)
0
2
4
6
8
10
0
200
400
600
800
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
Great Miami
Discharge
Nitrate-N
Concentration (mg/L)
Discharge (m3/s)
0
5
10
15
20
0
200
400
600
800
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct


Muskingum
Discharge
Nitrate-N
Concentration (mg/L)
Discharge (m3/s)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
Cuyahoga
Discharge
Nitrate-N
Concentration (mg/L)
Discharge (m3/s)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct


Coldwater
Discharge
Nitrate-N
Concentration (mg/L)
Discharge (m3/s)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct
Chickasaw
Discharge
Nitrate-N
Concentration (mg/L)
Discharge (m3/s)
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct