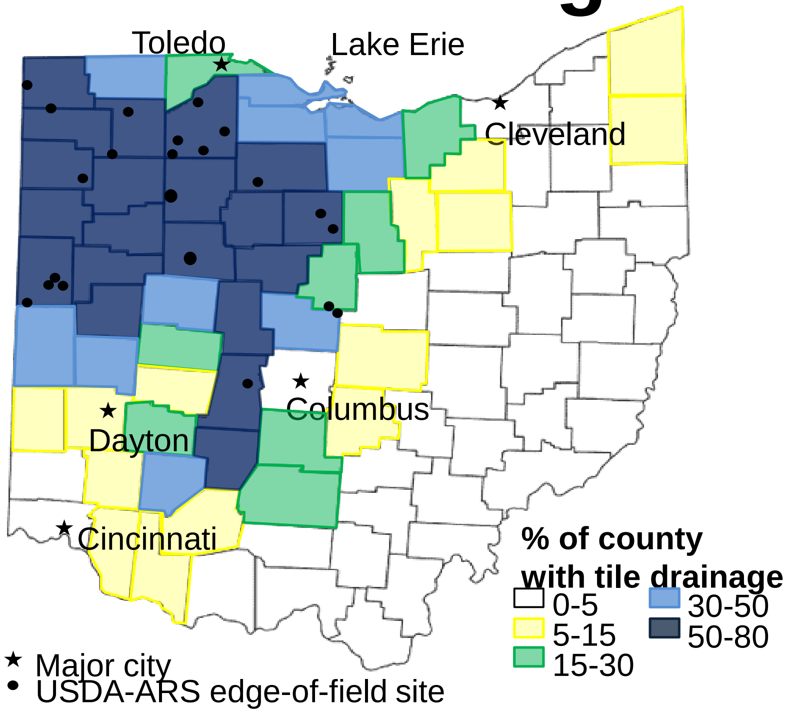
Instrumentation, Measurement and Findings from the USDA-ARS Edge-of-Field Research Network

Kevin W. King
USDA-Agricultural Research Service
Soil Drainage Research Unit
Columbus, OH

USDA-ARS edge-of-field network in Ohio



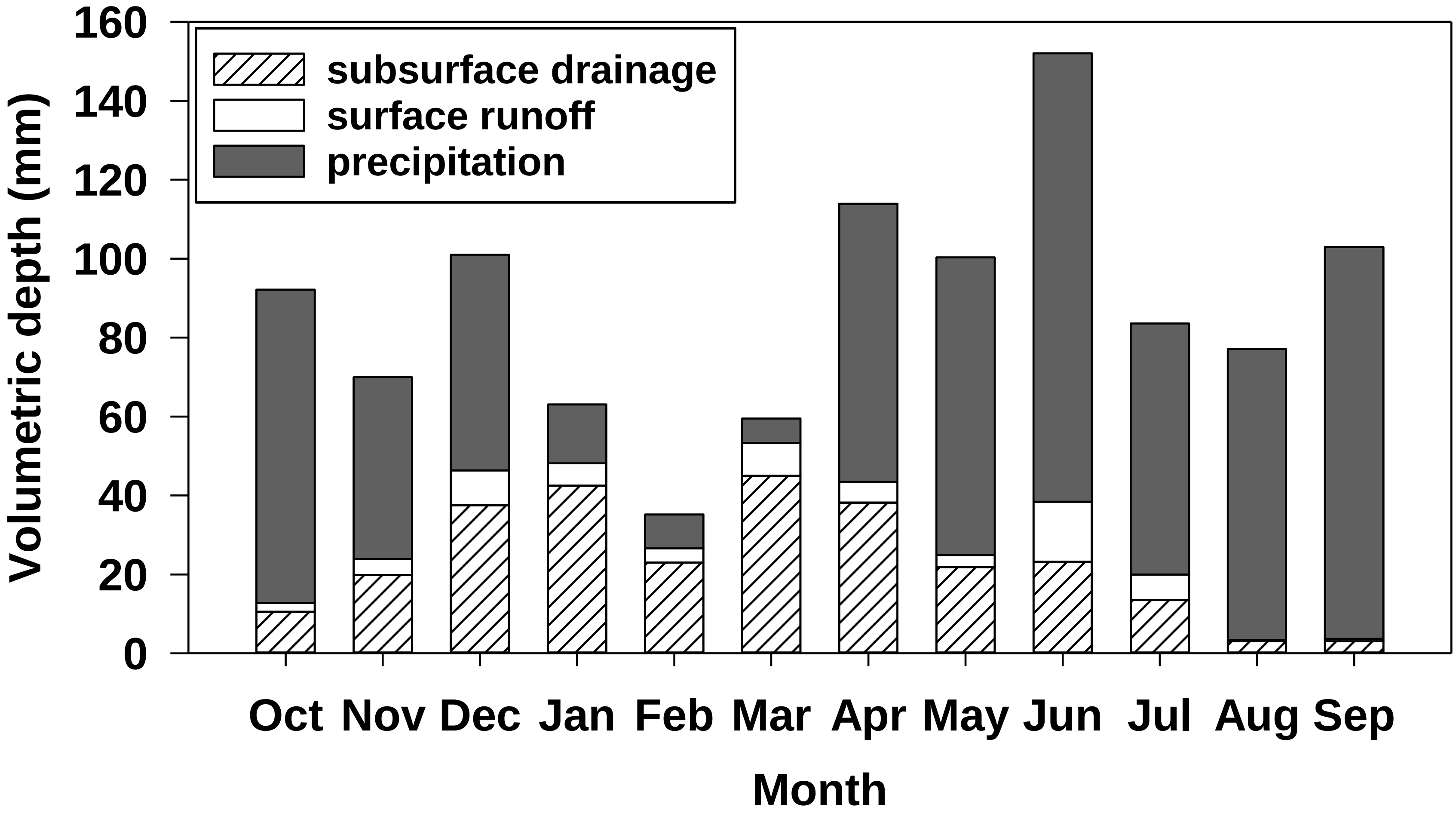
By the numbers

- 40 paired fields located on 20 farms
- ~90 automated Isco samplers
- Over 166 site years of data (surface & subsurface)

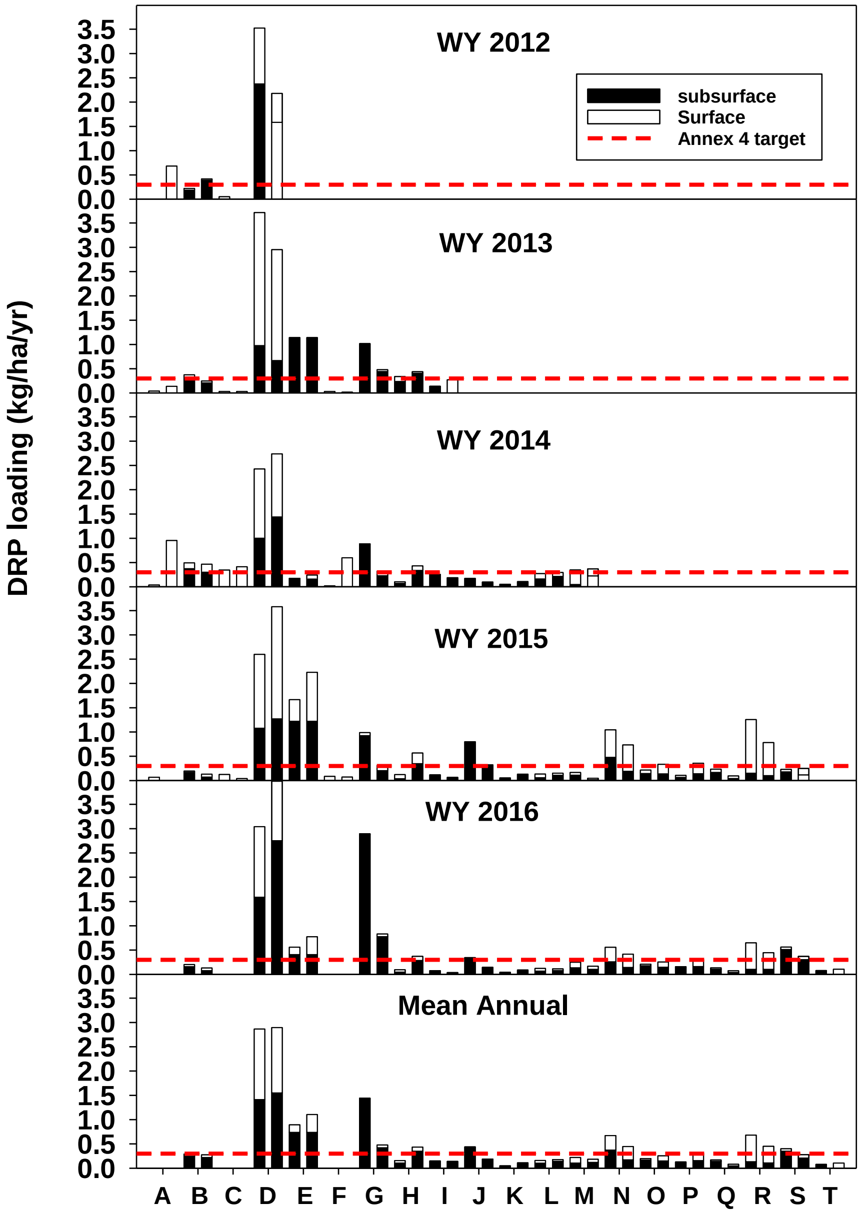
Typical edge-of-field site

Williams et al. 2016. J. Soil Water Conserv. 71:9-12

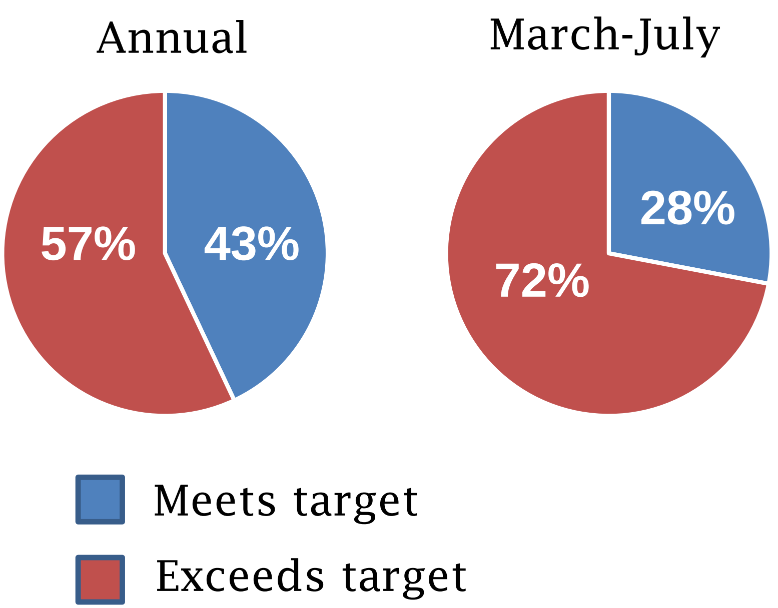
Discharge



subsurface drainage
surface runoff
precipitation
Volumetric depth (mm)
0
20
40
60
80
100
120
140
160
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Month

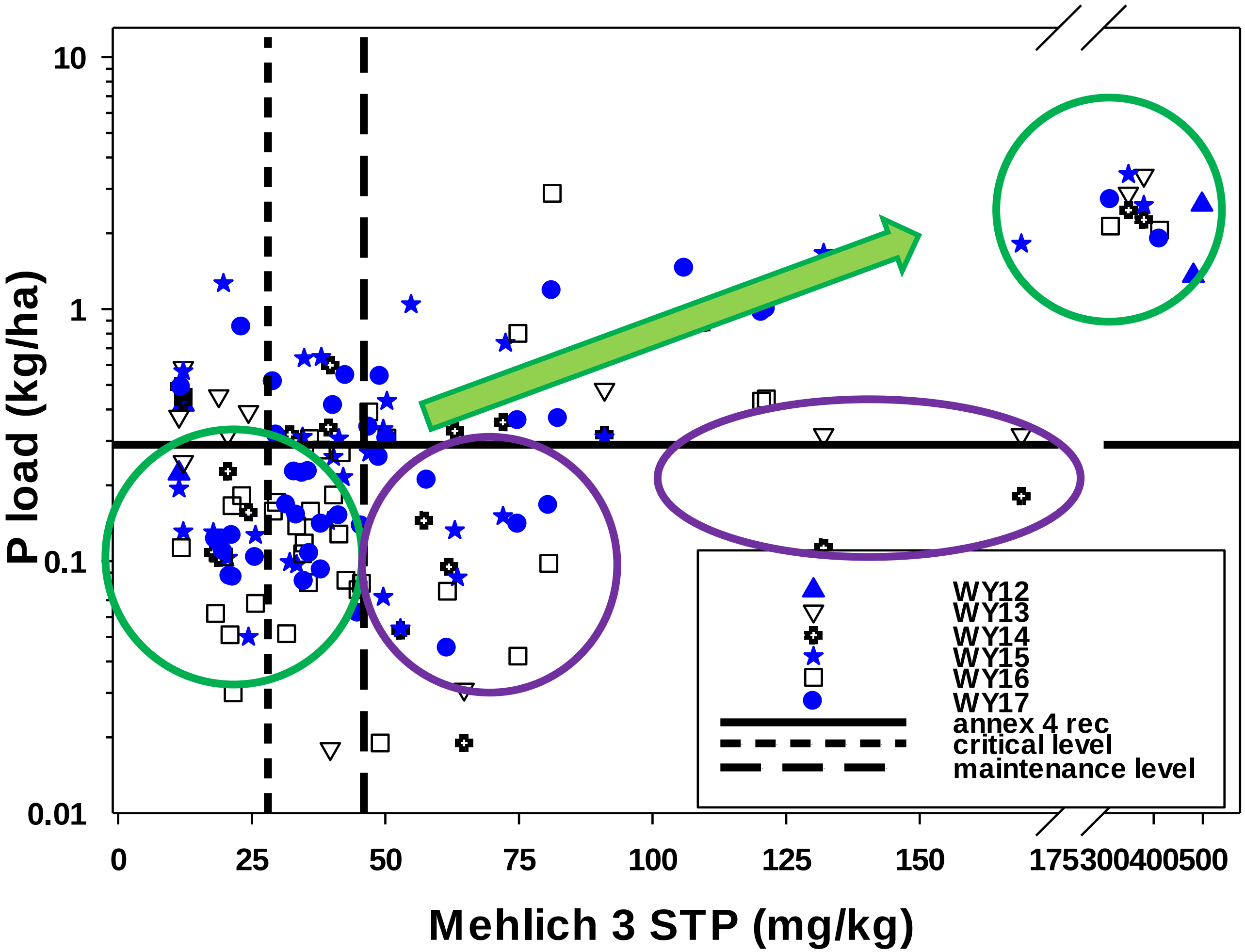


---- If 40% load reduction was applied to entire Maumee Basin



73±26% of total DRP load was from tile drainage

Soil Test P vs Environmental Risk



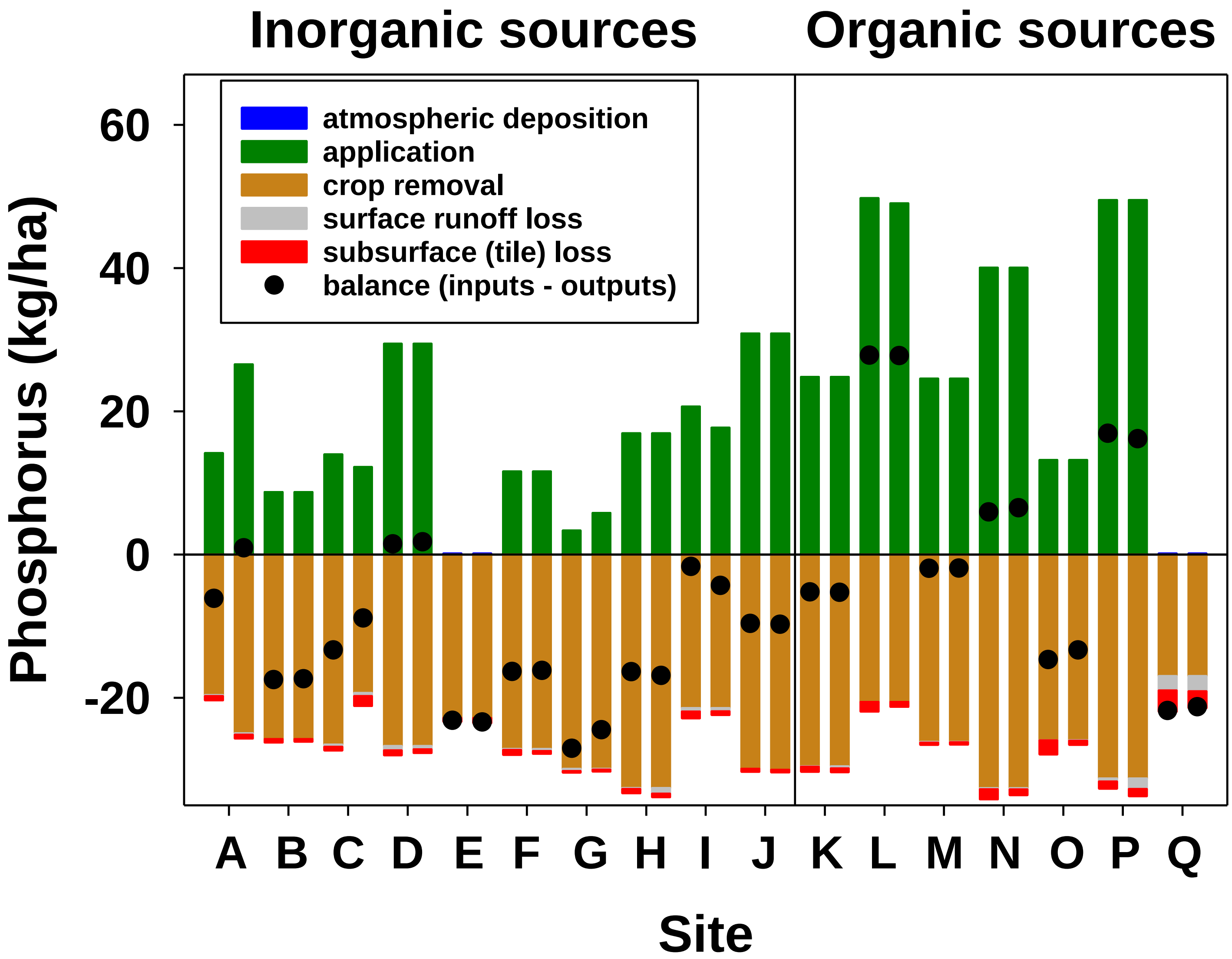
Soil Test P above **agronomic rates** poses an **environmental risk**

BUT **Soil Test P above agronomic rates** does **NOT** equal **environmental risk**

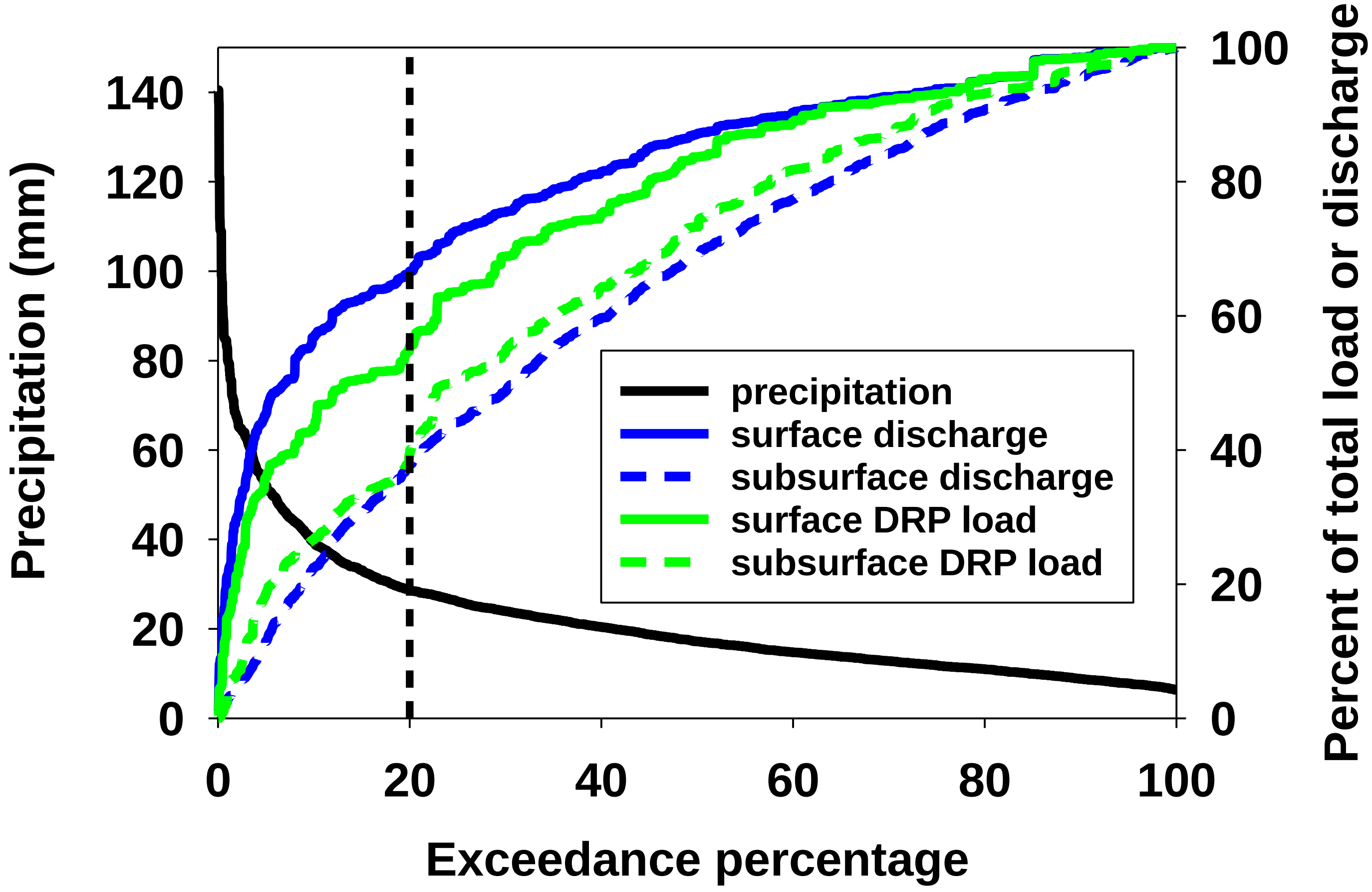
King et al., 2018

Duncan et al., 2017

P balances


Inorganic sources
Organic sources
atmospheric deposition
application
crop removal
surface runoff loss
subsurface (tile) loss
balance (inputs - outputs)
Phosphorus (kg/ha)
60
40
20
0
-20
A B C D E F G H I J K L M N O P Q
Site

Weather plays a major role



Precipitation and Discharge Volume

Statistical Analysis of Event Magnitude

Size of surface runoff events tied to the size of the rainfall event

Larger rainfall event = larger runoff event

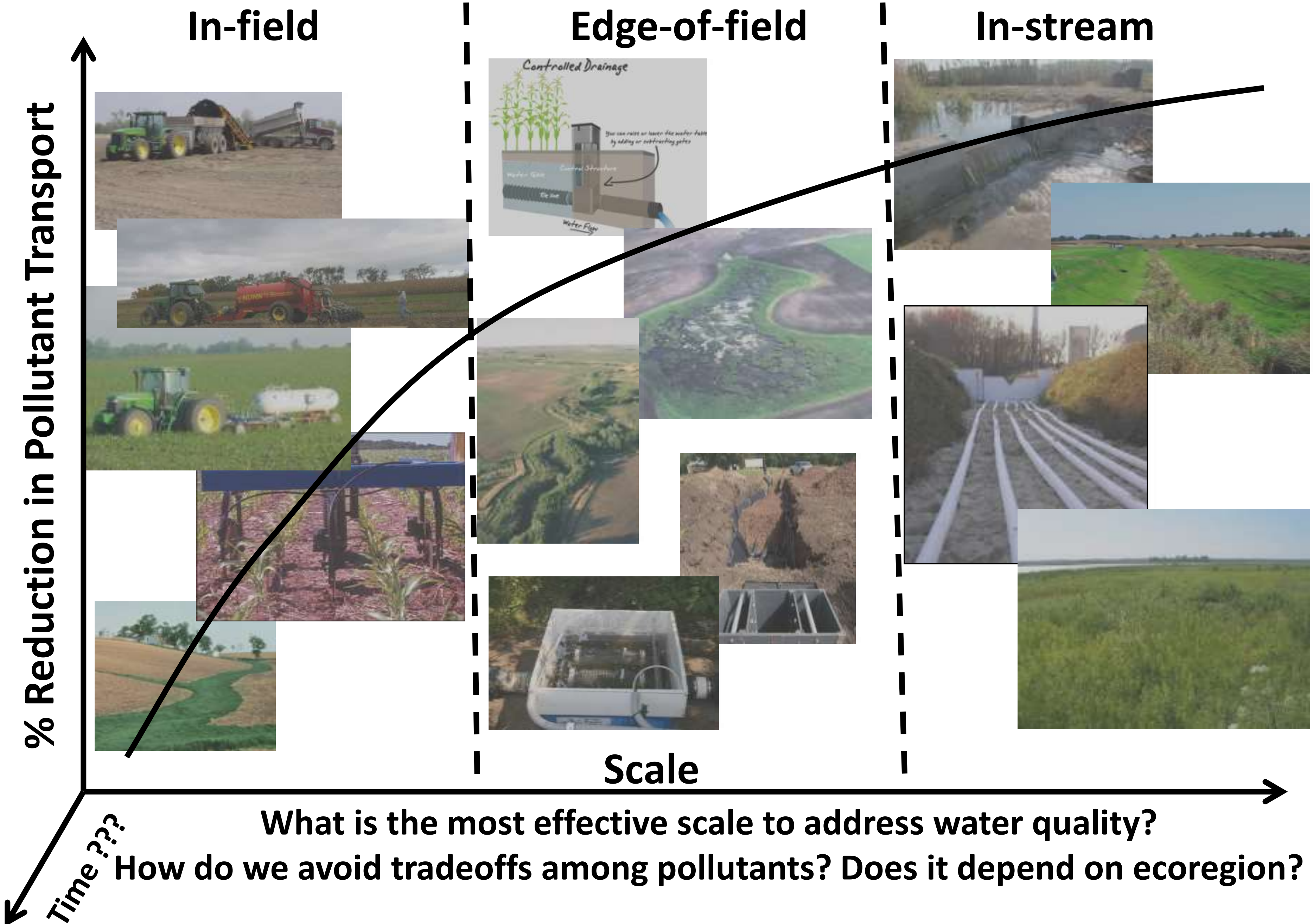
Size of tile discharge event tied to antecedent conditions

Higher flows associated with:

- Consecutive rainfall events within 48-h

Lower flows associated with:

- Single events and short duration events


In-field
Edge-of-field
In-stream
% Reduction in Pollutant Transport
Controlled Drainage
Scale
Time ???
What is the most effective scale to address water quality?
How do we avoid tradeoffs among pollutants? Does it depend on ecoregion?

Treatment practices

In-field

- 4Rs (source, rate, time, placement)
  - Organic vs inorganic
  - Zero P, half-rate, full-rate
  - Fall vs spring
  - Surface vs subsurface
- Gypsum as a surface amendment
- Cover crop vs no cover crops
- Crop rotation

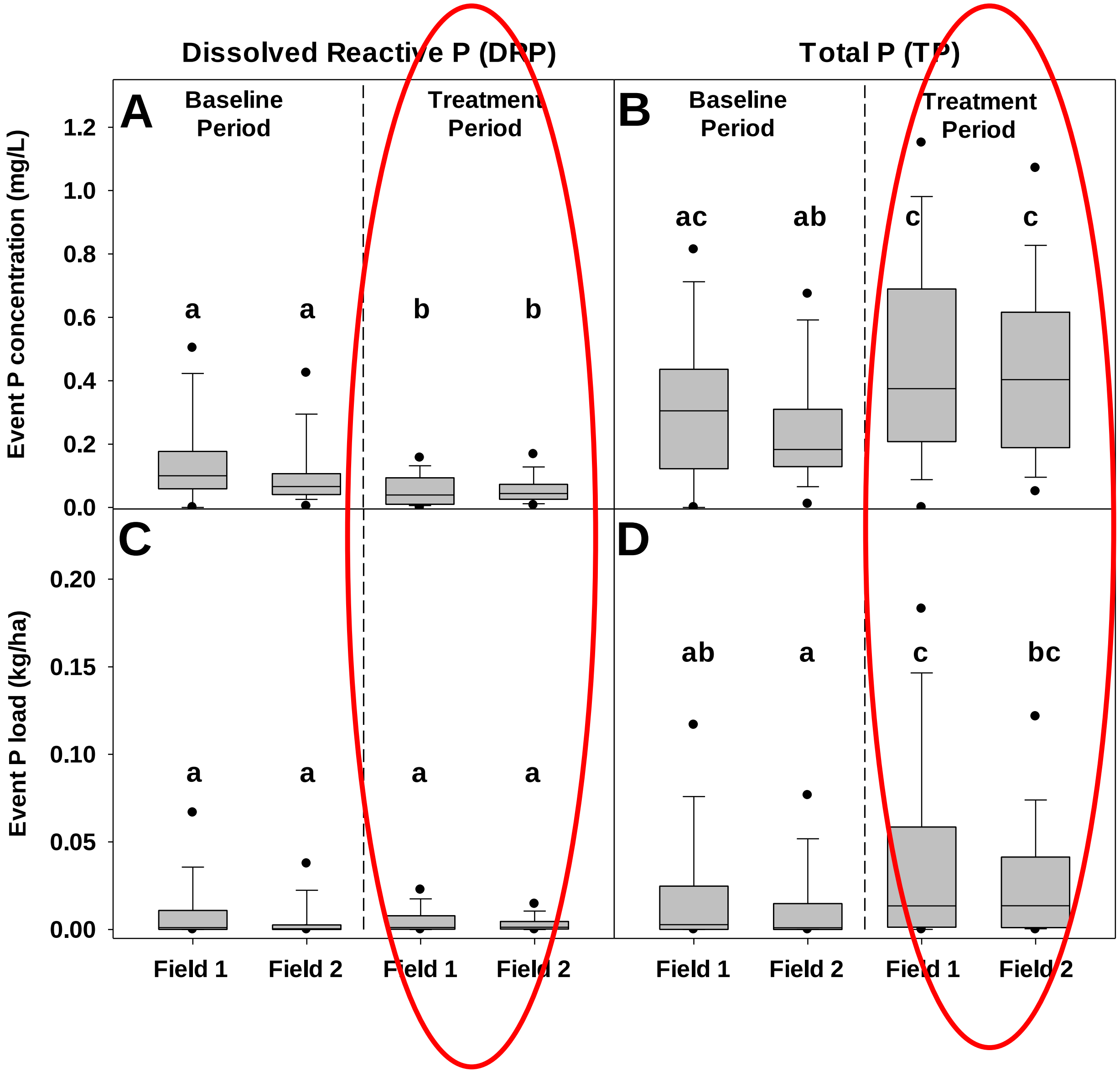
Edge-of-field

- Drainage water management
- Woodchip bioreactors and P filters

In-stream

- Two-stage ditch design

Fertilizer Source



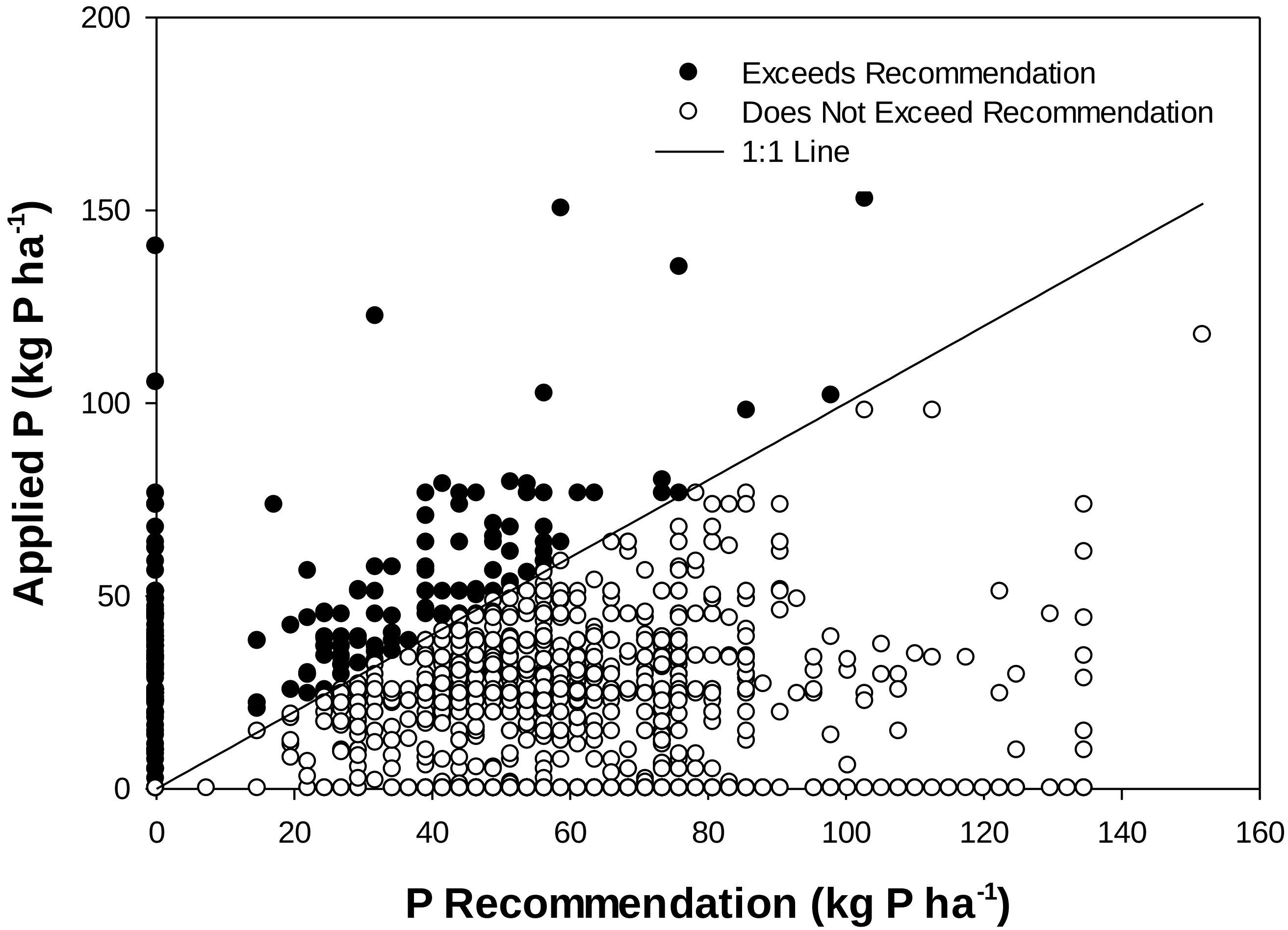
Field 1: Liquid dairy manure

Field 2: MAP

Ohio – Crop Rotation Application Rates

90% of fields have P application at or below recommendations

58% of fields had zero P applied

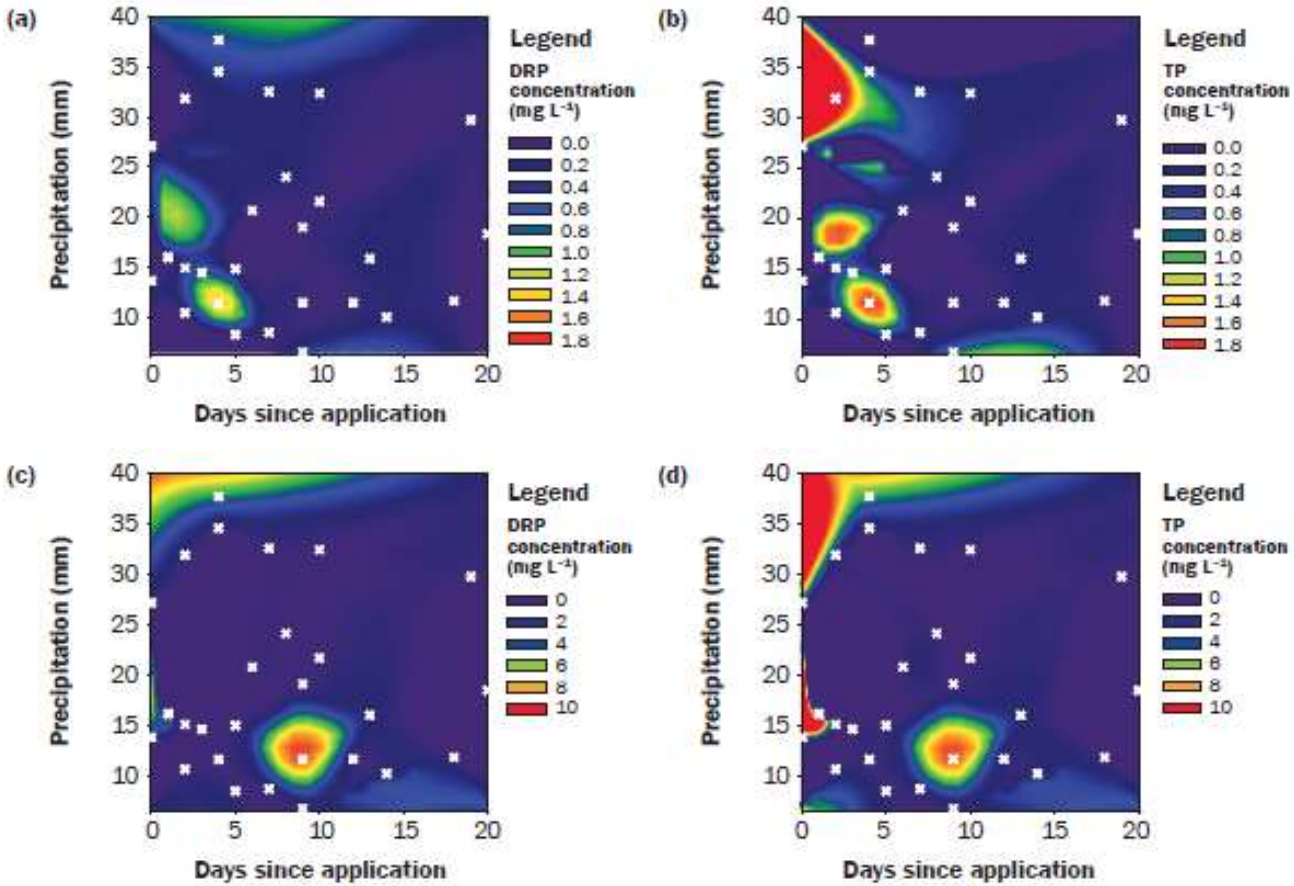


Provided by Doug Smith

P losses and time of application

Tile drainage

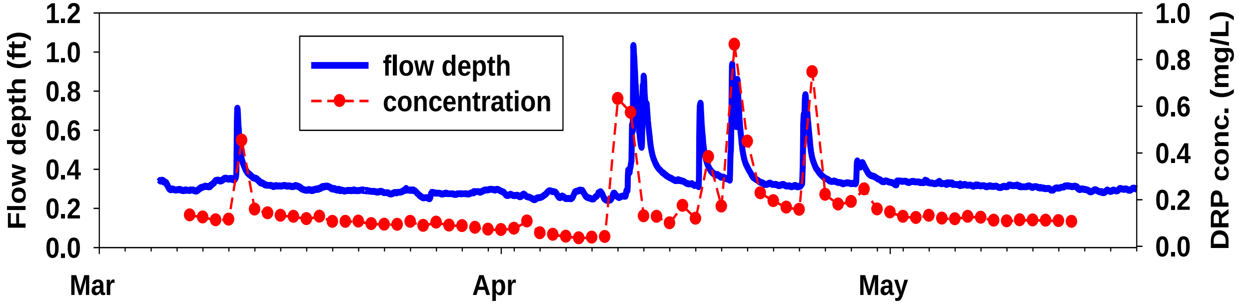
Surface runoff

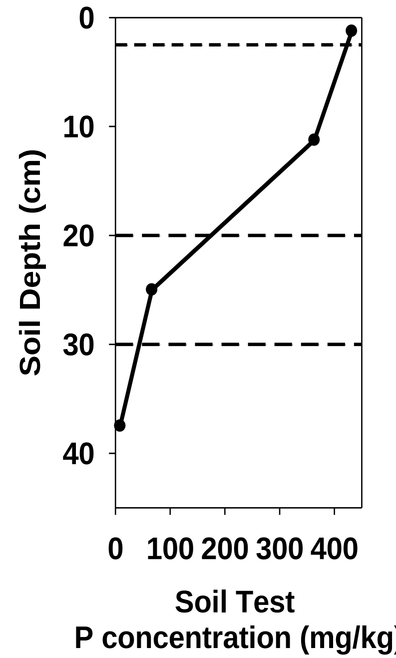


- Greater potential for losses when application is followed shortly by precipitation

King et al., 2018

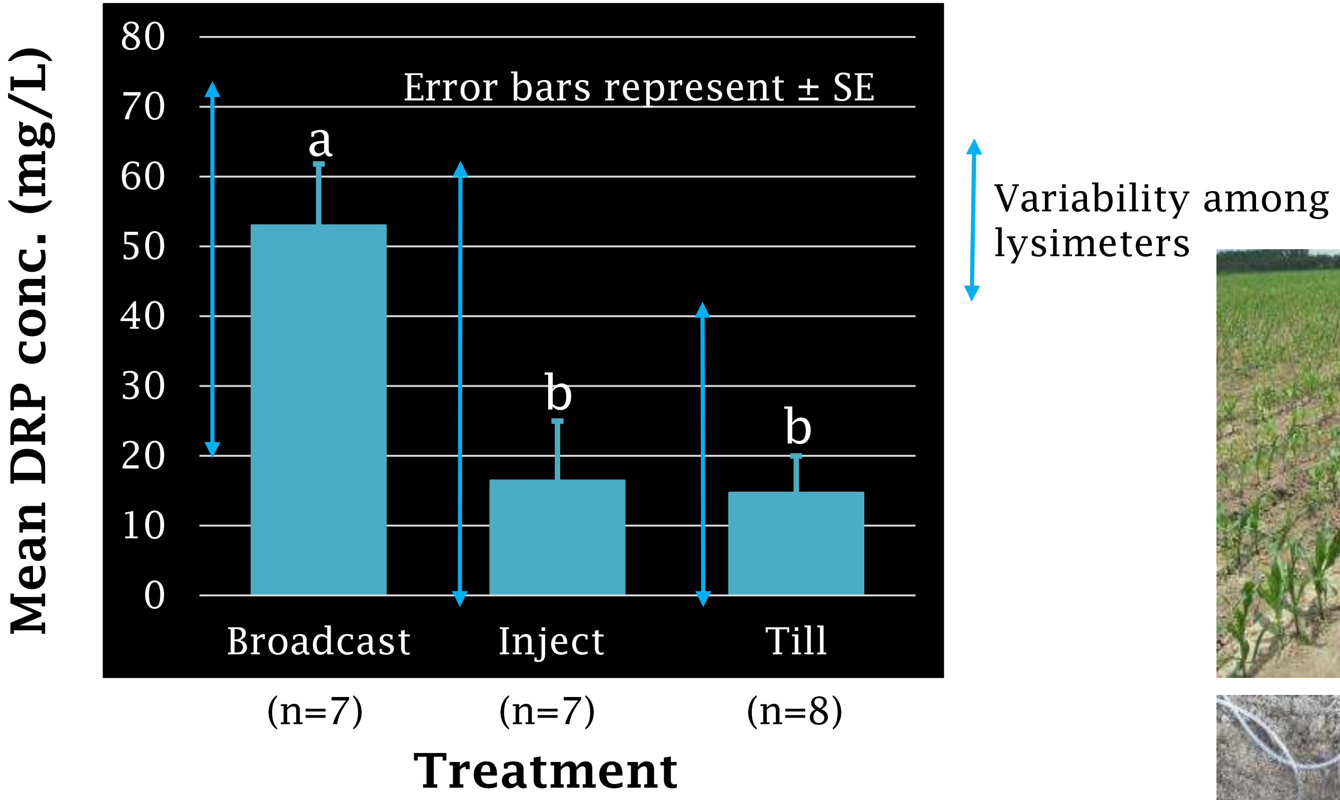
Evidence of Preferential Flow





Positive correlation between peaks in P concentrations and tile discharge indicate fast flow processes (preferential flow) and connection to surface sources

P losses and fertilizer placement

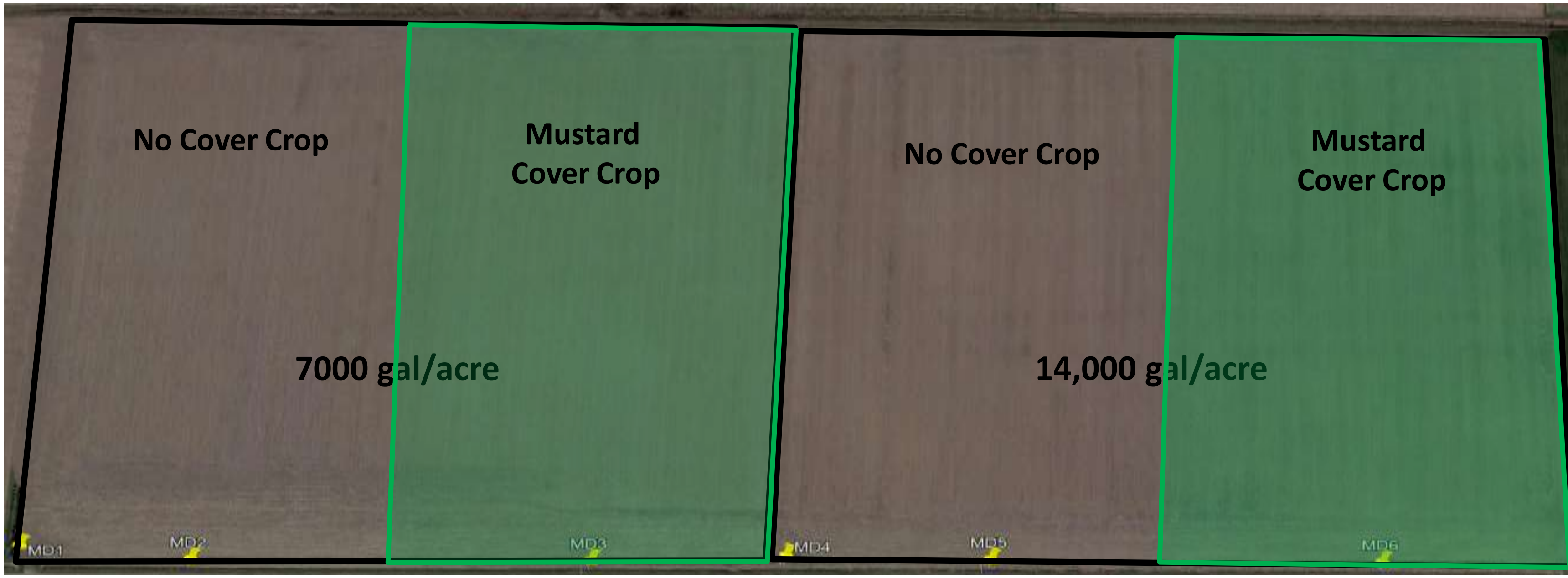


Williams et al., 2018

Cover/catch Crop x Rate study

7/6/2017: 7000 gal/ac liquid dairy manure (15.3,5.4,13.5)

7/31/2017: 7000 gal/ac liquid dairy manure (15.3,5.4,13.5)



	Precipitation (inches)	Discharge (inches)	NO3-N (lbs/ac)	DRP (lbs/ac)	Discharge (inches)	NO3-N (lbs/ac)	DRP (lbs/ac)	Discharge (inches)	NO3-N (lbs/ac)	DRP (lbs/ac)	Discharge (inches)	NO3-N (lbs/ac)	DRP (lbs/ac)
Oct	2.94	0.84	3.92	0.04	0.20	1.16	0.00	0.25	1.07	0.00	0.09	0.32	0.00
Nov	5.87	1.74	10.69	0.08	0.70	1.34	0.01	1.83	20.49	0.02	1.19	1.60	0.01
Dec	0.32	0.20	0.27	0.01	0.08	0.04	0.00	0.05	0.06	0.00	0.20	0.00	0.00
Total	9.13	2.77	14.87	0.12	0.98	2.54	0.01	2.12	21.62	0.02	1.48	1.92	0.01

Preliminary data suggests: Rate and cover crop have a significant impact on NO3-N tile drainage losses but no effect on DRP

Ground Cover and Discharge Volume

Statistical Analysis of Event Magnitude

Grass-type crops associated with lower tile discharge

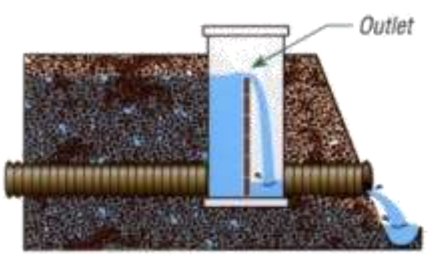
- Includes corn, wheat, forage grasses, and grass-type cover crops

Ground cover had less of an effect on event size than rainfall characteristics

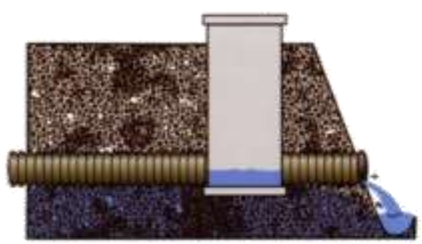
Edge of Field Practices

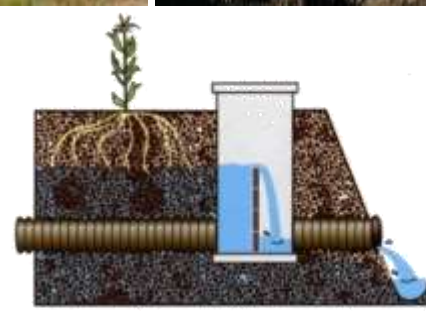
Drainage Water Management (DWM)

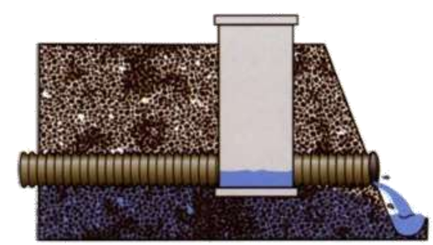


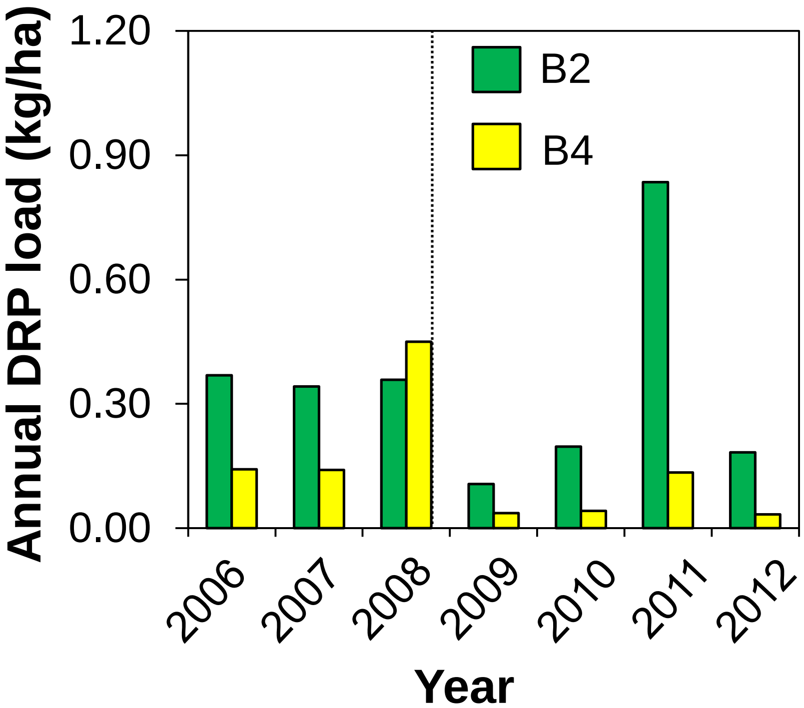
Non-Growing Season


Planting


Growing Season


Harvest

DWM - Case Study

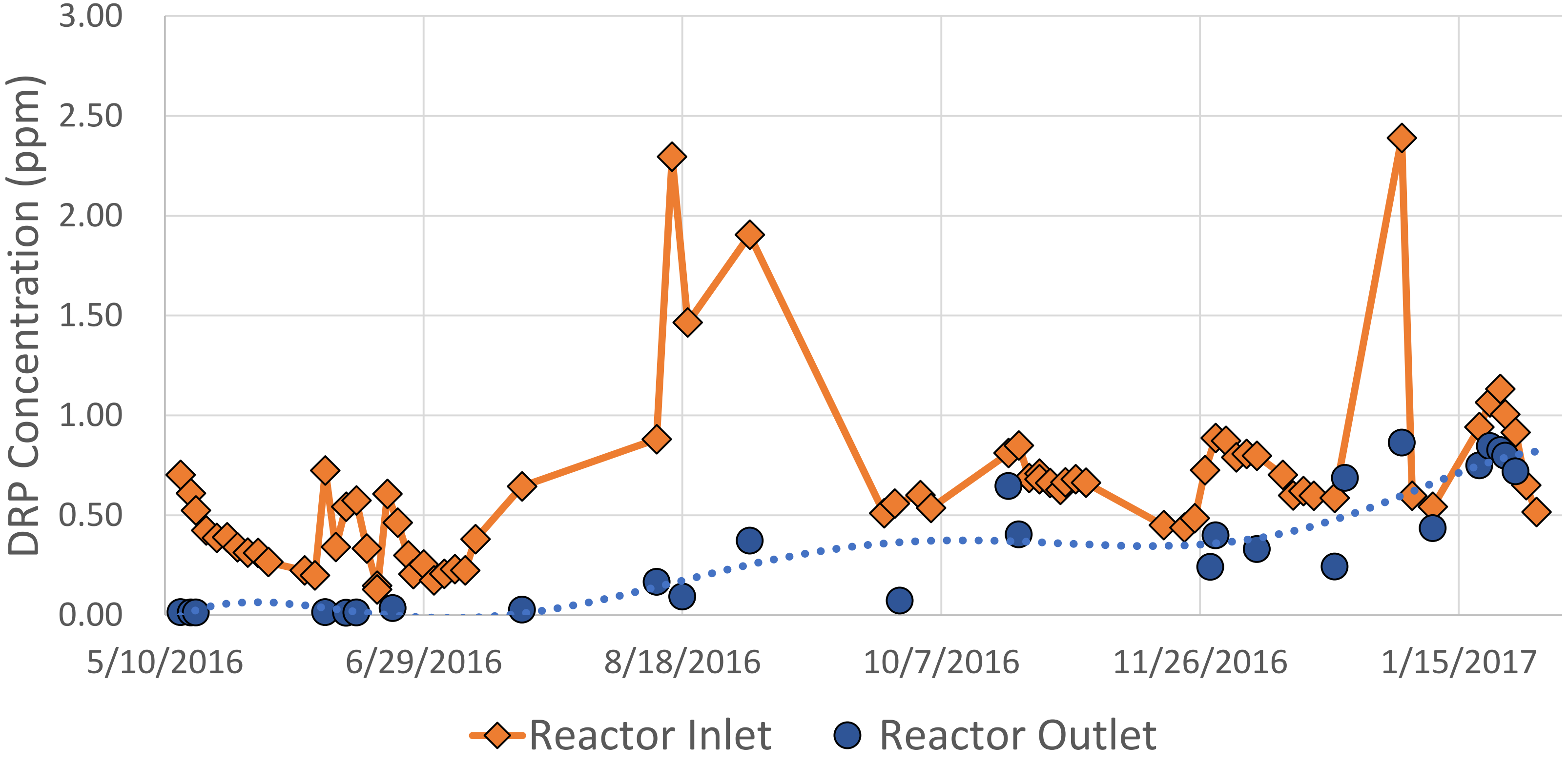


B2 – free drainage
B4 – drainage water management

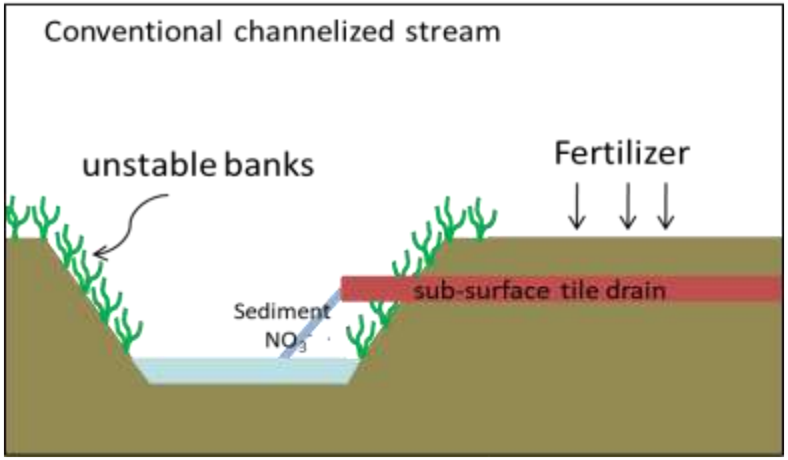
- **Annual discharge reduction:**
  17% to 73% across sites
  41% on average
- **Daily discharge reduction:**
  50% on average during management
  (*Gunn et al. 2015*)
- **DWM did not significantly affect DRP concentration**
- **8-40% reduction in annual DRP load with DWM**

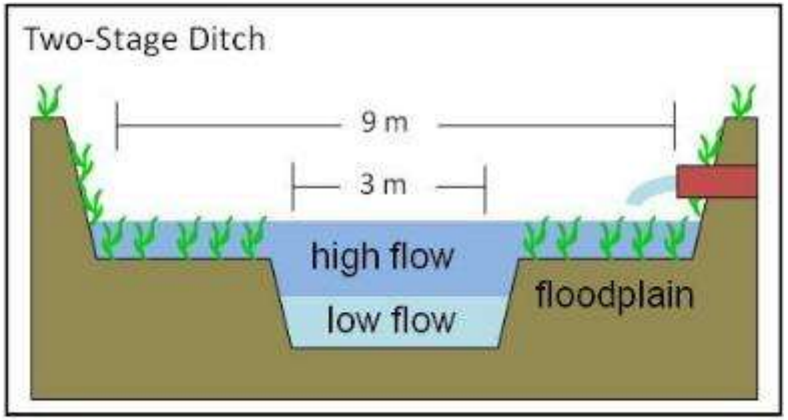
Phosphorus Removal Structures

DRP Concentration Reduction



Drainage Ditch Design



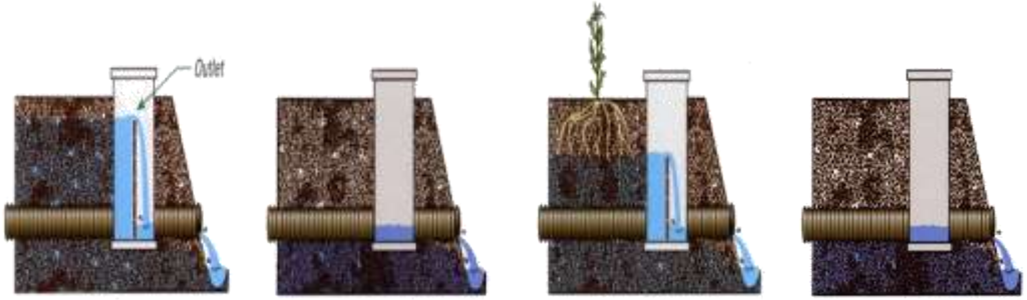


Source: Hanrahan 2017

Directionally Correct Practices

- 4Rs of nutrient management (Right source, rate, time, placement)

- Disconnecting hydrologic pathways (DWM, blind inlets, linear wetlands, water storage/increased OM)

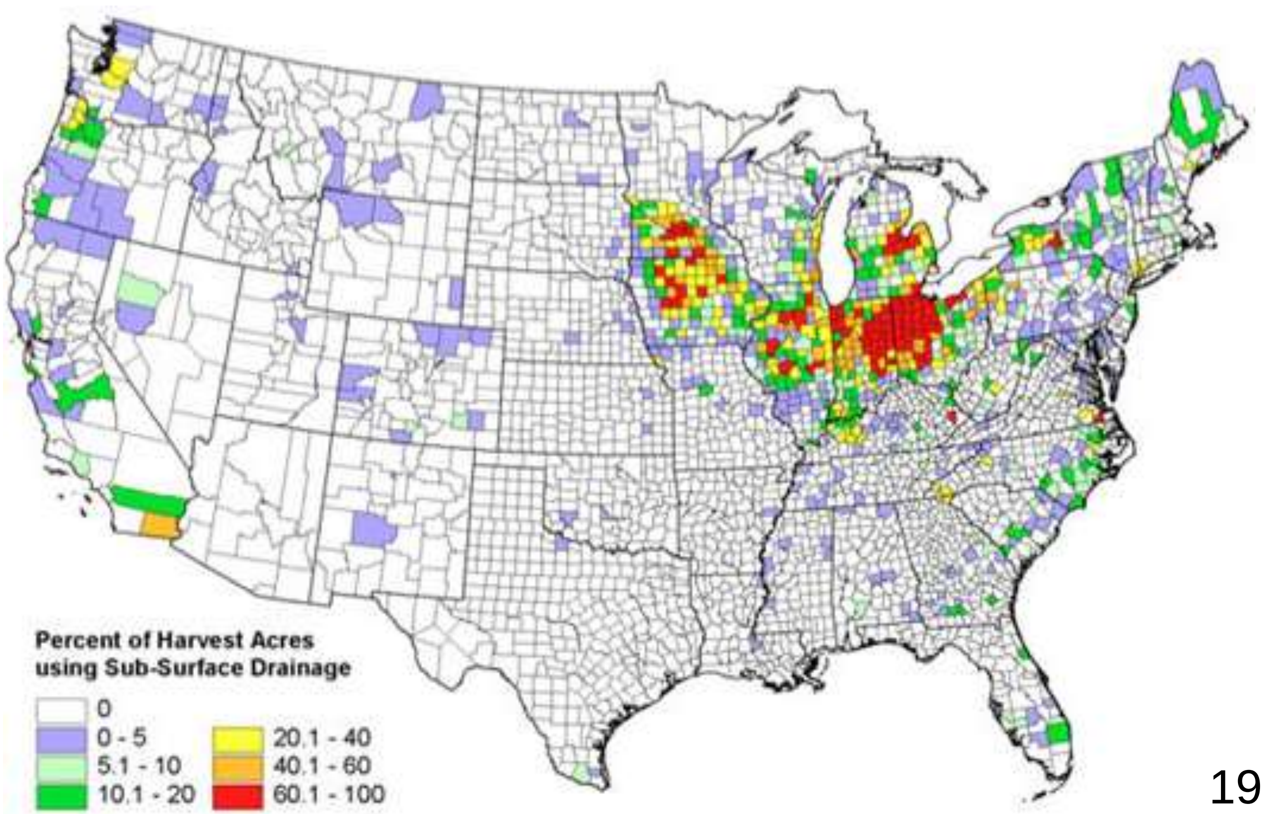


- Do not increase erosion potential (subsurface placement)

The extent of subsurface drainage in Ohio

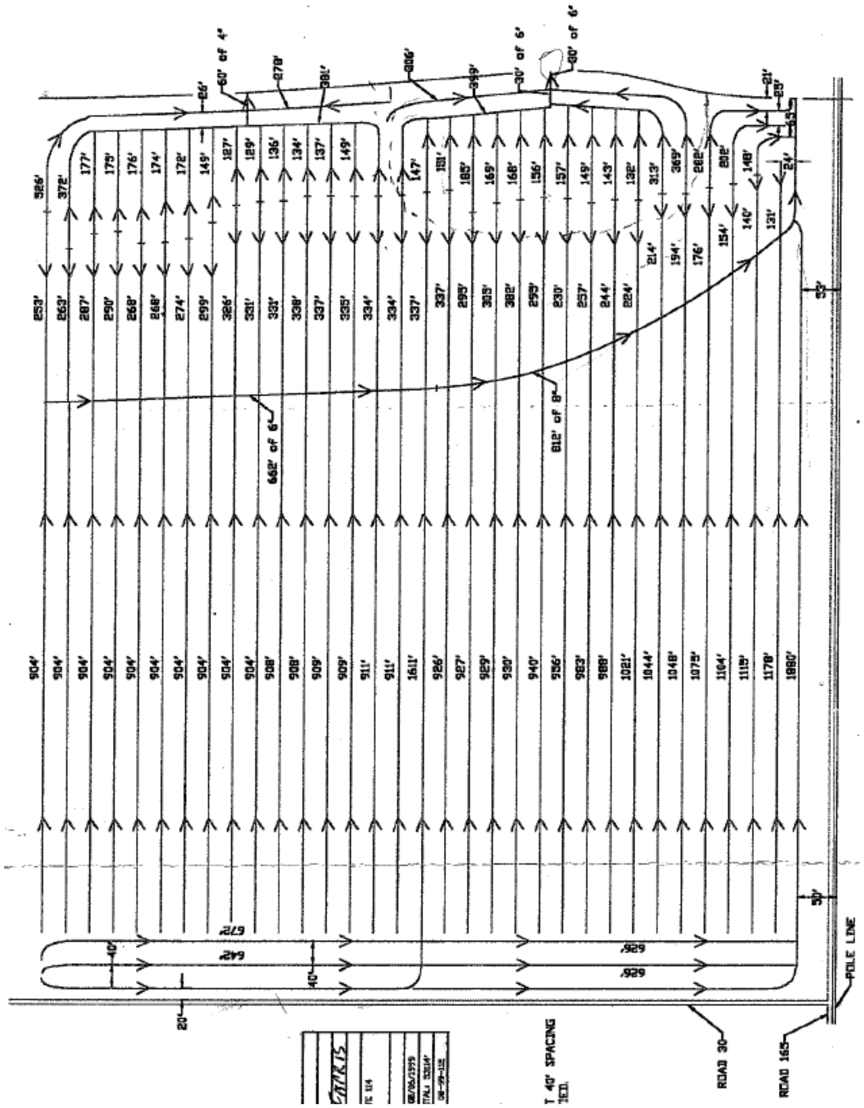
Between 1974 and 2012, the number of acres with tile drainage increased by 1.14 million acres (~22%)

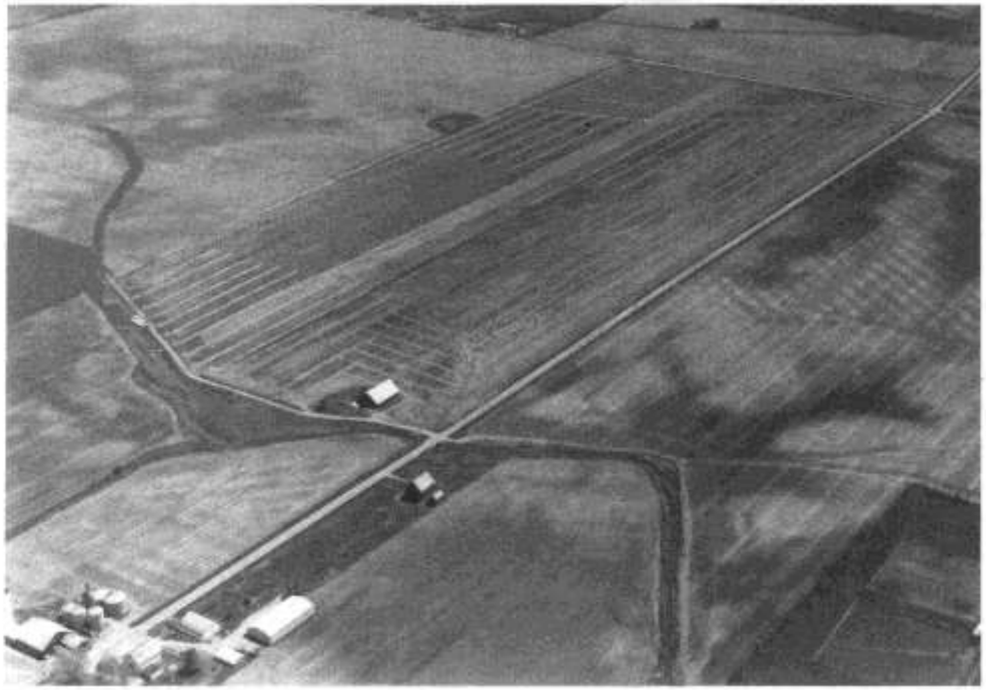
U.S. Census of Agriculture (2012)



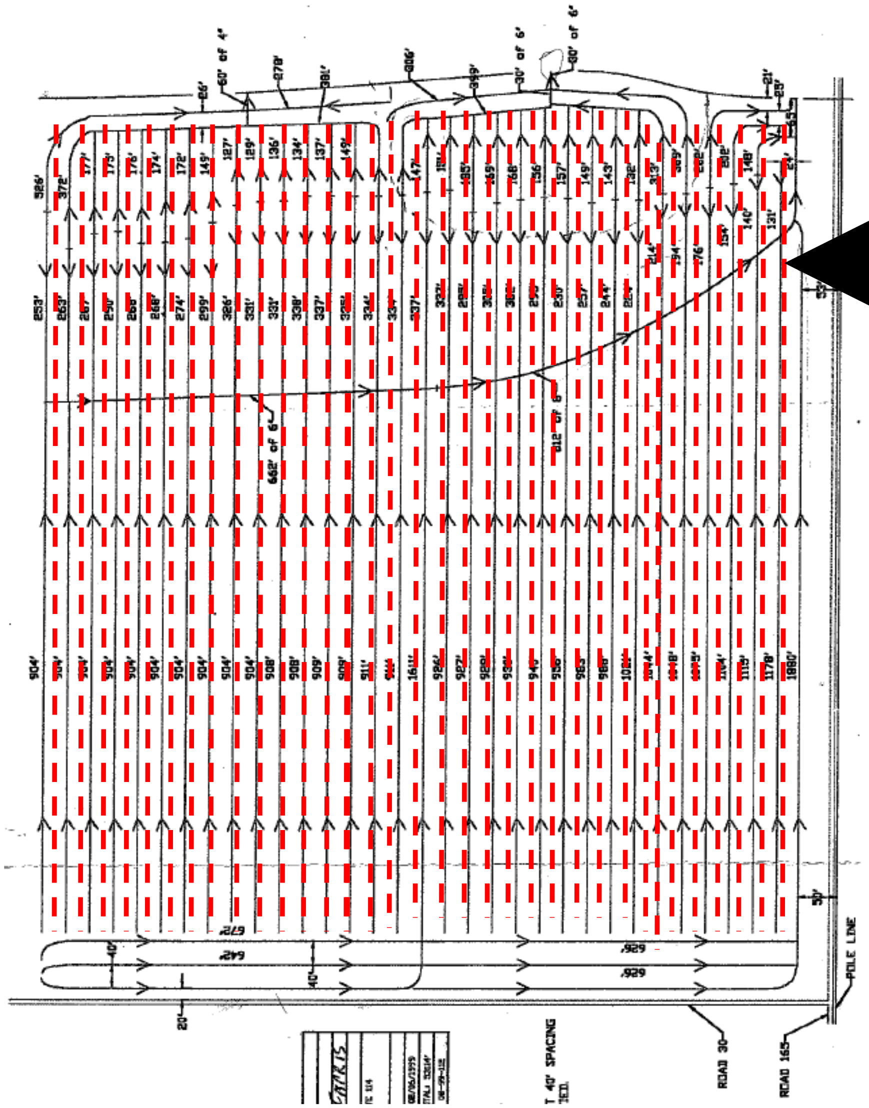
1998 Estimate

Systematic Tile Drainage





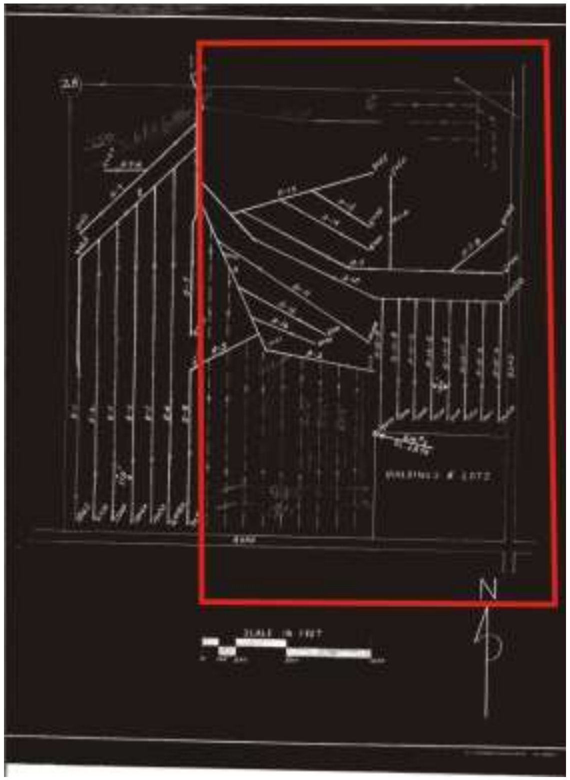
Splitting Systematic Tile Drainage



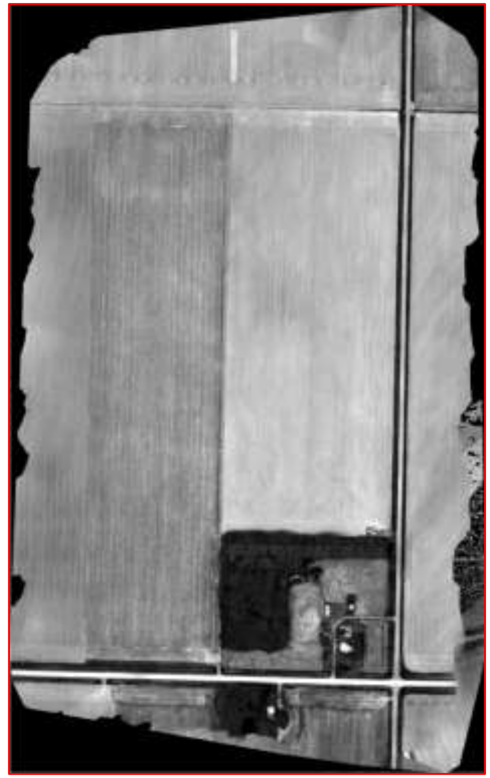
- 50 ft down to 25 ft (15.2m to 7.6m)
- 40 ft down to 20 ft (12.2m to 6.1m)
- 30 ft down to 15 ft (9m to 4.5m)

How narrow is narrow enough?

Results of Thermal Infrared Drone Survey Conducted Near Spencer, Iowa.



As-Built Map of Field Subsurface Drainage System. Boundary of Drone Survey is Highlighted in Red.

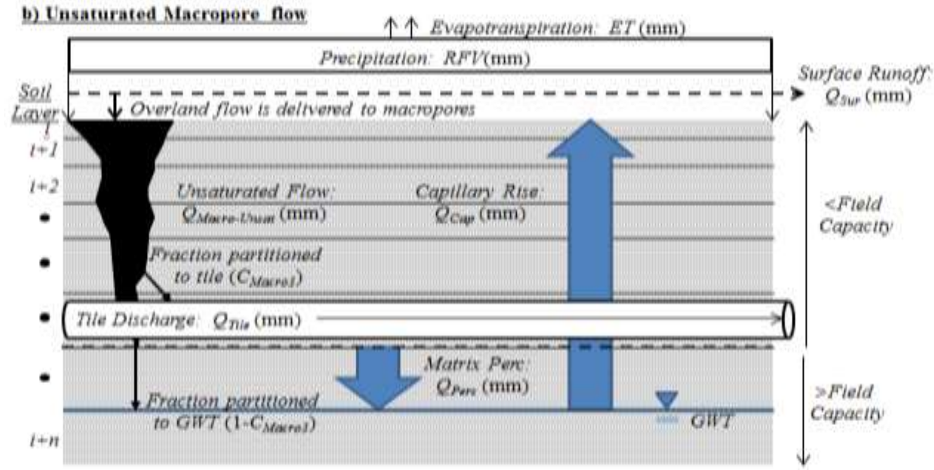


Field Thermal Infrared Orthomosaic from One Day <u>Before</u> 3” Rainfall Exhibiting no Drainage Pipe Responses.

Field Thermal Infrared Orthomosaic from One Day <u>After</u> 3” Rainfall Showing Drainage Pipe Patterns. (Compare to As-Built Drainage Map.)

Modeling Related Collaboration
APEX

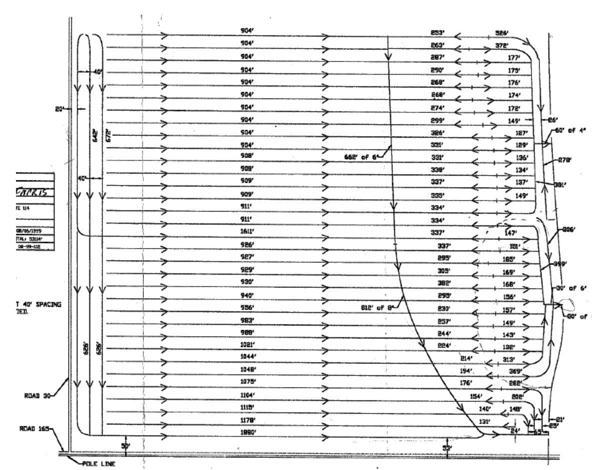
- Dr. Bill Ford (University of KY) – macropore flow routine and drainage water management



Ford et al., 2017

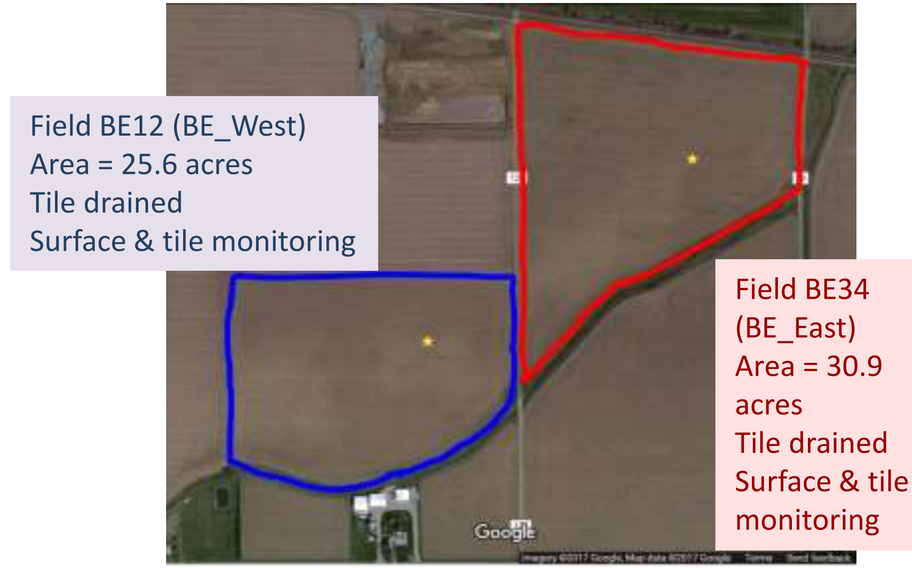
- Dr. Rem Confessor (NCWQR at Heidelberg) - NTT

- Dr. Daniel Moriasi (USDA-ARS) – improved subsurface drainage routines

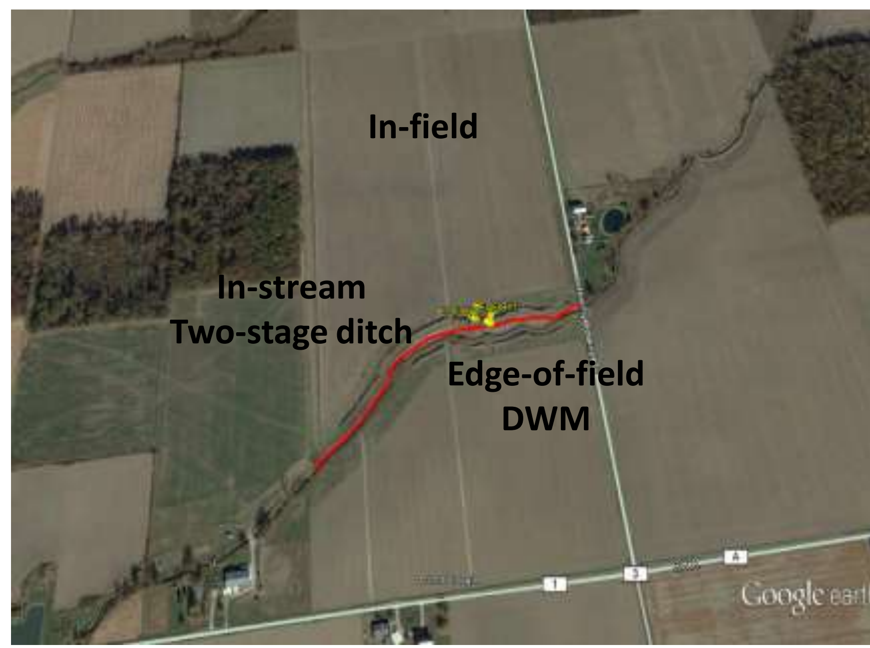


Modeling Related Collaboration
SWAT

- Drs. Todd Redder and Chelsea Boles (LimnoTech) – 4R assessment

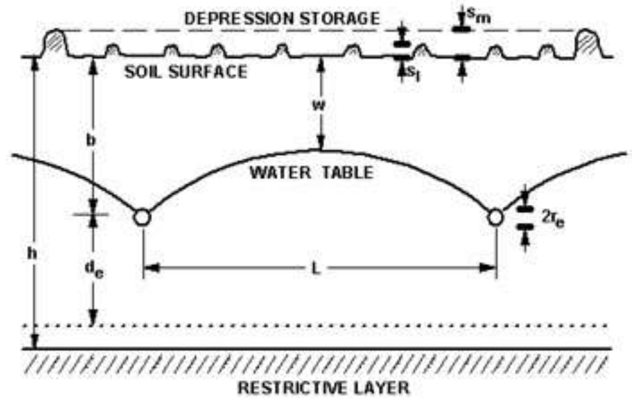


- Dr. Margaret Kalcic (Ohio State Univ.) – multiple initiatives

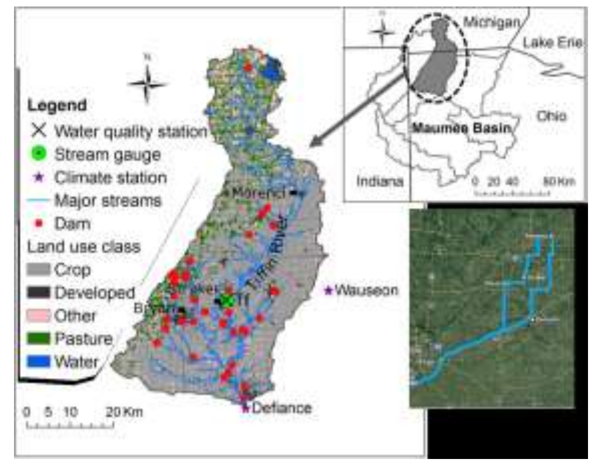


Modeling Related Collaboration

- DRAINMOD-P: Dr. Mohamed Yousef (NC State Univ.)



- MIKESHE: Dr. Margaret Gitau (Purdue University) - Tiffin watershed



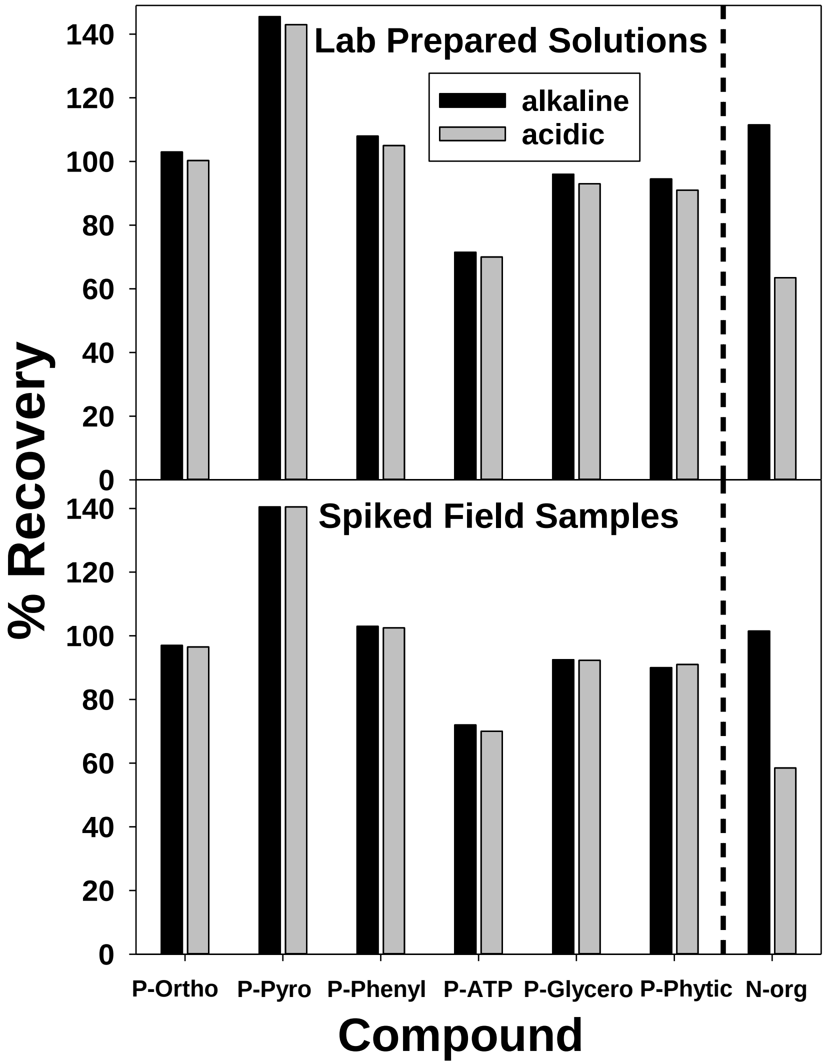
- Dustin Goering (National Weather Service) – flood and precipitation forecasting for Maumee River watershed

Contact Information

Kevin King
590 Woody Hayes Dr.
Columbus, OH 43210

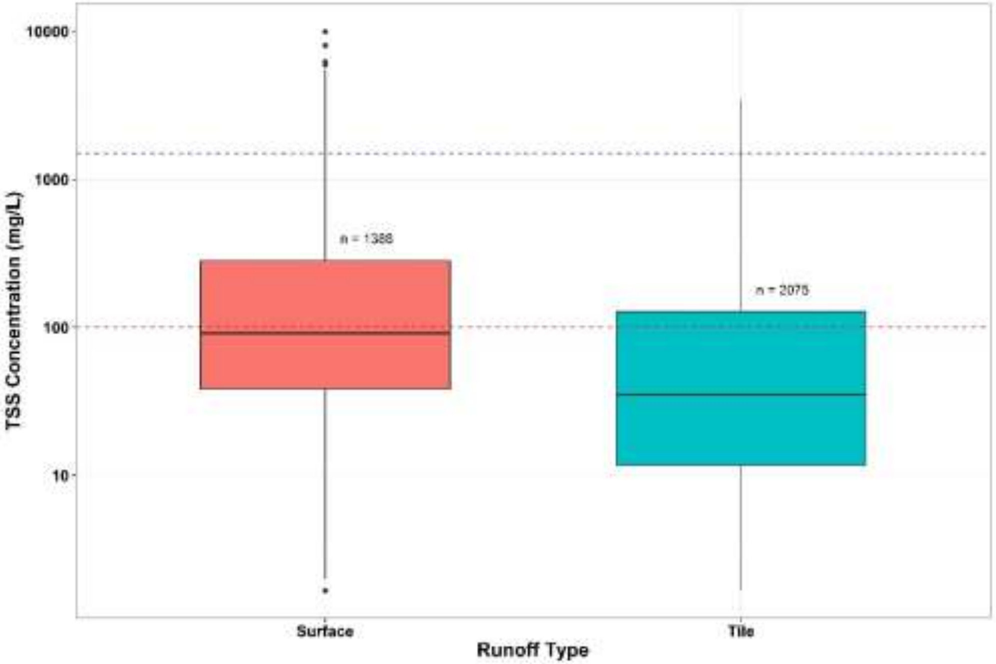
kevin.king@ars.usda.gov

Combined Determination of Total P and Total N Using Persulfate Oxidation

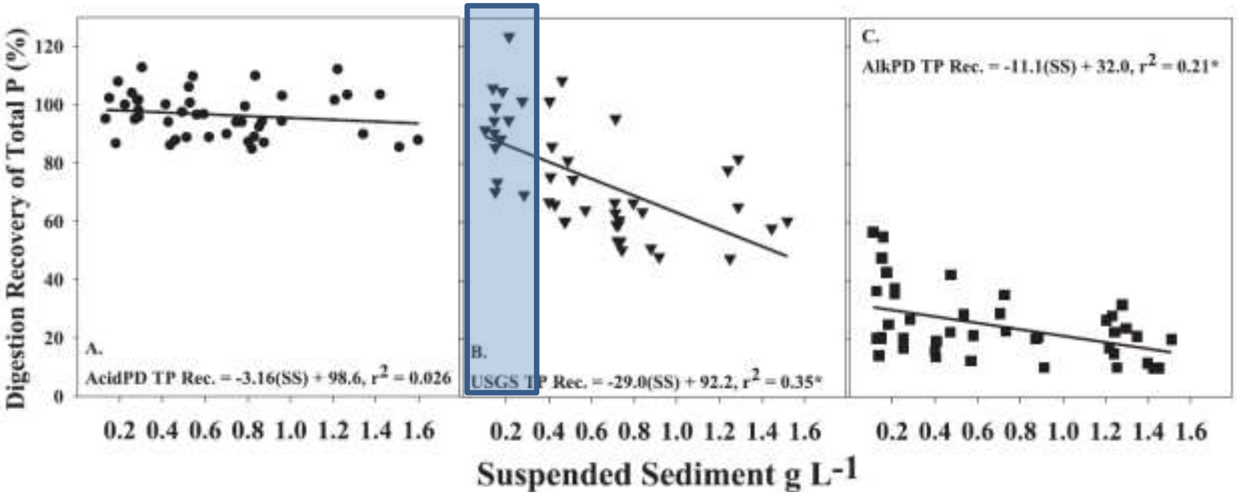


- ✓ Combined TP and TN determination is required due to number of samples (10,000+ annually)
- ✓ USGS method is valid and acceptable method Patton and Kryskalla (2003)
- ✓ Recovery of total-P is nearly identical in both the alkaline and acidic persulfate oxidation methods
- ✓ Excluding P-Pyro and P-ATP, which had bad recoveries for both alkaline and acid methods, total P recoveries ranged from 94% to 108% in lab prepared solutions and 90% to 104% in unfiltered field samples.
- ✓ However, recovery of total-N is significantly lower in the acidic method
- ✓ USGS method in use since WY2015 (Oct 1, 2014): > 70% of site yrs and > 77% of all water samples to date (9/30/2017)

Observed Total Suspended Solids in EOF



Dayton et al. (2017) SS range



- Minimum SS in Dayton et al (2017) is greater than 50th percentile for observed surface samples and 70th percentile for tile samples

- Shaded area is typical sediment concentration range for monitored fields (75th percentile for surface and ~90th percentile for tile)