Reducing Phosphorus Loss from Ontario Farmland






Presentation to:

Agriculture Sector Working Group
May 27, 2016

Rural Point vs. Non-point P Loss

Non-point Sources:
(broadscale, indirect)

- Edge of field losses
  - Particulate P
  - Dissolved P

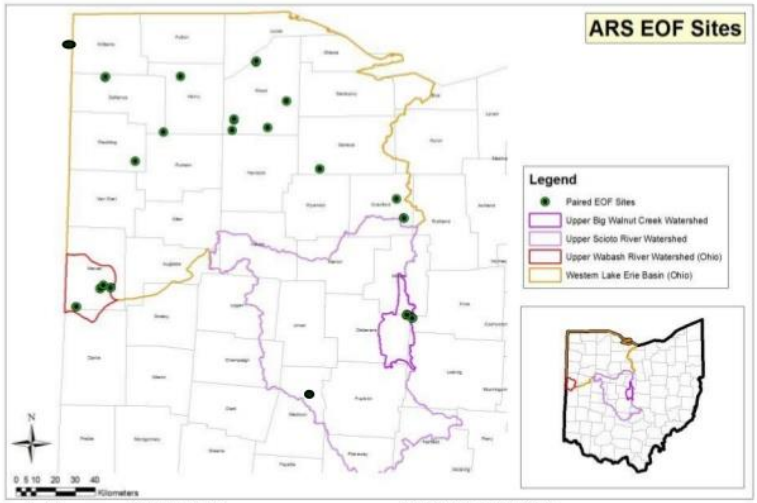
Point Sources:
(local, direct, quantifiable, significant?)

- Washwater discharge (e.g. milking centre)
  (e.g. 60 cows ~ 800-1000 L/day ~ 15 kg P/yr)
- Manure storage/yard runoff
- Livestock access

Non-Point Source: How Much P is Coming off the Land?

Ohio Observations

(Source: Kevin King – USDA-ARS , Columbus, OH)



Funding Sources:
4R Research Fund
USDA-ARS: USDA-Agriculture Research Service
CEAP: Conservation Effects Assessment Project
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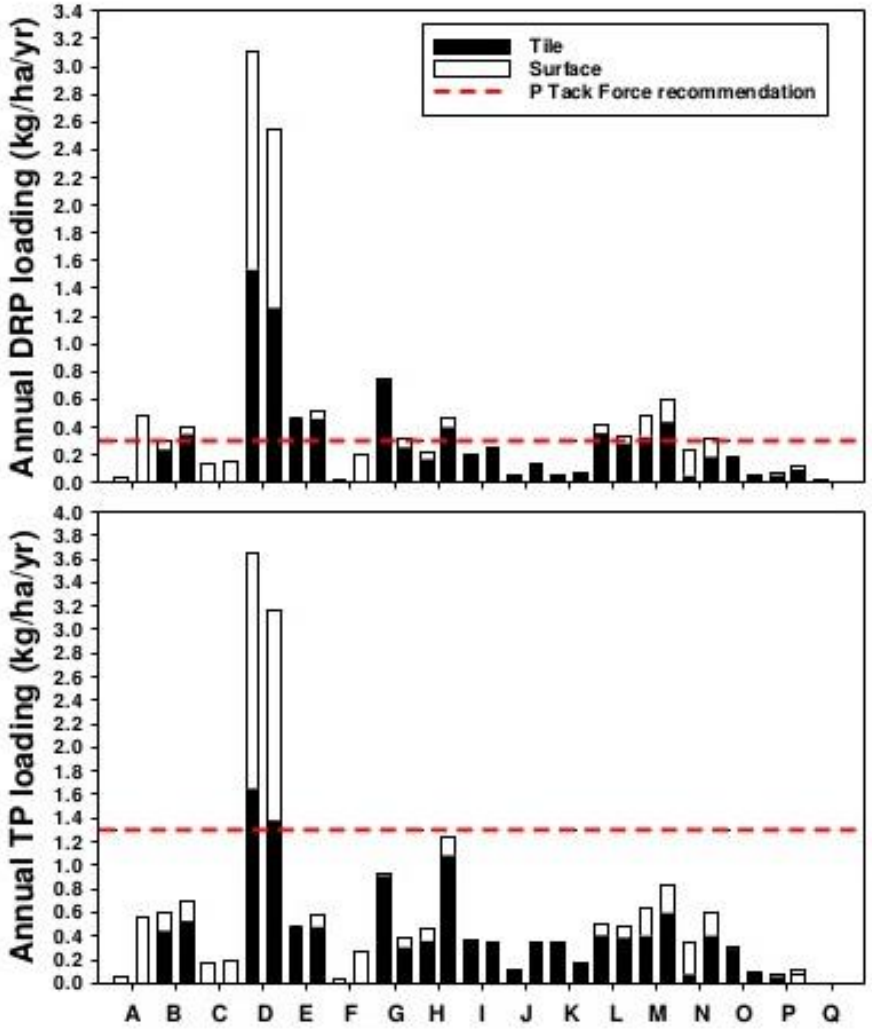
Ohio Corn and Wheat Growers
CIG: 69-3A75-12-231 (OSU)
CIG: 69-3A75-13-216 (Heidelberg University)
MRBI: Mississippi River Basin Initiative
The Nature Conservancy
Becks Hybrids/Ohio State University
Ohio Soybean Association

~ 20 Paired Edge of Field Sites - Ohio



TP Loss Range: 0.3 to 3 kgP/ha/yr

How Much P is Coming off the Land?

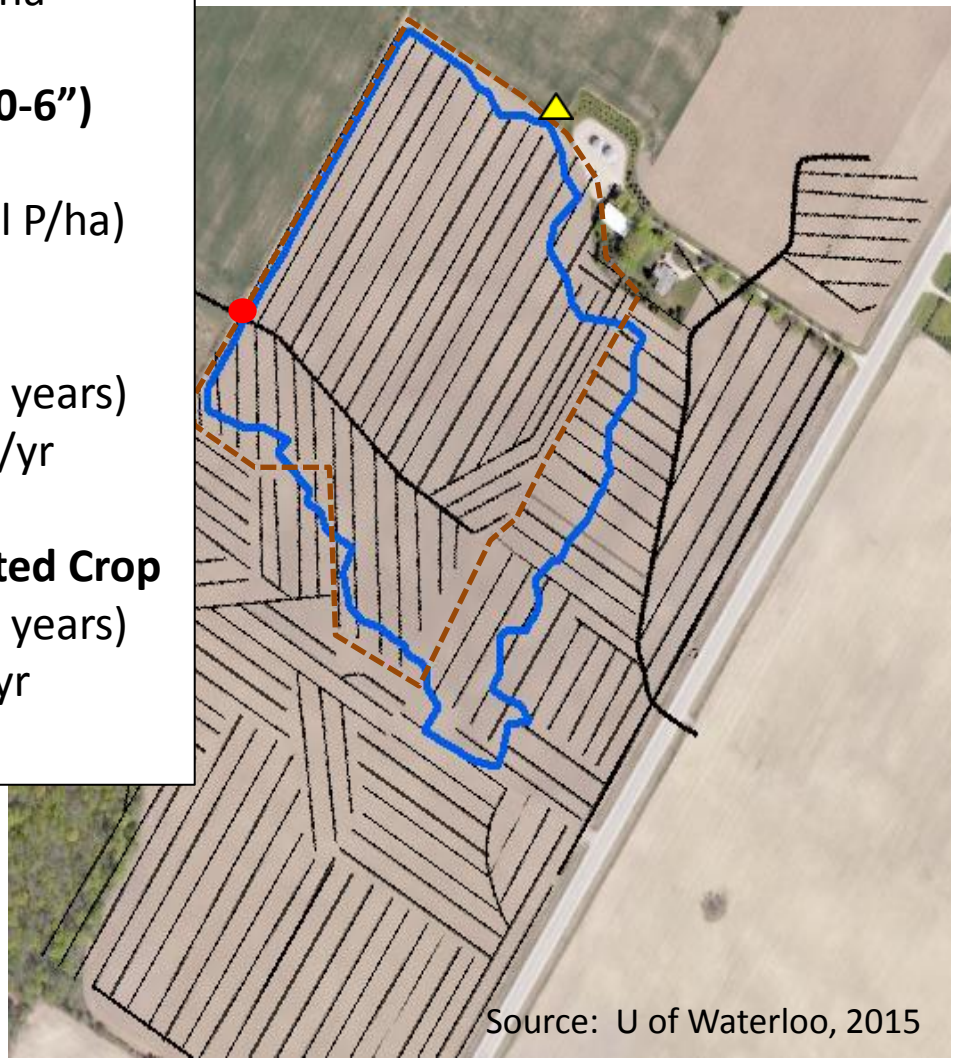
Ontario Observations

Total P in soil (0-6”)
~1670 kg P/ha

Soil Test P (0-6”)
11 mg/kg
(~22 kg avail P/ha)

P Applied
(Avg. over 3 years)
~30 kg P/ha/yr

P in Harvested Crop
(Avg. over 3 years)
25 kg P/ha/yr



3 years (CBW rotation)
(Perth Clay Loam, 0.2%-3.5%)

Avg Precip: 954 mm
Avg Runoff: 331 mm
overland:tile ~ 20:80

Avg. annual P loss to water:
TP 0.3-0.5 kg/ha
overland:tile ~ 50:50

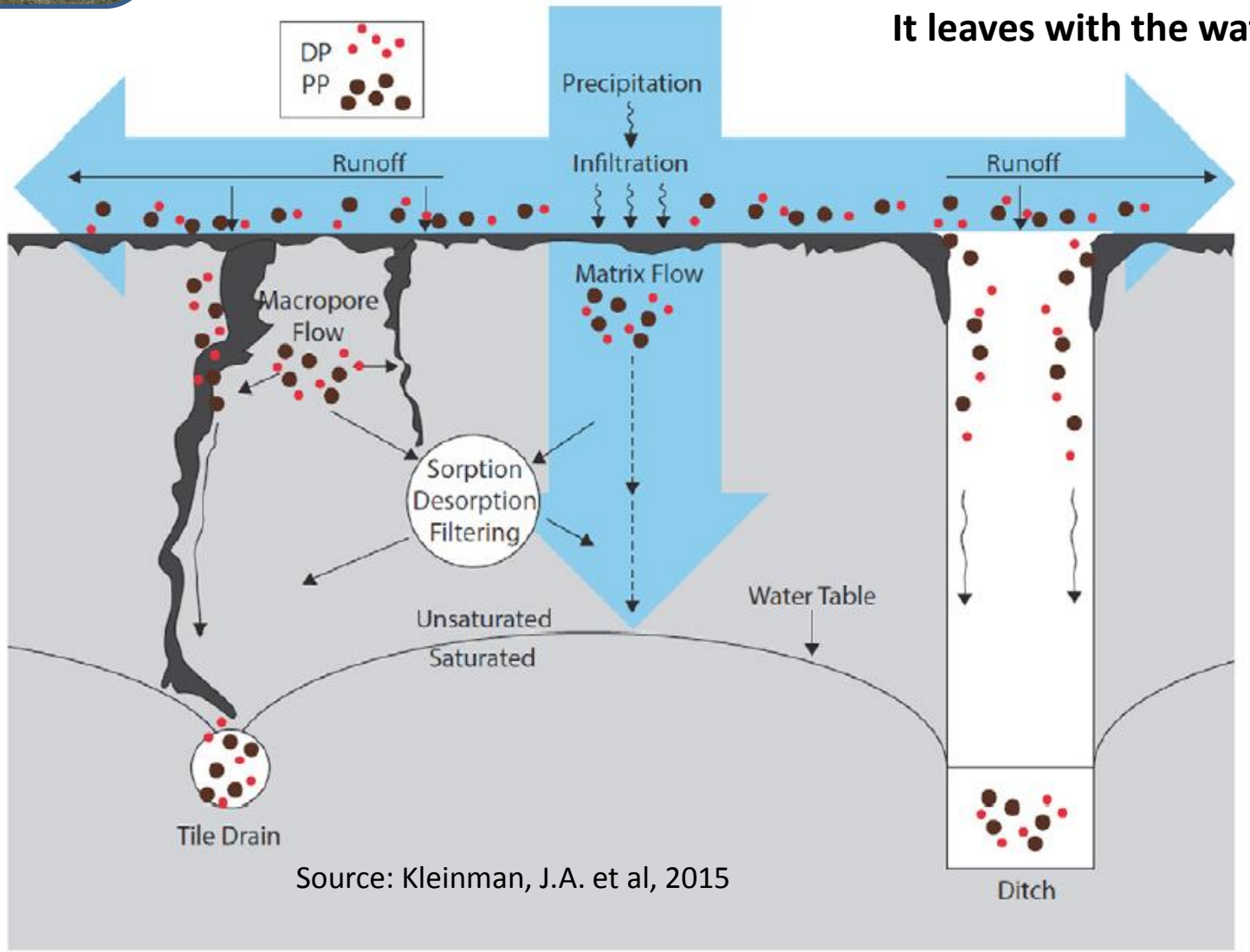
Legend

- Surface watershed boundary
- Tile watershed boundary
- Field edge monitoring point
- On-site climate station

Pathways for P Loss from Fields

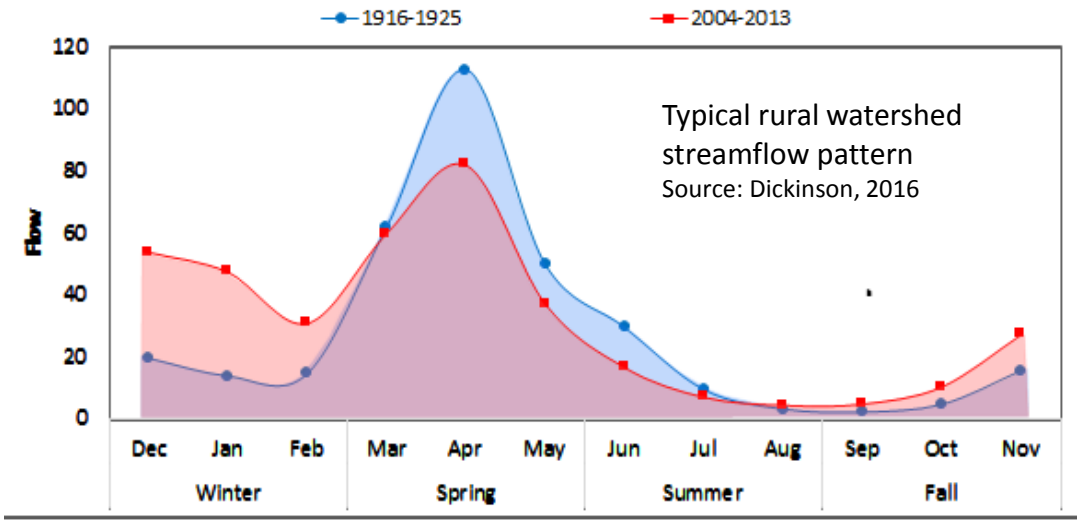
DP = Dissolved P
PP = Particulate P

It leaves with the water!



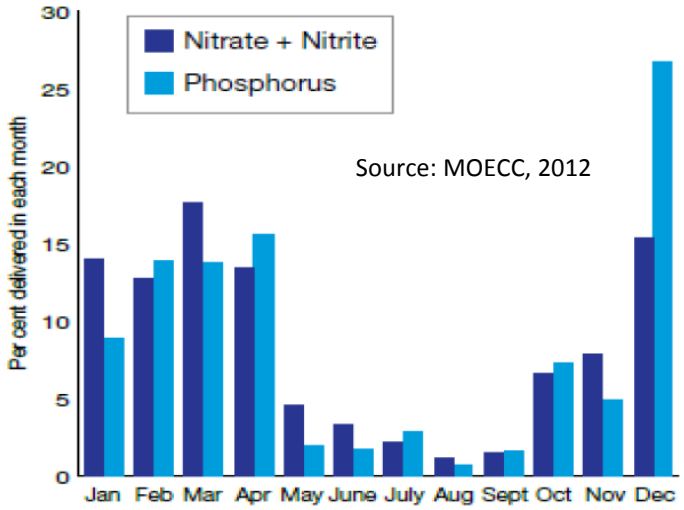
Source: Kleinman, J.A. et al, 2015

When Does P Leave the Field?



Typical rural watershed streamflow pattern
Source: Dickinson, 2016

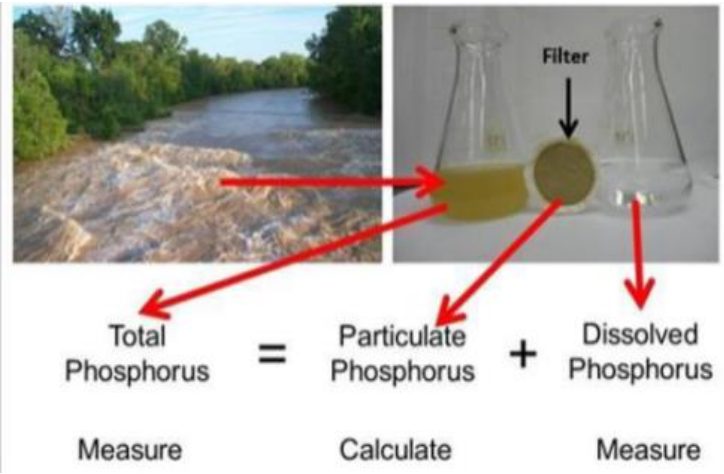
May - Oct



Source: MOECC, 2012

Nov - Apr

P leaves with the: Harvested Crop, Water



Field Conditions Influencing P Loss

(source: P Index Keith Reid – AAFC, Guelph)

Condition	Source	X	Transport
1 (Inherent)	Particulate P (P_p) attached to eroded soil	X	Amount of delivered sediment
2 (Inherent)	Dissolved P (P_{Diss}) carried in overland runoff	X	Amount of overland runoff
3 (Inherent)	$P_p + P_{Diss}$ carried in tile water	X	Amount of tile water
4 (Applied)	P in Fertilizer vulnerable to direct water contact	X	P_{Diss} in overland and tile flow
5 (Applied)	P in Manure vulnerable to direct water contact	X	P_{Diss} in overland and tile flow

Note: Field Conditions Change by Season (growing season vs. non-growing season)

Managing Inherent P Loss

1) Control Soil Erosion

Source: Keep soil P tests low – because higher soil P soils have higher concentrations of P in eroded sediment (i.e. manage rates)

Transport: Reduce erosion and sediment delivery to watercourse

Erosion Control Principles:

- Maintain good soil cover (preferably living) year around
- Reduce soil movement due to tillage action
- Protect vulnerable areas (e.g. drainage pathways)

Soil Health Principles (parallel principles):

- Maintain "armour" on the soil (no bare ground)
- Keep mechanical disturbance to a minimum
- Diversify crops, vegetative cover
- Keep a living root in ground as long as possible

In-Field (Sheet and Rill) Erosion Control

Relative Erosion Control Benefits of different Field Management Practices

County	Soil Type	Slope		Crop and Tillage	RUSLE2 Erosion Rate (t/ac/yr)	Soil Conditioning Index (soil health indicator)
		Grade (%)	Length (ft)			
Huron	Huron CL	6	150	soybeans fall tillage	8.7	-0.8
Haldimand	Hldmd SiC	0.5	100	soybeans fall tillage	0.52	-0.09
Huron	Huron CL	6	150	soybean w. wheat rotation	5.3	-0.2
Haldimand	Hldmd SiC	0.5	100		0.31	+0.3
Huron	Huron CL	6	150	NT soys into rye cc planted October	1.4	+0.4
Haldimand	Hldmd SiC	0.5	100		0.14	+0.5

Reduced tillage, crop diversity and cover crops reduce erosion, improve soil health - regardless of the setting.

Soil Erosion Control in Concentrated Flowpaths

Control Channel (gully) and Ditchbank erosion as well as field erosion

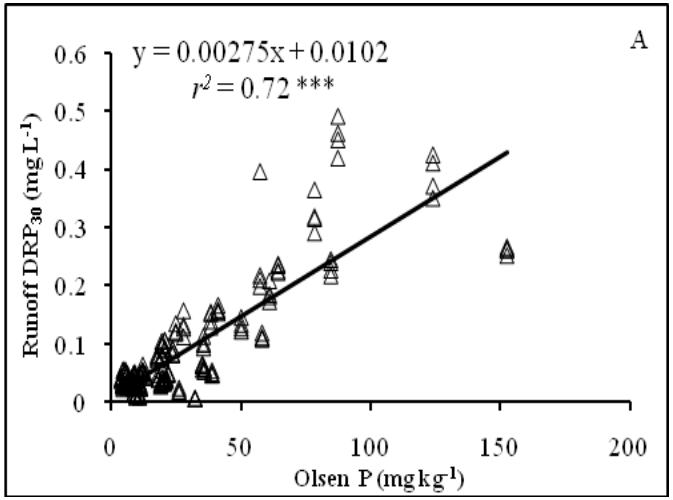
A system of practices (field and flowpath erosion control) is needed

Managing Inherent P loss

2) Reduce the chances of dissolved P being carried by overland water to watercourses

Source: Keep soil P tests low (manage rates)

- Higher soil tests = higher dissolved P in runoff water



(Wang 2010 thesis)

Surface soil layers have the most contact with runoff water

Avoid significant P stratification

Depth	Olsen P
0-1"	22.25
1-2“	17.5
2-6"	8.75
6-12"	5.25
12-18"	5
18=24"	3.5
24-30"	3.75
Avg (0-6")	**12.5**

Transport: Improve soil infiltration capacity to reduce overland runoff

2) Reduce the chances of dissolved P being carried by overland water to watercourses

No Till + CC 10 yrs **Conv till w 30% residue cvr** **No Till 10 yrs** **Conv Till** **Woodlot**

Back Jar: Infiltration

Front Jar: Overland Runoff

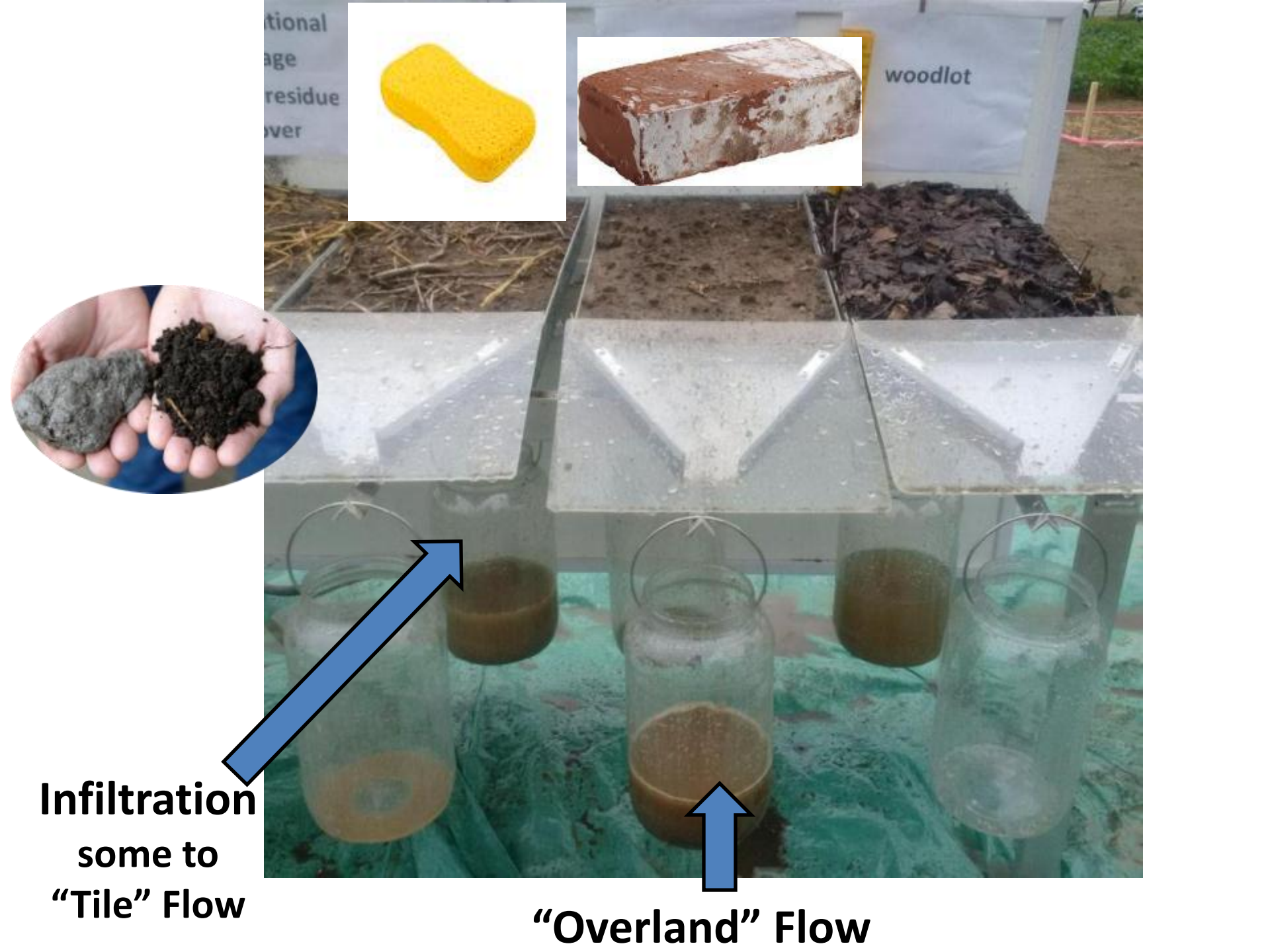
IS YOUR SOIL

A BRICK?

OR

A SPONGE?

Improving soil health, reducing compaction improves soil infiltration


woodlot
Infiltration
some to
"Tile" Flow
"Overland" Flow

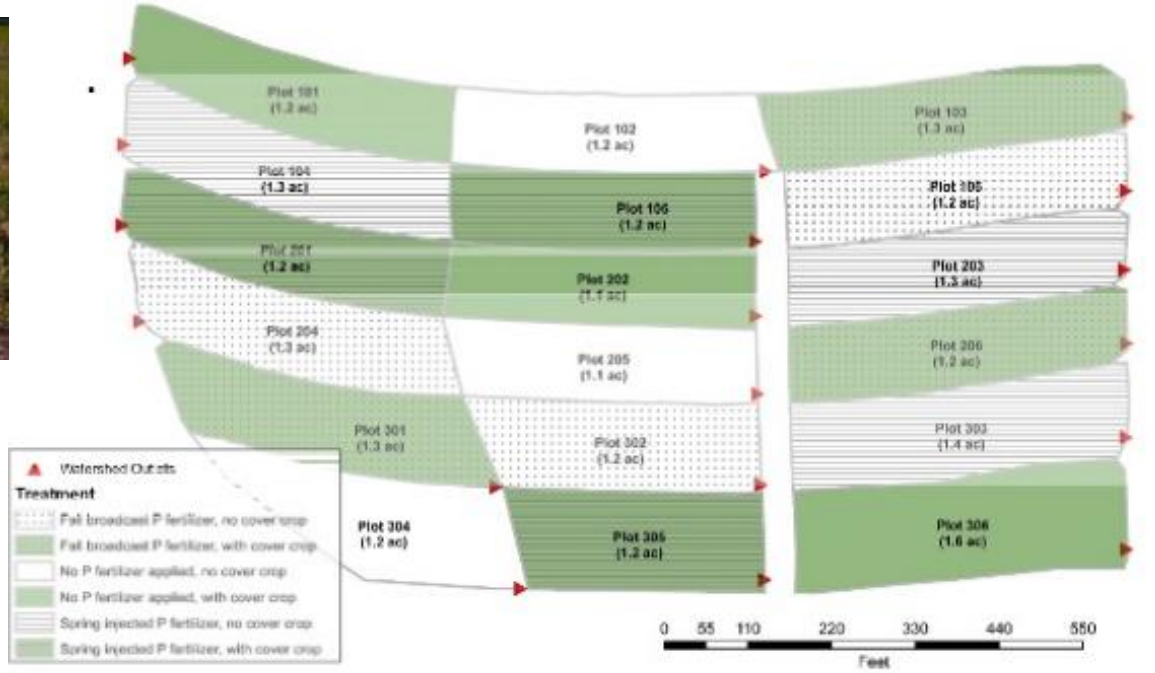
Cover Crops

Show Promise to:

- Improve soil structure (infiltration)
- Improve soil water holding capacity (OM)
- Increase ET (Less water = less runoff volume)
- Reduce erosion (particulate P loss)
- Function in the critical non-growing season

KAW Field Lab

Kansas Agricultural Watersheds Field Lab



Cover Crop Effects: 2015 (12 runoff events)

16% reduction in runoff with cover crops

>50% reduction in sediment loss
(6.2 -> 2.8 MT/ha)

>50% reduction in TP loss
(3.3 –> 1.6 kg/ha)

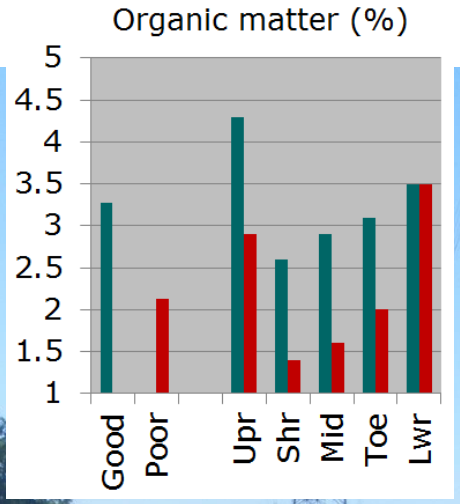
>50% reduction in SRP loss
(0.3 –> 0.1 kg/ha)

Source: Nelson et al. (2015) SWCS Edge of Field Monitoring Conference, Memphis, TN

Maintained/Improved Soil Health

(has yield benefits in the long-term)

65 bushels/acre



201 bushels/acre

Managing Inherent P Loss

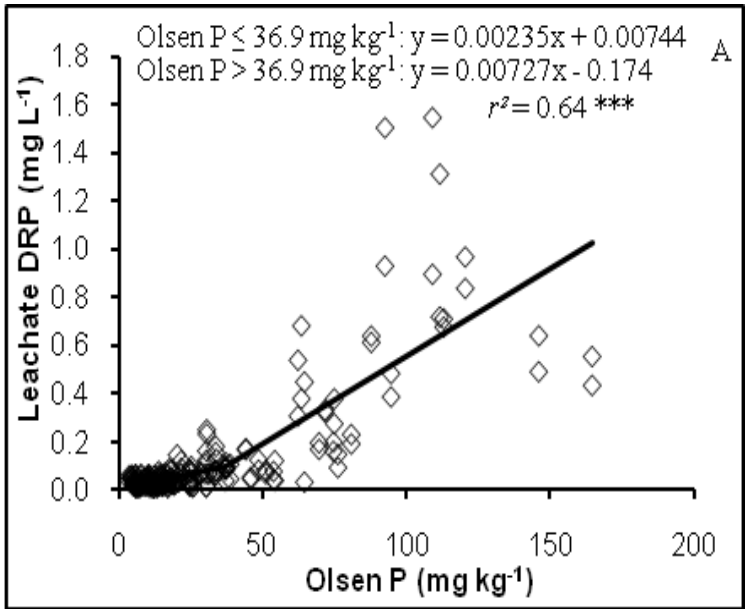
3) Reduce the chances of dissolved and particulate P being carried by tile water to the watercourses

Source: Keep soil P tests low (manage rates)

- Higher soil tests = higher P concentrations in soil water

Transport: Minimize use of surface inlets (esp. in tilled fields)

DRP in Leachate

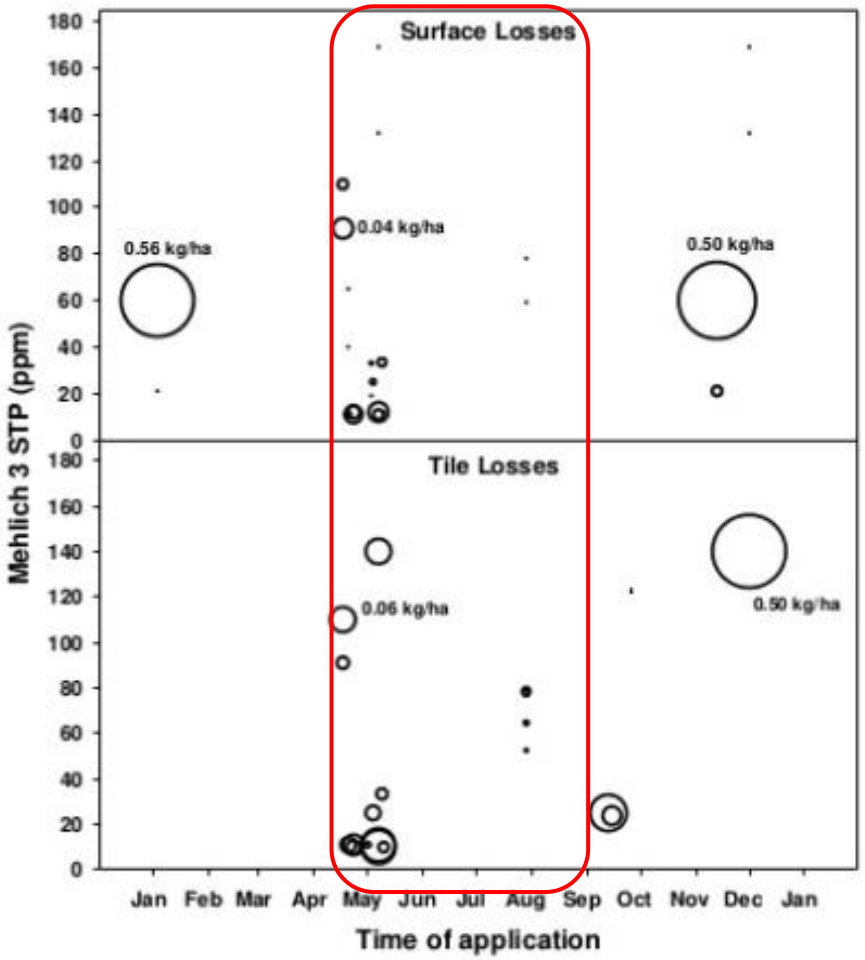


It is better for drainage water to reach drainage tile by moving through the soil profile than via macropores or surface inlets.
E.g. Tile P study: Surface runoff [P] 3x to 5x higher than tile [P]

Managing Application P Loss

1) Timing - Apply Fertilizer and Manure at times when there is the least risk of water runoff

Source King, K. 2015 (Edge of Field Monitoring Conference – Memphis, TN)



Time of Application

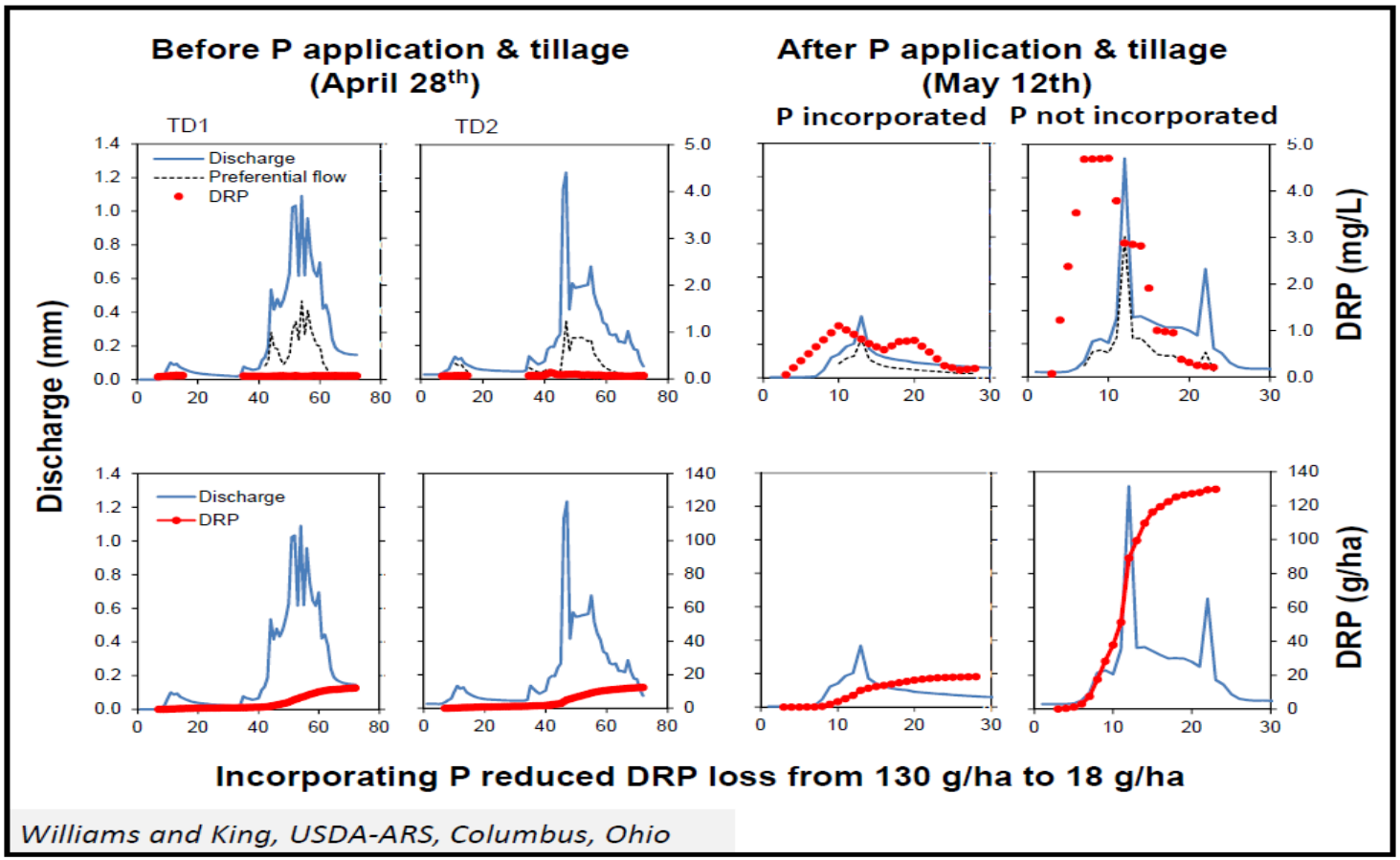
- Greatest potential for surface and tile losses occurs with fall and winter application
- Applying P in spring or after wheat harvest seems to minimize surface and tile losses

Managing Application P Loss

2) Placement - Apply Fertilizer and Manure so it is not exposed to runoff and can bind to soil quickly

Source King, K. 2015 (Edge of Field Monitoring Conference – Memphis, TN)

Tile Drainage Observations



Need to balance off the need for incorporation with risk of soil erosion!

Summary of Application BMP Effectiveness

	BMP	Growing Season	Non-Growing Season	High Flow Events
Managing Nutrients	Right Place	H	H	H
	No Winter Spreading	N/A	H	H
	Right Time	H	H	H
	Right Rate	H	M	H
	Soil Testing and P recommendations	H	M	M
	Test organic amendments	H	M	M
	Right Source	M	M	M
	P in Feed Rations	H	H	H
	Nutrient Mgmt Planning	H	M	M
Water Infiltration	Crop Rotation	M	M	M
	Cover Crops	L	M to H	M to H
	Conservation Tillage	M	M	M

Summary

- Phosphorus is in two main forms (particulate, dissolved)
- Phosphorus in both forms leaves with the runoff water (overland + tile)
- The majority of runoff (and therefore P loss) occurs during the non-growing season
- Soil erosion control, including field erosion (sheet and rill), channel erosion (gully) and ditchbank erosion is important
- A systems approach to erosion control is most effective
- Maintaining low soil P levels further reduces inherent P loss
- Improved soil health encourages infiltration
- Drainage water filtered by the soil matrix has a lower P concentration than overland water moving through macropores or surface inlets
- Cover crops show promise in improving soil health and indirectly, water quality – especially for the critical non-growing season
- A suite of practices, tailored to the site, will have greater success in controlling P loss under a range of weather/seasonal patterns.