Phosphorus (P) Risk Index

The P index was initially developed to identify agricultural fields vulnerable to P loss

Lemunyon & Gilbert, 1993

"Critical source areas are dependent on the coincidence of transport (surface runoff, erosion and subsurface flow) and source factors (soil, fertilizer, manure) as influenced by site management."

Sharpley et al., 2003

USDA-NRCS
Phosphorus Risk Index Framework

P Index Score = **Transport Factors** X **Source Factors**

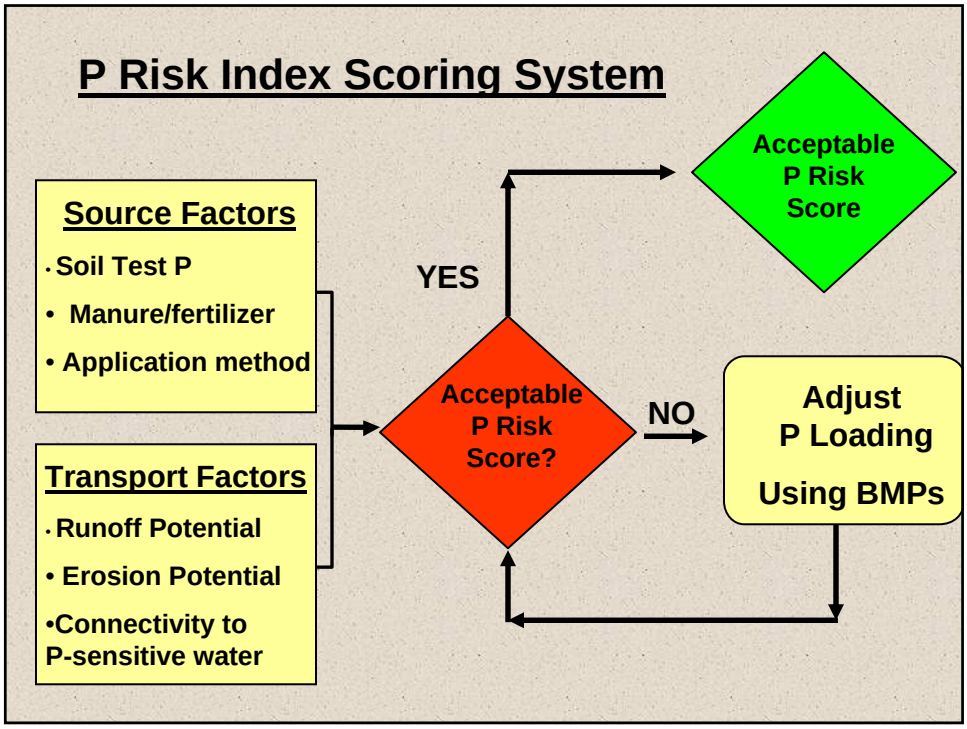
Transport Factors
- Runoff potential
- Erosion potential
- Connectivity to P-sensitive water

Source Factors
- Soil test P
- Applied P
- Application method

Utility of a P Index Framework

Initially used to assess risk, the P index has developed and been modified to also evaluate alternative management practices for planning and regulation of P application

Benning and Wortmann, 2005



Adjustments/Modifiers

Soil Test P modifiers based on soil properties
NH, VT, WY,

Solubility of P (manure/biosolids) applied
AR, DE, FL, GA, LA, MD, PA, TN, VA

Frequency of flooding:
AK, VT

BMPs
AL, AZ, AR, CO, IA, NE, NM, NC, ND, RI

Prioritize sensitivity of receiving water
AL, AK, DE, FL, KY, LA, ME, MD, OK

Sharpley et al., 2003

Sensitivity Analysis of P Index Factors

Benning and Wortmann, 2005 JSWC

- **Normalized P Index scores for 4 Midwest states**
- **Examined how varying individual P index factors affected P Index scores**

1. **Increasing STP from 30 to 90 mg/kg**
   Increased index scores from 0 to 300%
2. **Surface vs. incorporated manure**
   surface increased scores from 0 to 64%
3. **Decreasing from 100 to 50 ft from water**
   increased index scores from 0 to 29%
4. **Increasing erosion loss from 2.3 to 11.3 Mg/ha**
   Increased index scores from 30 to 244%

Example of a P Indexing Approach

Pennsylvania

Part A

Screening

Mehlich III STP > 200 mg P kg^{-1}

or

< 150 ft from water

Sharpley et al., 2003

Part B
P Source Factors

Mehlich III STP	**STP rating = 0.2 * STP mg kg^{-1}**				
Fertilizer/ manure	**lbs P_2O_5**				
Application method	**0.2** inject>2”	**0.4** incorp<1wk	**0.6** incorp.>1wk April-Oct	**0.8** incorp>1wk Nov-March	**1.0** surface frozen soil
	Fertilizer rating = rate*method				
Manure Availability	**0.5** Treated manure/biosolid		**0.8** Dairy	**1.0** Poultry/Swine	
	Manure Rating = rate x method x availability				
Source factor rating = STP + Fertilizer + Manure					

Part C
Transport Factors

Erosion	**Soil loss (ton $acre^{-1}$ yr^{-1})**				
Runoff Potential	**0** Very low	**2** Low	**4** Medium	**6** High	**8** Very high
Sub-surface Drainage	**0** none		**1** Some		**2** patterned
Contributing Distance (ft)	**0** >500	**2** 500-350	**4** 350-250	**6** 150-250	**8** < 150
Transport Sum = Runoff Potential + Sub-surface Drainage + Contributing Distance					
Modified Connectivity	**0.7** Riparian buffer < 150 ft		**1.0** Grassed waterway or none		**1.1** Direct connection > 150 ft
Transport factor = Modified connectivity x (Transport Sum/22)					

P Index Value

= 2 x Source factor x Transport factor

P Index Score	Risk	Management Guidance
< 60	Low	N- based applications
60 – 79	Medium	N-based applications
80 - 100	High	P application limited to crop P removal
> 100	Very High	No P applied

Example Scenario using PA

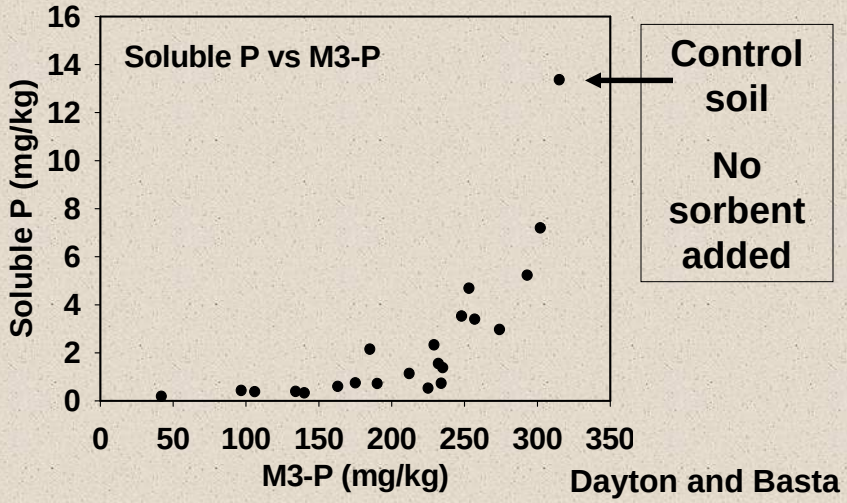
Source Factors		
STP (mg kg^{-1})		300
Manure rate (lbs P_2O_5 $acre^{-1}$)	2 ton $acre^{-1}$	100
Manure Application Method	April - Oct	0.6
Manure P Availability	Poultry	1
Transport Factors		
Erosion (tons $acre^{-1}$ yr^{-1})	1 ton $acre^{-1}$	1
Runoff Class	Medium	4
Sub-Surface Drainage	Some	1
Contributing Distance	350-250 ft	4
Modified Connectivity	Grassed Waterway	1

Results for Example Scenario

P Risk	Score
Low < 60	
Medium 60-79	
High 80-100	
Very High > 100	110

Reducing STP with Sorbent

3 Sorbents added to high STP (315 mg/kg) soil at 0, 1, 2.5, 5 or 10%



Dayton and Basta

Modify Soil Test P

Soil incorporation of P Sorbent

Reduce STP by 50% (300 to 150 mg kg^{-1})

Part A

Screening

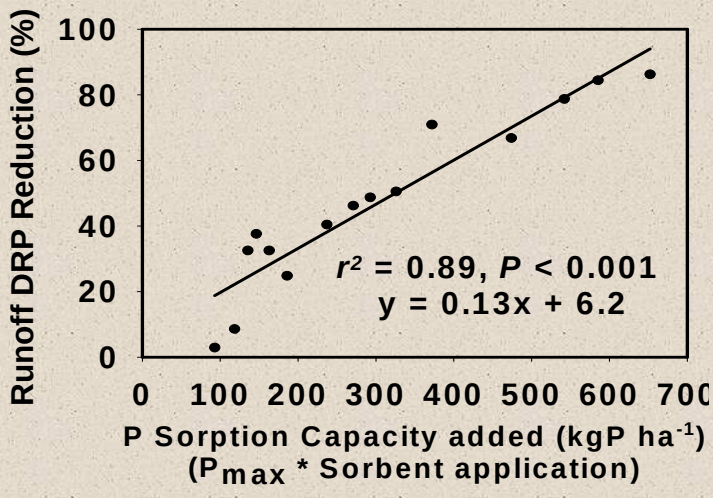
Mehlich III STP > 200 mg P kg^{-1}

< 150 ft from water

No further testing is needed
Risk is assumed to be low

Modified Connectivity

Control = 31 mg P /L
P Sorbent additions of 5, 10, 20 Mg/ha in a filter strip



Dayton & Basta, 2005, JEQ 34:2112-2117

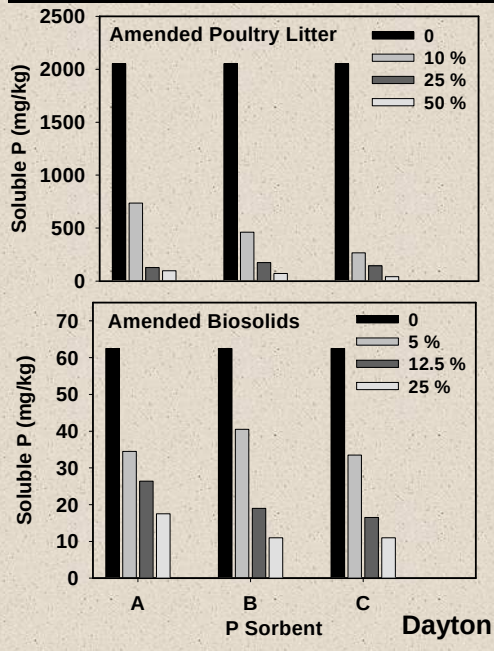
Example Scenario Modified Transport Factor

Modify Connectivity (1 to 0.7)
Change from grassed waterway to buffer strip with applied WTR

			Modify
P Risk	Score	Original	Connectivity
Low	< 60		
Medium	60-79		76
High	80-100		
Very High	> 100	110	

Is 0.7 the right modifier to use??
"Enhanced Buffer Strip" with sorbent should there be more credit given??

Reducing Manure P Solubility with Sorbent



Biosolids P is 33 times less soluble than poultry litter P at same total P (20g/kg)

Sorbent addition dramatically reduces P solubility

Dayton & Basta, 2005, JEQ 34:2112-2117

Example Scenario Modified Source Factor

Manure availability (1 to 0.5)

			Modify	
P Risk	Score	Original	connectivity	Manure
Low	< 60			
Medium	60-79		76	
High	80-100			82
Very High	> 100	110		

Modify Both Connectivity and Manure Availability

			Modify		
P Risk	Score	Original	connectivity	Manure	Both
Low	< 60				57
Medium	60-79		76		
High	80-100			82	
Very High	> 100	110			

Conclusions

Testing and validation of a P index is needed to ensure the success of P-based nutrient management at the farm and watershed scale

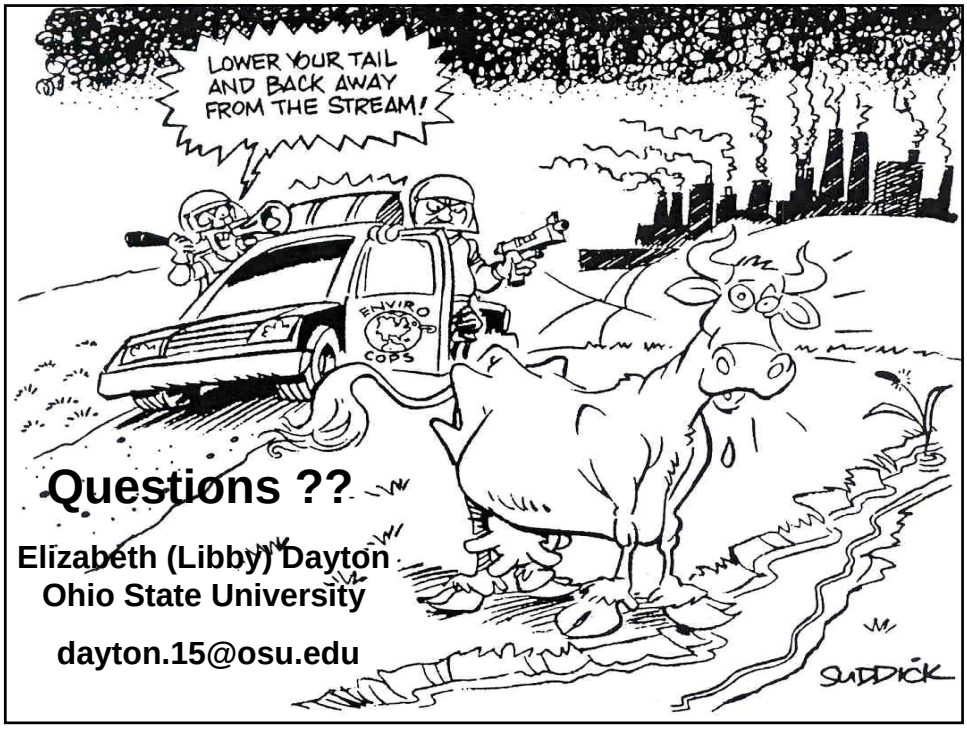
To increase the utility of the P Index, Adjustments (BMPs) to reduce P index scores need to be developed and validated

By considering P source and transport factors as well as management systems, a robust P Index Framework can provide flexibility in reducing risk of agricultural P transport

Laboratory Chemistry and Bench Testing

Plant Bioassay and Runoff Studies

Field Projects Validation Studies



Questions ??

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