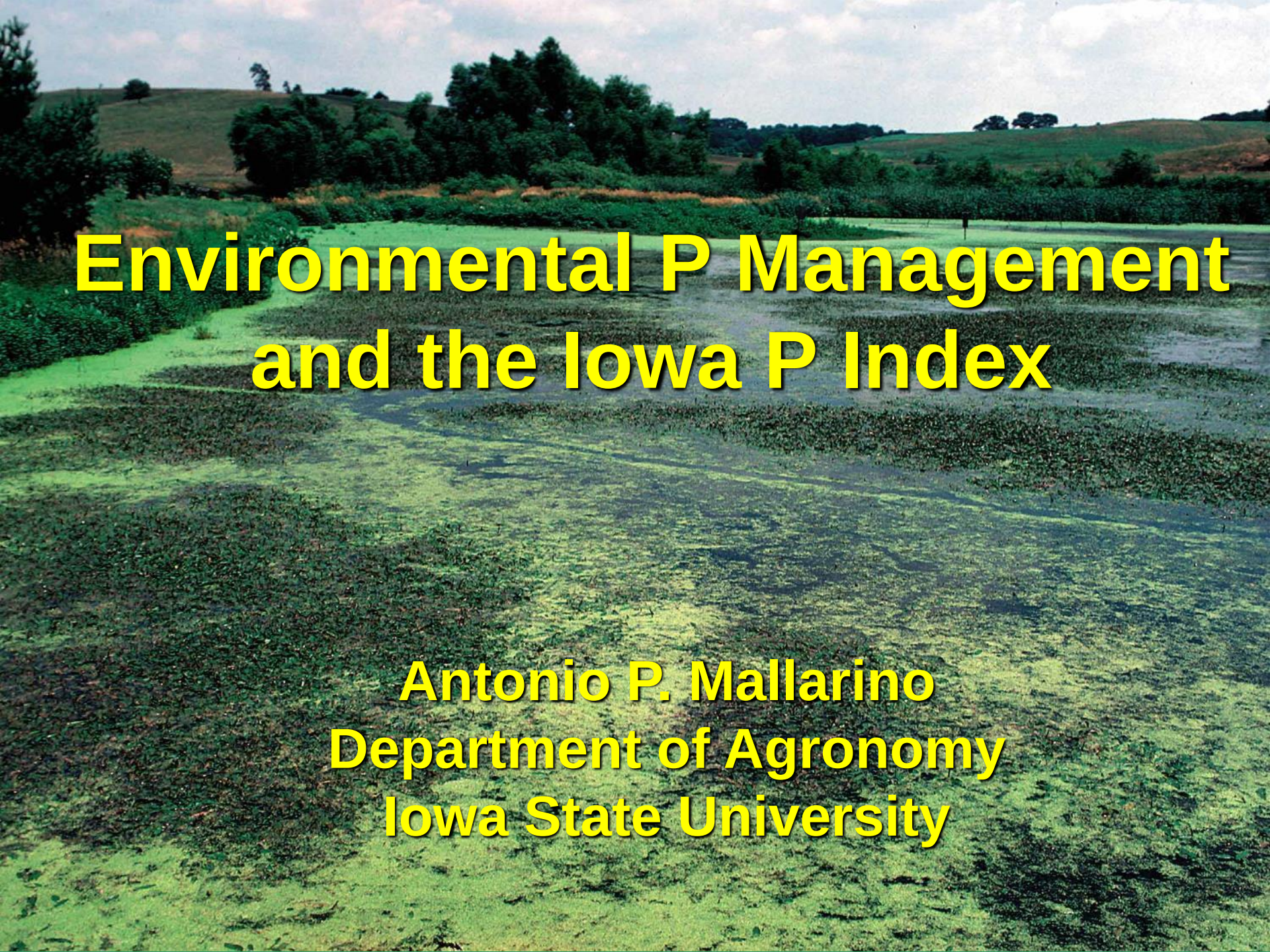

Environmental P Management and the Iowa P Index

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Department of Agronomy
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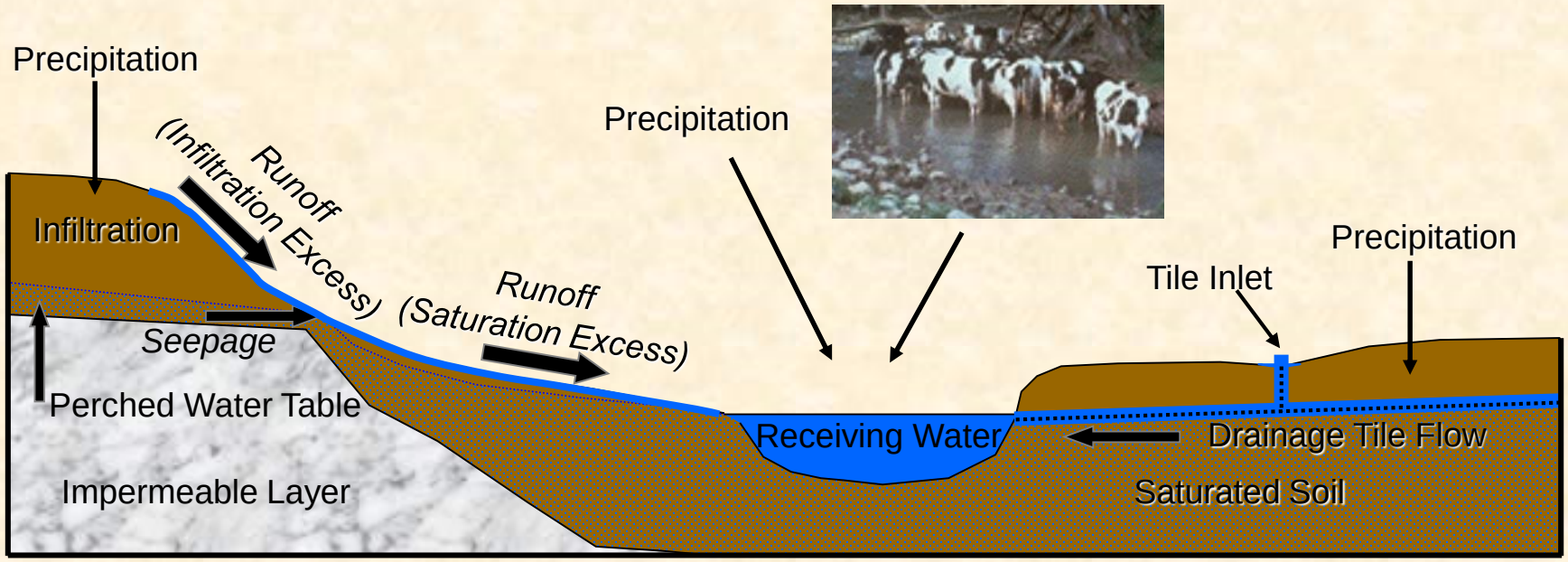
Impact of P on Water Quality

Attribute	Oligotrophic 0-20 ppb	Mesotrophic 20-70 ppb	Eutrophic 70-200 ppb	Hyper Eutrophic 200+ ppb
Clarity	Excellent	Good	Poor	Very Poor
Oxygen	Abundant	Adequate	Hypoxic	Anoxic
Toxic Algae	Absent	Absent	Frequent	Constant
Bacteria	Rare	Rare	Abundant	Very Abundant
Silt / Filling	Very Slow	Slow	Rapid	Very Rapid
NH_3 Toxicity	Improbable	Infrequent	Frequent	Constant
Biodiversity	High	Good	Poor	Very Poor
Fish & Wildlife Habitat	Good	Excellent	Poor	Very Poor
Sport Fish	High Quality	Good Quality	Poor Quality	Rough Fish

Pathways for P Loss

- **Soil erosion**:
  - gully
  - sheet and rill
  - stream bank
- **Surface runoff**:
  - infiltration excess
  - saturation excess
  - seepage
- **Subsurface drainage**:
  - tiles
  - coarse soil/subsoil



Forms of Soil P Lost

- **Dissolved P in water: immediate but short-term impact on water quality of streams and lakes:**
  - **surface water runoff**
  - **through the soil profile (tiles)**
- **P bound to sediment (particulate P): slow but large long-term impacts mainly on lake water**

The Need for a P Index

- Soil-test P interpretation classes and P recommendations for crops do not apply for environmental purposes
- Factors influencing P transport with soil and water loss (erosion, runoff, drainage) often are more important
- Soil P, P management, and soil & water transport factors should be integrated into a risk rating system

Advantages of the P Index

- The P index seems a complicated tool, but is the best one
- Use of a simple soil P threshold would not be effective, will be too low in some conditions and unnecessarily restrictive in others
- The P index is field specific, and gives producers needed flexibility

P Index, Nutrient Reduction Strategy

	Practice	Comments	% P Load Reduction[a]	% Corn Yield Change[b]
			Average (SD[c])	Average (SD[c])
Phosphorus Management Practices	Phosphorus Application	Applying P based on crop removal – Assuming optimal STP level and P incorporation	0.6[d]	0
		Soil-Test P – No P applied until STP drops to optimum or, when manure is applied, to levels indicated by the P Index[f]	17[e]	0
	Source of Phosphorus	Liquid swine, dairy, and poultry manure compared to commercial fertilizer – Runoff shortly after application	46 (45)	-1 (13)
		Beef manure compared to commercial fertilizer – Runoff shortly after application	46 (96)	
	Placement of Phosphorus	Broadcast incorporated within 1 week compared to no incorporation, same tillage	36 (27)	0
		With seed or knifed bands compared to surface application, no incorporation	24 (46)	0
	Cover Crops	Winter rye	29 (37)	-6 (7)
	Tillage	Conservation till – chisel plowing compared to moldboard plowing	33 (49)	0 (6)
		No till compared to chisel plowing	90 (17)	-6 (8)
Land Use Change	Perennial Vegetation	Energy Crops	34 (34)	
		Land Retirement (CRP)	75	
		Grazed pastures	59 (42)	
Erosion Control and Edge-of-Field Practices	Terraces		77 (19)	
	Buffers		58 (32)	
	Control	Sedimentation basins or ponds	85	

P Index Three Components

Soil Erosion
(Particulate P)

Source Factors
- soil P
- application method, timing, and rate

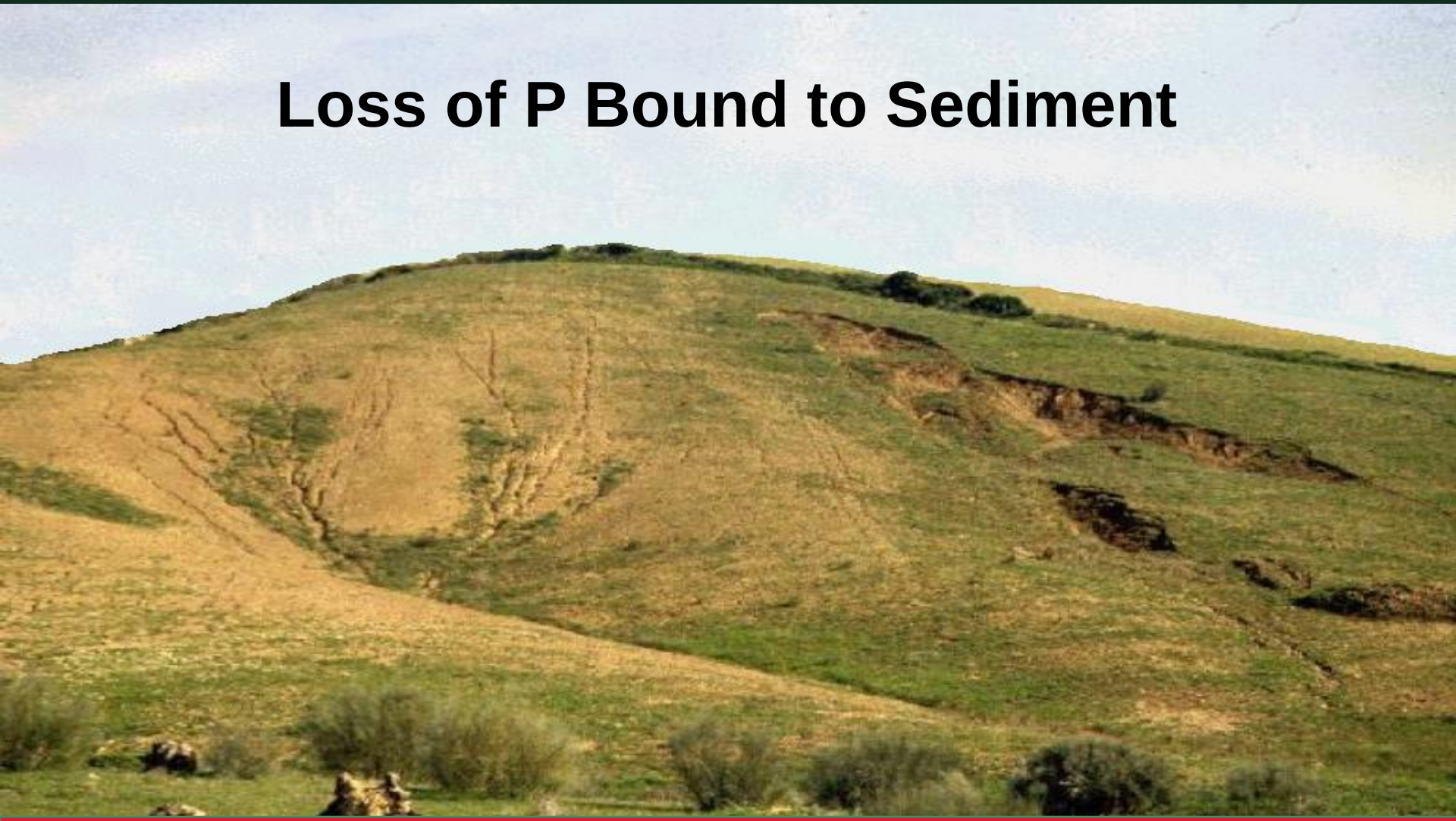
Water Runoff
(Dissolved P)

Tile Drainage
(Dissolved P)

Soil and water conservation practices

Soil Erosion Component

Loss of P Bound to Sediment



Soil P Loss and Soil Erosion

- Estimates P in sediment that is effectively transported to a stream
- Various factors:
  - Total soil P
  - Soil loss (RUSLE 2 estimate)
  - Sediment traps and delivery, filter strips, sediment enrichment in P
  - Distance to channeled water flow
  - Availability for algae growth

Estimating Total Soil P

- Can be measured by testing but it is a highly variable and expensive test
- Uses an equation based on data from Iowa and neighboring states
  - Average total P in the 6-inch layer of low-testing soils
  - A recent routing soil P test
  - Total P = 500 + (3 x Bray-1 Soil P)

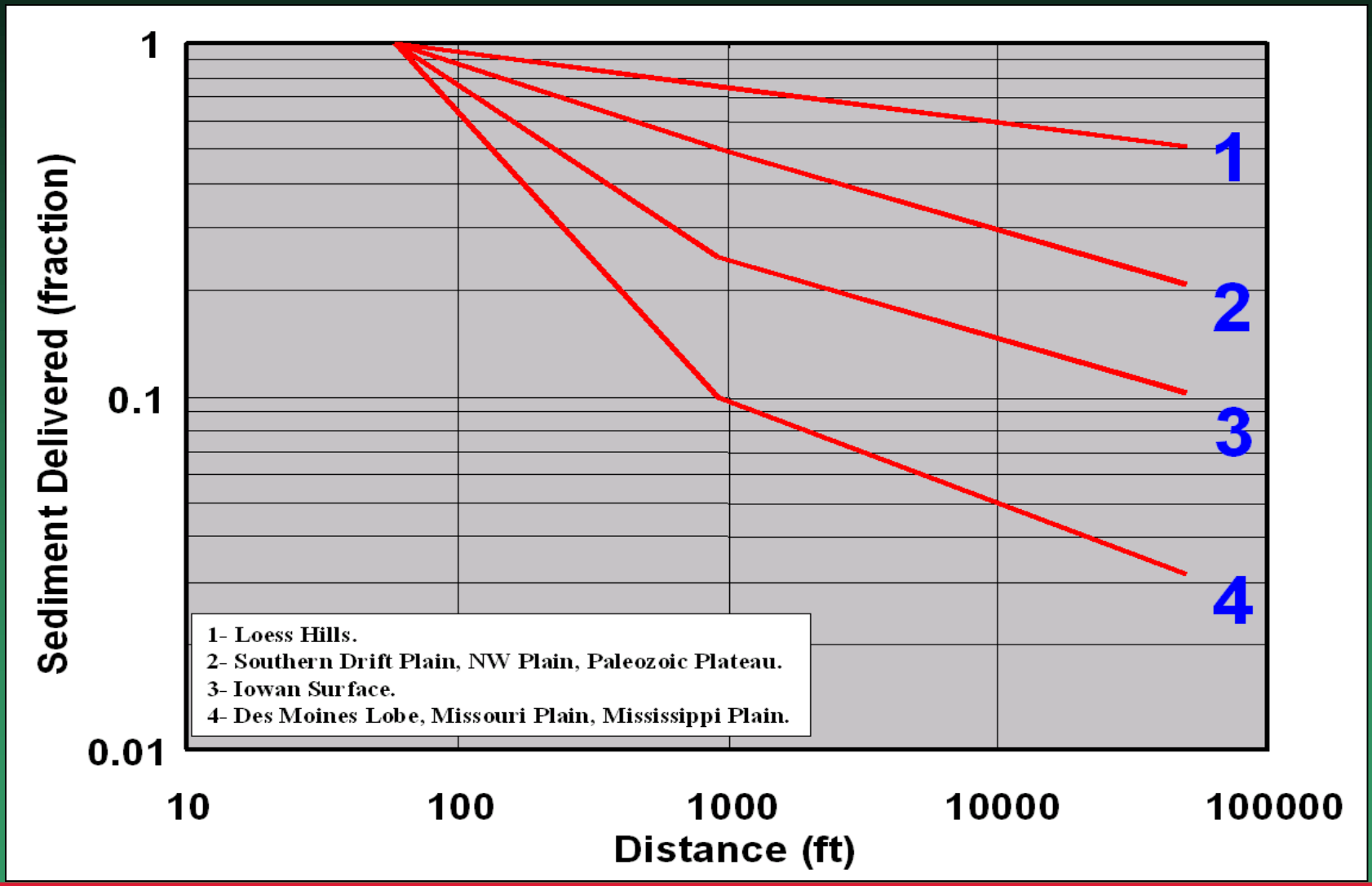
Sediment Trap Factor

Conservation Practice	Factor
Level terrace	0.00
Ponds, tile inlet terrace, or grade stabilization impoundment	0.05
Water & sediment control basin	0.20

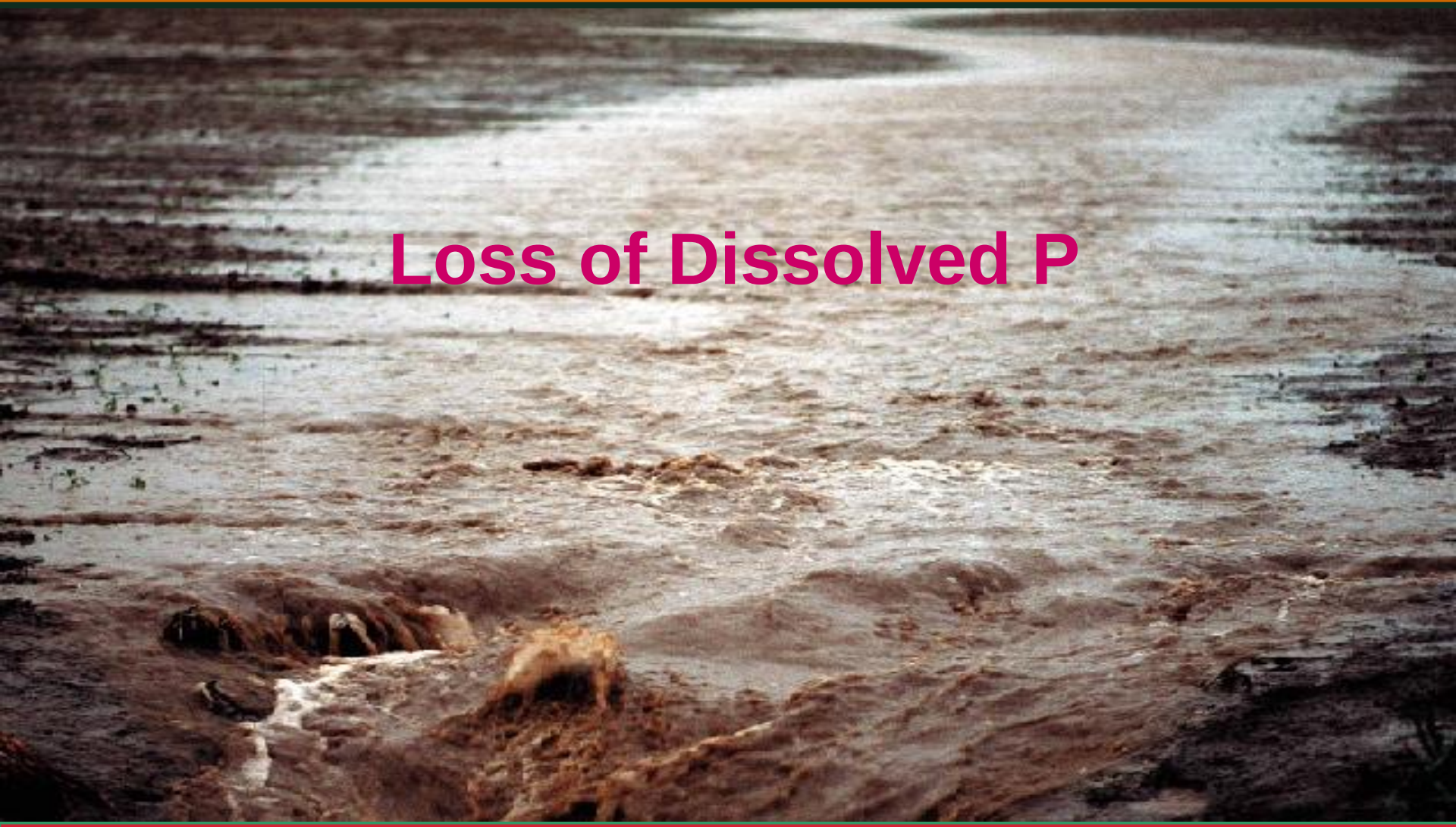
Filter Strip Factor

Buffer Width	Factor
Less than 20 feet	1.0
20 to 75 feet	0.7
More than 75 feet	0.5

Estimate of Sediment Delivery



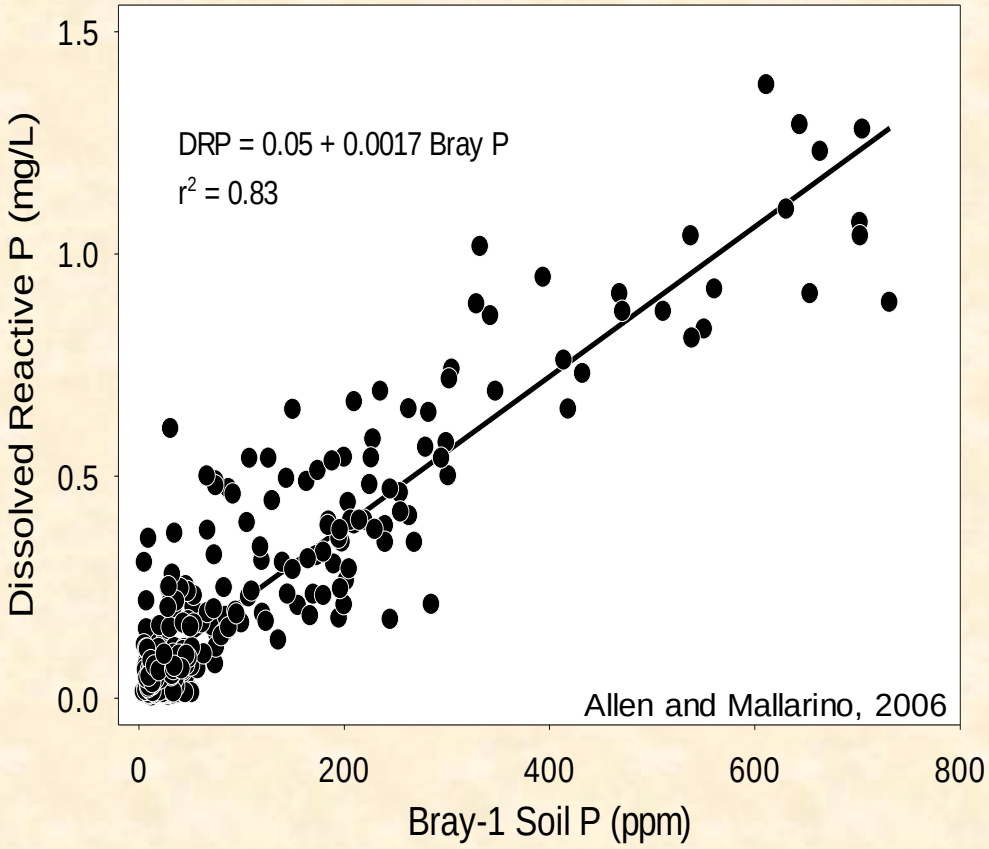
Surface Runoff Component

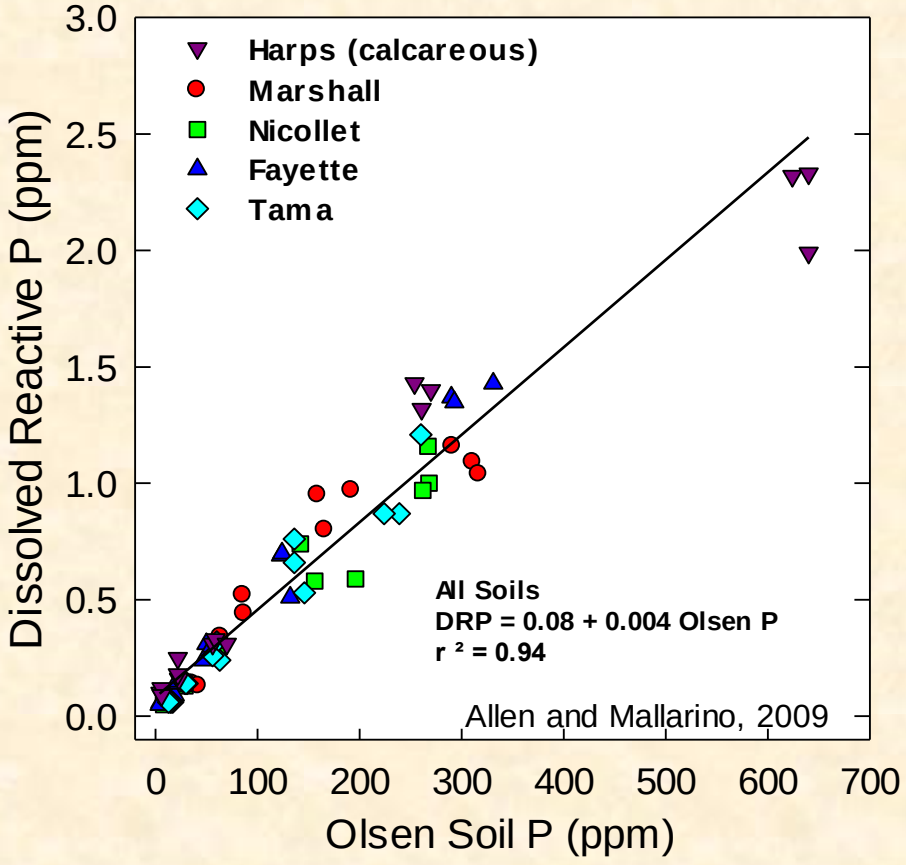


Soil P Loss and Surface Runoff

- Estimate of surface runoff volume (NRCS runoff curve numbers)
- Dissolved P concentration in runoff increases with increasing soil-test P, uses average relationships from research in Iowa and other states
- Use agronomic soil-test P methods and sampling depth recommended for crop production in Iowa

Runoff P Loss and Soil-Test P Level

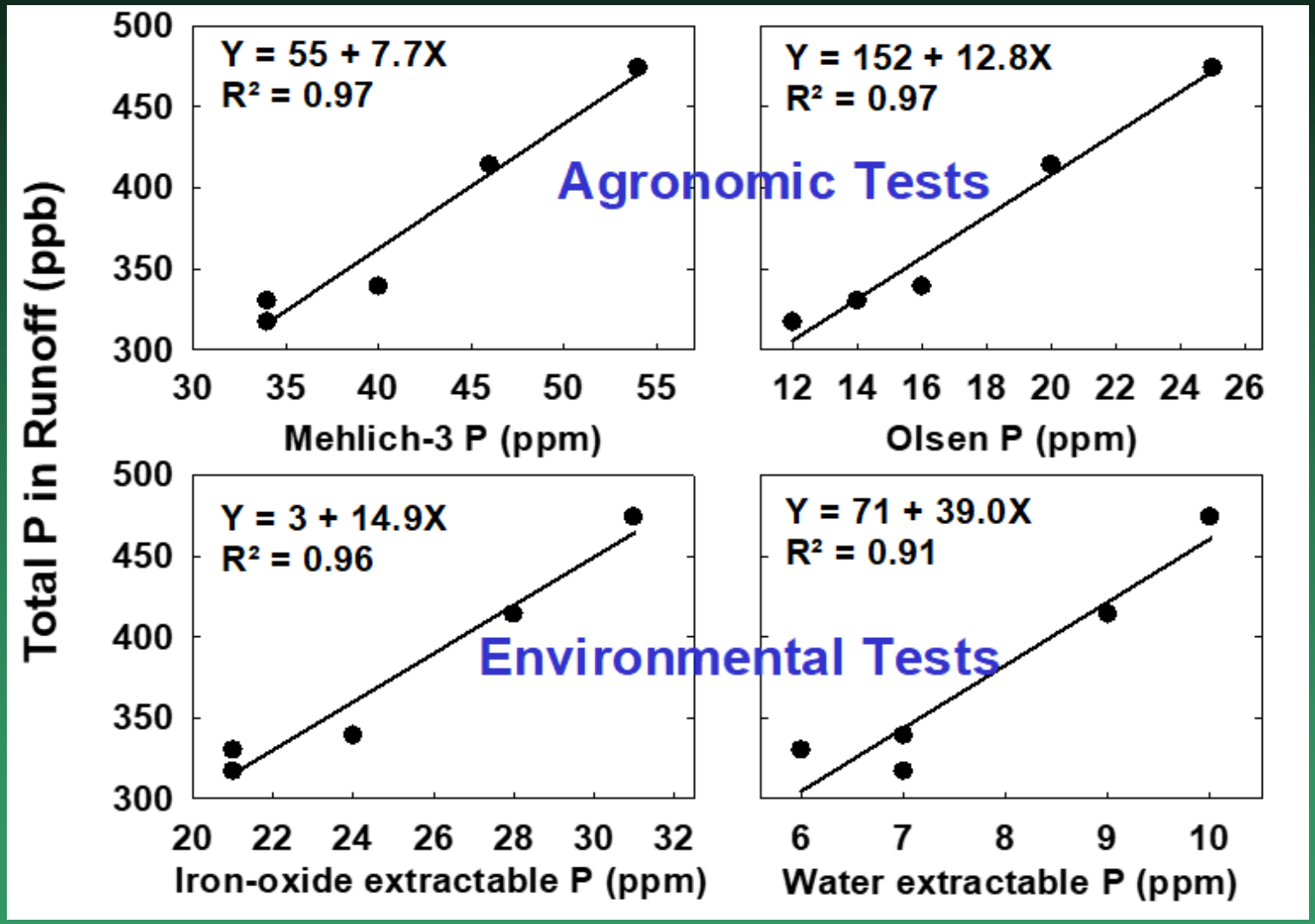




Mallarino, Haq, Allen, Baker; ISU

P in Surface Runoff and Soil P

P in Surface Runoff and Soil P



Mallarino & Klatt; ISU

P Rate and Application Factors

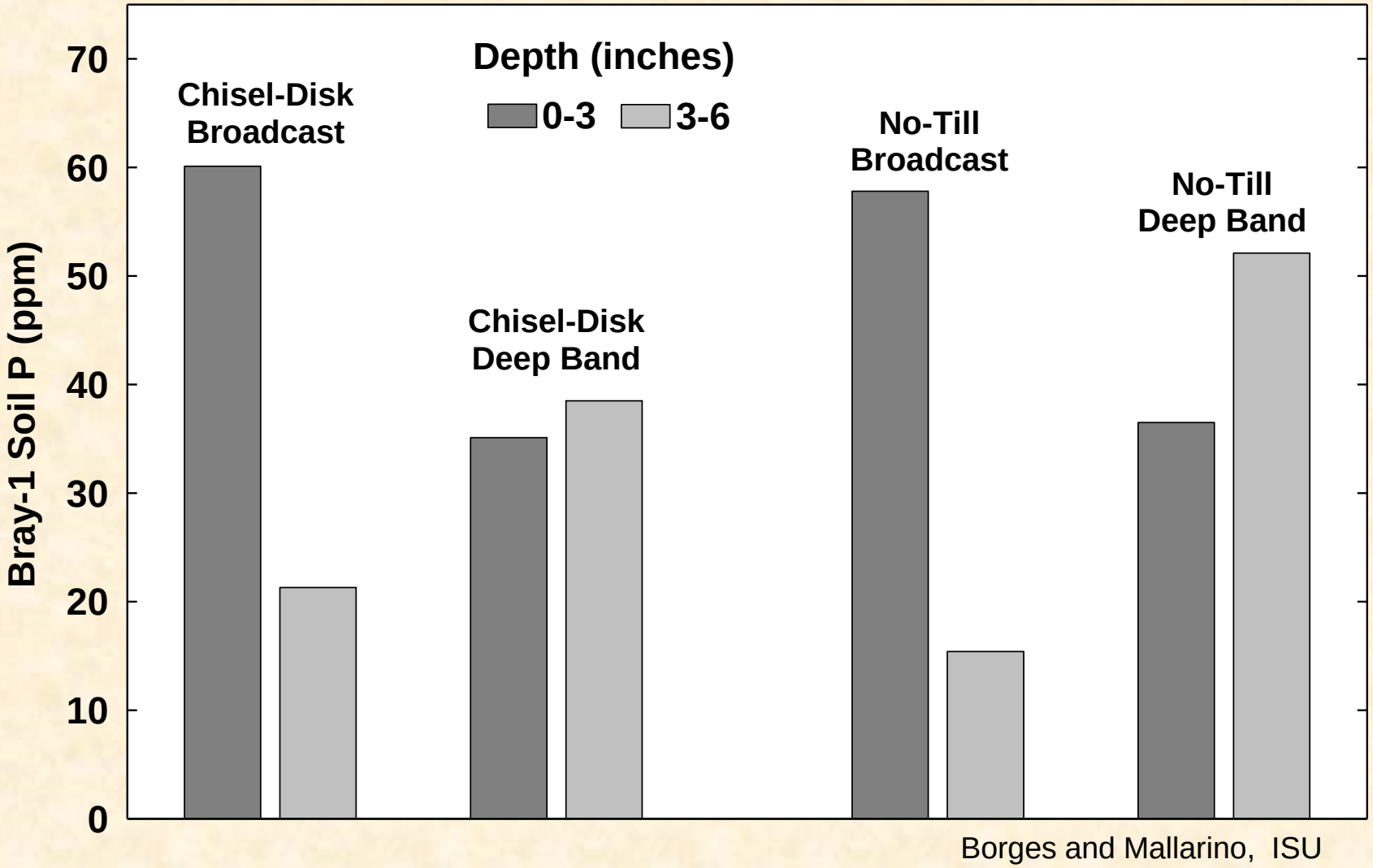
P Rate and Application Factors

- The main way the Index accounts for P rate is through long-term effects on soil-test P
- This factor applies to recent fertilizer or manure application, since the last soil test
  - Impacts of the P application rate, method, and timing of application on dissolved P loss

Method and Time of P Application

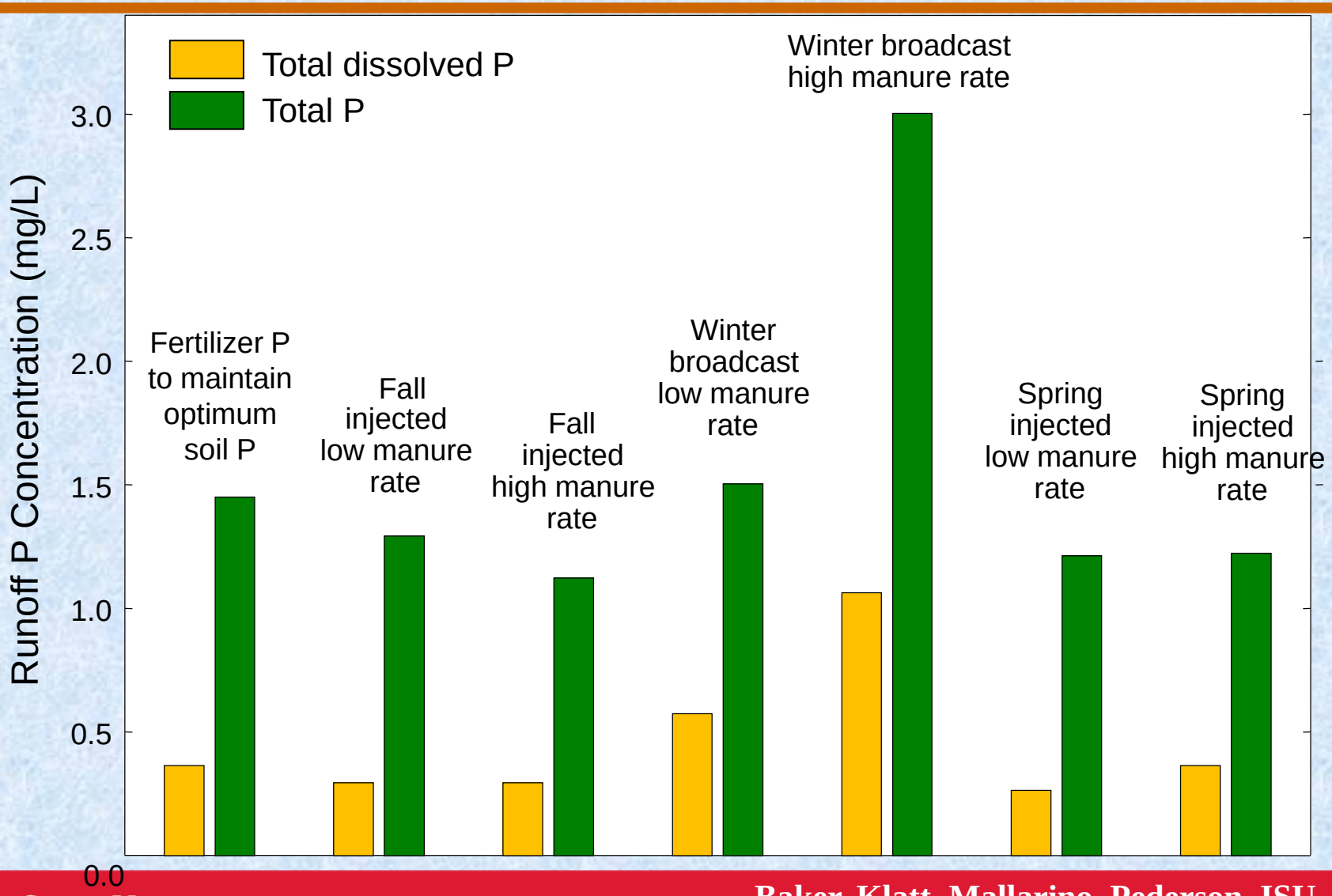
Method/Time of Application	Coefficient
Incorporation/injection within 24 hrs	0.4
Incorporate within one week	0.6
Surface applied (good conditions)	1.0
Surface app. to frozen/snow ground	1.5

Deep P Placement



Borges and Mallarino, ISU

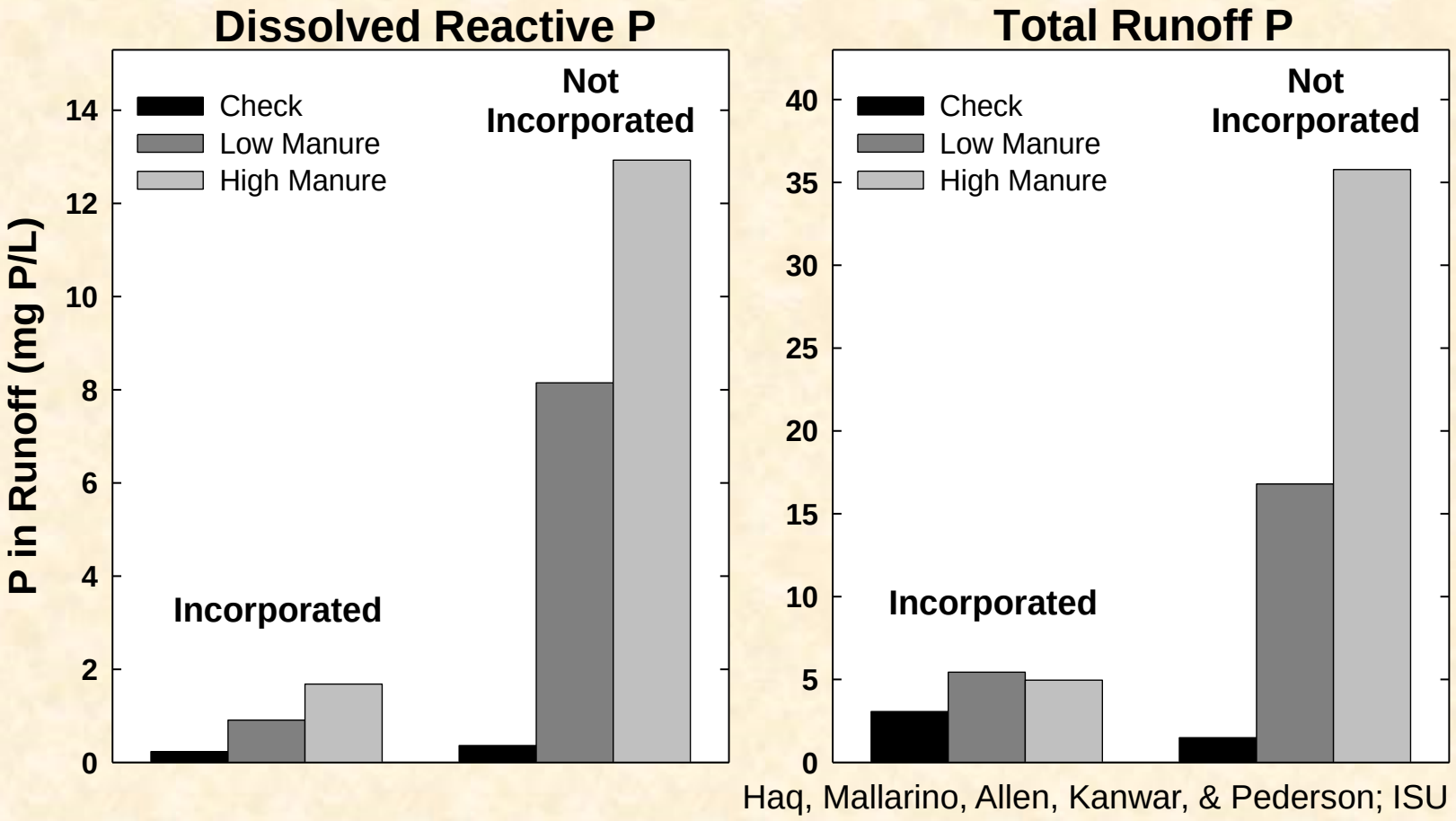
Swine Manure Placement and Runoff P



Baker, Klatt, Mallarino, Pederson. ISU

Manure Incorporation and Runoff P Loss

Poultry Manure at 0, 150, and 300 lb N/acre, Shortly After Application
Averages Across Six Years, One Site



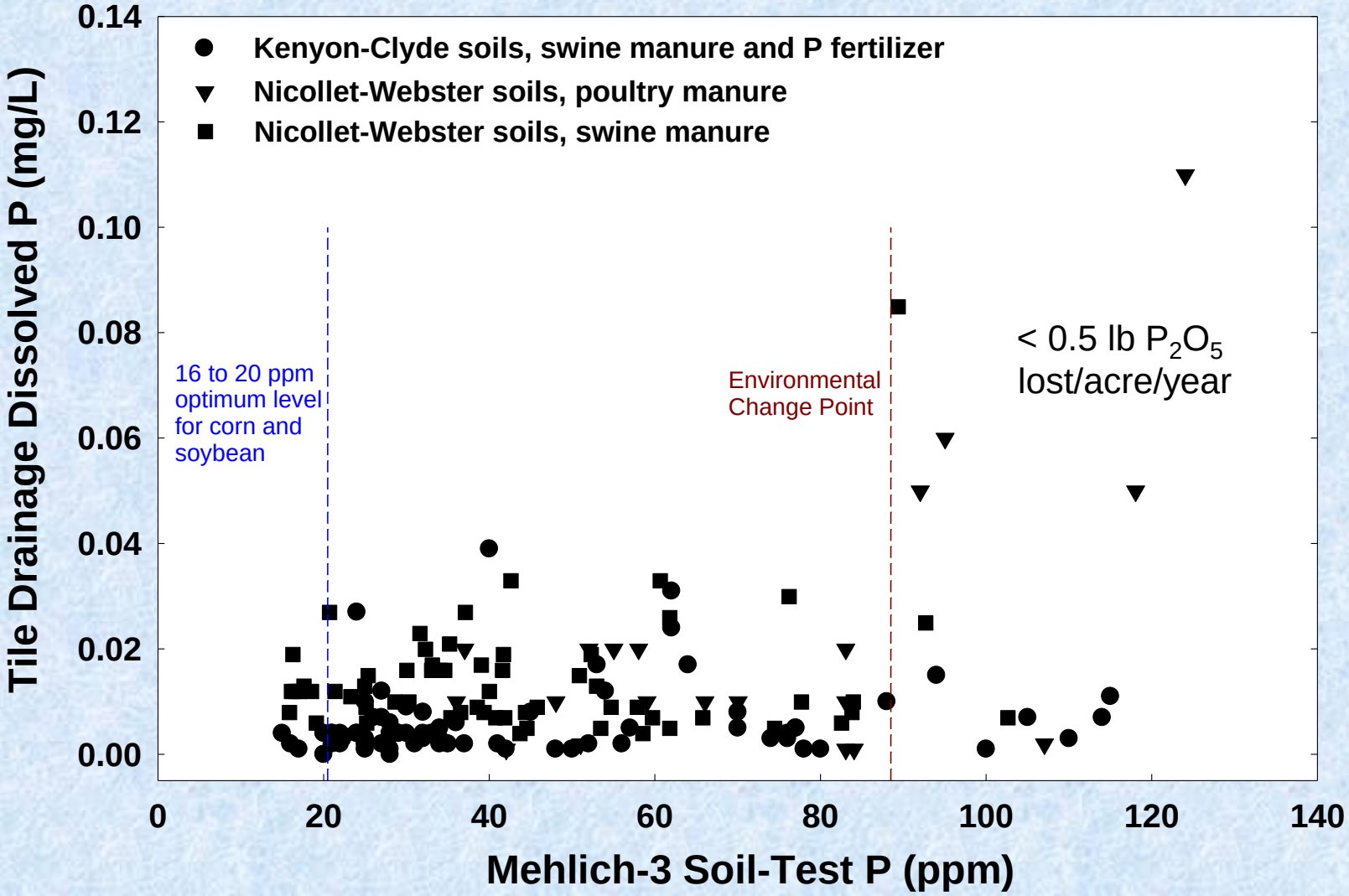
Haq, Mallarino, Allen, Kanwar, & Pederson; ISU

Subsurface Drainage Component

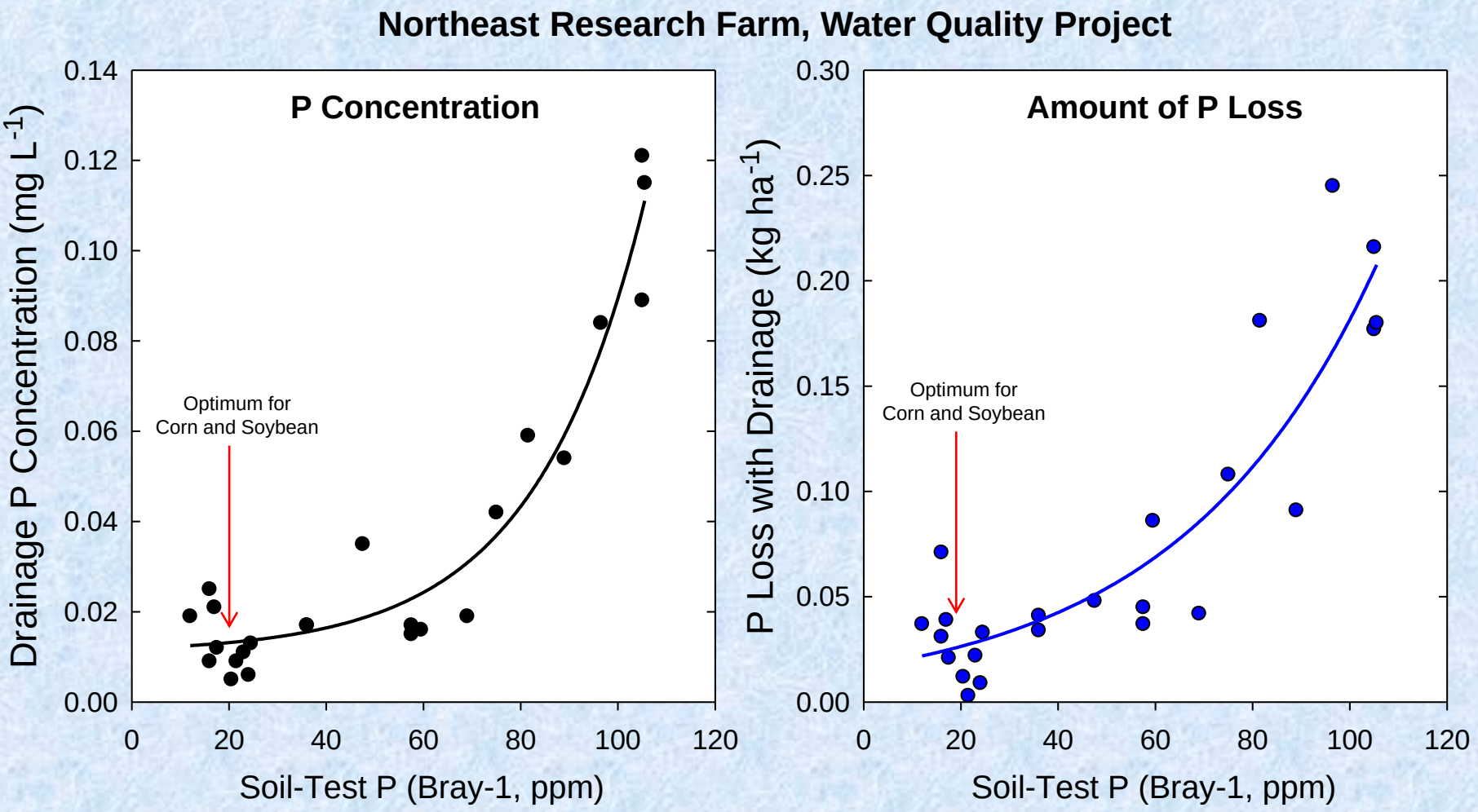
Soil P Loss and Subsurface Drainage

- Assumes water flow as 10% of annual precipitation
- Are tiles or sandy subsoil present?
- Assume no P loss if answer is no
- Soil-test P drainage factor:
  - 0.1 if Bray P is less than 100 ppm
  - 0.2 if Bray P is 100 ppm or higher

Soil-Test P and Tile Drainage P Loss

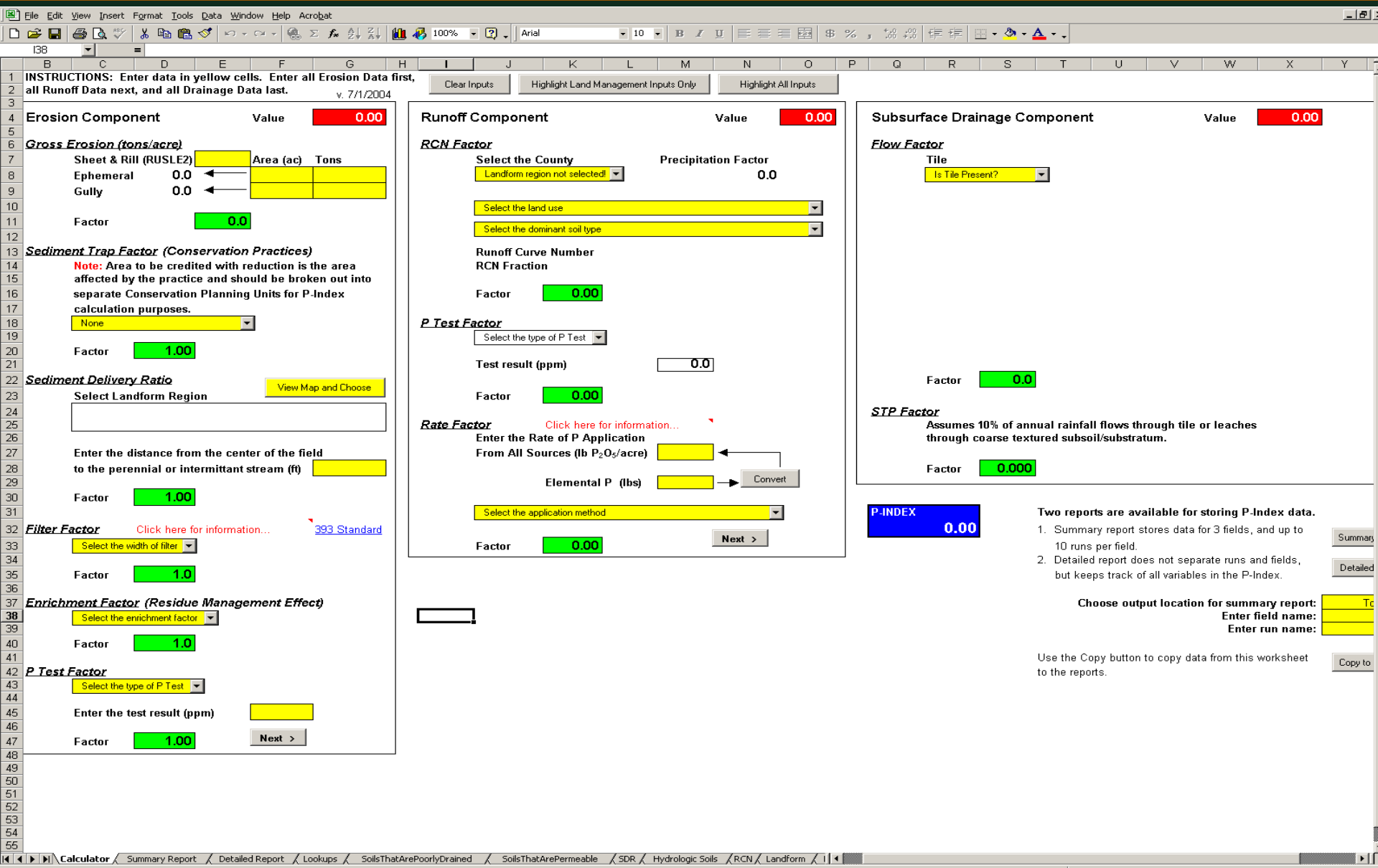


Tile Drainage P and STP



Haq, Mallarino, Baker, Helmers, Pederson; 2011

The P Index Calculator



P Index Risk Ratings

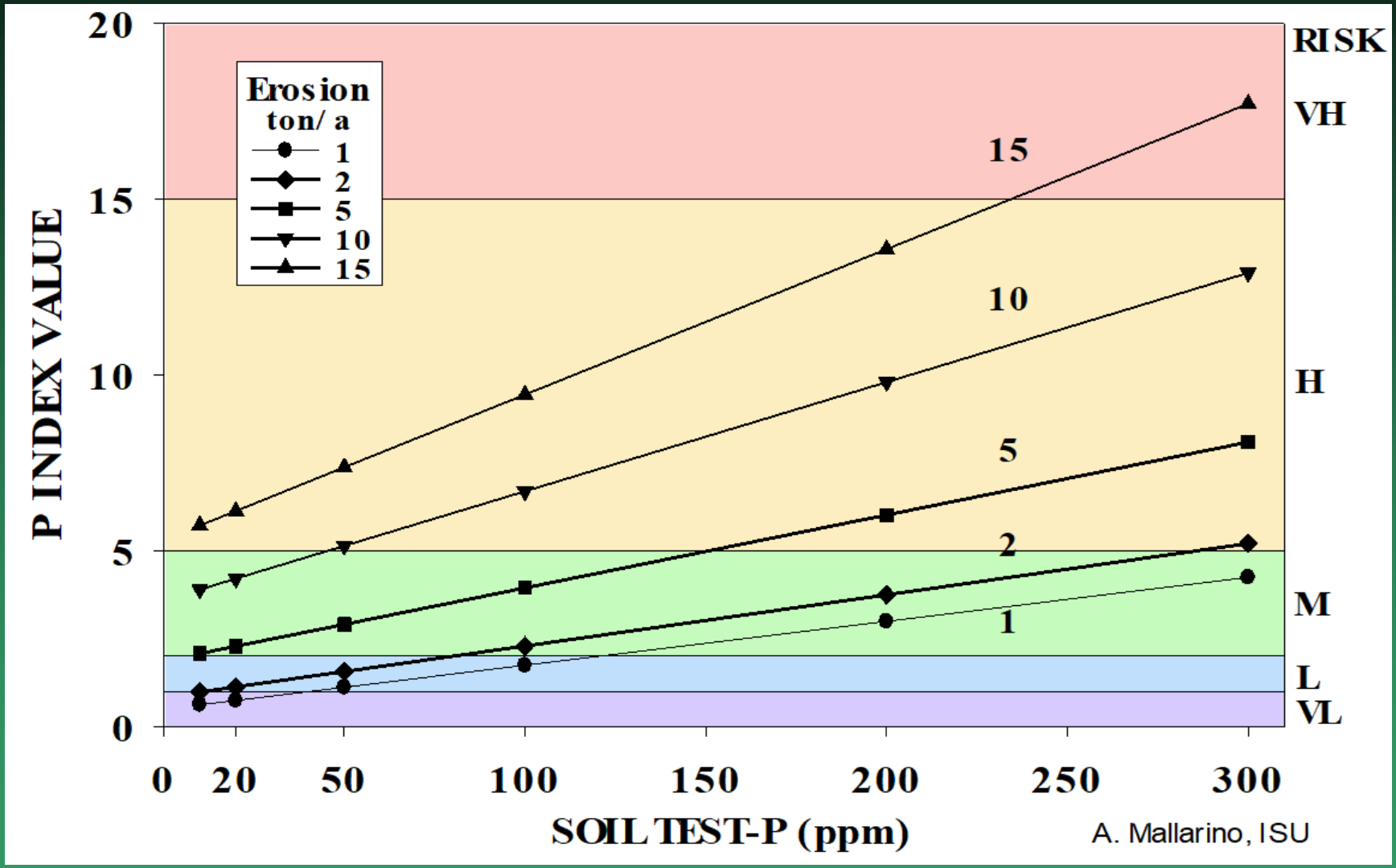
Current P and soil conservation practices result in:

- **Very Low or Low impacts**
  - **Excellent from an ecological water quality perspective**
- **Medium impact**
  - **Acceptable P loss, but future practices should not increase the risk of P loss**

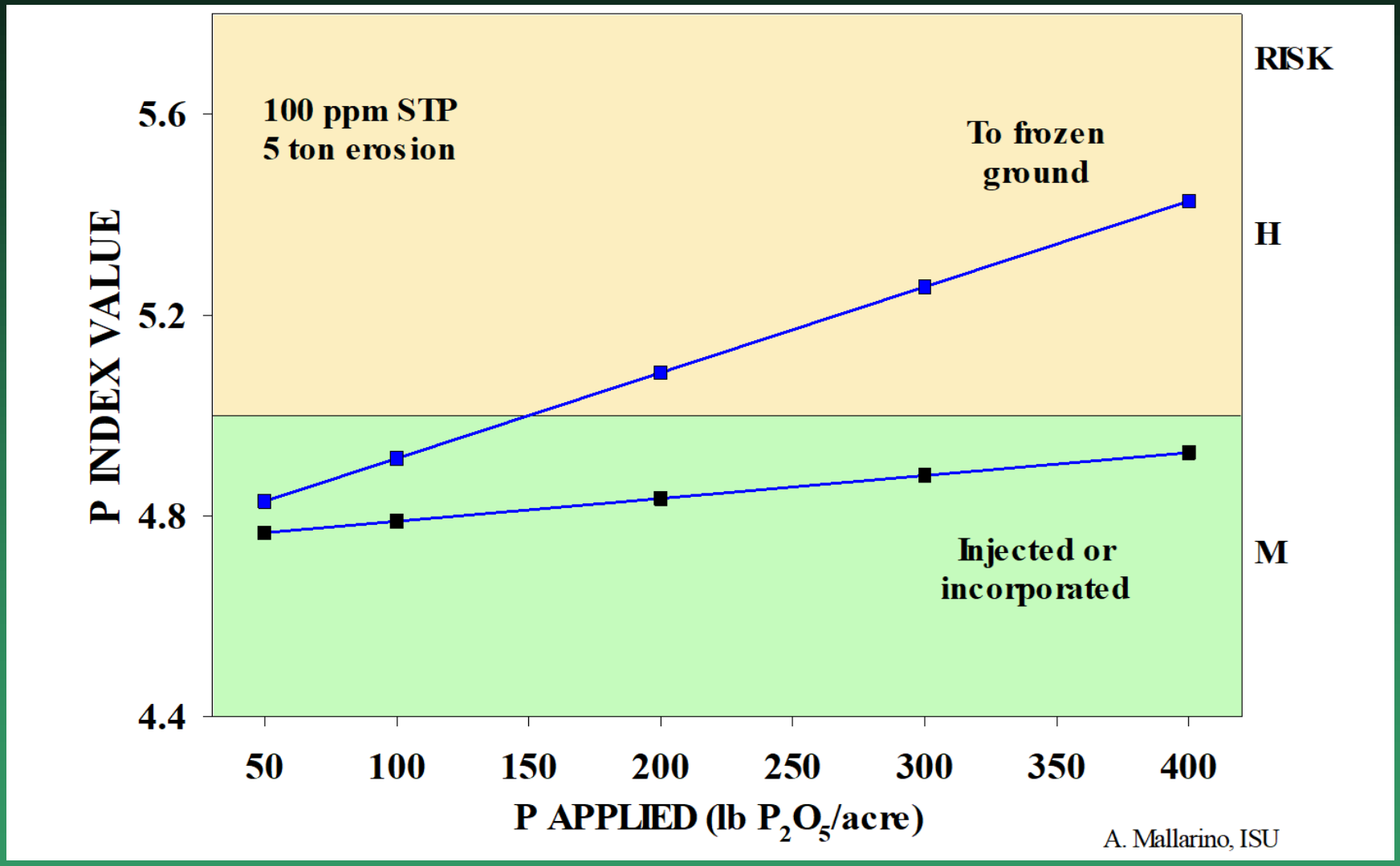
Site Vulnerability Ratings

- **High impact**
  - Obvious problem, new soil conservation **and/or** P management practices should be implemented
- **Very High impact**
  - Extreme problem, new soil conservation **and** P management practices that **may** require no P application are needed

Combined Effects: Erosion and Soil P

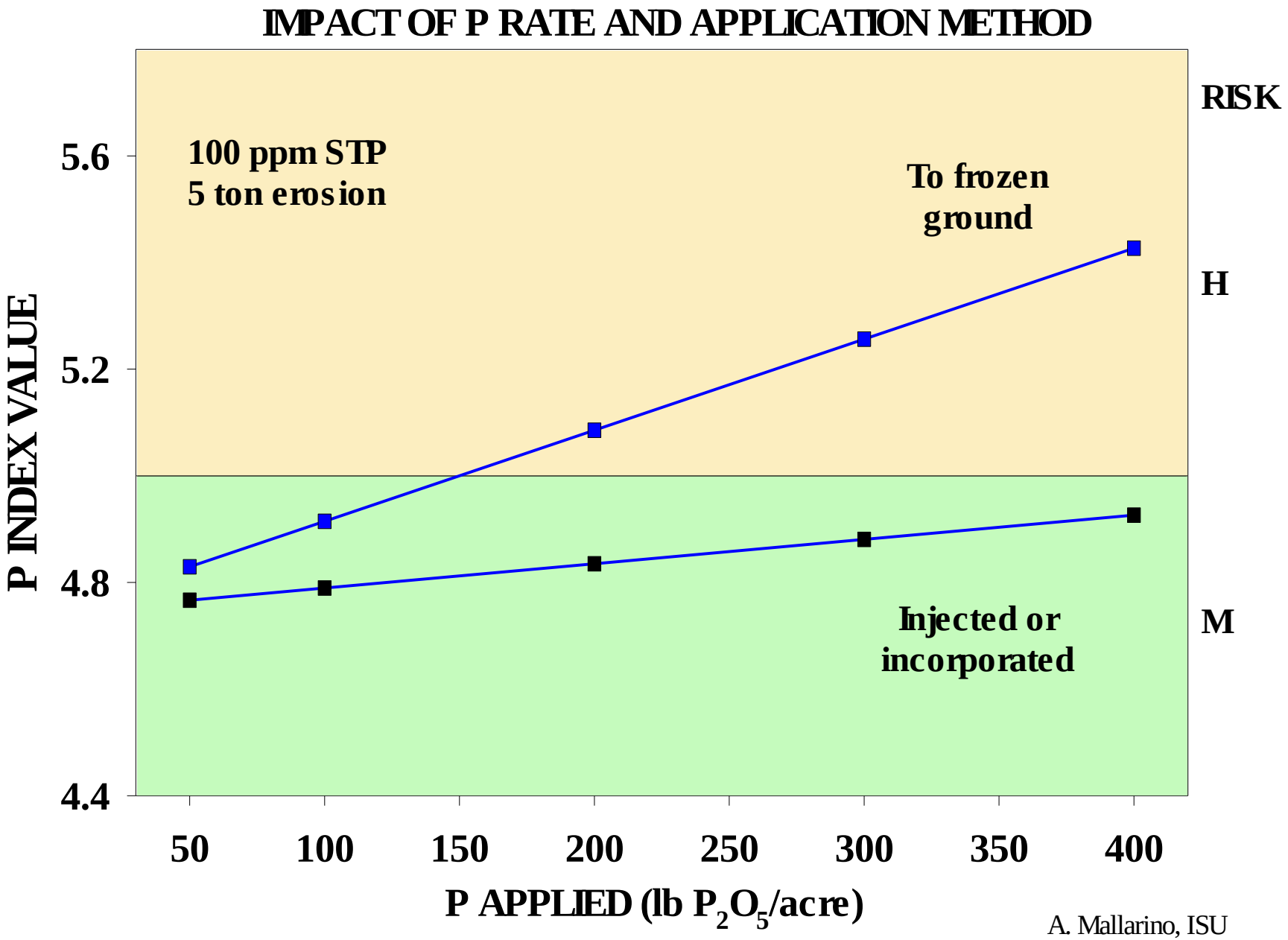


Combined Effects: Application Method and Soil P



Study Individual Components

Index Component		Very High Soil Test, High Erosion
Gross Erosion	10	RUSLE erosion: 10 ton
Sediment Trap/SDR	0.49	SIDP: 1,000 feet
Buffer Factor	1	Buffer: None
Enrichment Factor	1.1	Tillage without Buffer
STP Erosion Factor	1.54	Bray 1-P: 200 ppm
→ Erosion	8.30	
Runoff Factor	0.21	RCN: 78
Precipitation Factor	7.9	Adams County
STP Runoff Factor	1.05	Bray 1-P: 200 ppm
P Application Factor	0.02	100 lb P_2O_5/acre; 24 hr. incorp.
→ Runoff	1.78	
Flow Factor	0.1	Tile/Coarse Subsurface: Yes
Precipitation Factor	7.9	Adams County
STP Drainage Factor	0.2	Bray 1-P: 200 ppm
→ Subsurface	0.16	
→ P- Index	10.2	High Risk Rating


IMPACT OF P RATE AND APPLICATION METHOD
RISK
100 ppm STP
5 ton erosion
To frozen ground
H
Injected or incorporated
M
P INDEX VALUE
5.6
5.2
4.8
4.4
50
100
150
200
250
300
350
400
P APPLIED (lb P_2O_5/acre)
A. Mallarino, ISU

Meaning of Partial P Index Values

- The index provide partial ratings for Erosion, Runoff and Subsurface Drainage components
- The partial ratings are very useful:
  - identify reasons of high loss risk
  - suggests what P management or soil conservation practices will be more effective

Index Component	Very High Soil Test, High Erosion	
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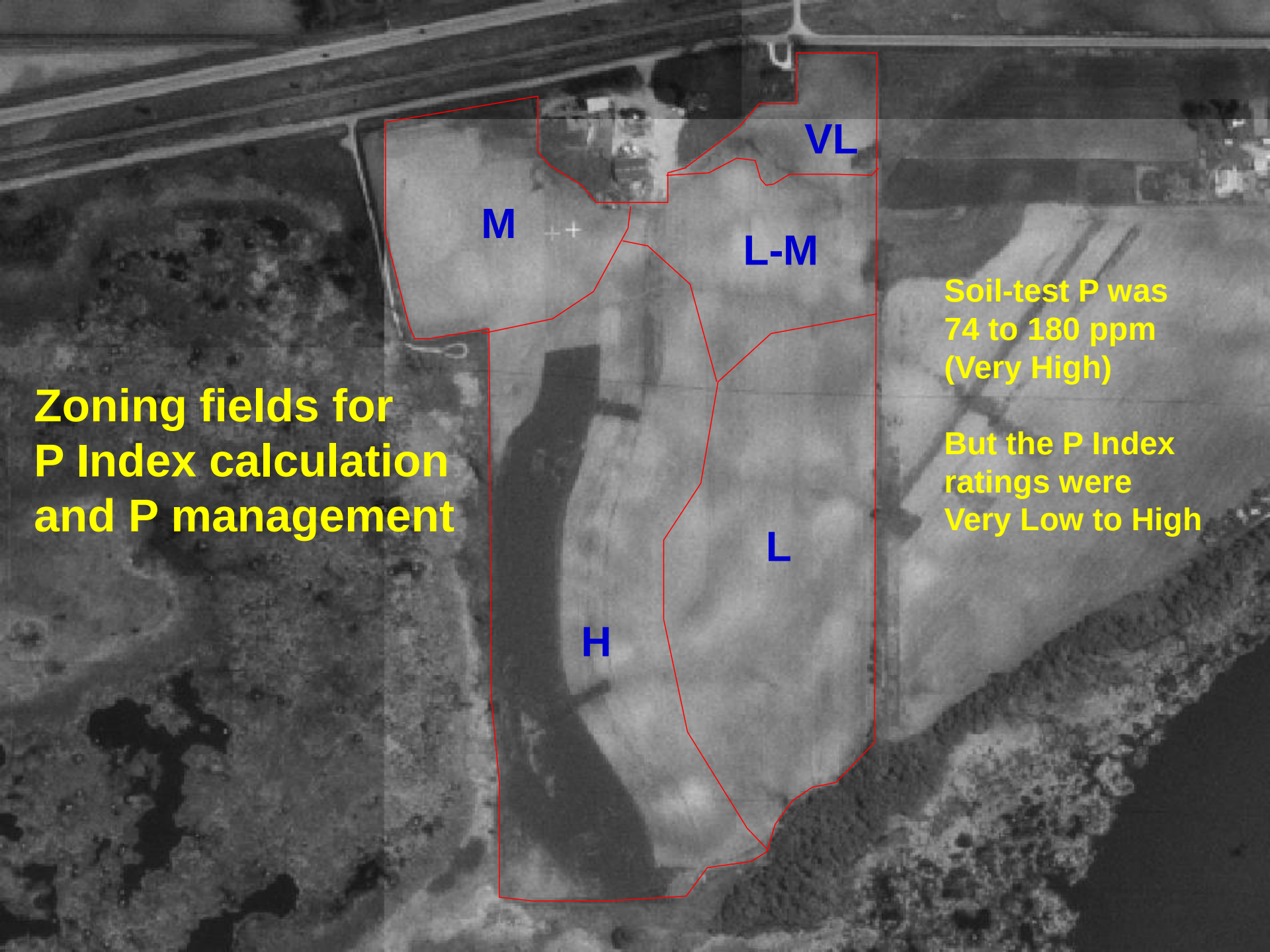


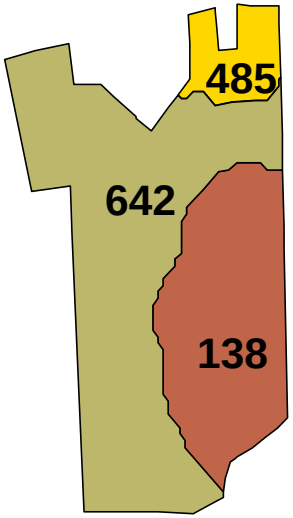
Zoning fields for P Index calculation and P management

Soil-test P was 74 to 180 ppm (Very High)

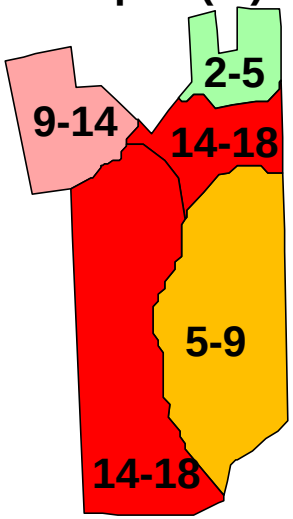
But the P Index ratings were Very Low to High

Delineate Field Zones for P Index Calculation

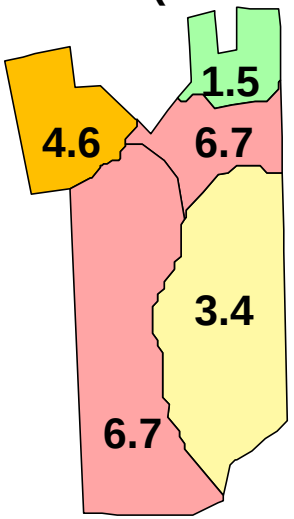
Soil Series



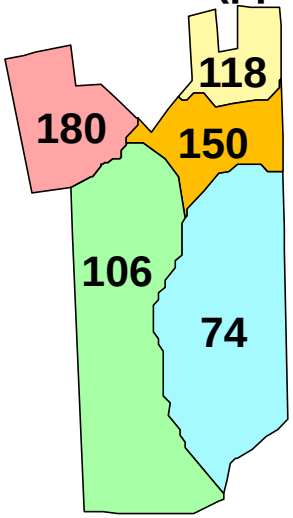
Slopes (%)



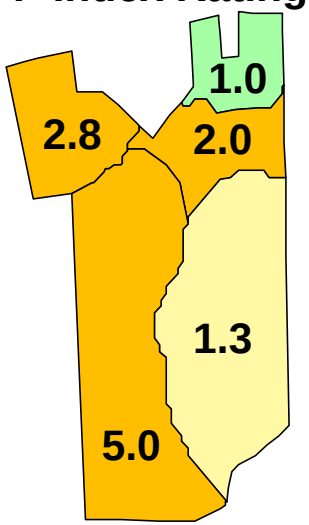
Erosion (ton/acre)



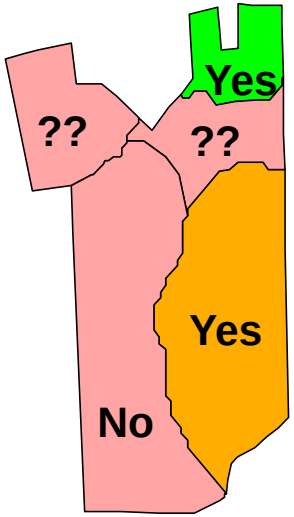
Soil-Test P (ppm)



P Index Rating



N-Based Manure?



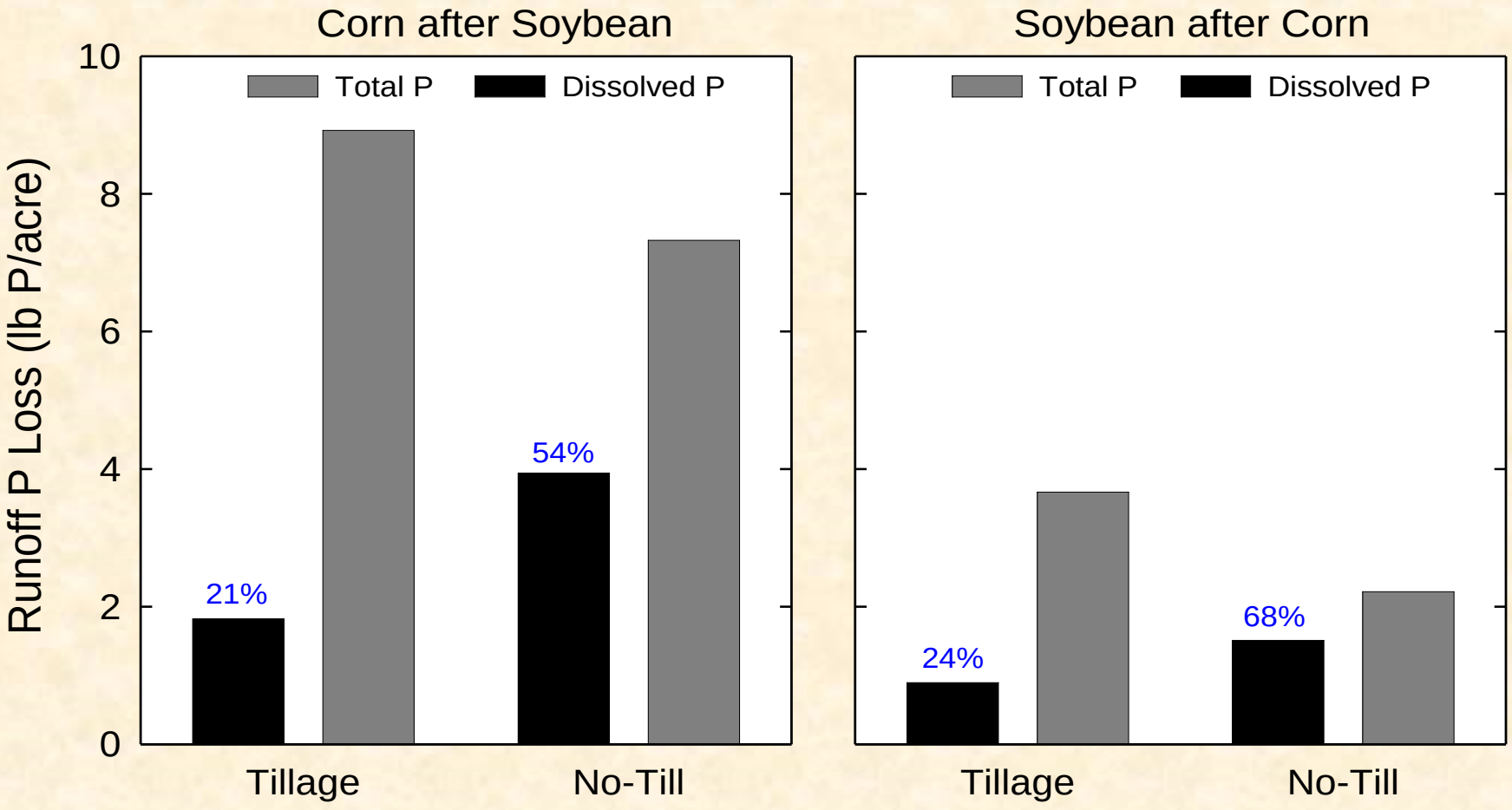
Mallarino, Wittry, & Stewart. ISU & NRCS

P Index and P Management

- The index is a P assessment tool
- Identifies reasons for high P loss, but has no built-in limits for soil-test P or P application rates
- Suggests alternative field-specific management and soil & and water conservation practices to reduce risk of P loss

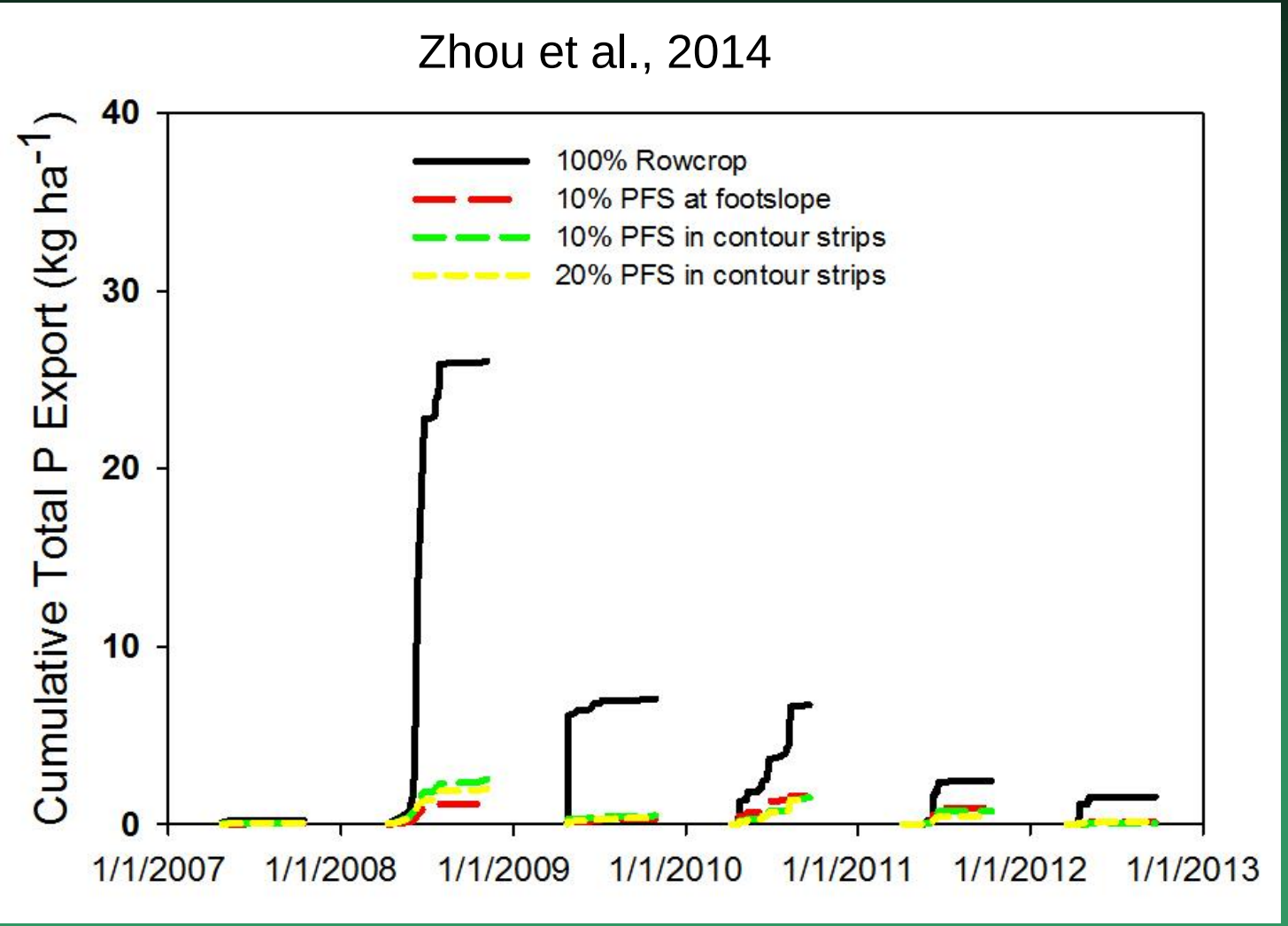
Northwest Iowa Runoff P Study

Natural Rainfall, 100 lb P_2O_5/acre to Corn for the C-S Rotation (6 Years Avgs.)



Mallarino, Haq, et al., 2012

Grass Filter Strips



>90% Reduction in P export from watersheds with prairie filter strips.

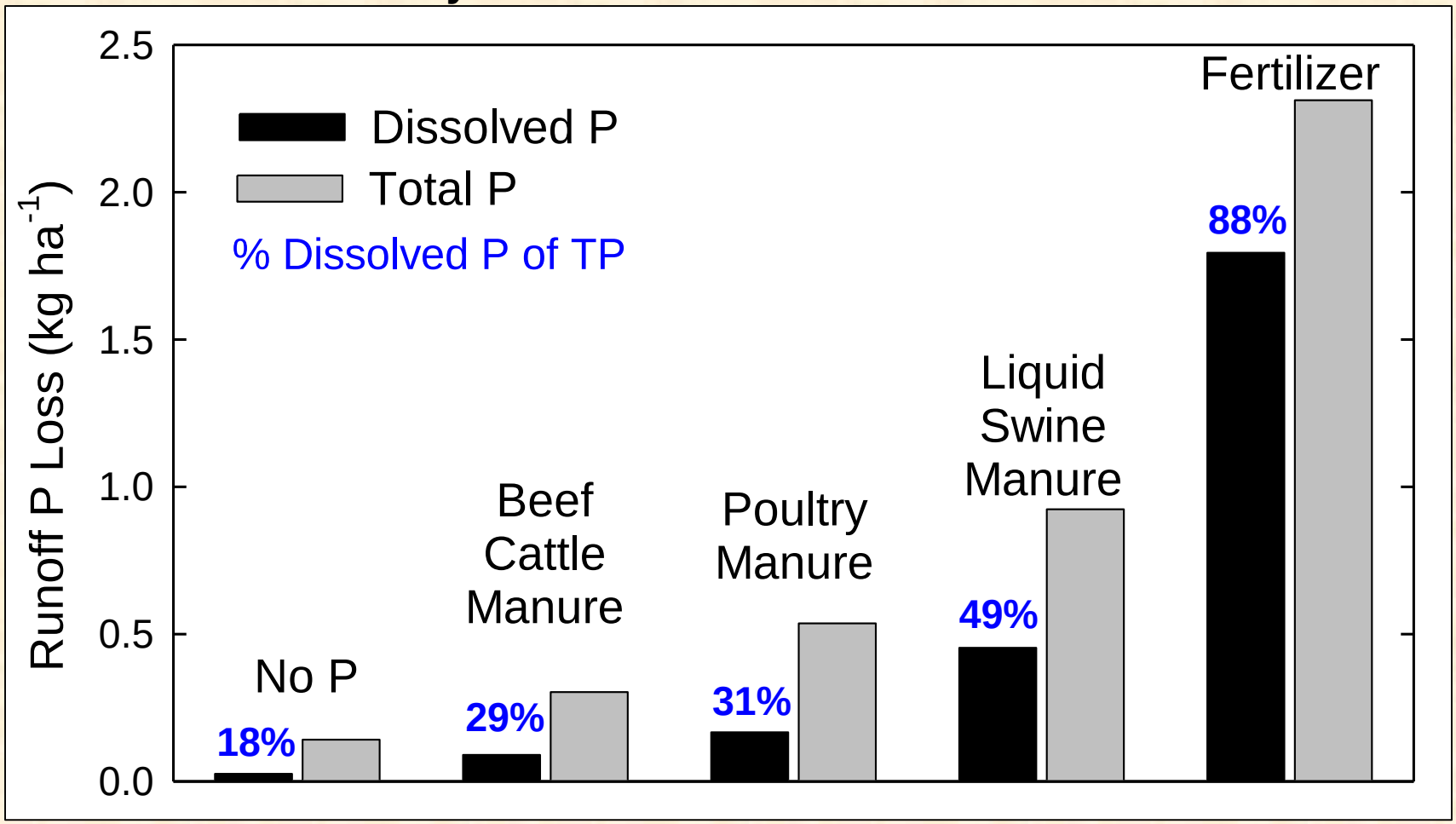
But recent research shows can increase dissolved P loss

Field Rainfall Simulations

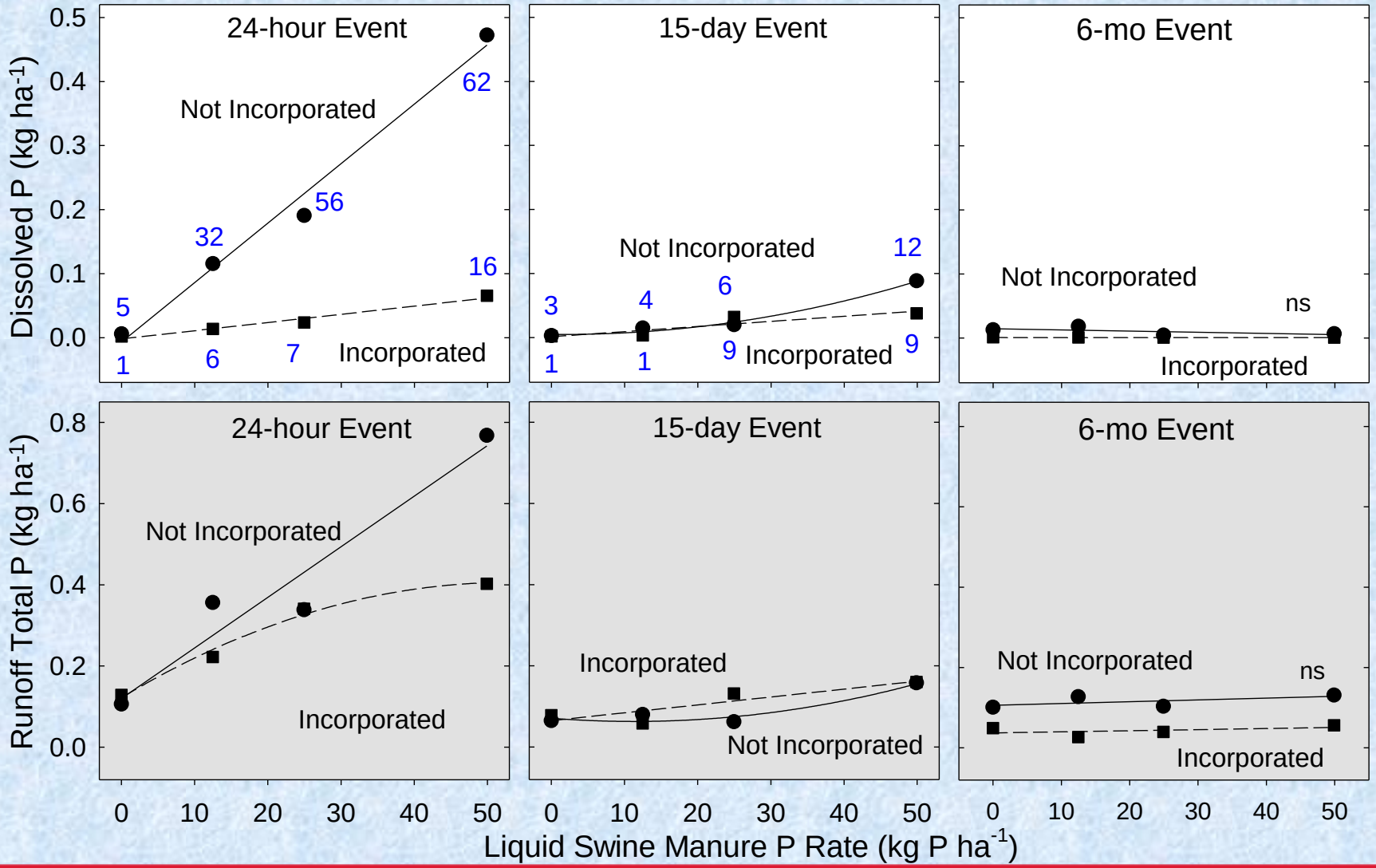
Differences between fertilizer and manure P sources and of time to a runoff event on P loss with surface runoff after applying P with or without incorporation

P Source Effects: Immediate Runoff Event

Runoff within 24 hours, No Incorporation, Broadcast 100 lb P_2O_5/a to Soybean Residue - Means of 21 Fields

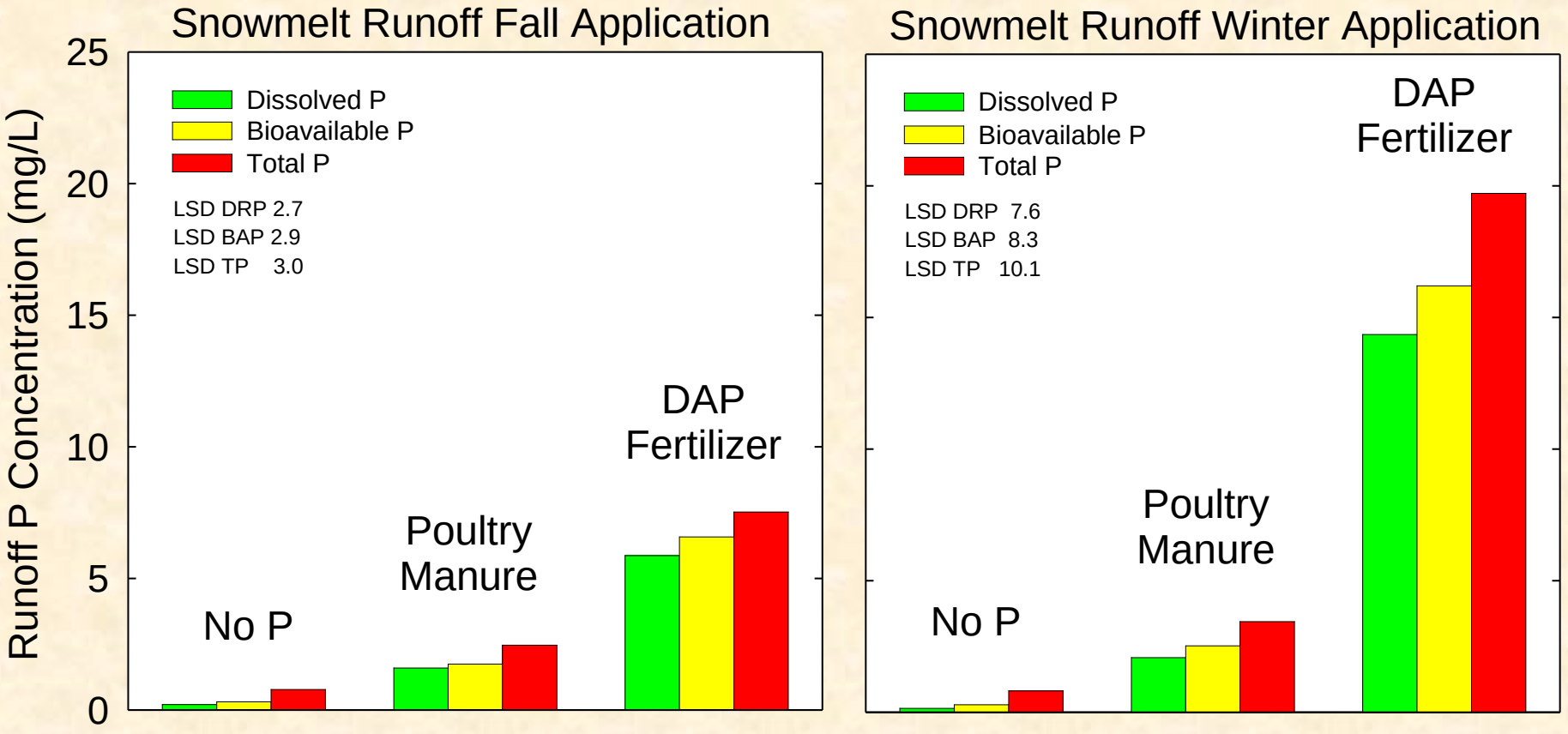


P Rate, Incorporation, Time to Runoff



P Sources Applied in Fall or Winter

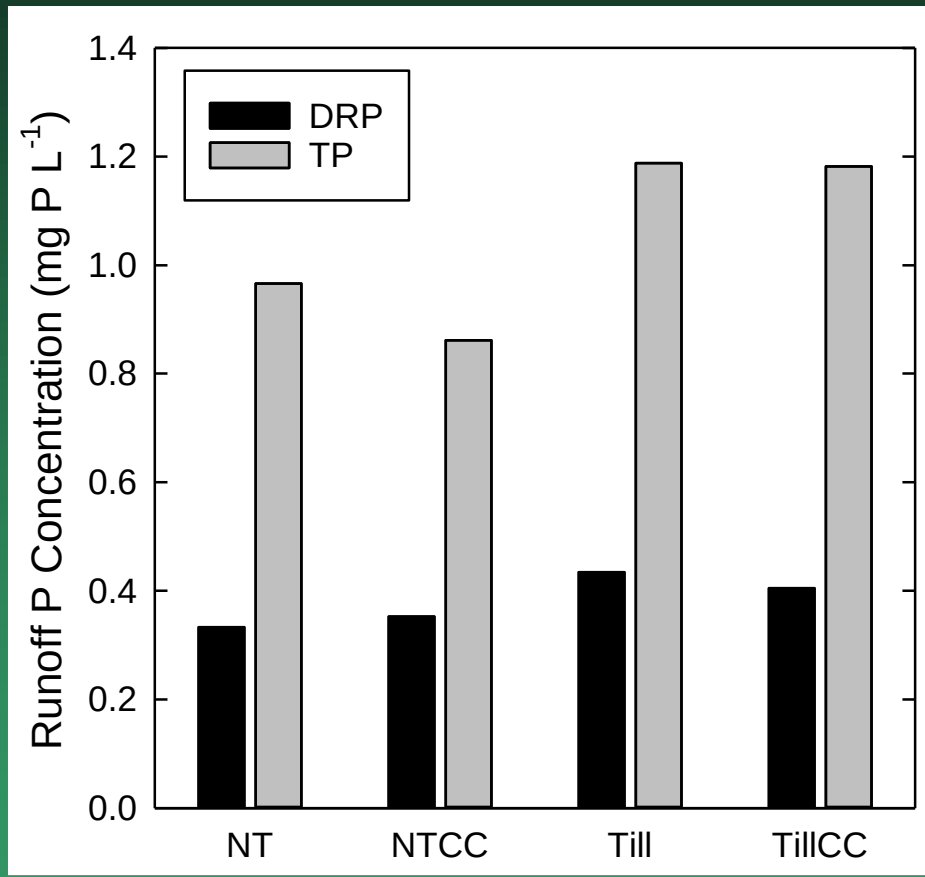
100 lb P_2O_5/acre to Soybean Residue, No Incorporation
Averages of 3 Fields

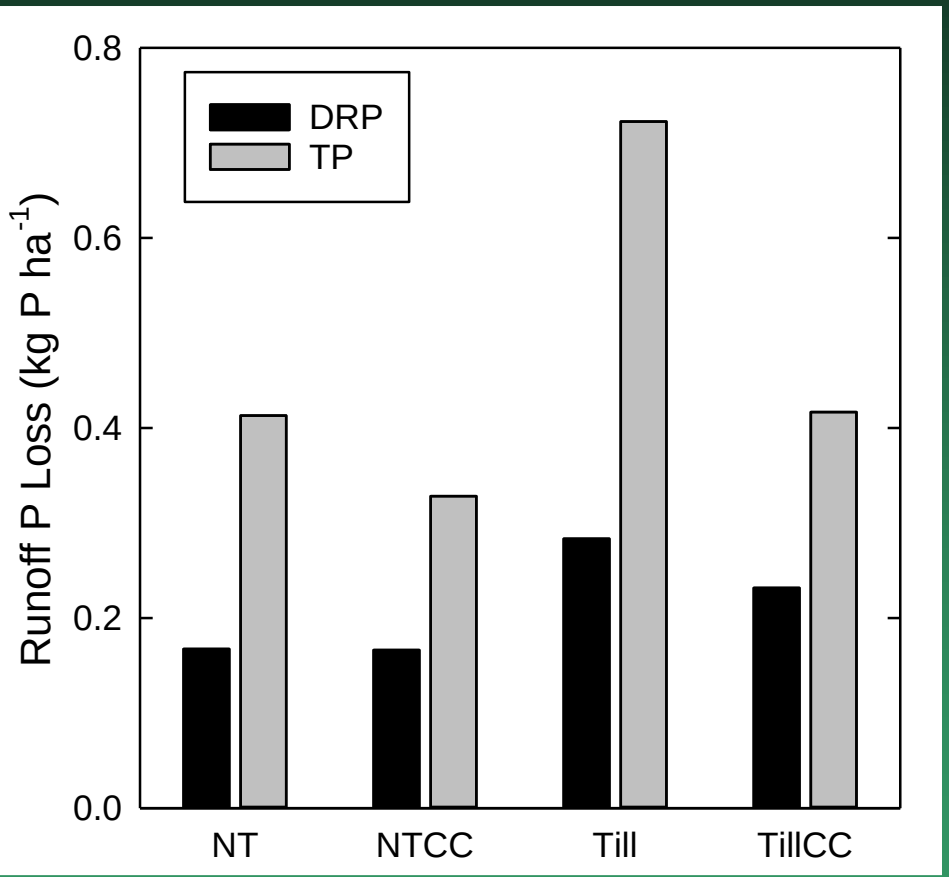


Haq and Mallarino, 2012

Cover Crops and P Loss with Runoff

Averages of Four Years





When do P losses occur?

- When there is soil erosion or water runoff!

- **Late February to late June**:
  - Snow melt and high-rainfall period
  - Little or no crop canopy
  - Saturated soils (moisture, floods)
  - Reduced conditions (soluble Fe^{+2})
  - Soils tilled and with little cover

Sound Phosphorus Management

- Use conservation practices!
- Apply manure based on crop nutrient needs and P index ratings.
- Reduce P of manure: feed phytase enzyme, low phytate grain, reduce P supplements as much as possible.
- Dedicate time to careful manure application. Incorporate or inject it without increasing soil erosion.

Soil Fertility Web Site
http://www.agronext.iastate.edu/soilfertility/

apmallar@iastate.edu
515-294-6200