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# UNDERSTANDING SOIL PHOSPHORUS

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Larry G. Bundy  
Dept. of Soil Science  
University of Wisconsin

# Why is Understanding Soil P Important?

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- Determine agronomic need for P
  - Water quality issues related to phosphorus (P)
  - Restructuring of nutrient management standard/rules to include control of P loss
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# Environmental Concerns

- Phosphorus is the major nutrient promoting algae and aquatic weed growth in freshwater lakes and streams.
  - Oxygen depletion and fish kills
  - Odor
  - Limits recreation and tourism
  - Quality of drinking water drawn from surface waters.



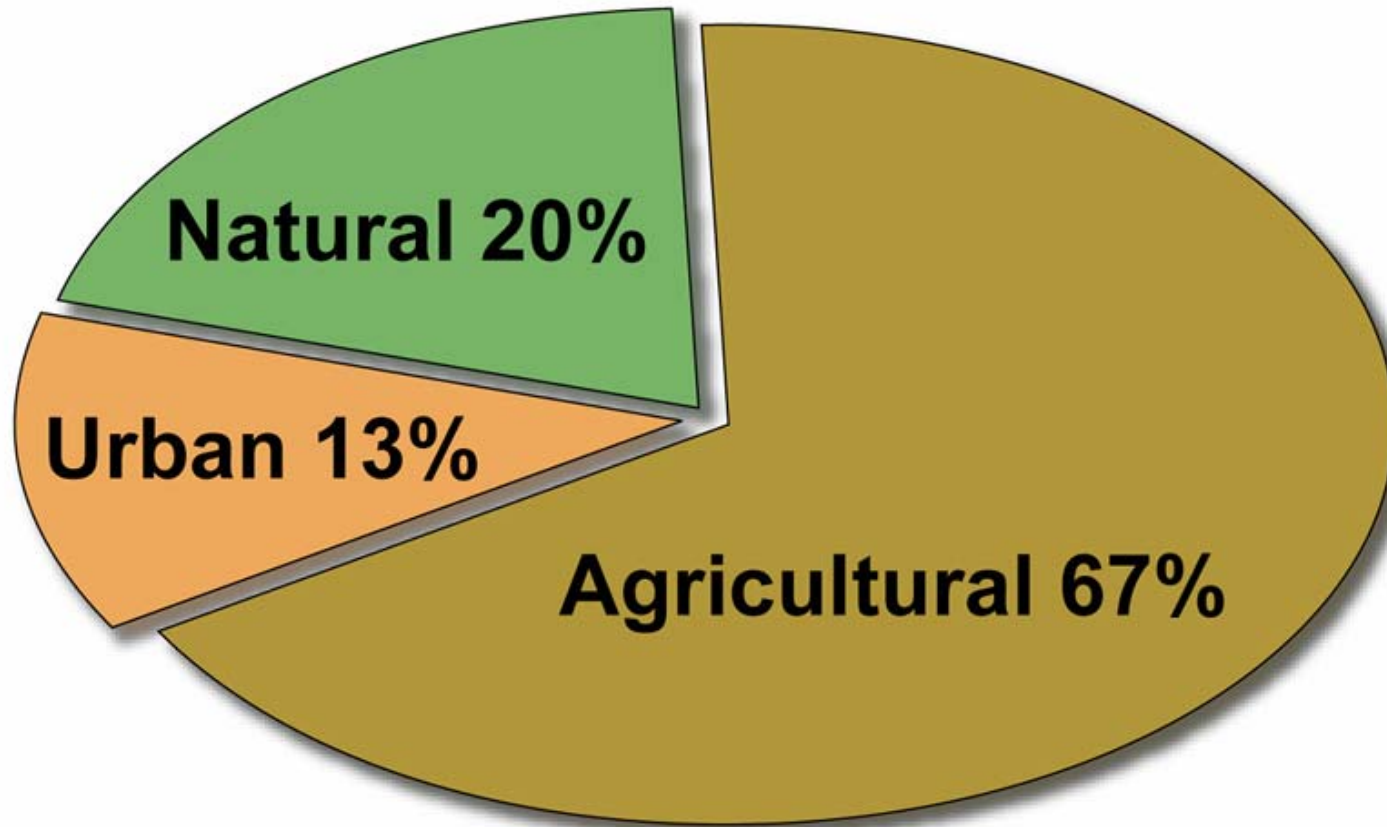


# PHOSPHORUS AND WATER QUALITY

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- Phosphorus additions to natural waters can stimulate weed and algae growth.
  - Phosphorus losses from agriculture can be a major source of P entering lakes and streams.
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# Sources of Phosphorus to Tainter Lake, WI



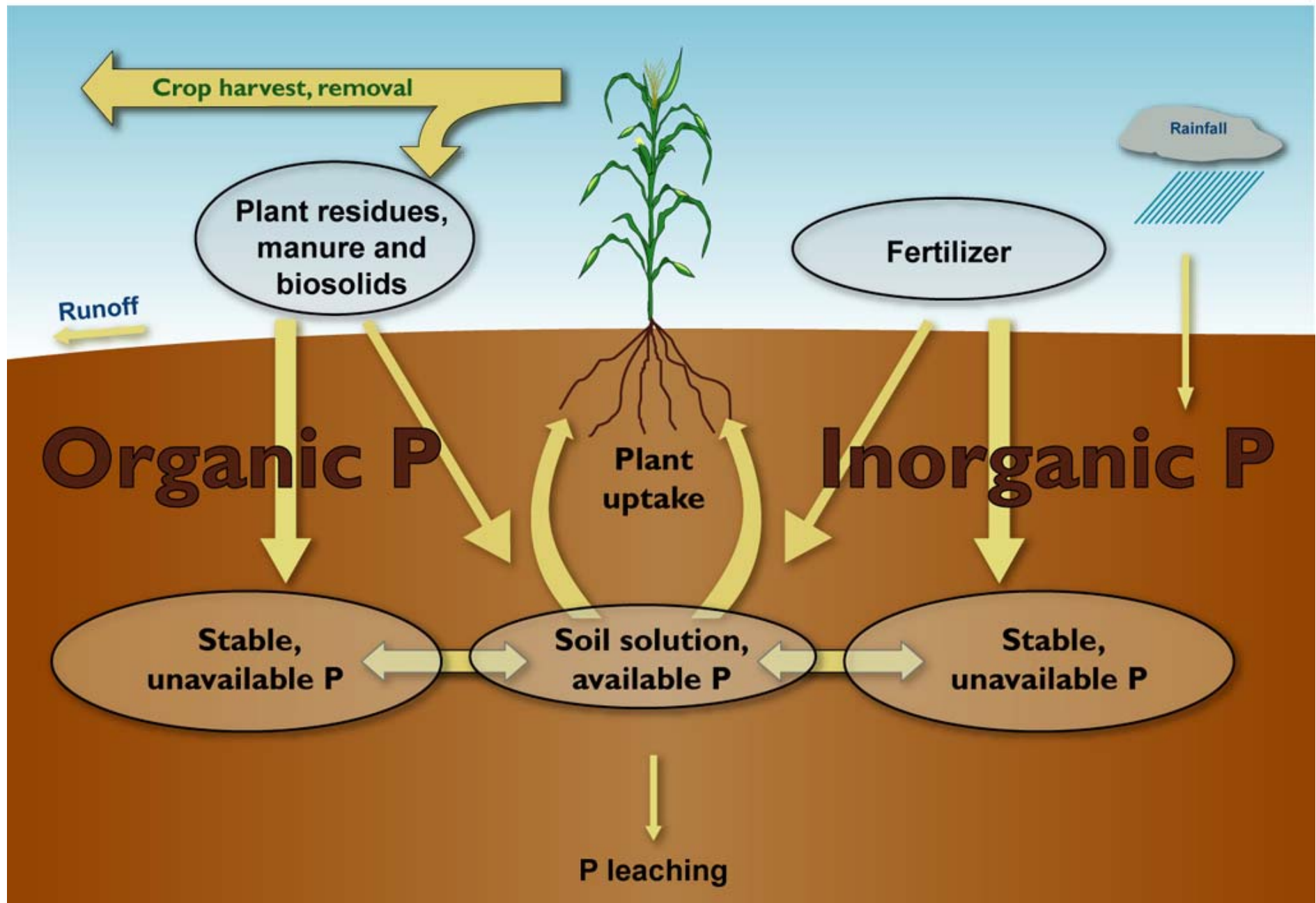
# Forms & Concentrations of Phosphorus (P) in Soils

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Form	Concentration (ppm)
Total	1000
Soil test P (available)	20-50
Soil solution	0.01-0.30

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# Phosphorus (P) Reactions in Soils

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- Soluble P additions (fertilizers) react quickly to form slowly soluble compounds:
    - Sorbed P
      - Clays
      - Al and Fe oxides
    - Secondary P minerals (precipitation/dissolution)
      - Ca, Fe, Al phosphates
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# Adsorption and Desorption of Phosphorus

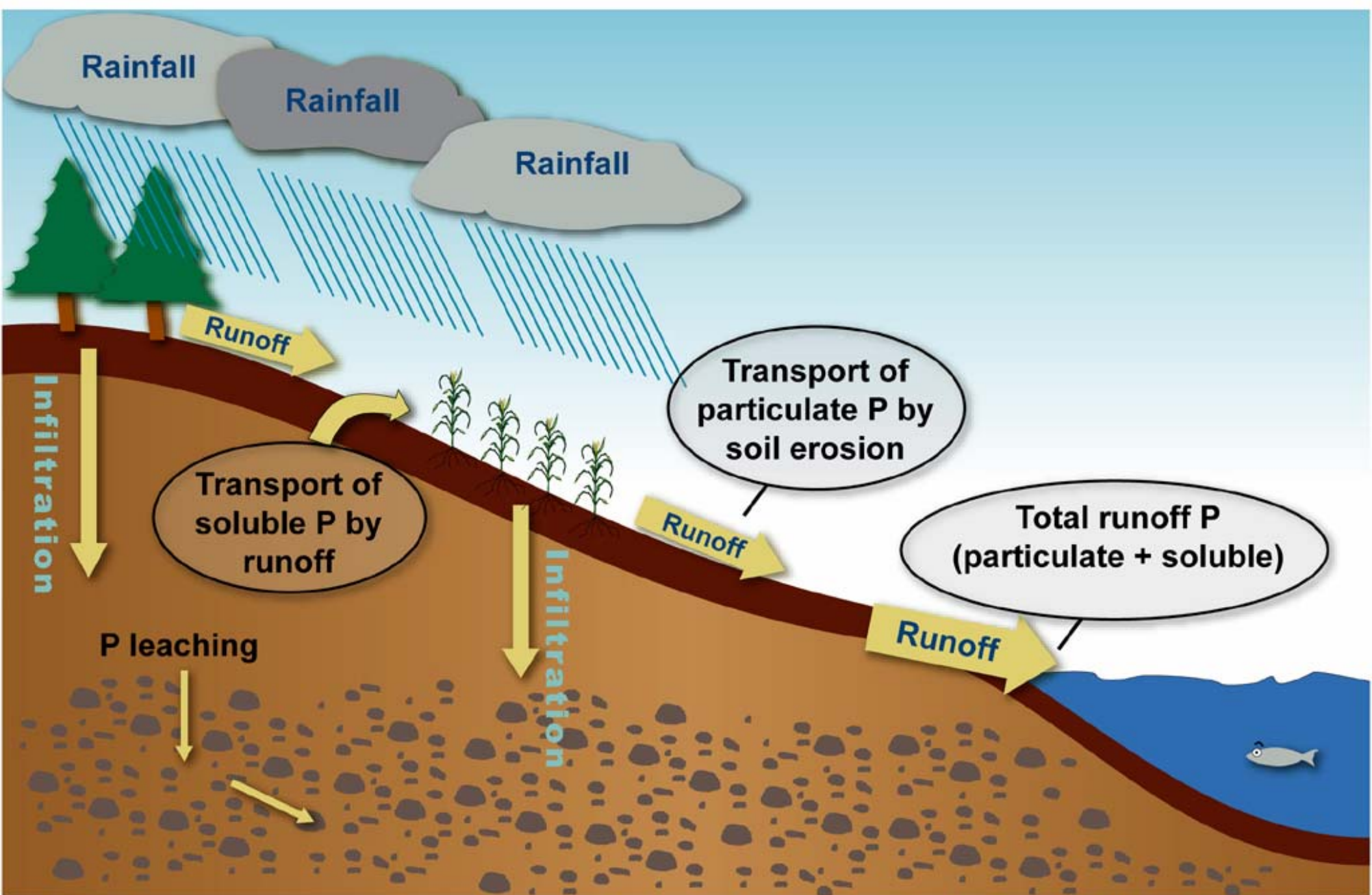
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- **Adsorption:** removal of ionic P ( $\text{H}_2\text{PO}_4^-$ ,  $\text{HPO}_4^{2-}$ ) from solution by reaction with solid phase of soil.
- **Solid phase:** clays, oxides or hydroxides of Fe and Al, calcium carbonates, organic matter.
- **Desorption (labile P):** Portion of adsorbed P available for plant uptake, extraction, or measured by soil test.

# Phosphorus (P) Loss Processes

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- In surface runoff:
  - Soluble (dissolved) P
  - Particulate P (soil particles)
- By leaching
  - Does phosphorus leach?







# PHOSPHORUS (P) IN RUNOFF

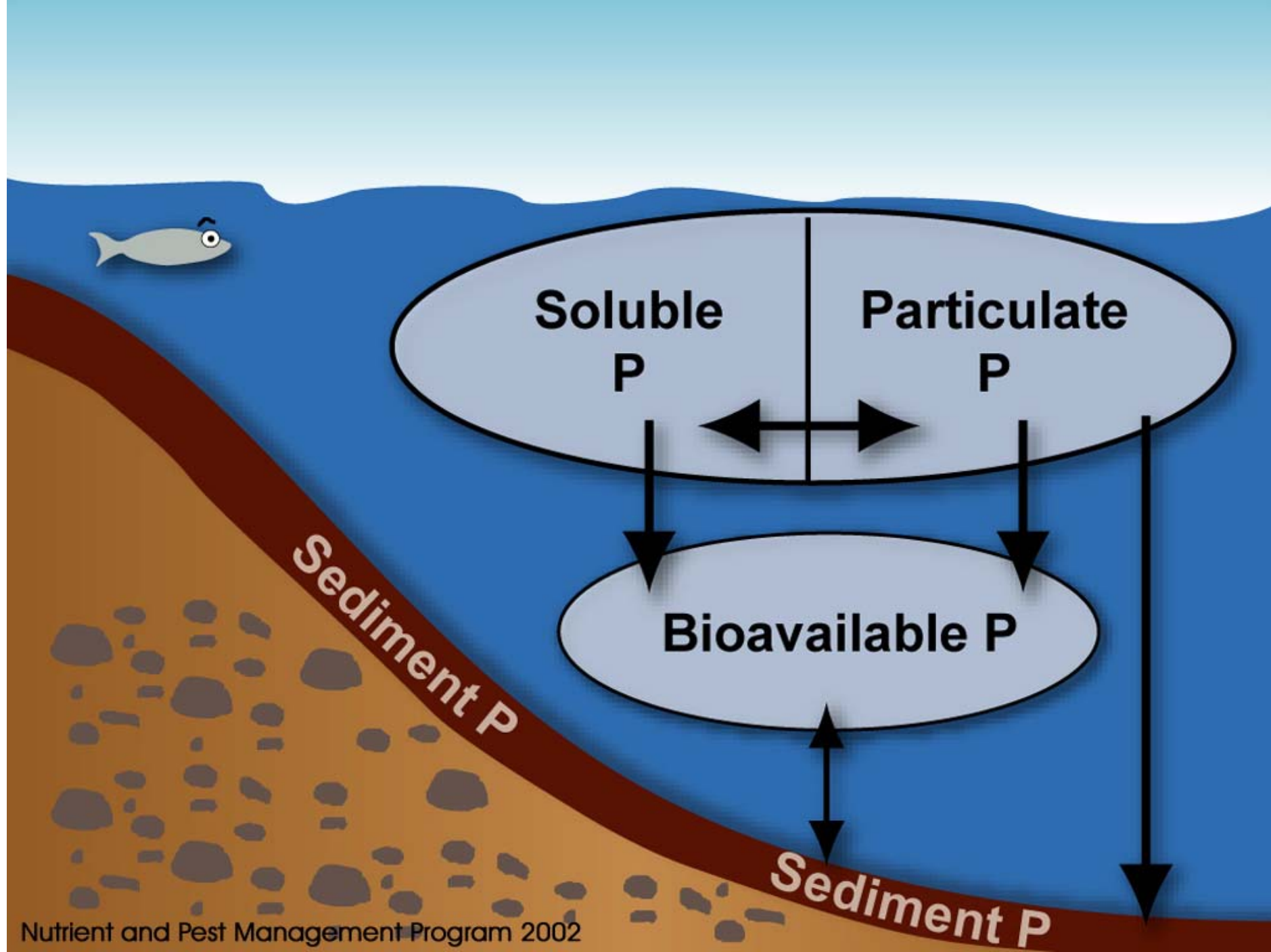
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- Dissolved (soluble P) (DP)
  - Particulate P (PP)
  - Total P (TP) – Includes DP and PP
  - Bioavailable P (BAP)
    - ✓ DP + part of PP
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# Critical Phosphorus Concentrations for Surface Waters

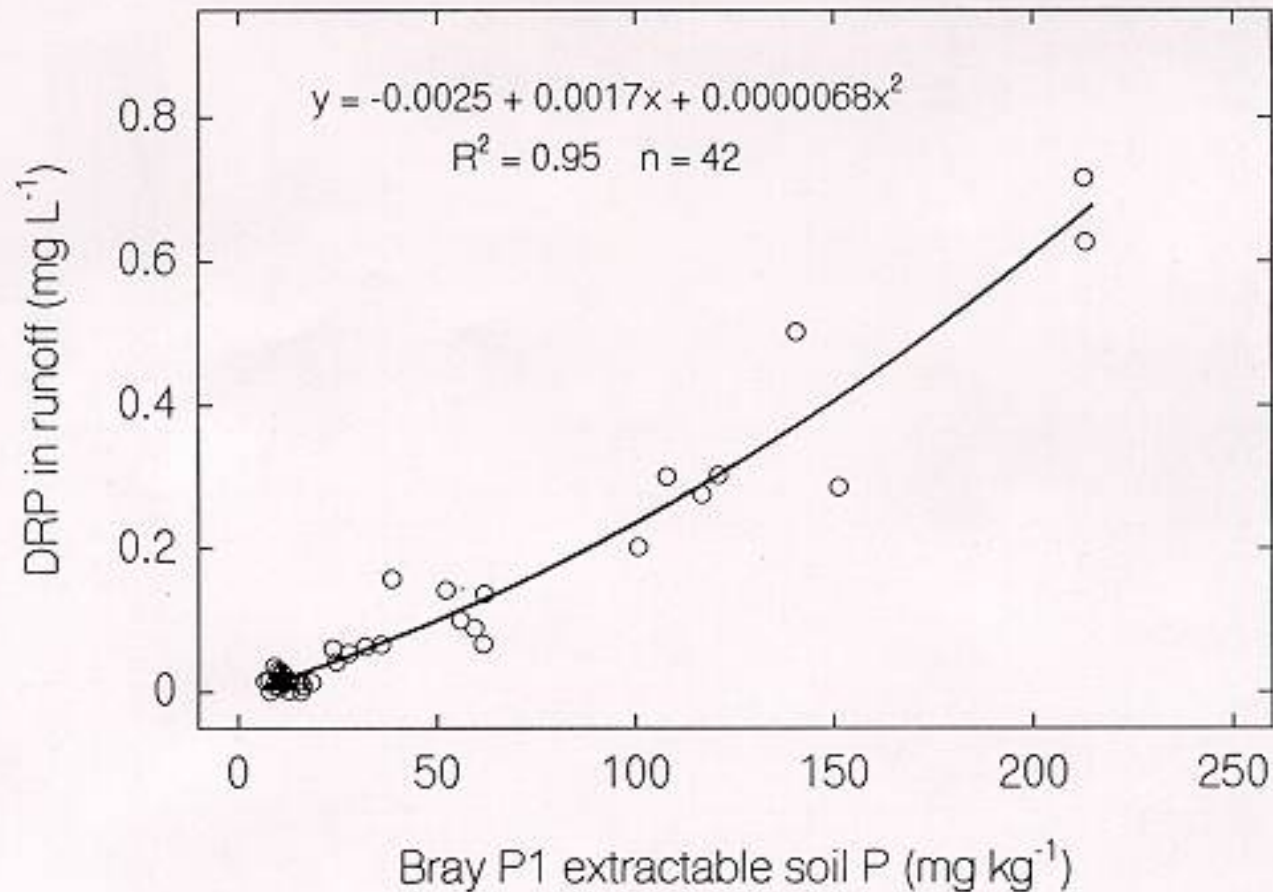
Type of water	Form of P	P conc. (ppm)
Lakes	Soluble P	0.01
Streams	Total P	0.10
Lakes	Total P	0.05

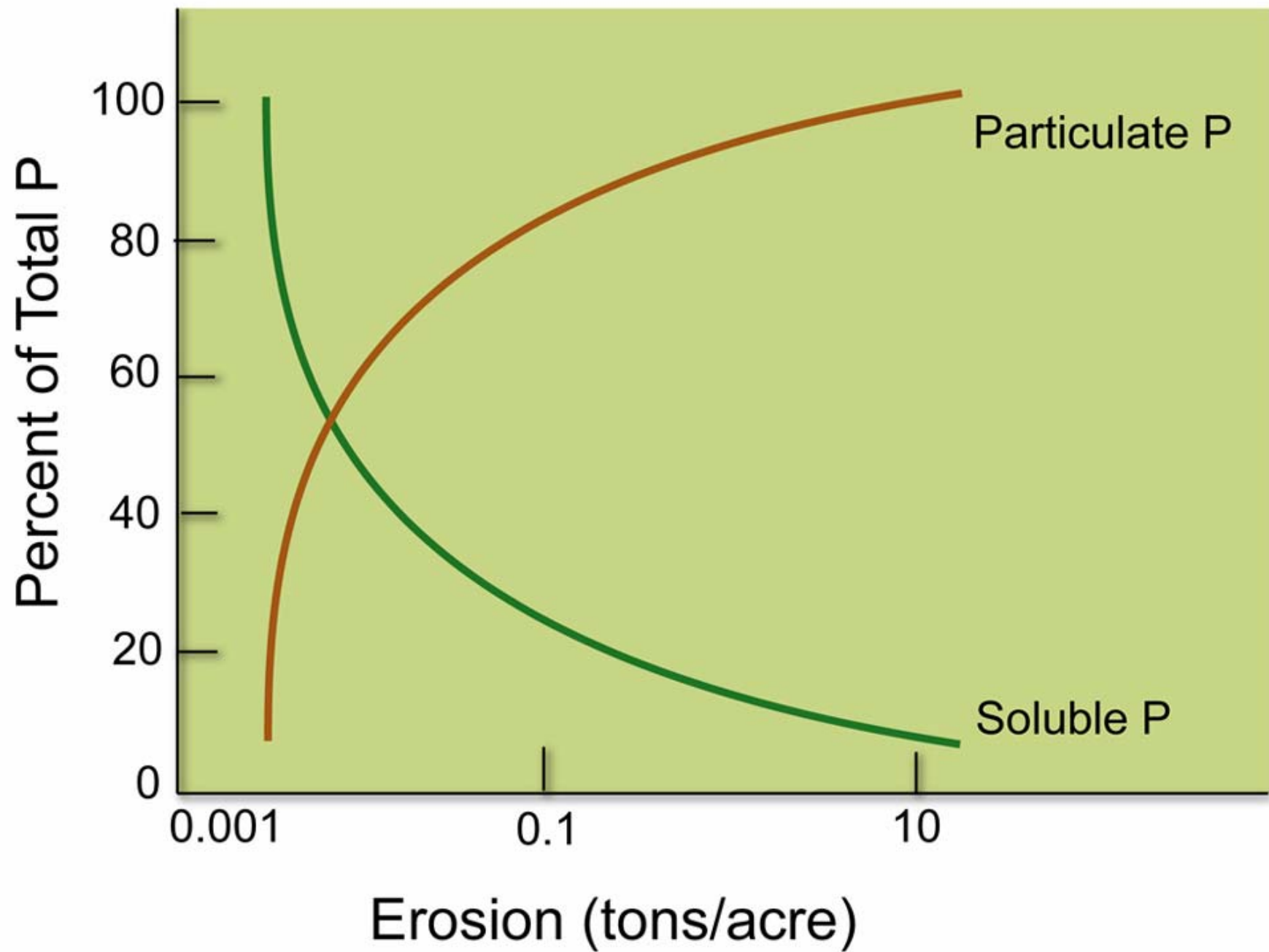






# Relationship between Bray P-1 (0-2 cm) and DRP in runoff.





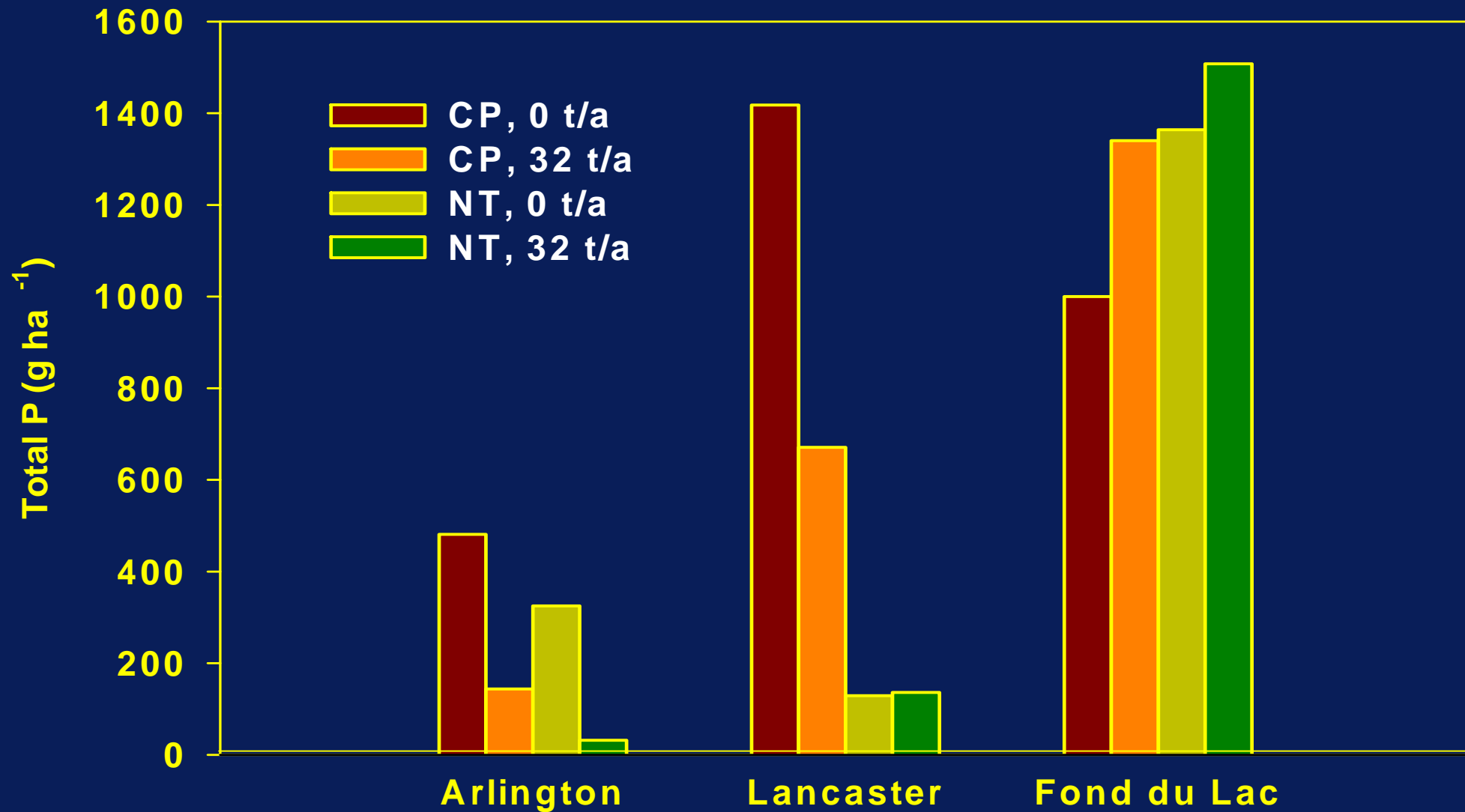
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# **Influence of tillage and manure**

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# Spring manure and tillage effects on total P load in runoff at three locations.





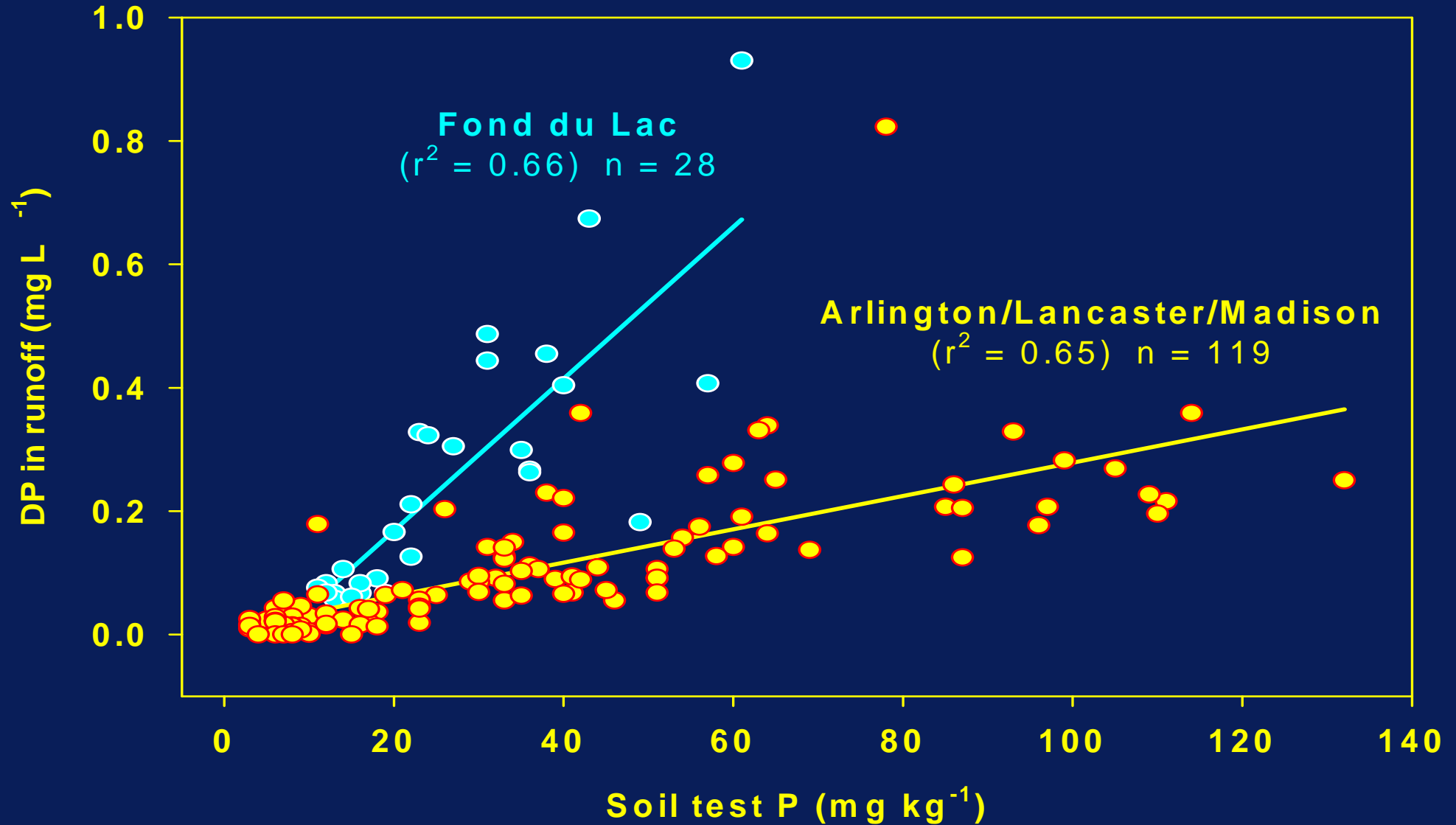
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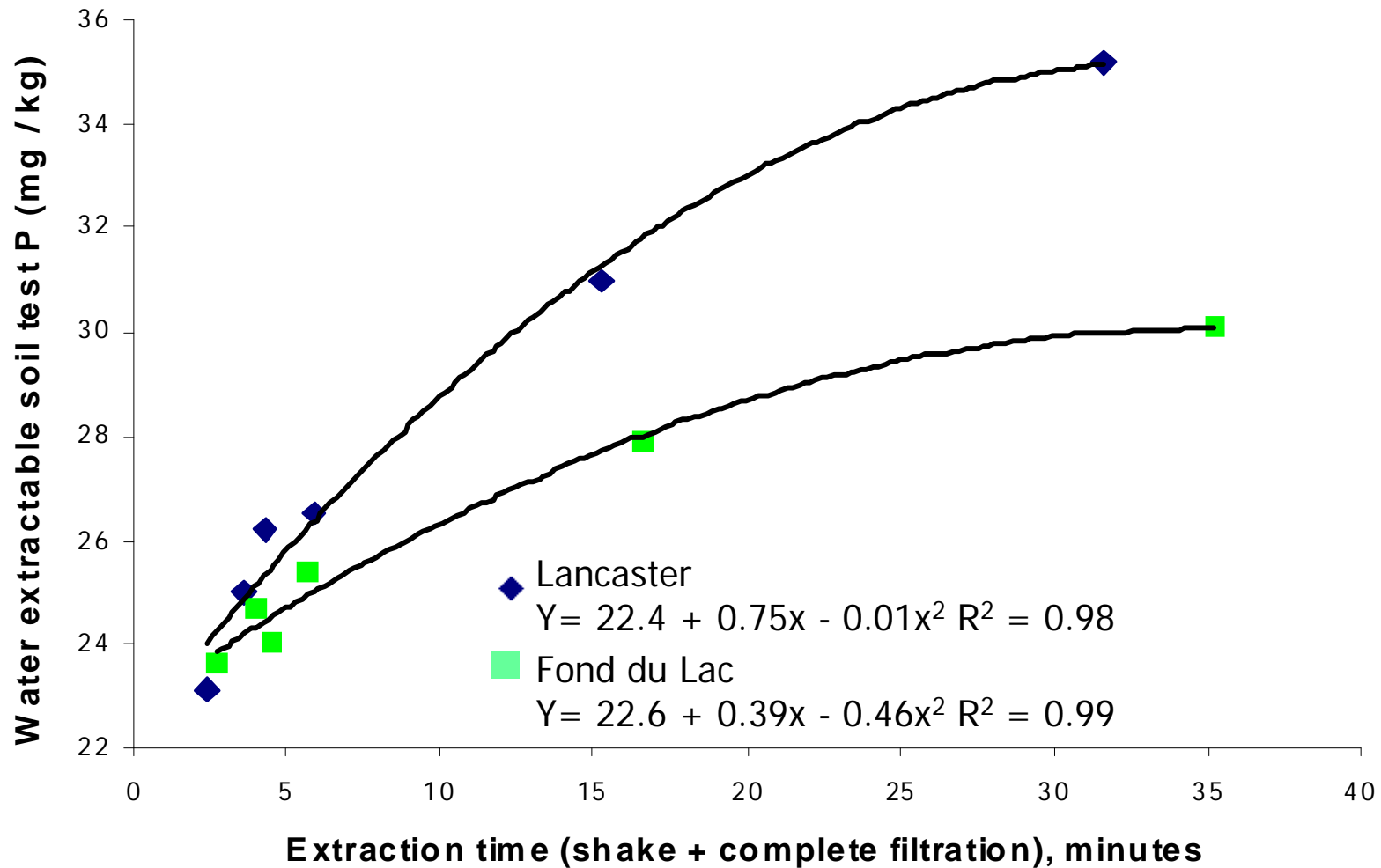
# Soil-specific effects on soluble P

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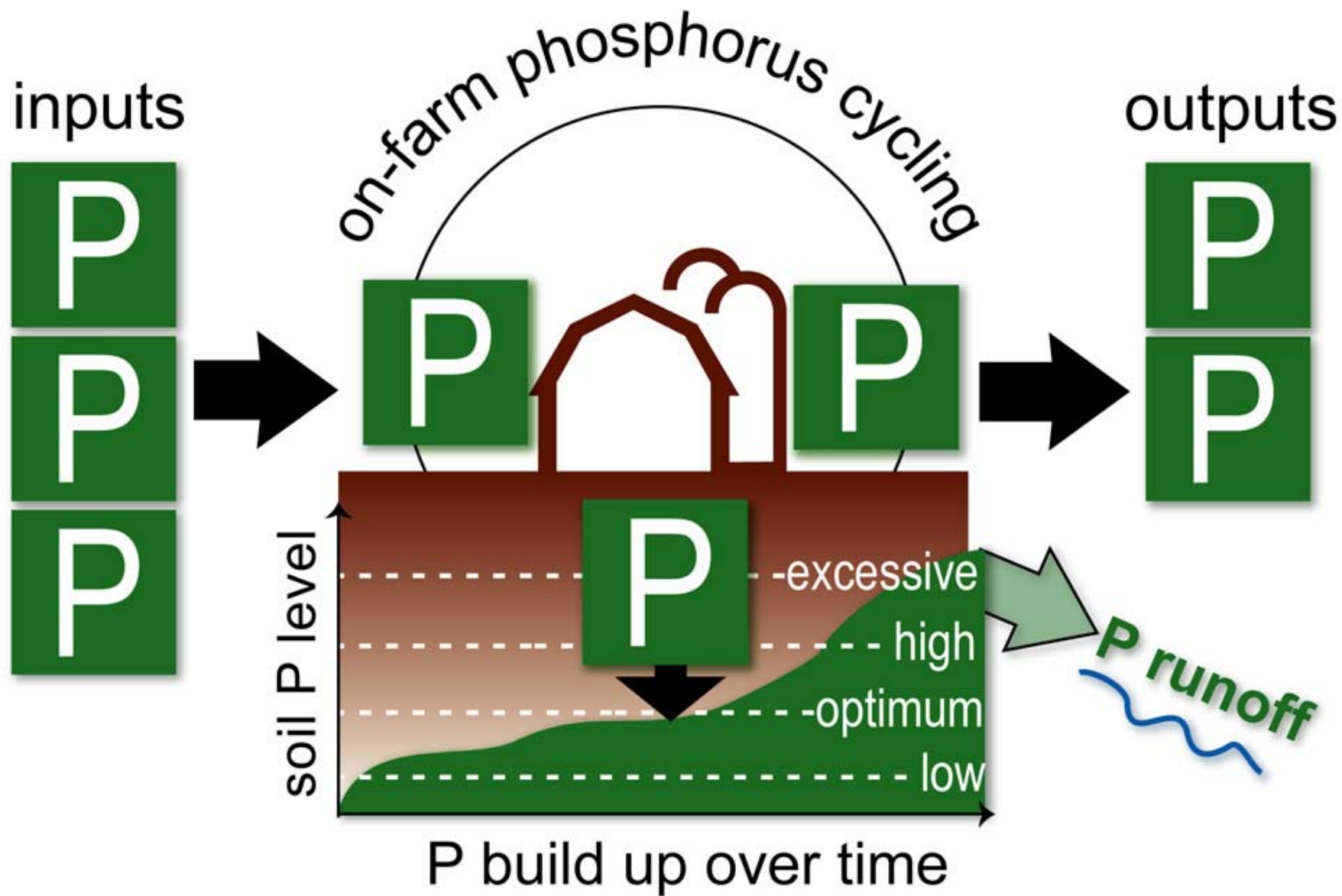
# Relationship between STP and DP concentration in runoff without spring applied manure.

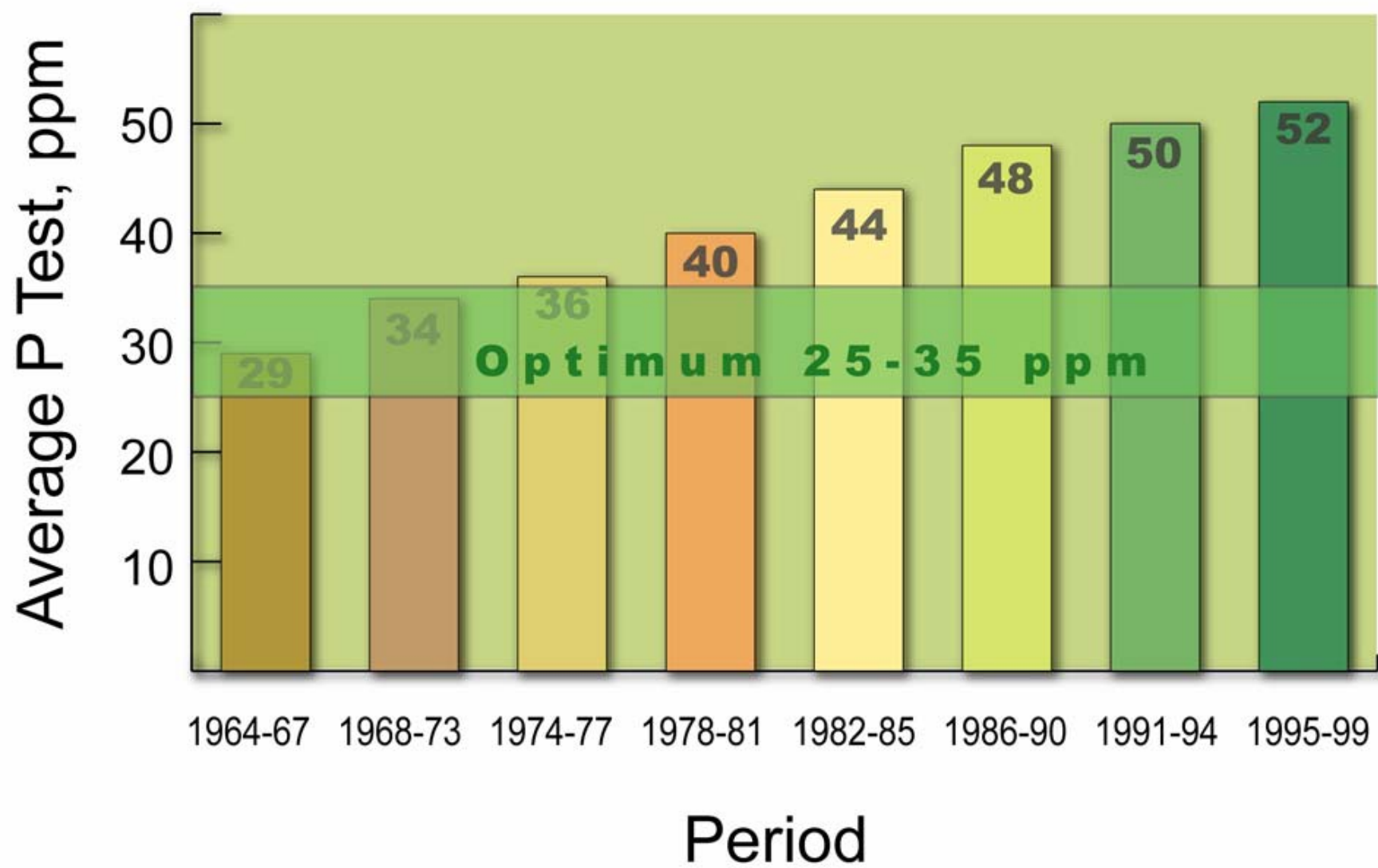


# Effect of soil extraction time on water extractable soil P concentration for two soils.



Respective soil test P (at 60-min) = 40 and 42 mg kg<sup>-1</sup> at Lancaster and Fond du Lac.  
Respective DP in runoff = 0.33 and 0.93 mg L<sup>-1</sup> at Lancaster and Fond du Lac.





# Interpreting Soil P Tests

Crop	Soil test P, ppm	
	Optimum	No response
Alfalfa	18-25	>35
Corn	15-20	>30
Soybean	10-15	>20

Medium and fine-textured soils, Bray P-1 test



# SOIL PHOSPHORUS BUFFERING CAPACITY

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- Soil test P changes slowly with P additions or removals.
- Ave. 18 lb.  $P_2O_5$ /acre needed to change P test by 1 ppm

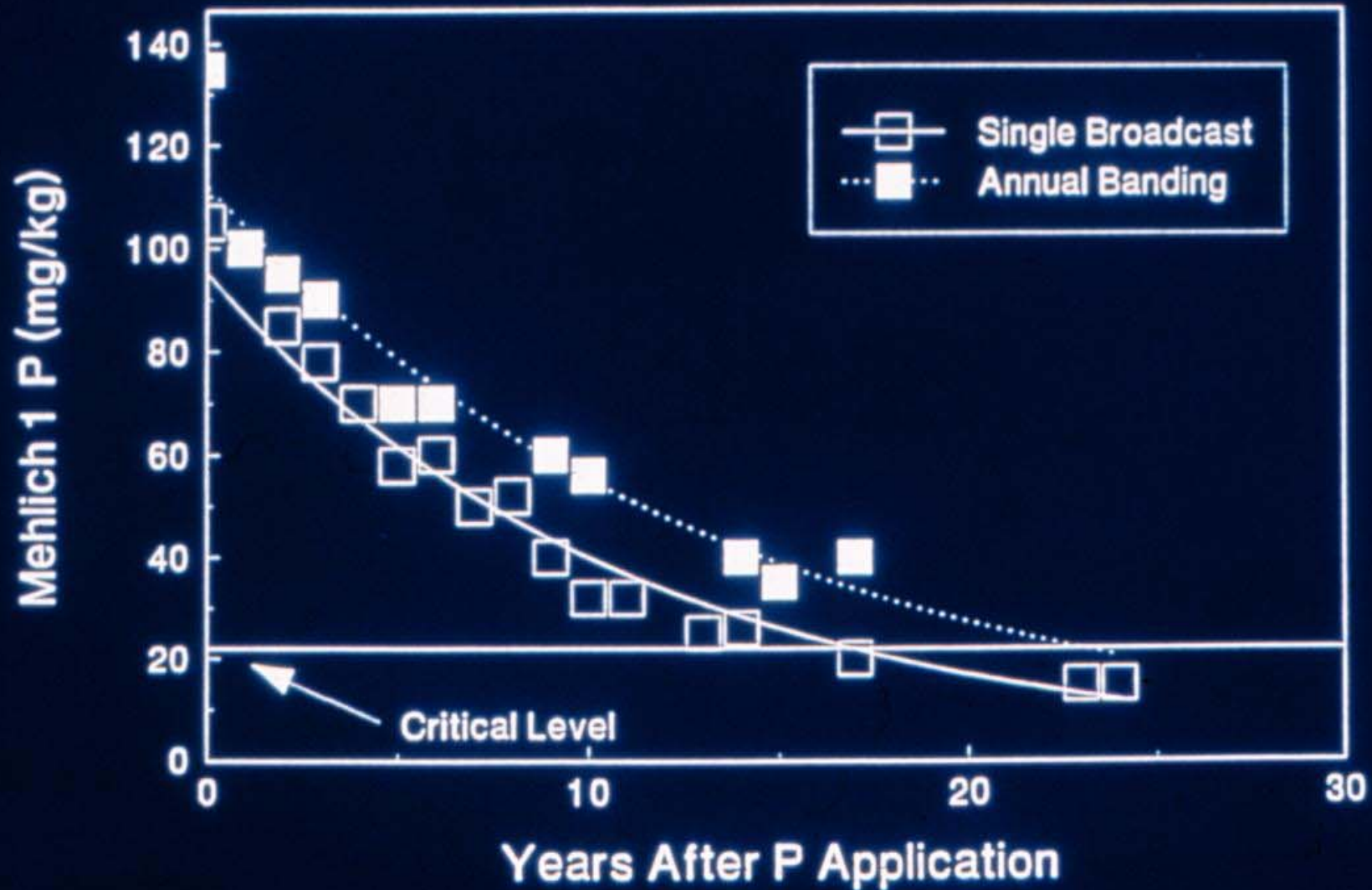
# Soil Test P Changes Slowly

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- Example:

- Soil P test = 100 ppm = EH
- Optimum soil test = 20 ppm
- Removal needed for EH to Opt. = 18  
lb  $P_2O_5$ /acre x 80 ppm = 1440 lb  $P_2O_5$
- Corn grain removes 60 lb  
 $P_2O_5$ /acre/year
- $1440/60 = 24$  yrs with no added P for  
EH change to optimum.

Decrease in soil test P in a corn-soybean rotation  
for 26 years. (McCollum, 1991)



# Relationship between P soil test and phosphorus fertilizer recommendation

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Soil Test

Recommendation

Low, very low

Crop removal +

Optimum

Crop removal

High

$\frac{1}{2}$  Crop removal

Excessively High

None



# Summary

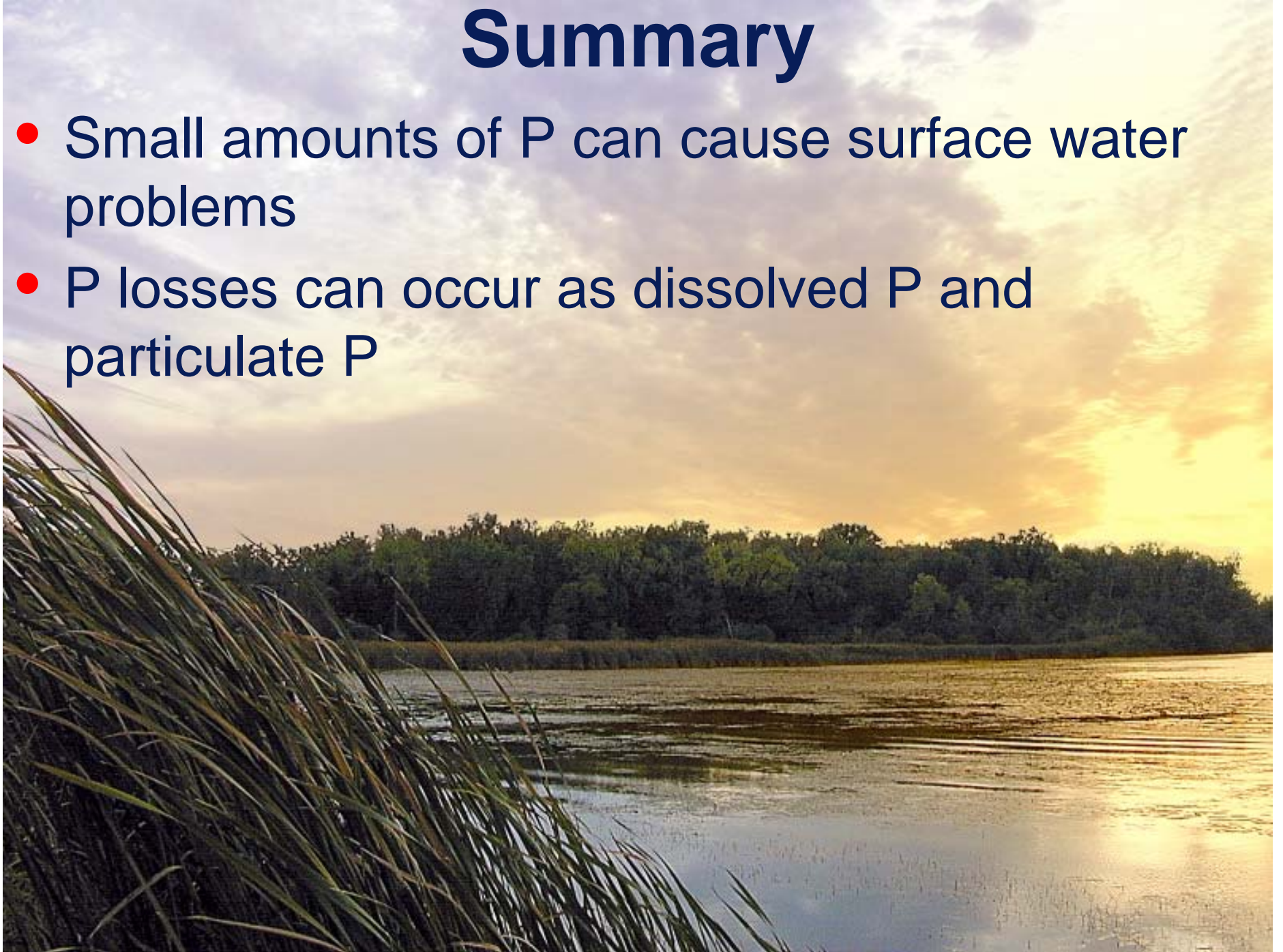
- Phosphorus (P) behavior in soil and management effects on P losses are complex





# Summary

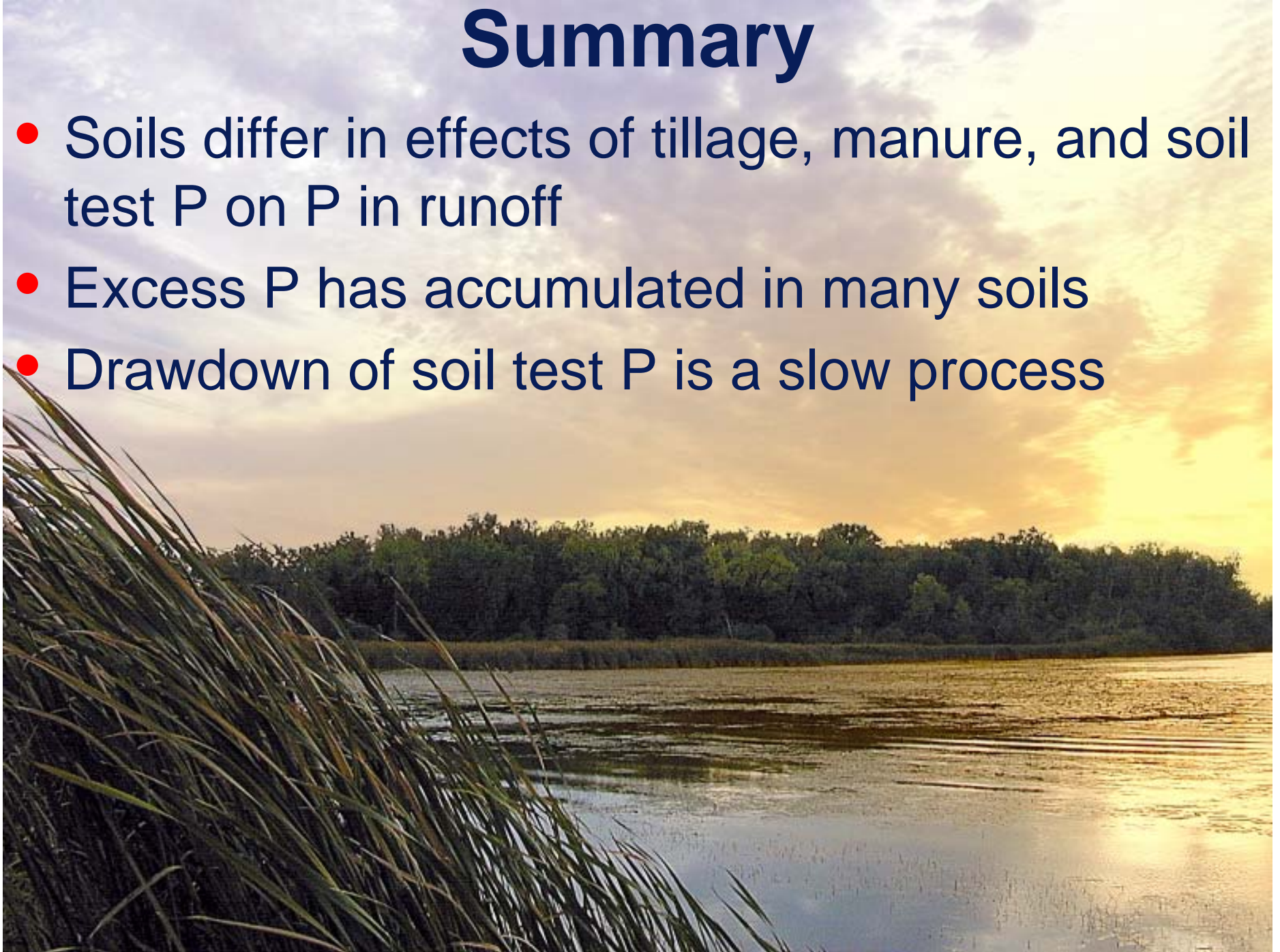
- Small amounts of P can cause surface water problems
- P losses can occur as dissolved P and particulate P





# Summary

- Soils differ in effects of tillage, manure, and soil test P on P in runoff
- Excess P has accumulated in many soils
- Drawdown of soil test P is a slow process





**<sup>UW</sup>  
Extension**



**Agriculture  
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