UNDERSTANDING SOIL PHOSPHORUS

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Why is Understanding Soil P Important?

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

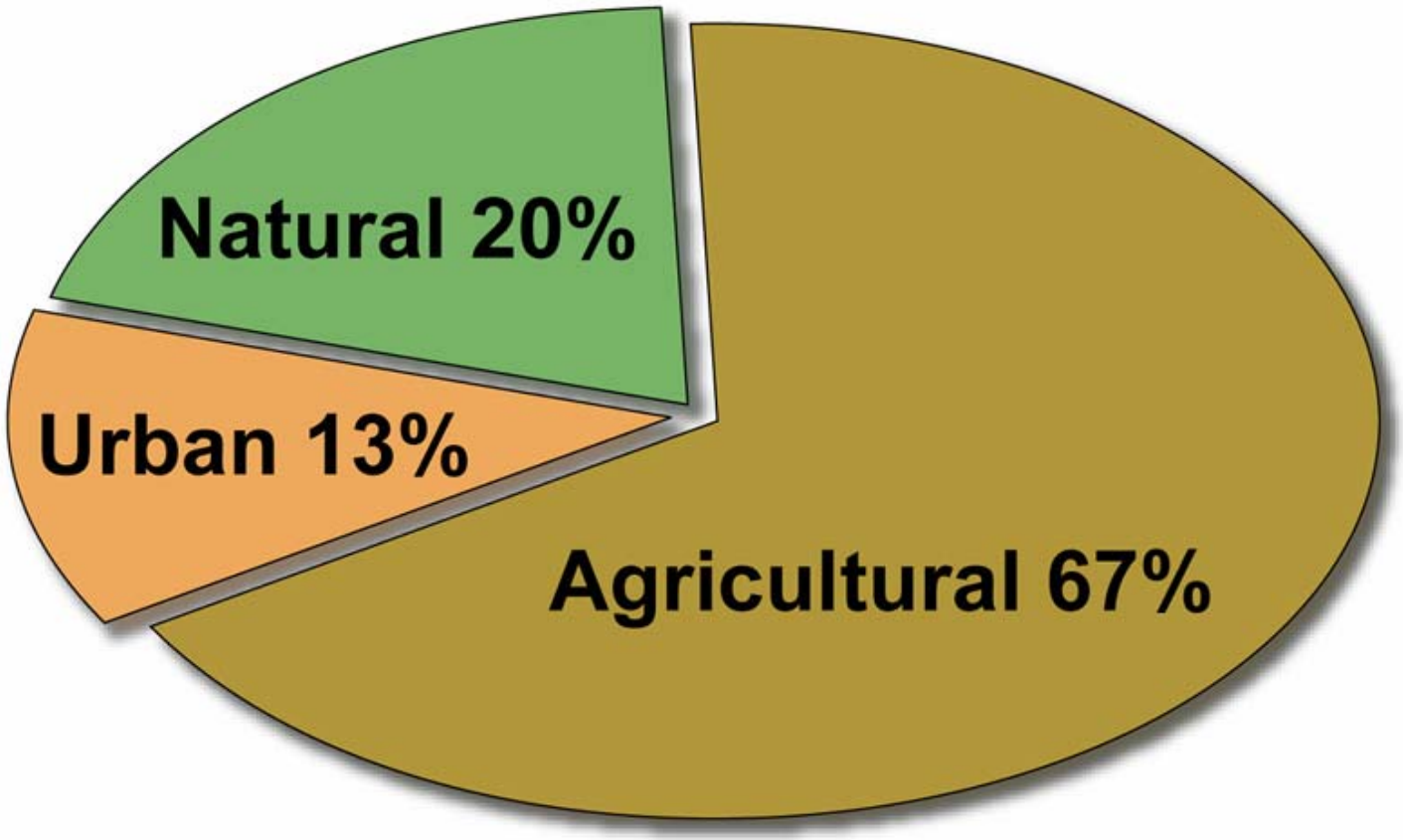
Environmental Concerns

- 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

- 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.

Sources of Phosphorus to Tainter Lake, WI



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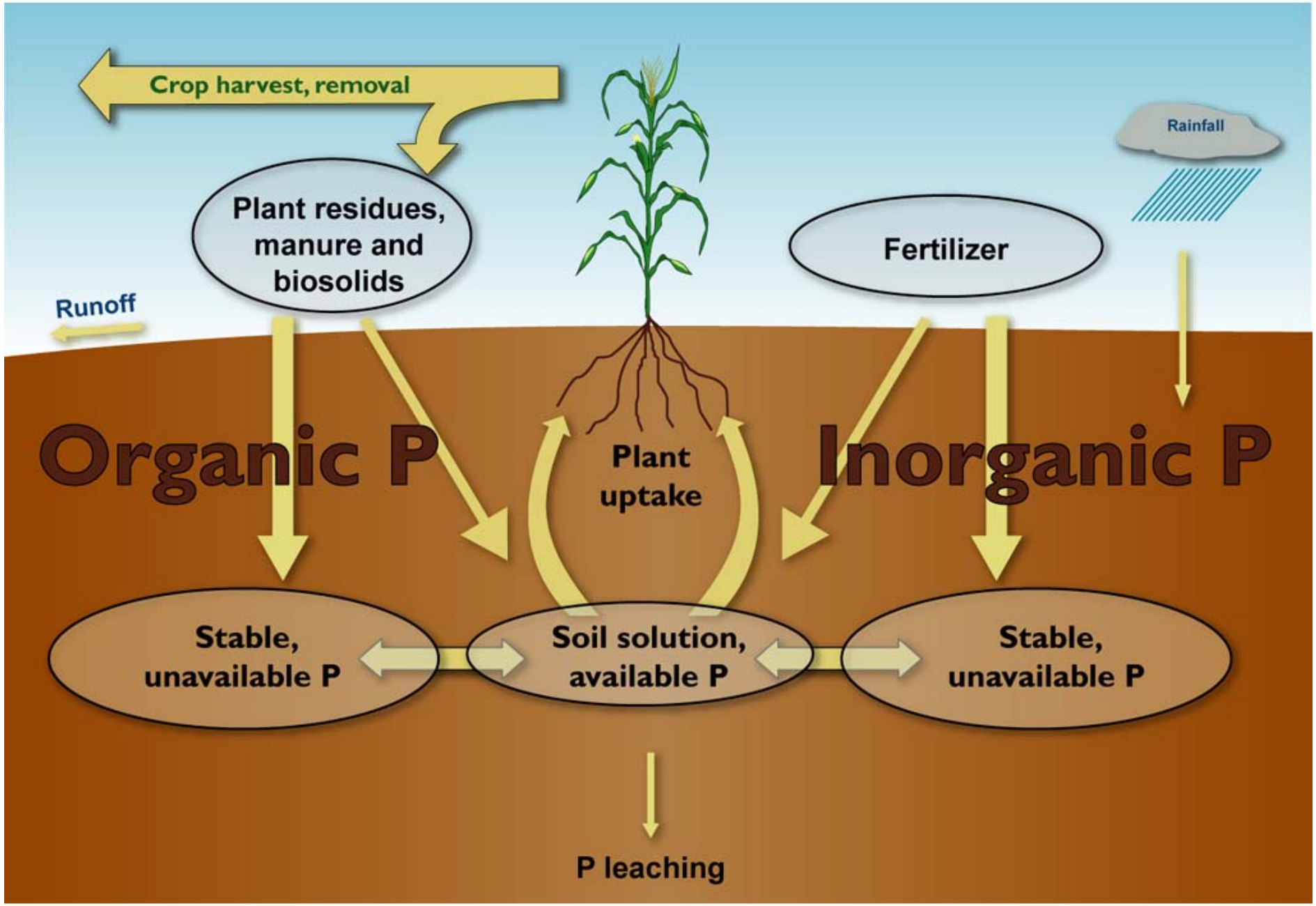
Forms & Concentrations of Phosphorus (P) in Soils

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


Crop harvest, removal
Plant residues, manure and biosolids
Rainfall
Fertilizer
Runoff
Organic P
Plant uptake
Inorganic P
Stable, unavailable P
Soil solution, available P
Stable, unavailable P
P leaching

Phosphorus (P) Reactions in Soils

- 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

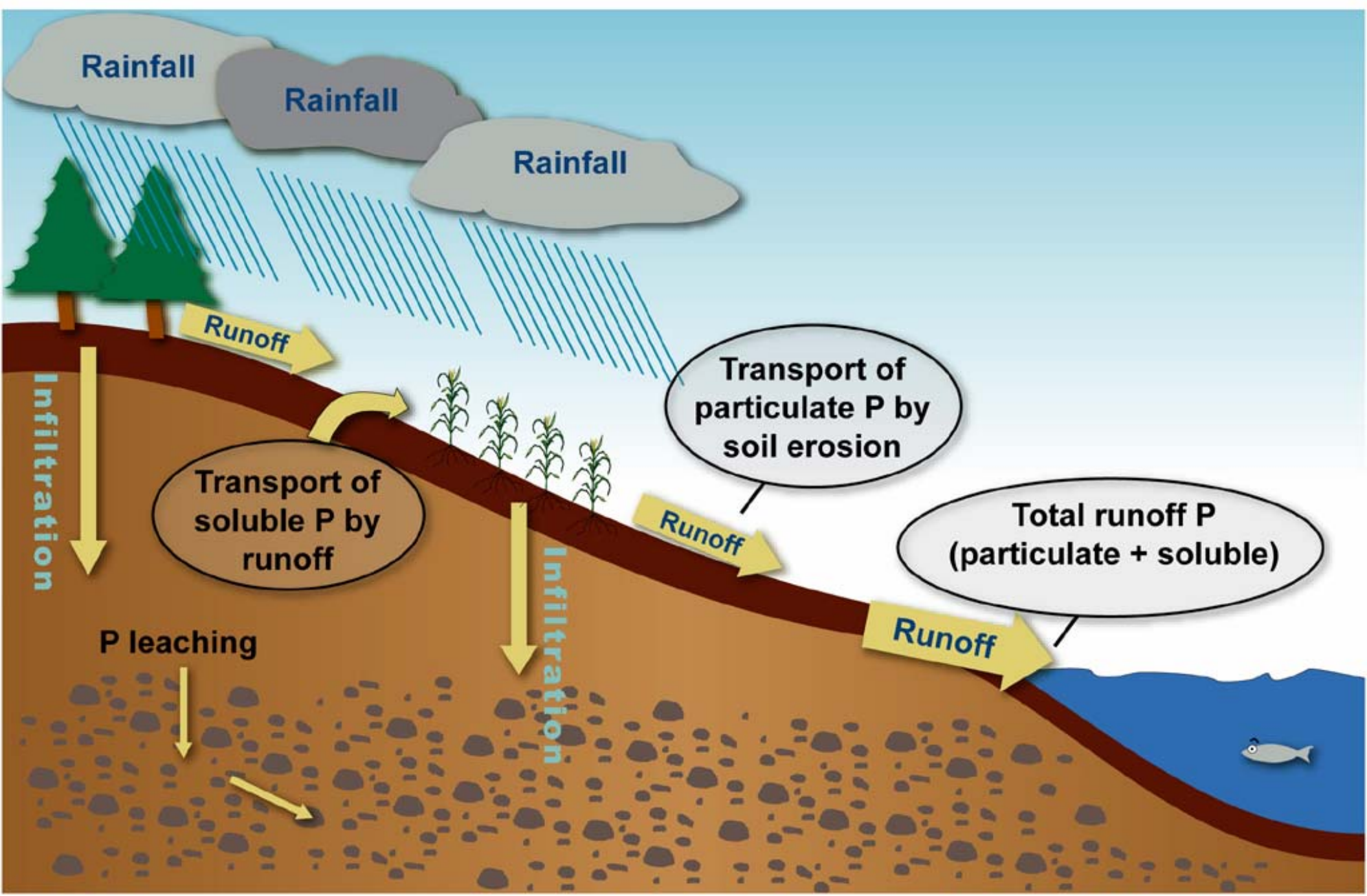
Adsorption and Desorption of Phosphorus

- Adsorption: removal of ionic P ($H_2PO_4^-$, 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

- In surface runoff:
  - Soluble (dissolved) P
  - Particulate P (soil particles)

- By leaching
  - Does phosphorus leach?

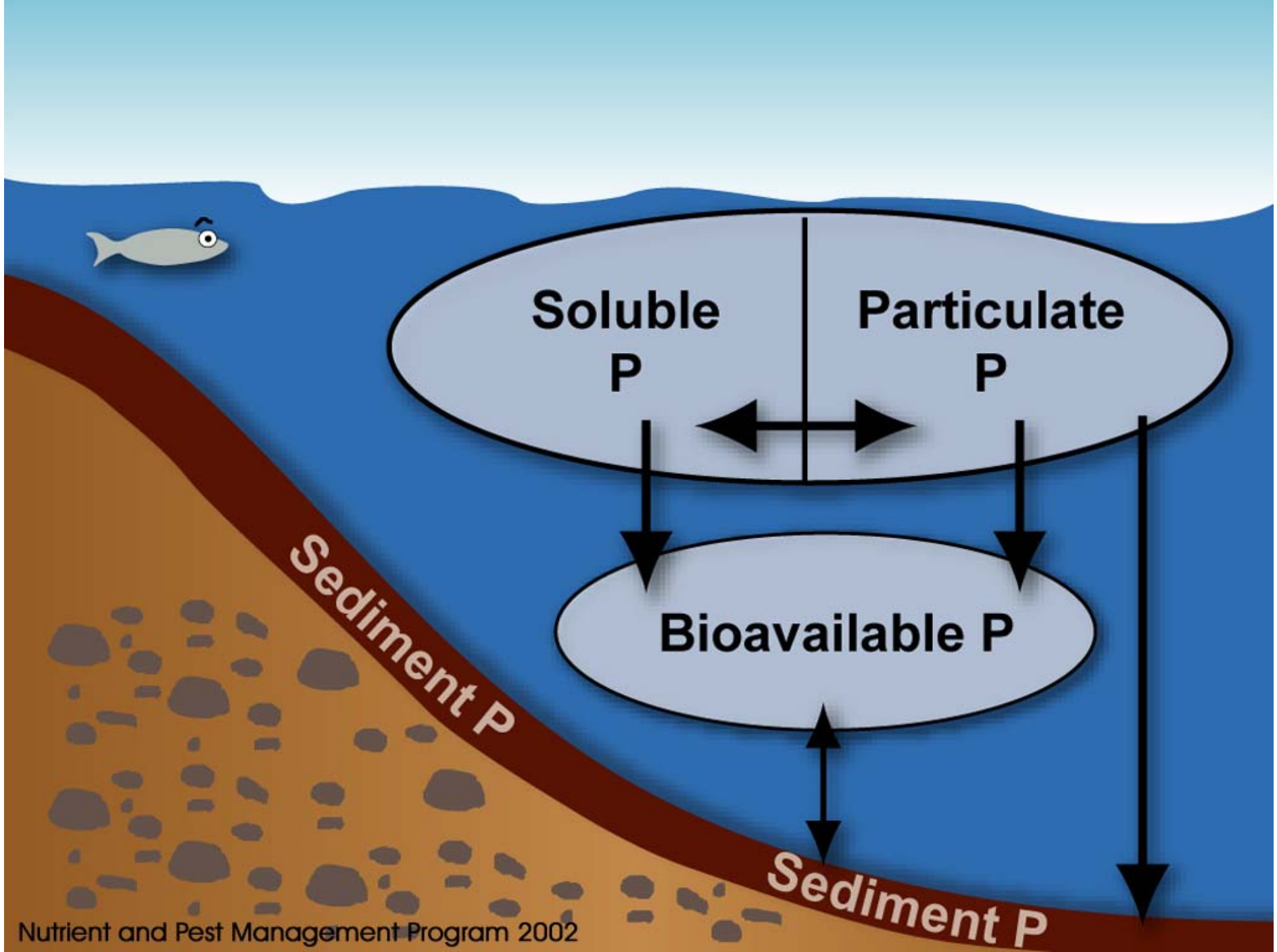

Rainfall
Rainfall
Rainfall
Runoff
Infiltration
Transport of soluble P by runoff
Transport of particulate P by soil erosion
Runoff
Total runoff P (particulate + soluble)
Runoff
Infiltration
P leaching

PHOSPHORUS (P) IN RUNOFF

- Dissolved (soluble P) (DP)
- Particulate P (PP)
- Total P (TP) – Includes DP and PP
- Bioavailable P (BAP)
  - ✓DP + part of PP

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


Soluble P
Particulate P
Bioavailable P
Sediment P
Sediment P
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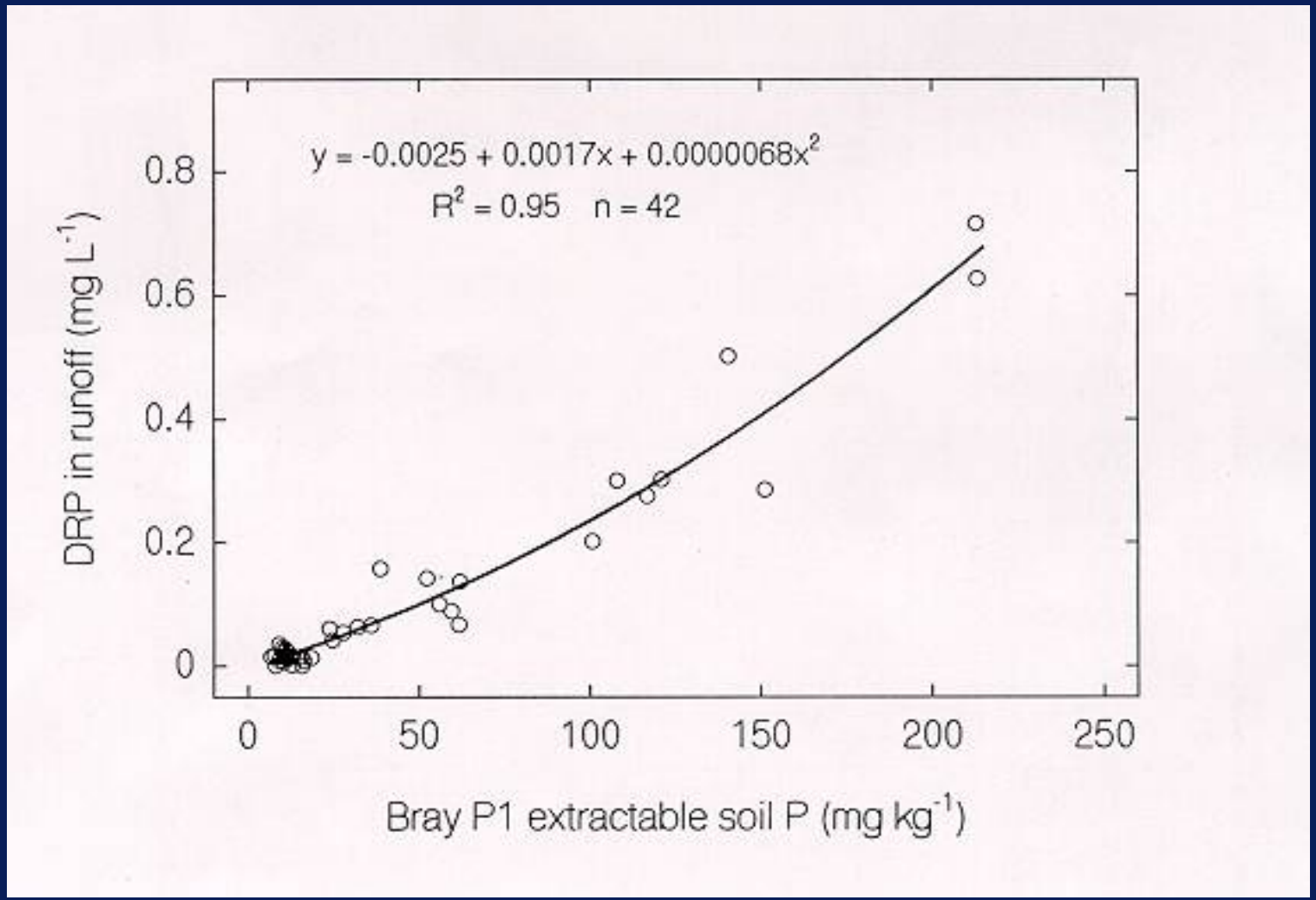
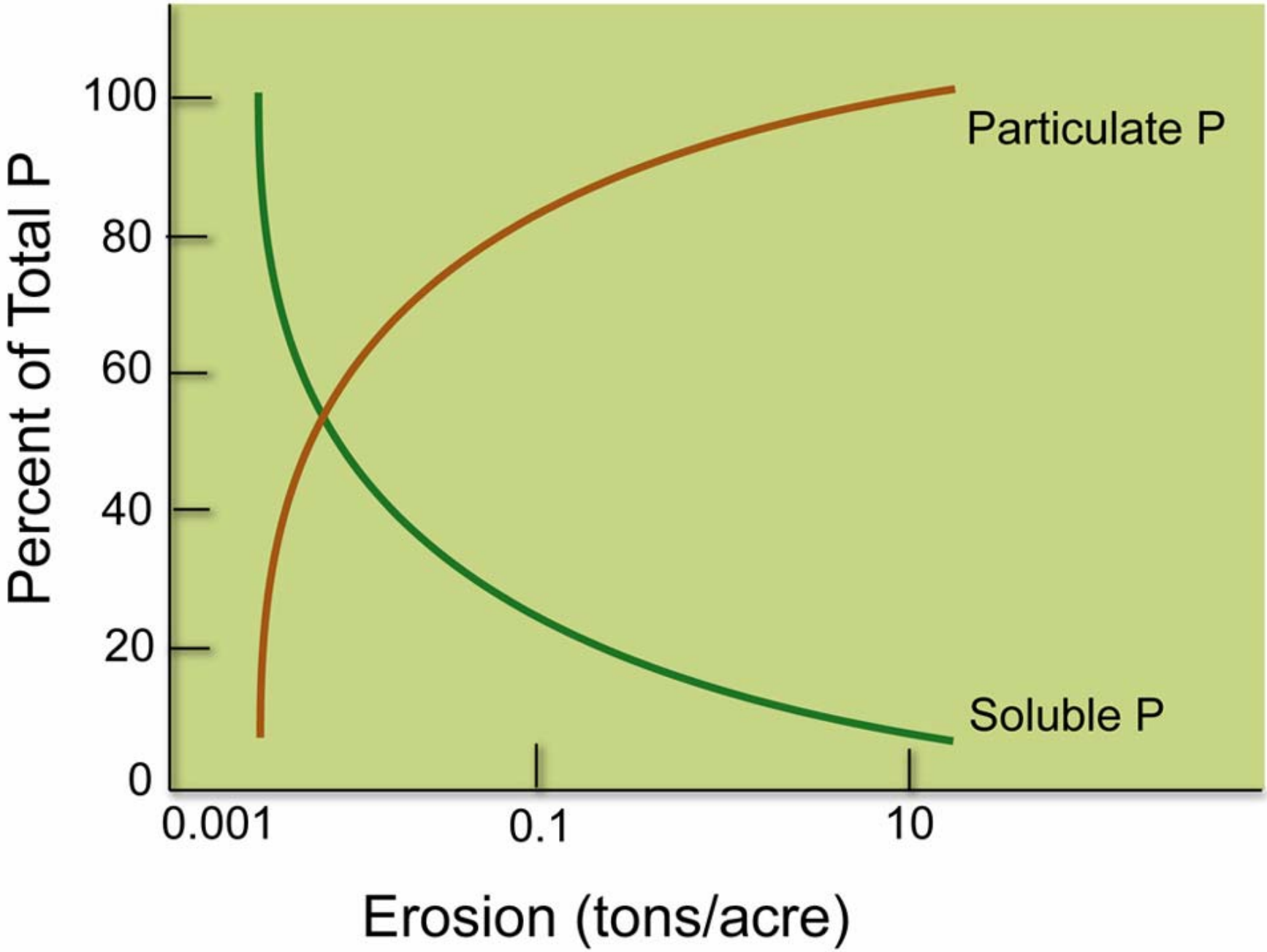
Relationship between Bray P-1 (0-2 cm) and DRP in runoff.





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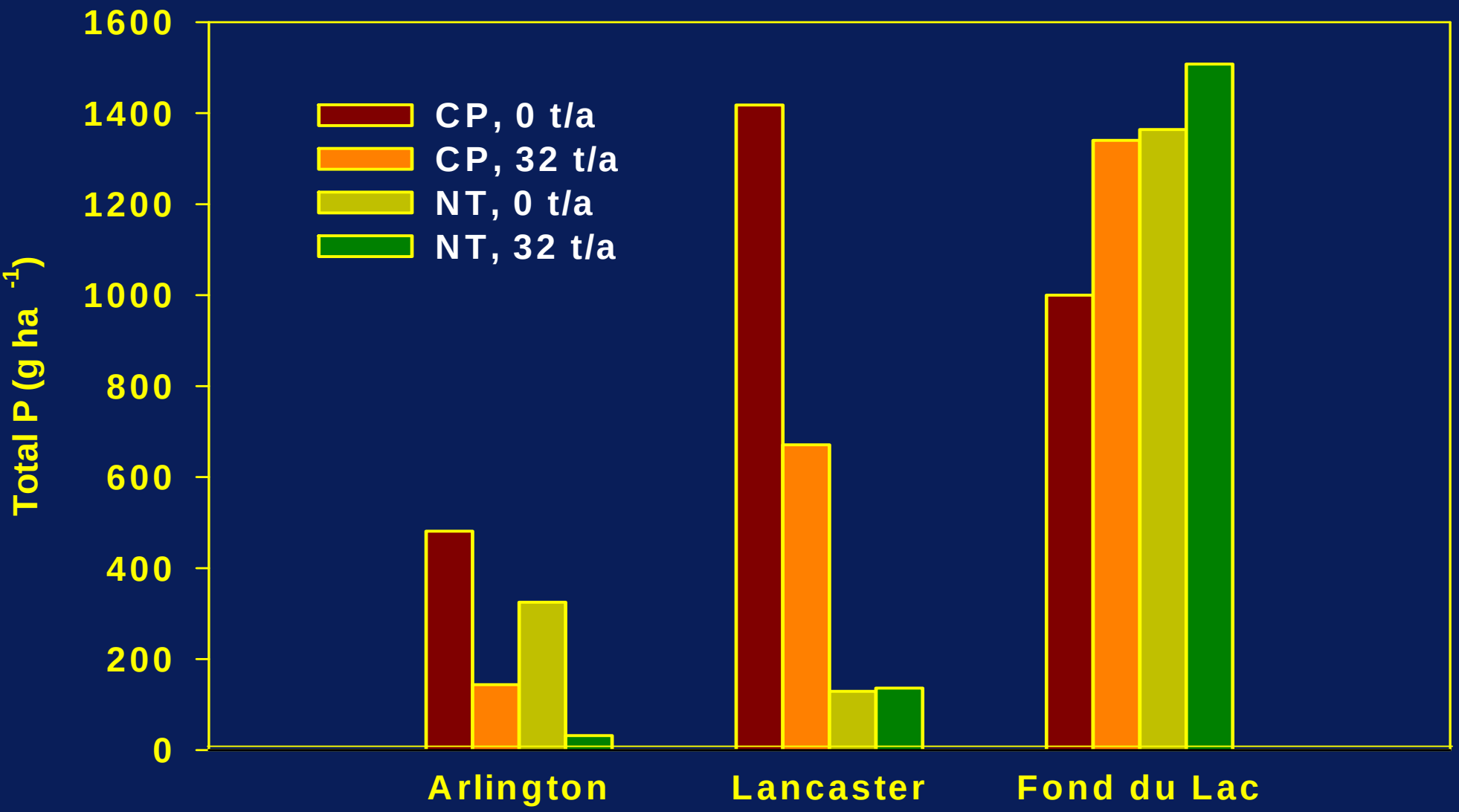
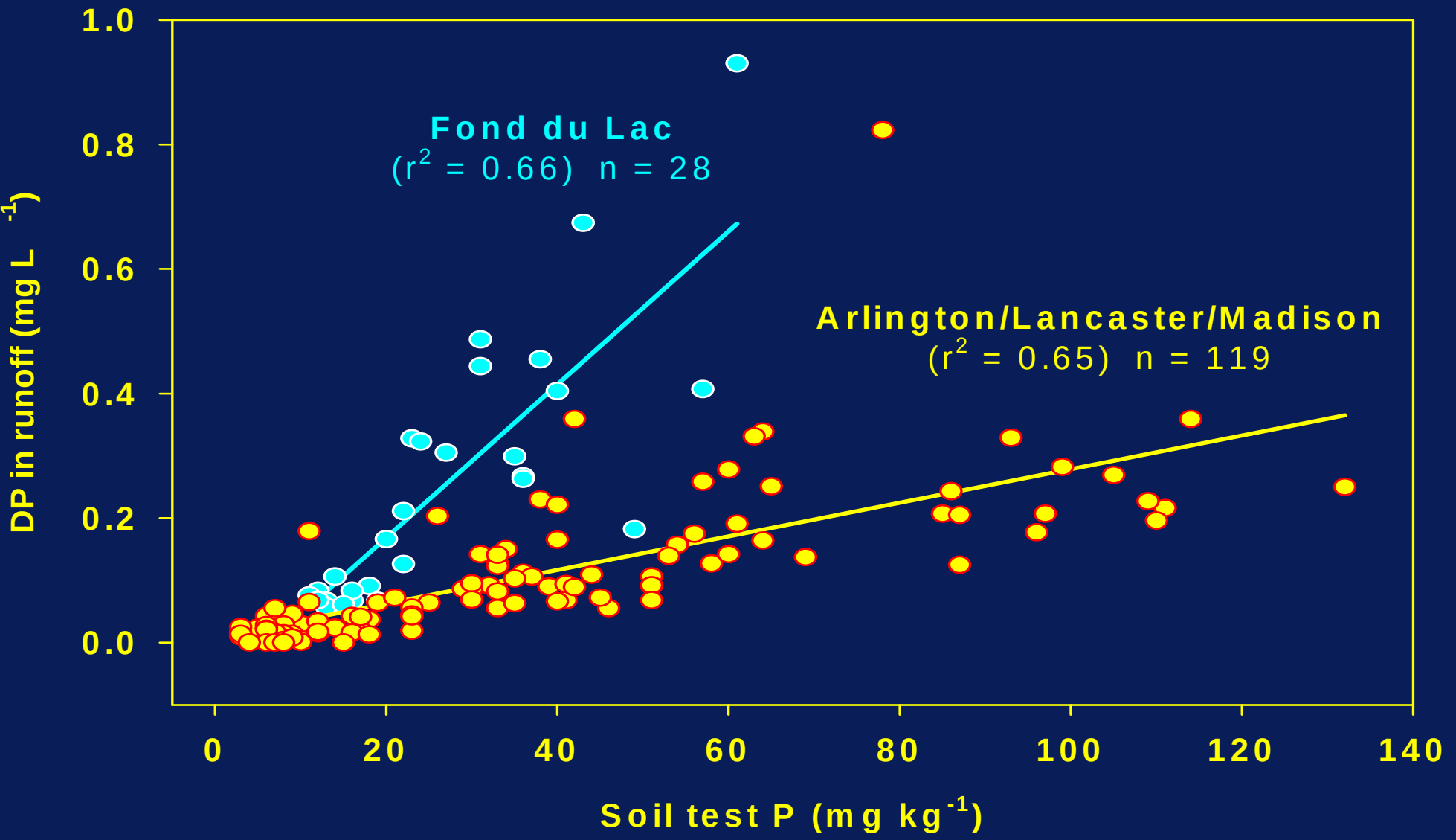
Influence of tillage and manure

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

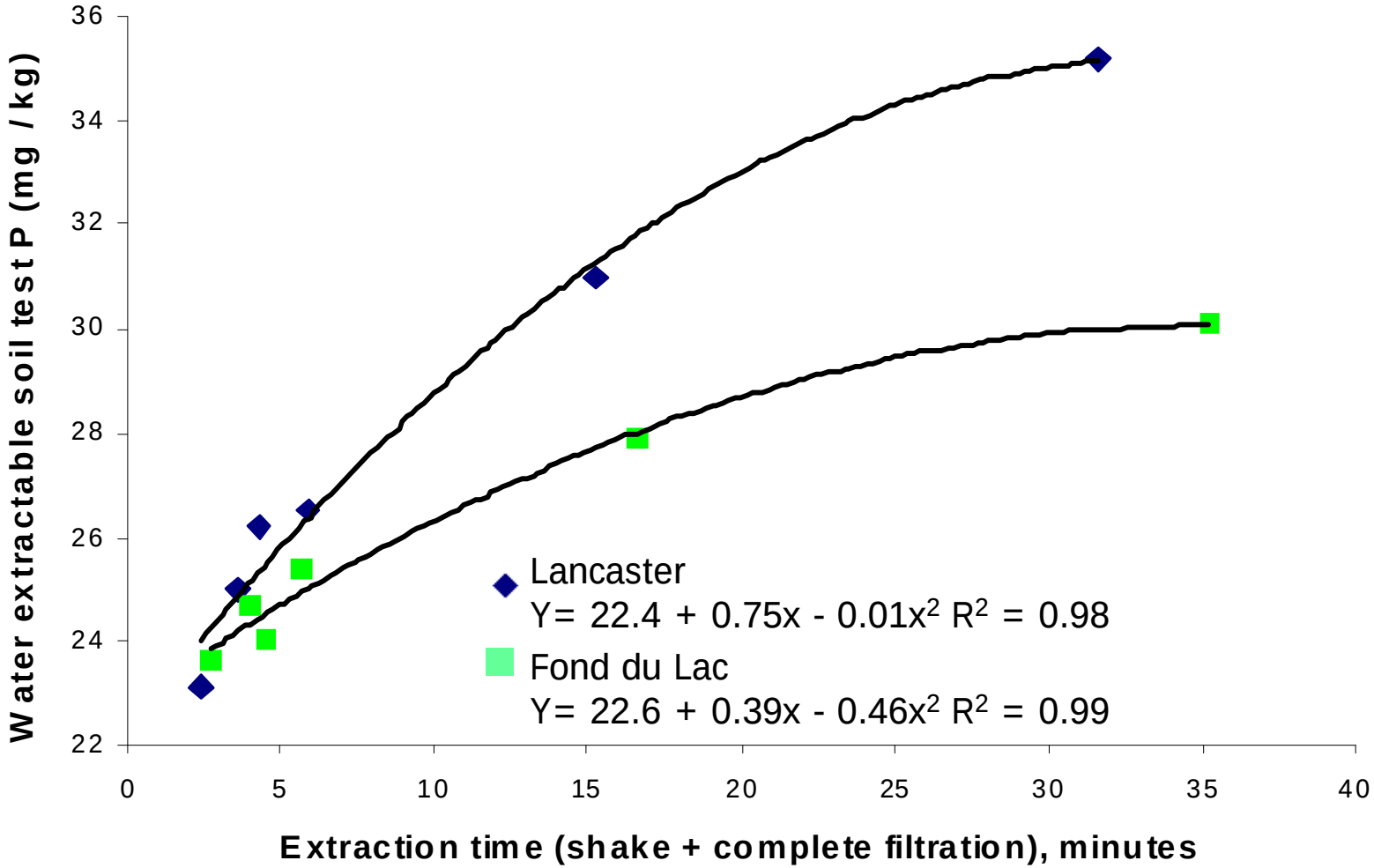


Soil-specific effects on soluble P

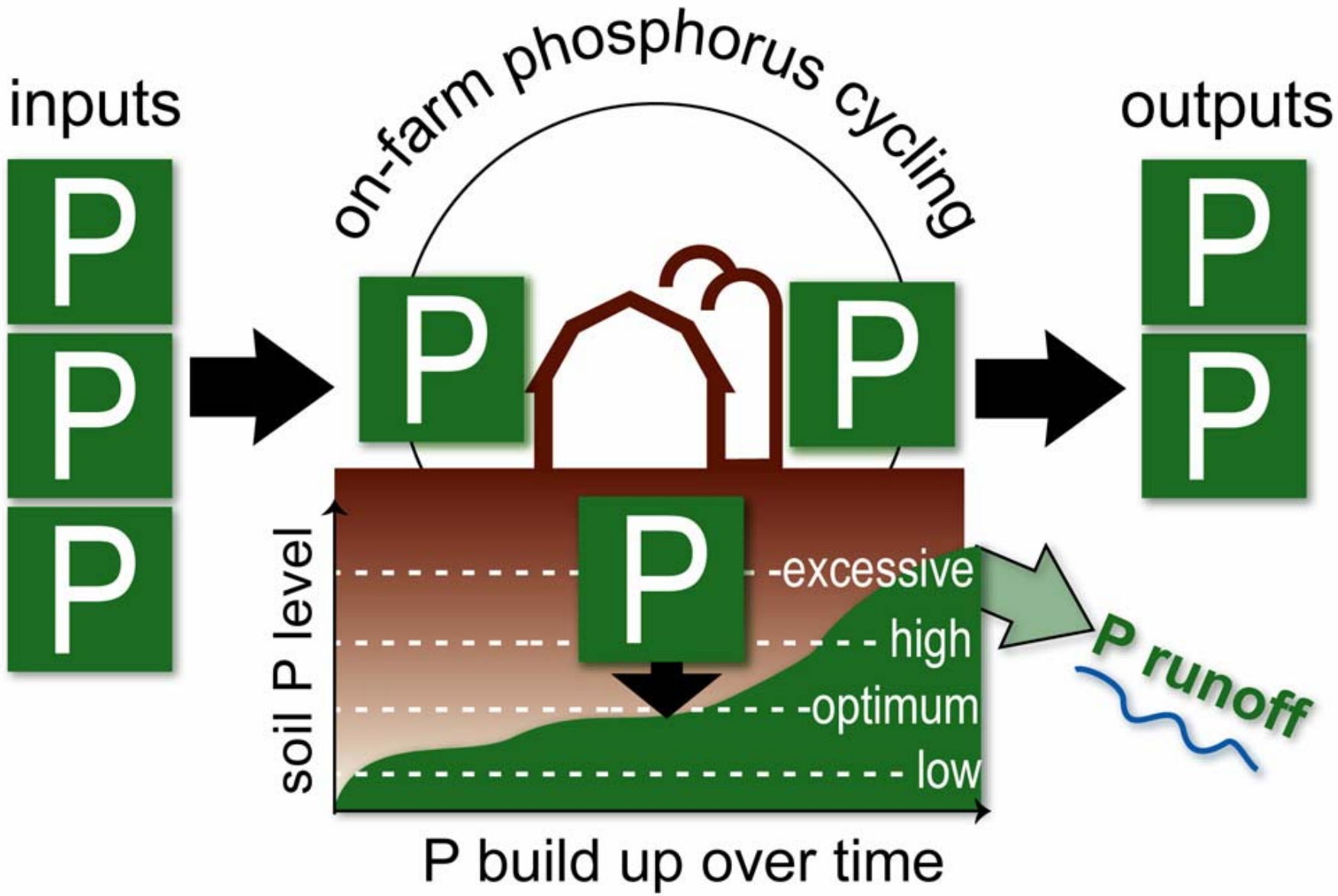
Relationship between STP and DP concentration in runoff without spring applied manure.



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-1 at Lancaster and Fond du Lac.
Respective DP in runoff = 0.33 and 0.93 mg L-1 at Lancaster and Fond du Lac.



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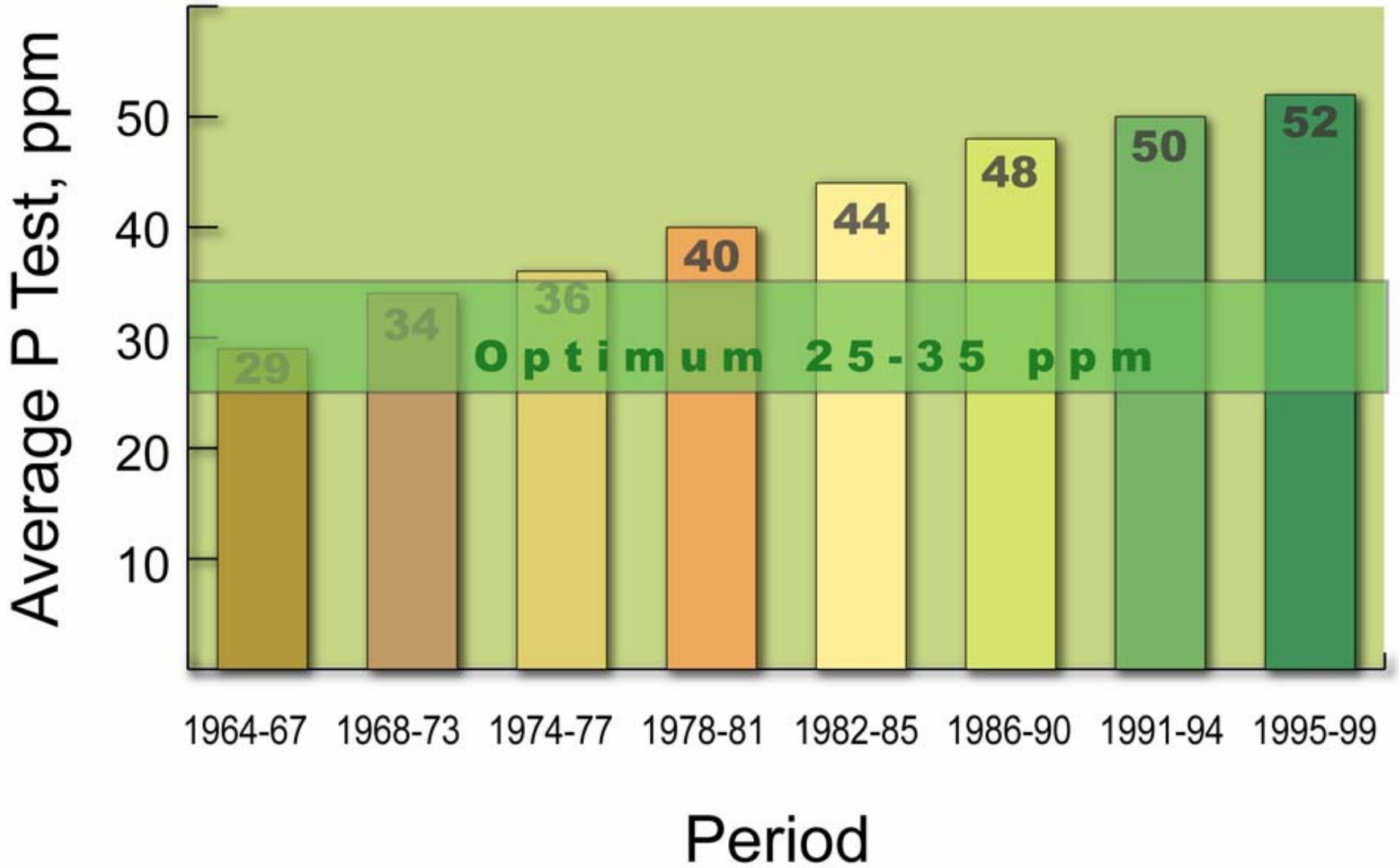

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Interpreting Soil P Tests

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

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

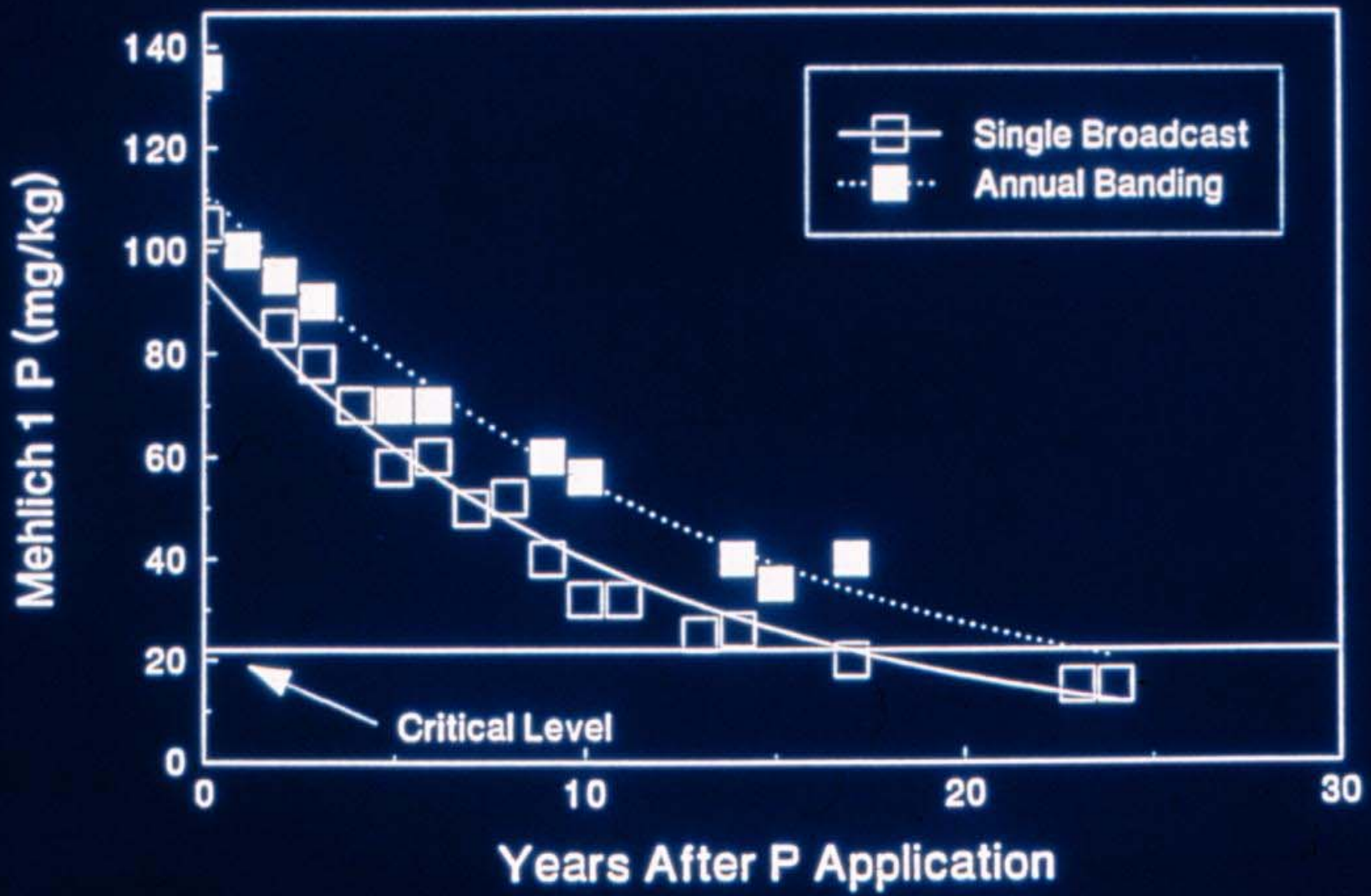
SOIL PHOSPHORUS BUFFERING CAPACITY

- 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

- 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

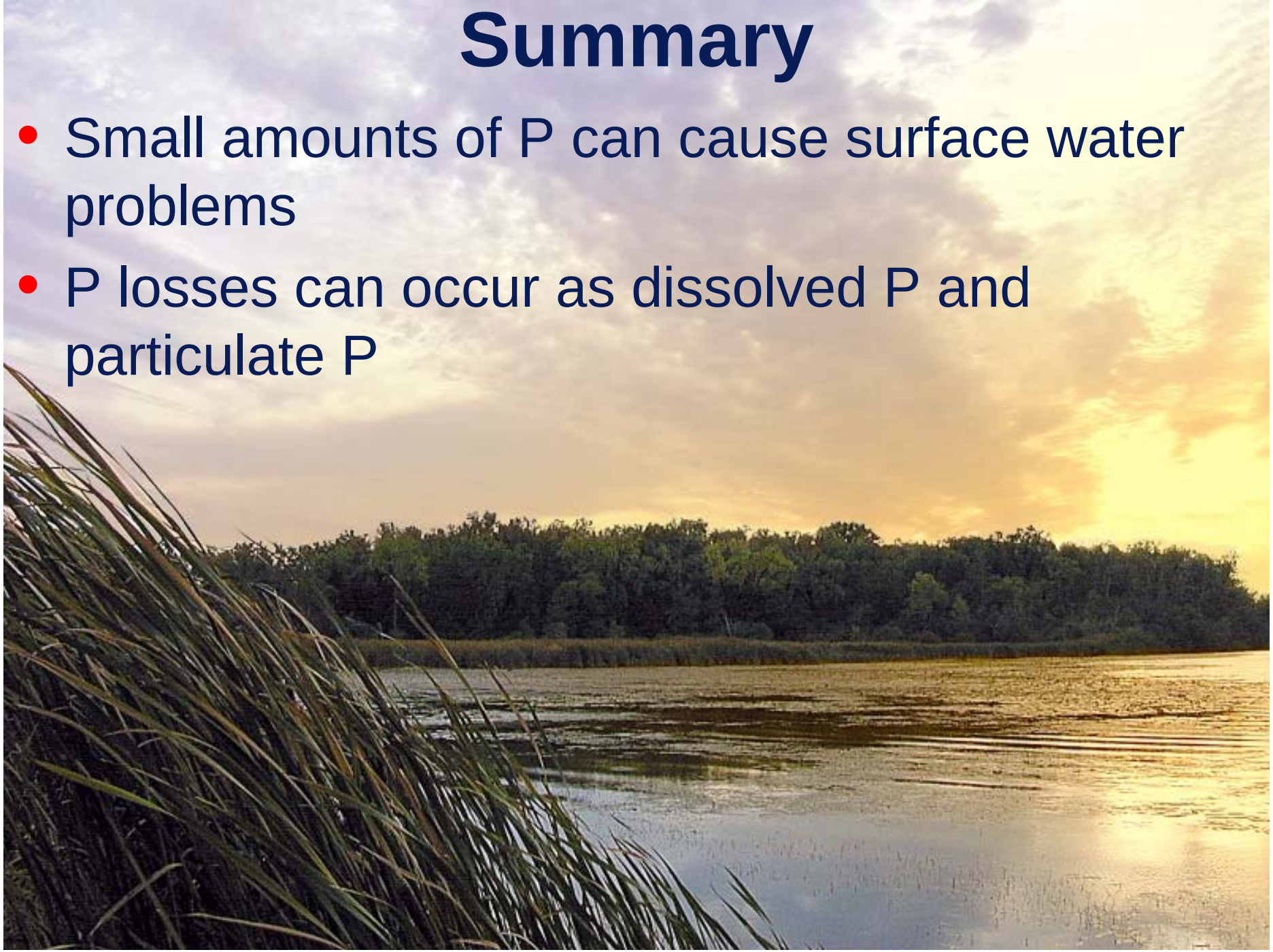
Soil Test	Recommendation
Low, very low	Crop removal +
Optimum	Crop removal
High	½ Crop removal
Excessively High	None

Summary

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

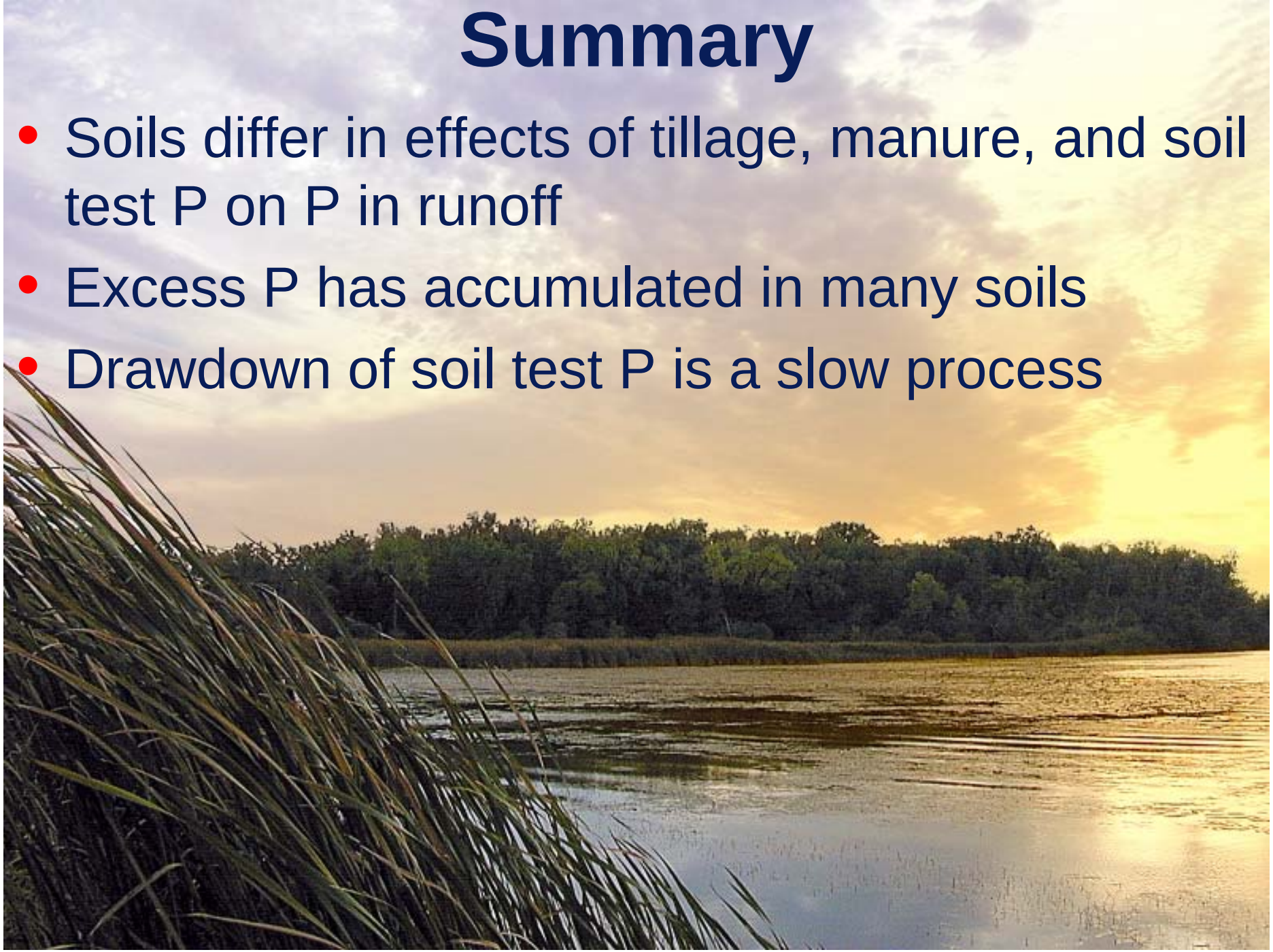
Summary

- 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



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