# UNDERSTANDING SOIL PHOSPHORUS

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

# 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

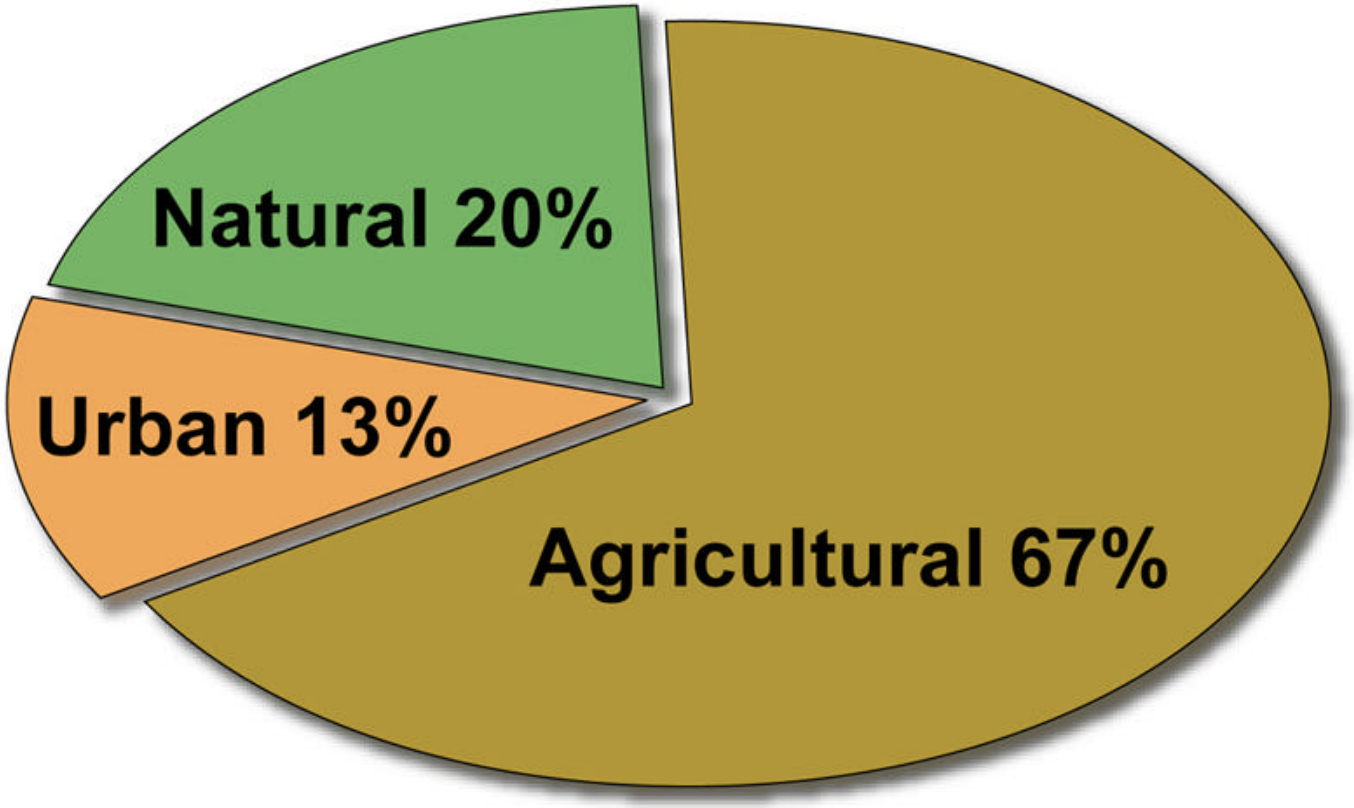
# Environmental Concerns

- 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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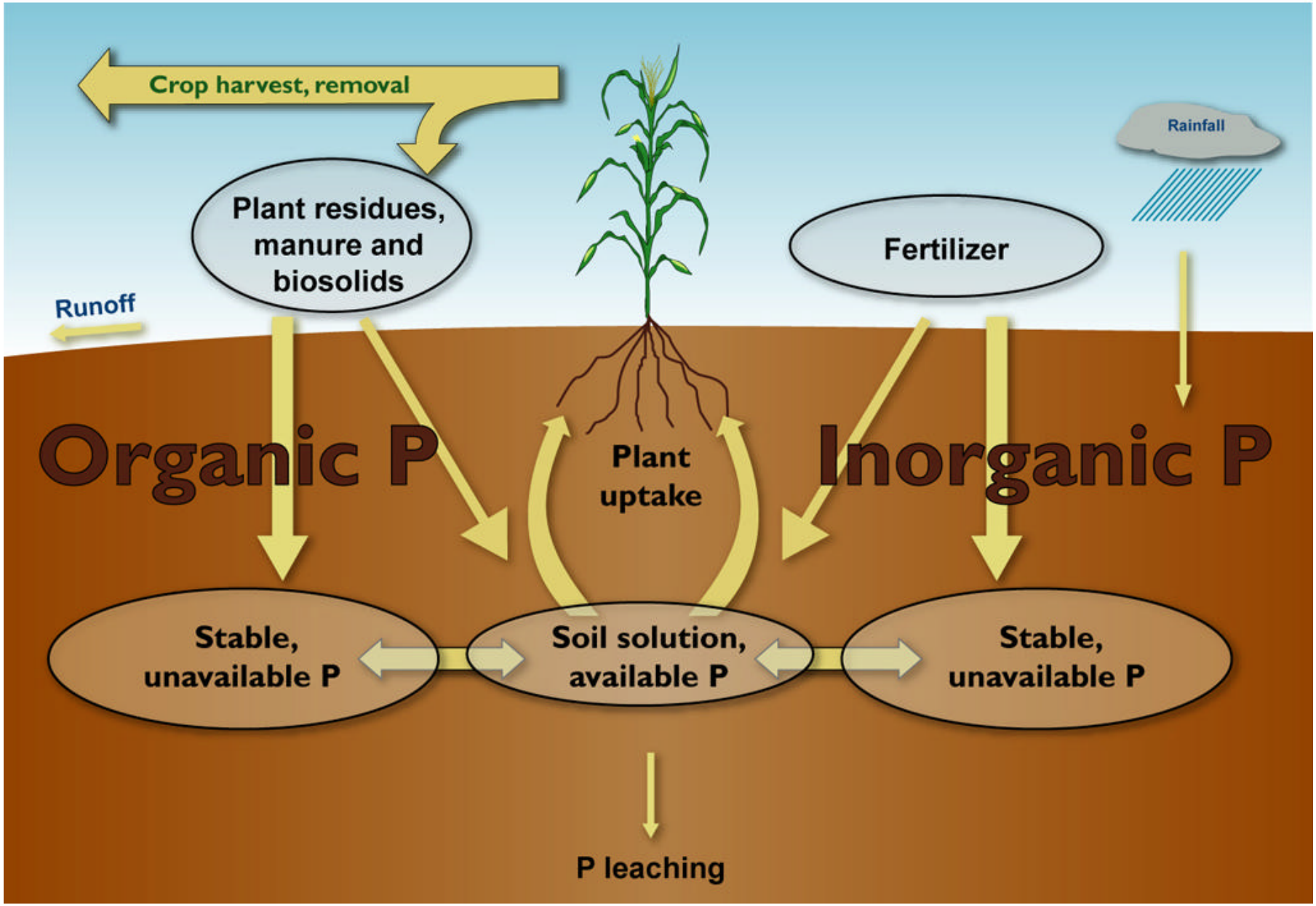
# Forms & Concentrations of Phosphorus (P) in Soils

| 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
Runoff
Rainfall
Fertilizer
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

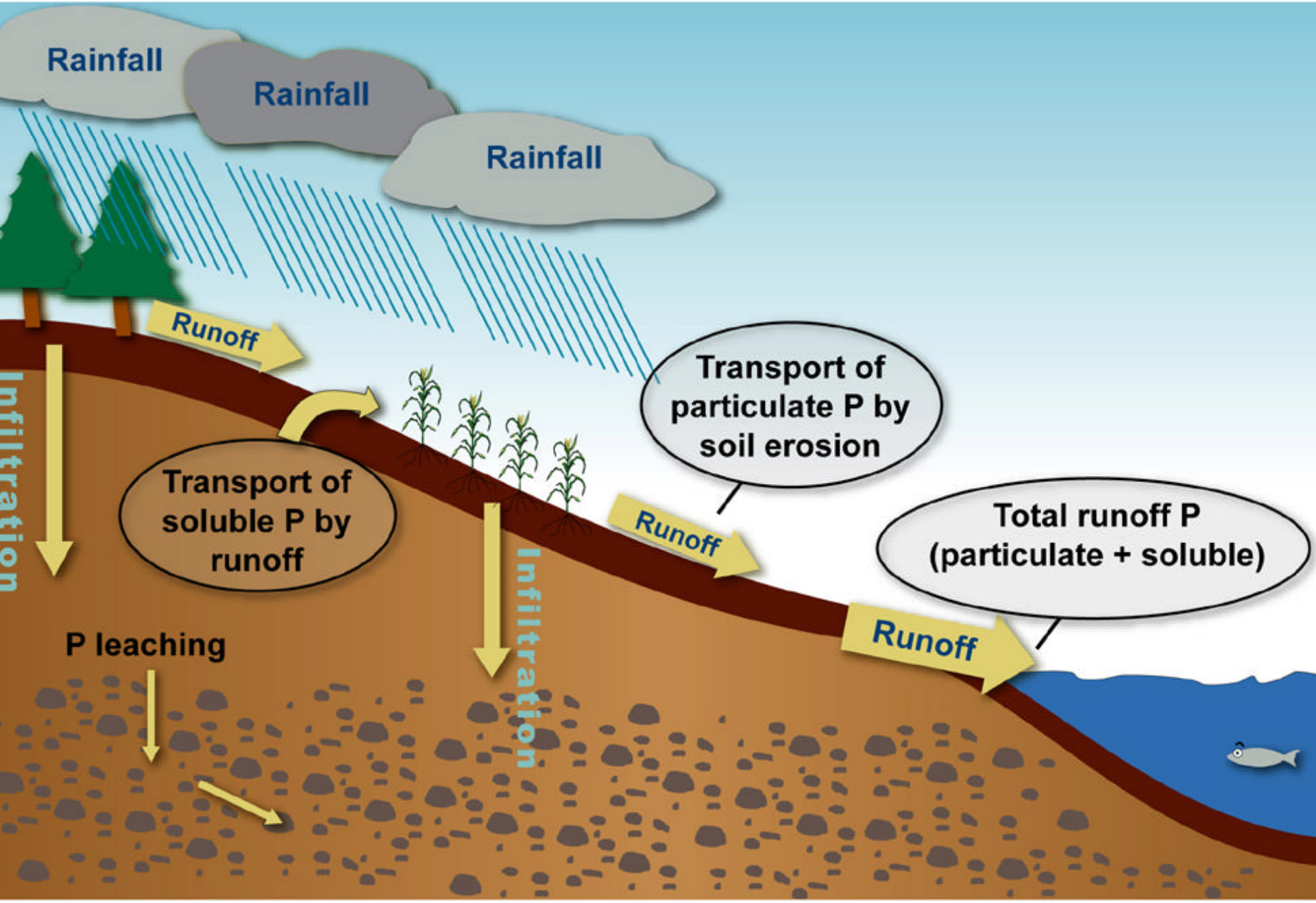
# Adsorption and Desorption of Phosphorus

- 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?

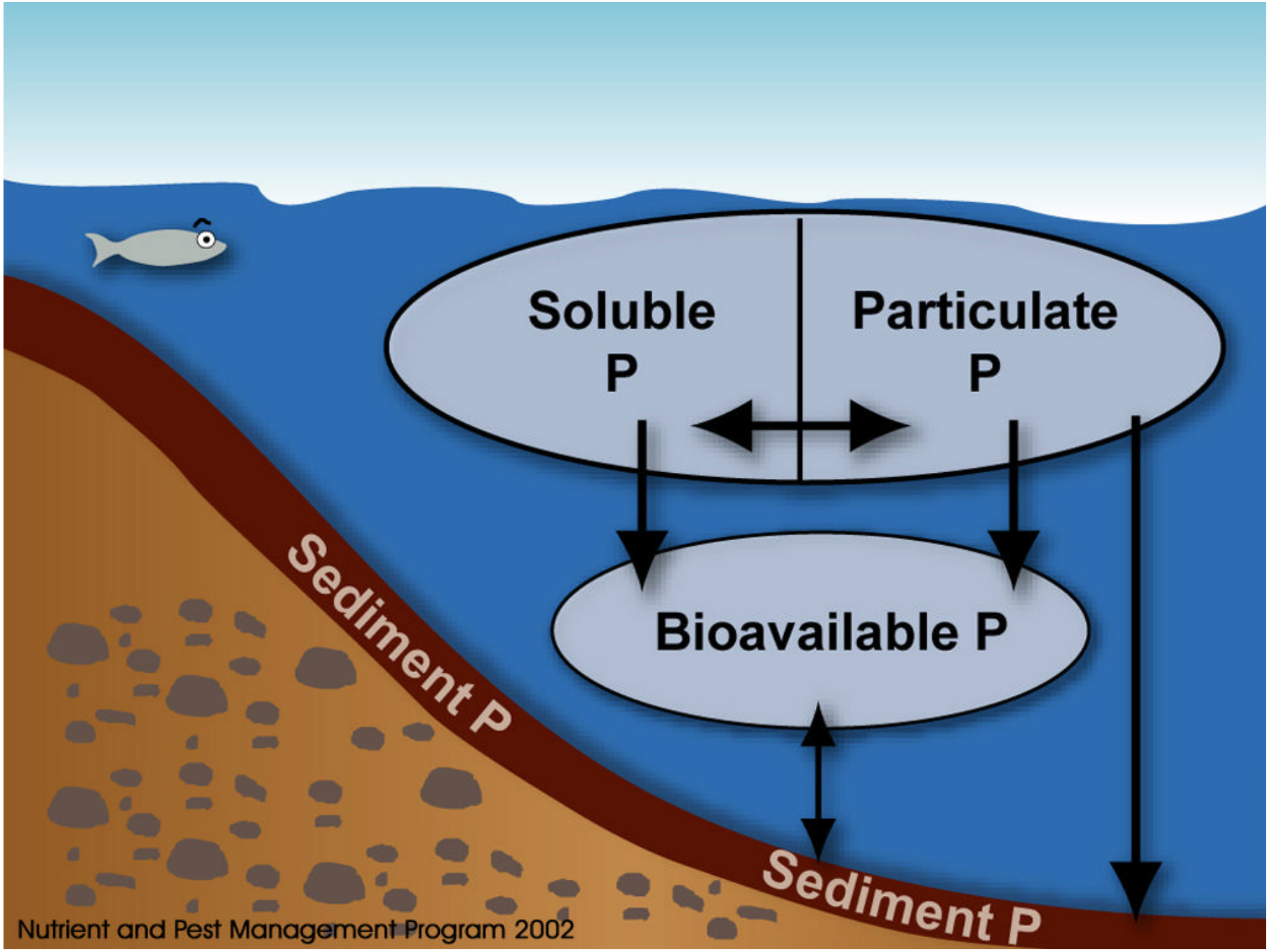

Rainfall
Rainfall
Rainfall
Runoff
Infiltration
Transport of soluble P by runoff
Transport of particulate P by soil erosion
Runoff
Total runoff P (particulate + soluble)
Runoff
Infiltration
P leaching

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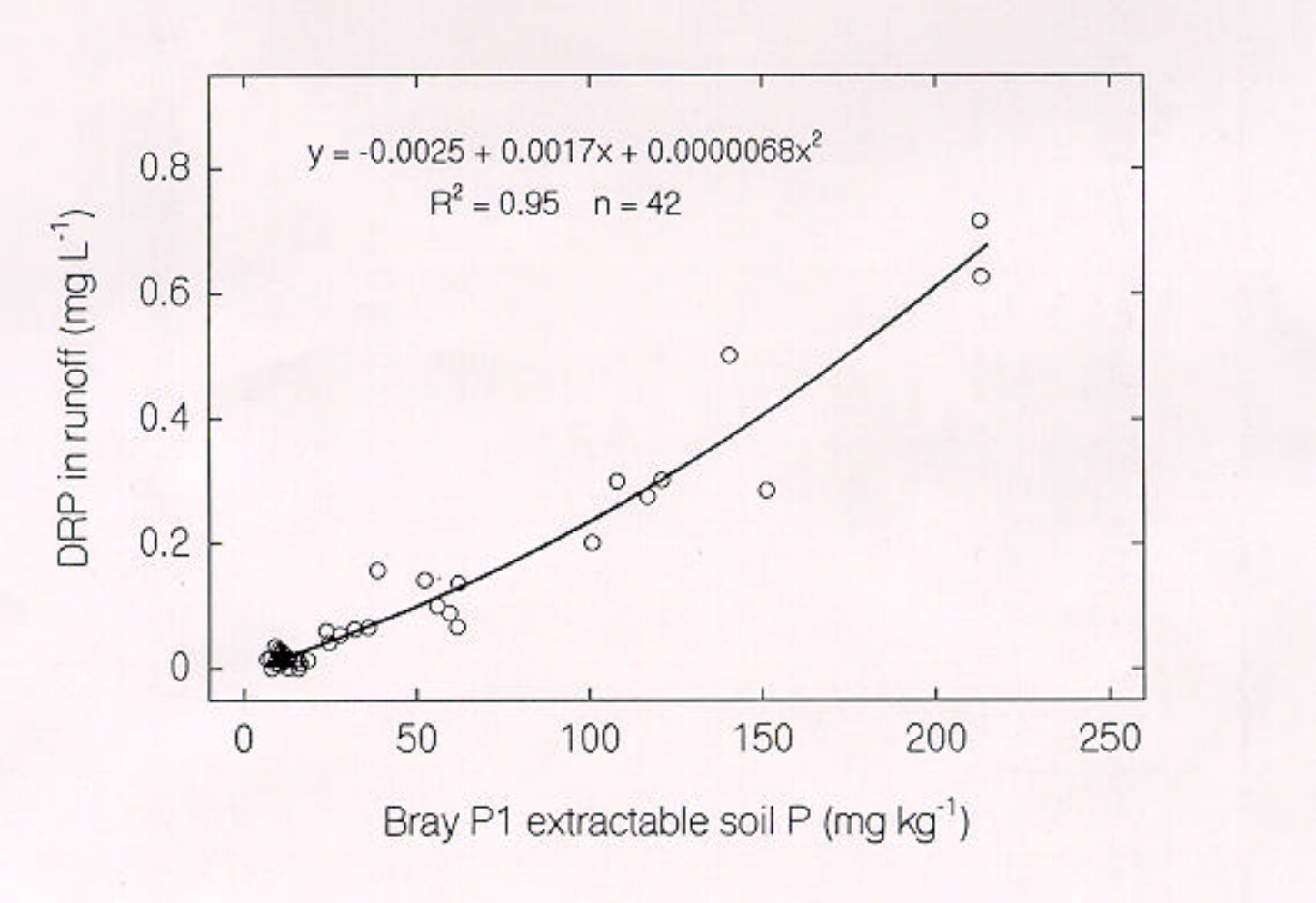
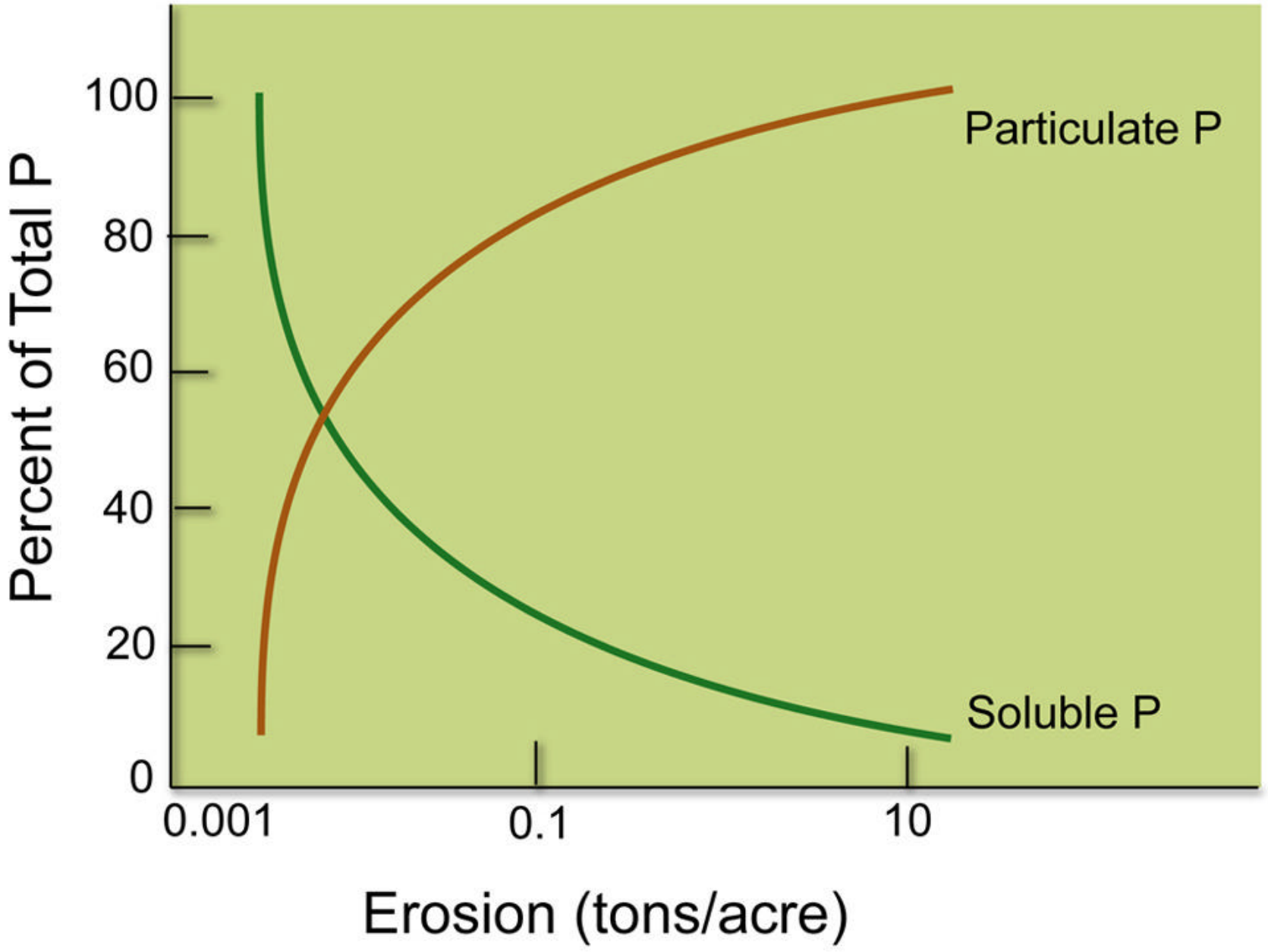
# Relationship between Bray P-1 (0-2 cm) and DRP in runoff.



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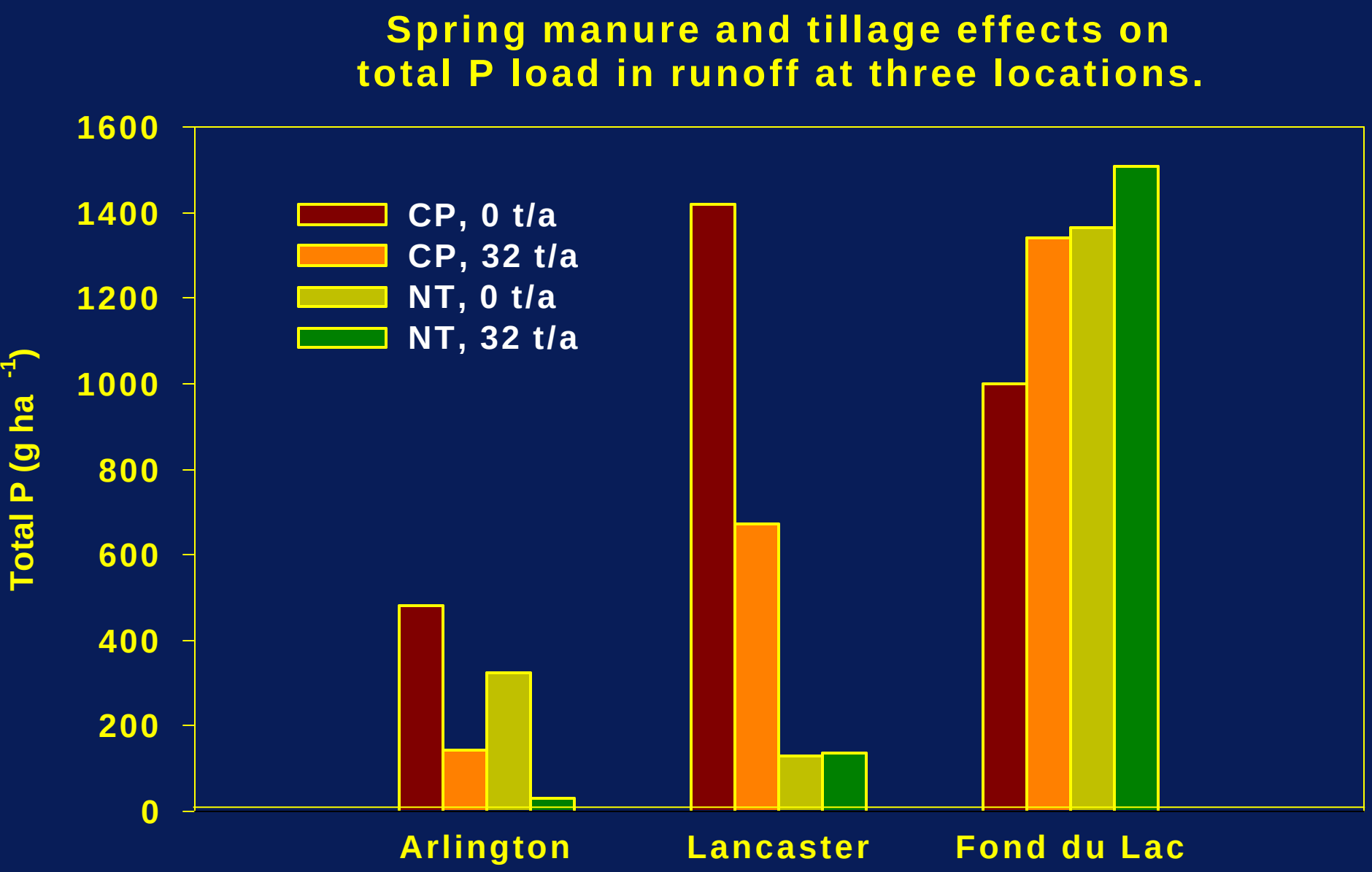
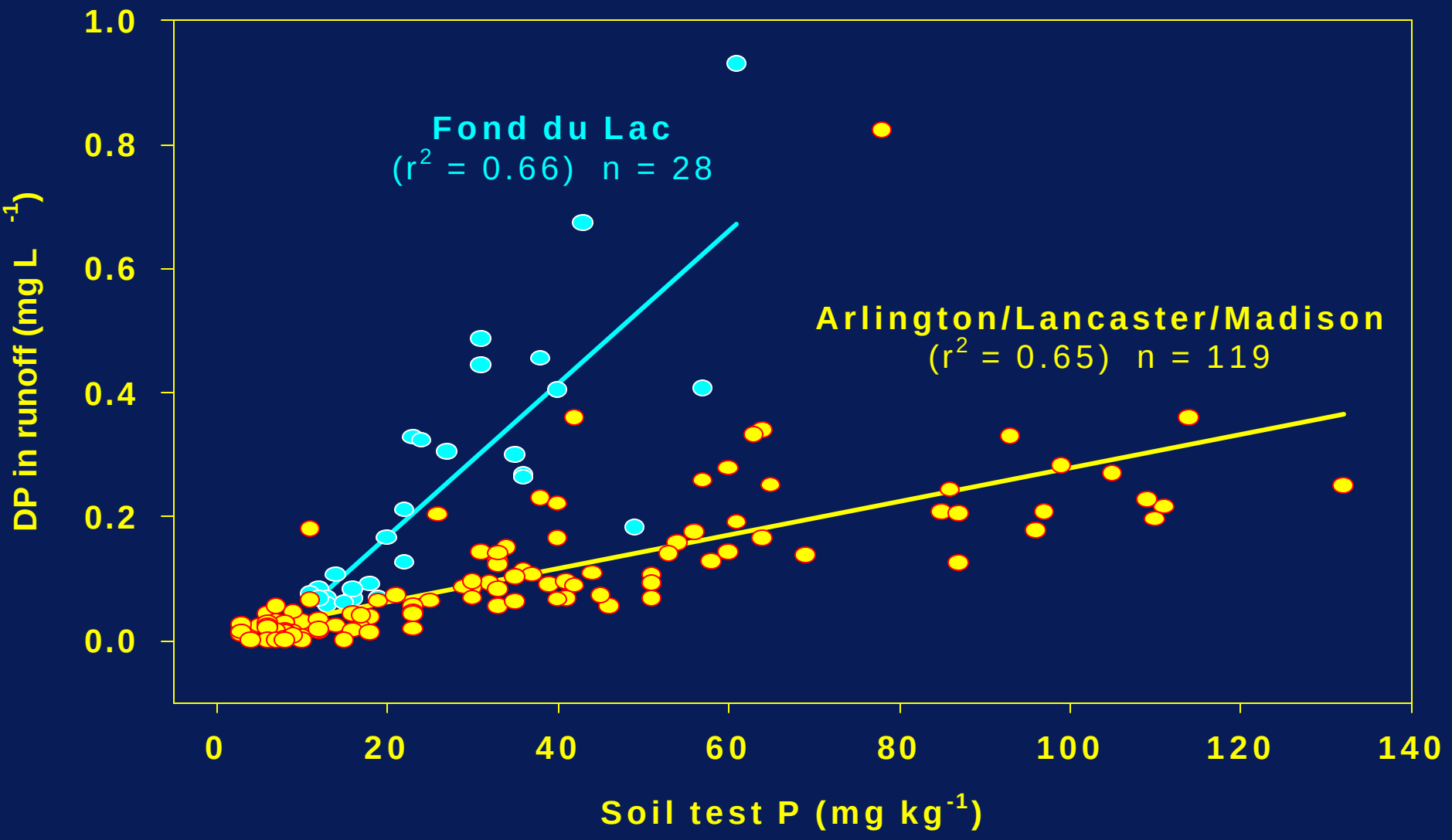
# Influence of tillage and manure

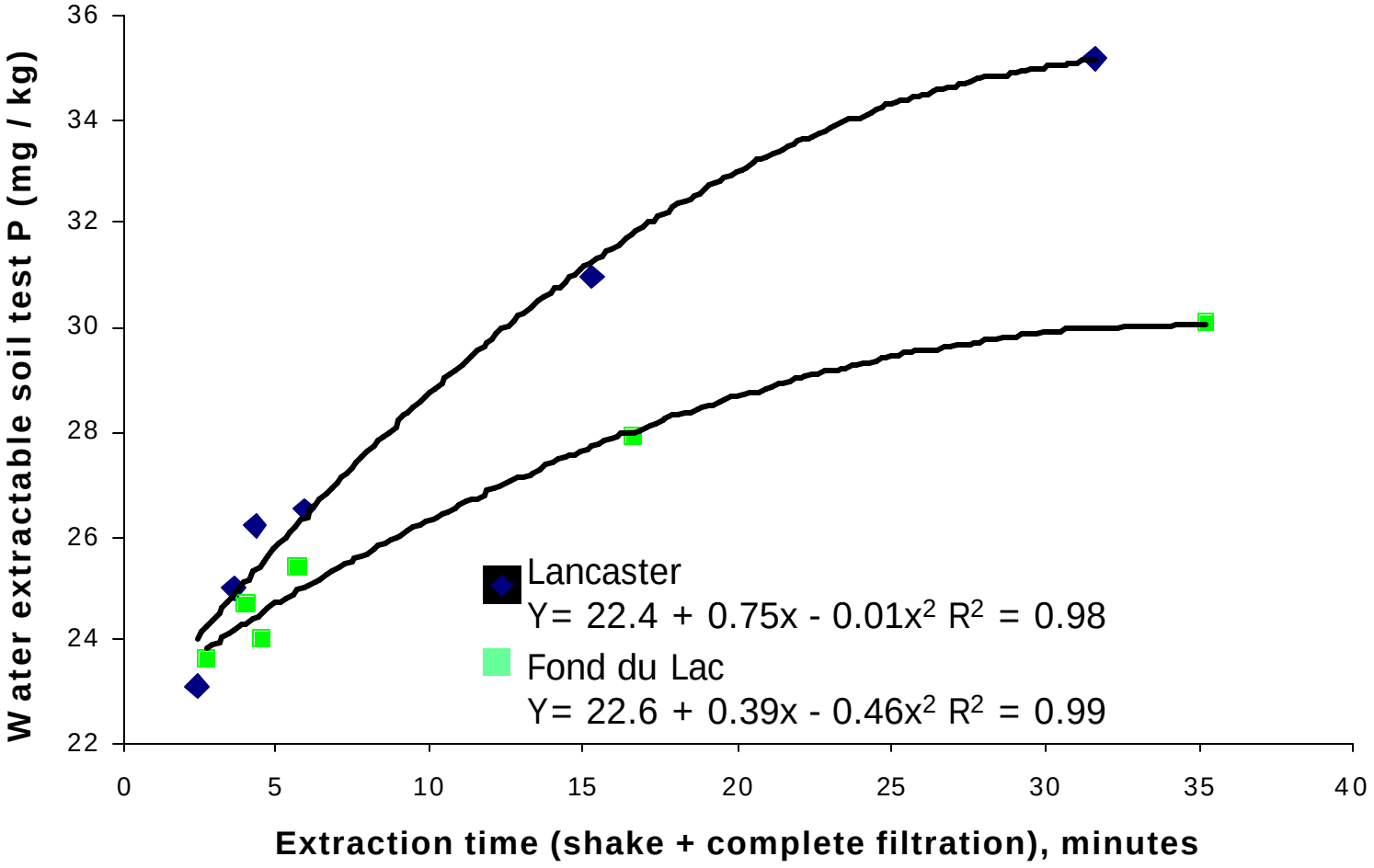

Spring manure and tillage effects on total P load in runoff at three locations.
Total P (g ha -1)
1600
1400
1200
1000
800
600
400
200
0
CP, 0 t/a
CP, 32 t/a
NT, 0 t/a
NT, 32 t/a
Arlington
Lancaster
Fond du Lac

# Soil-specific effects on soluble P

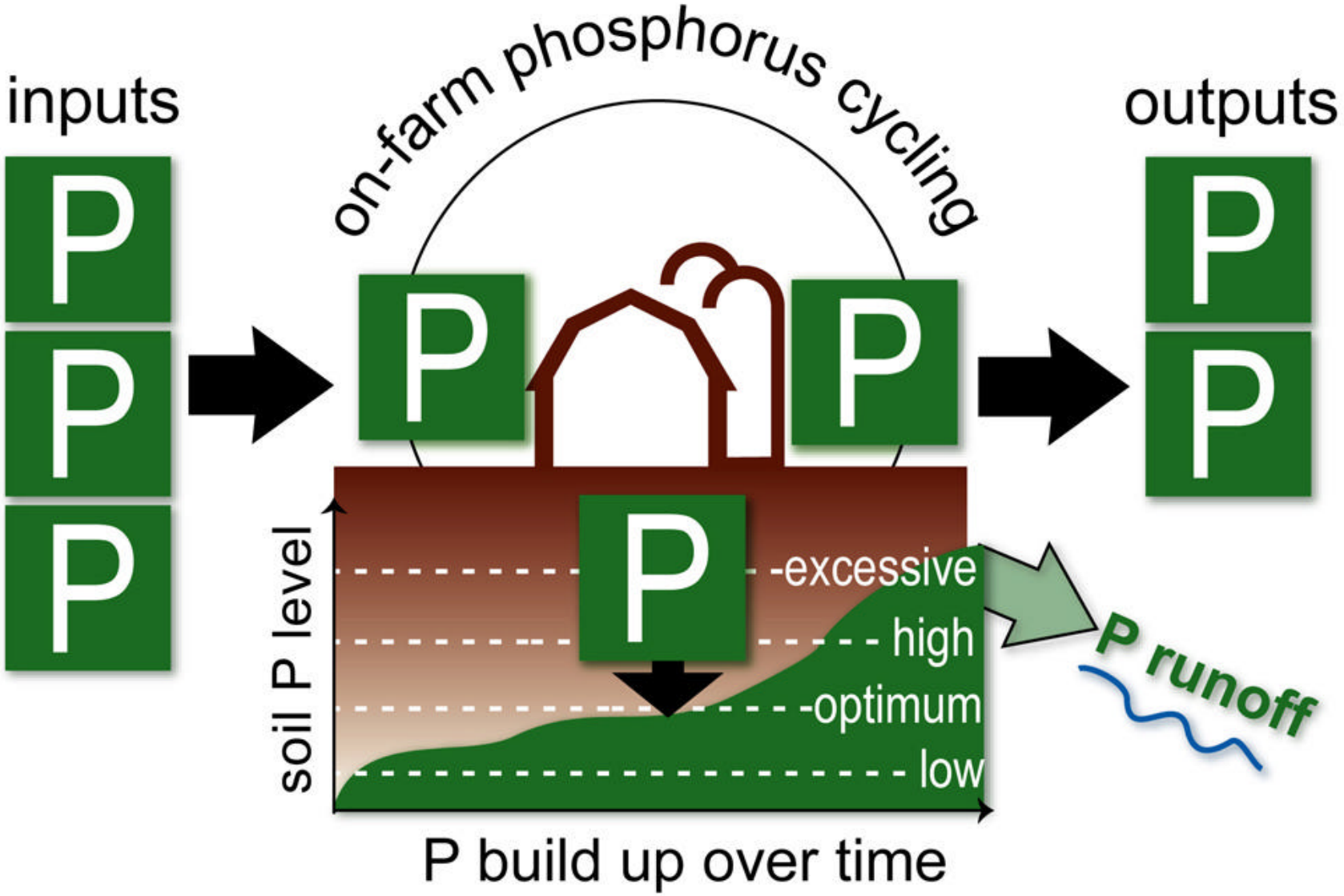
# Relationship between STP and DP concentration in runoff without spring applied manure.



# 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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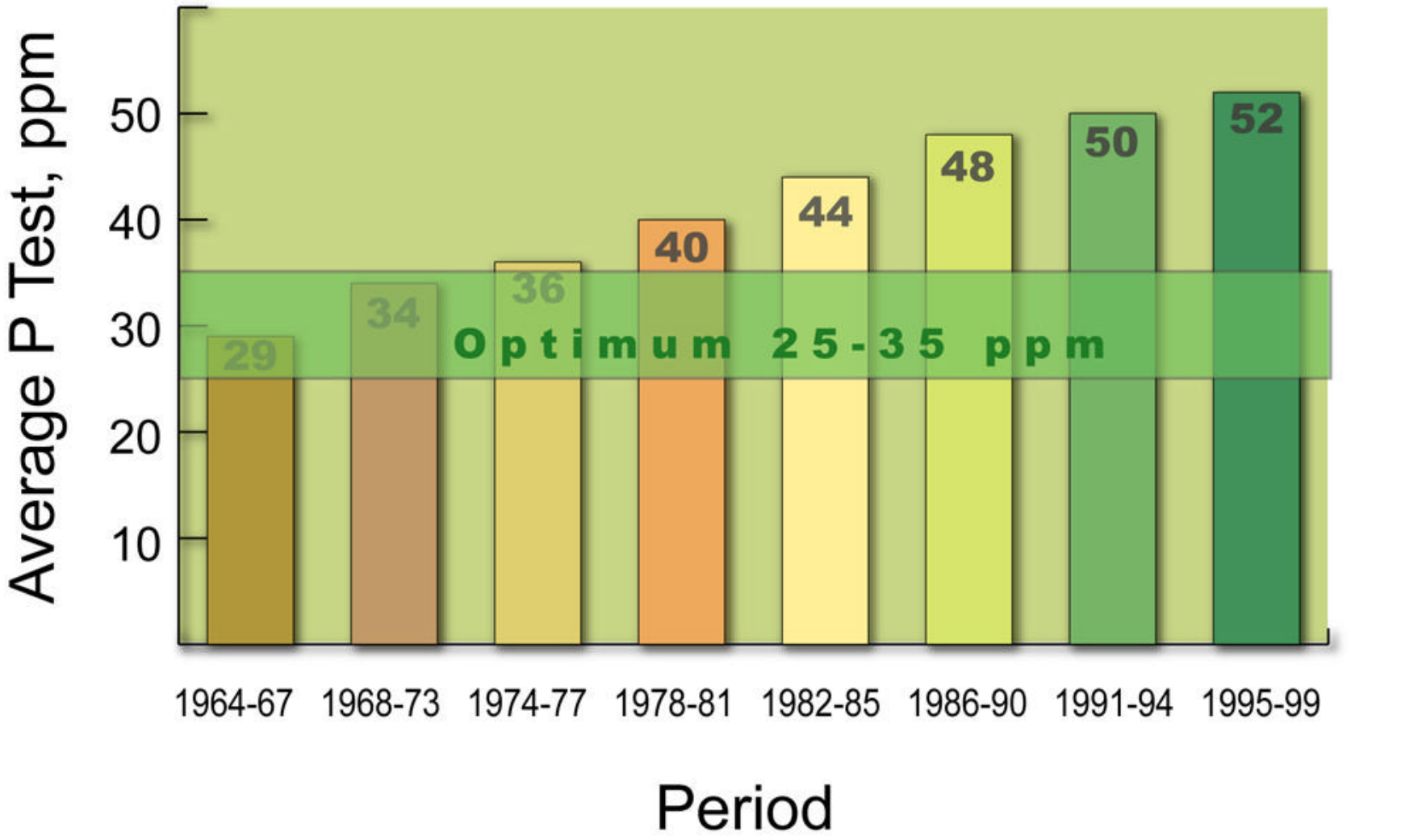


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# Interpreting Soil P Tests

| | 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

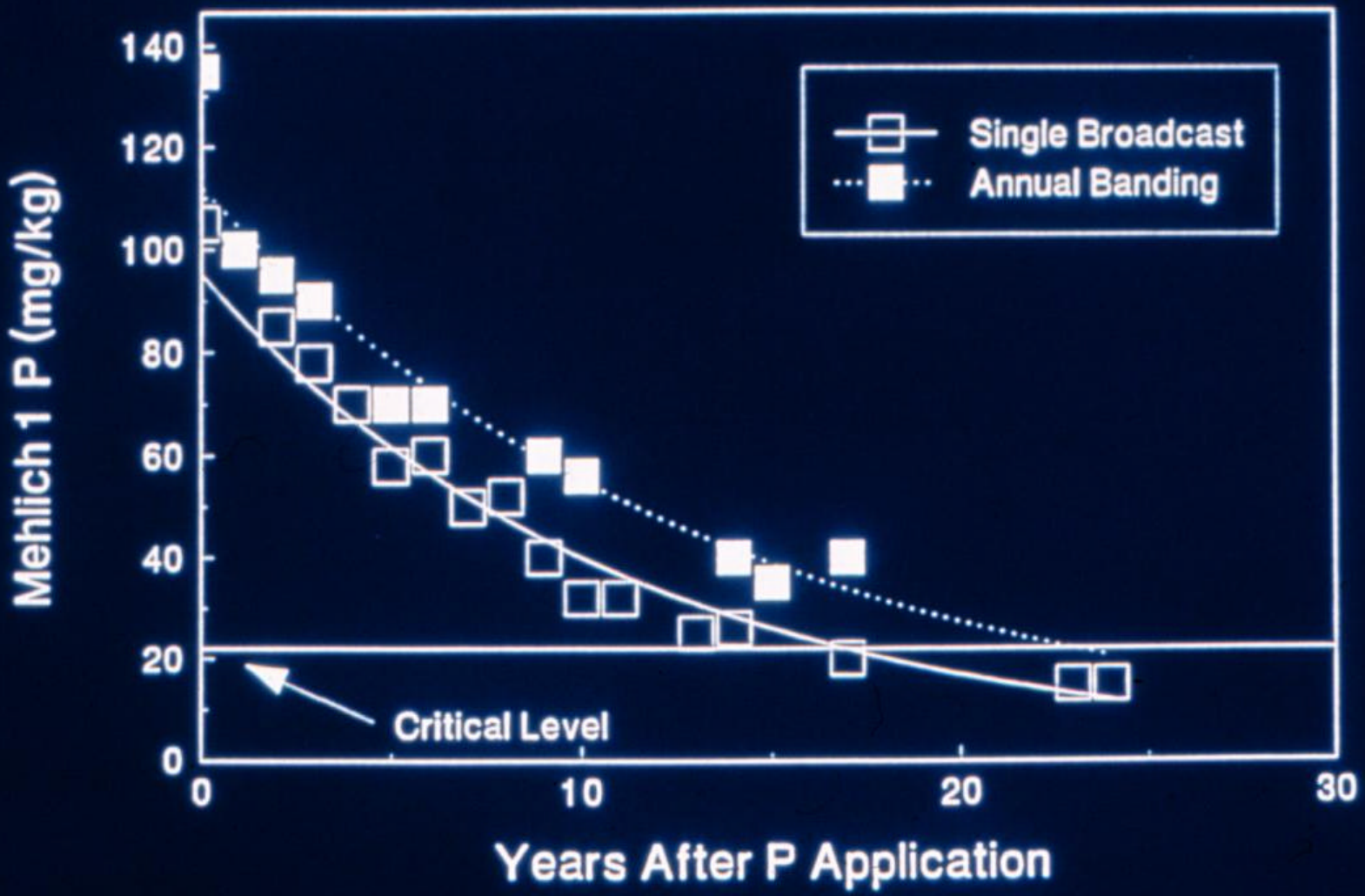
# SOIL PHOSPHORUS BUFFERING CAPACITY

- 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

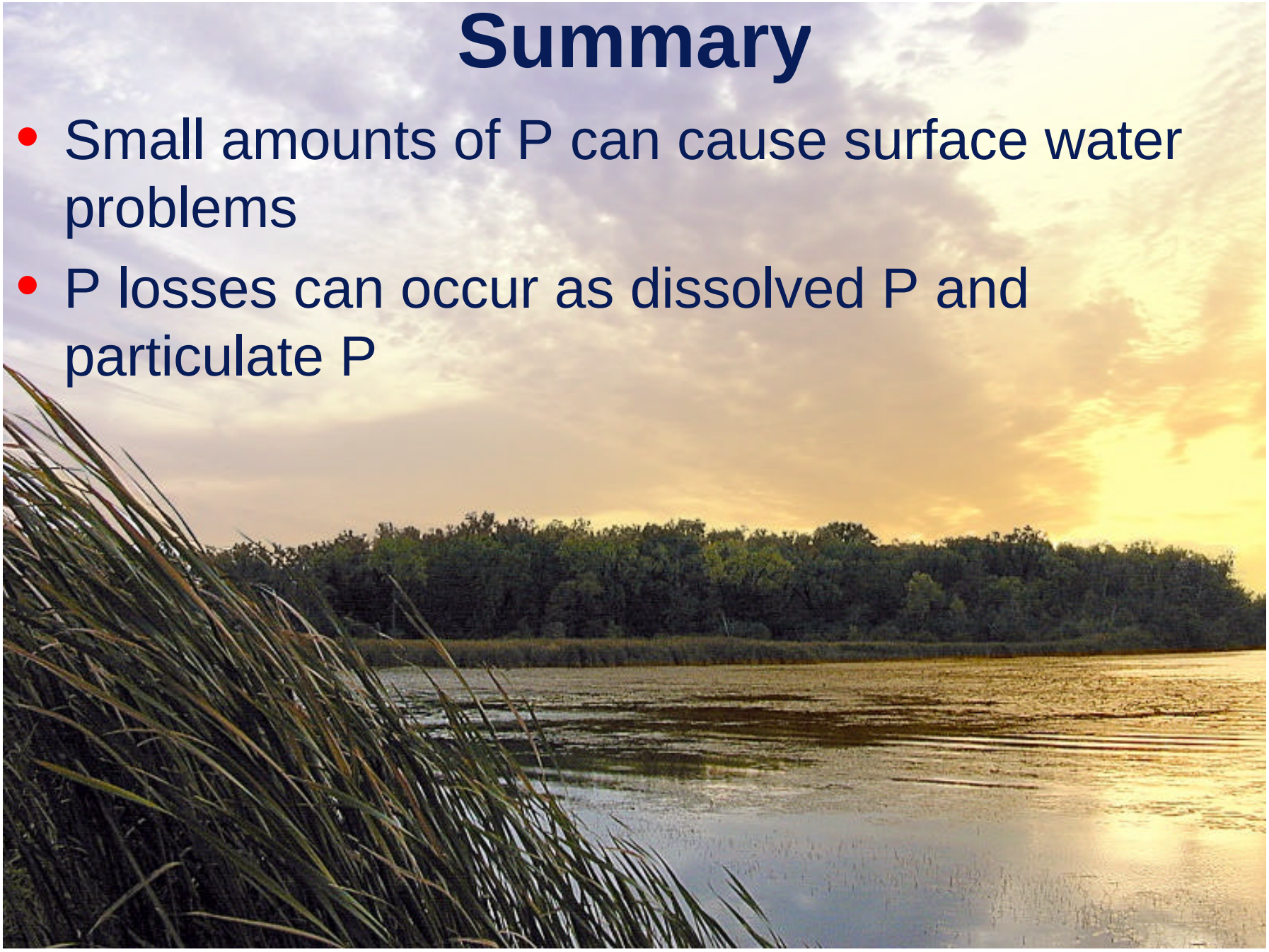
| Soil Test | Recommendation |
|---|---|
| Low, very low | Crop removal + |
| Optimum | Crop removal |
| High | ½ Crop removal |
| Excessively High | None |

# Summary

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

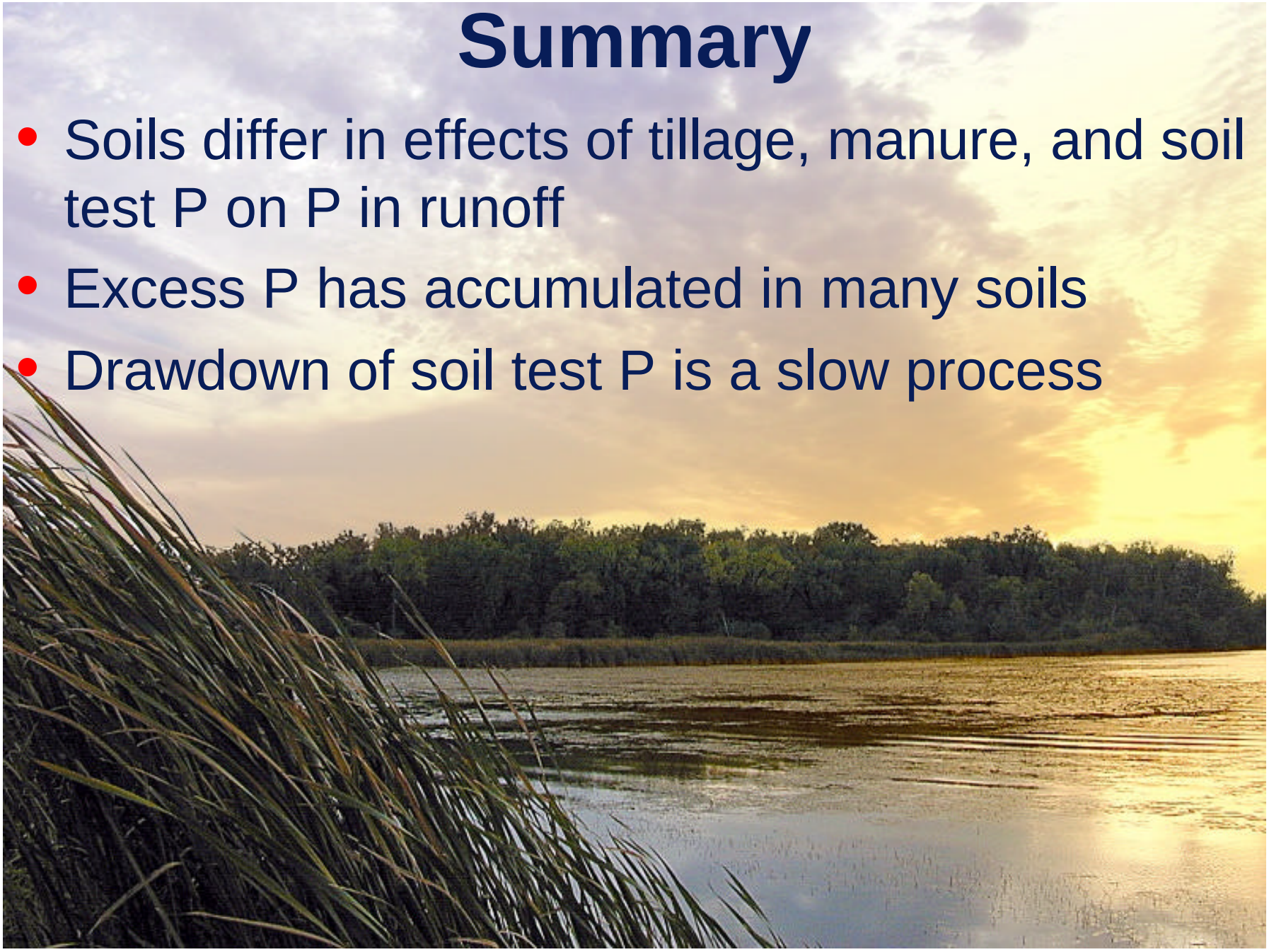
# Summary

- 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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