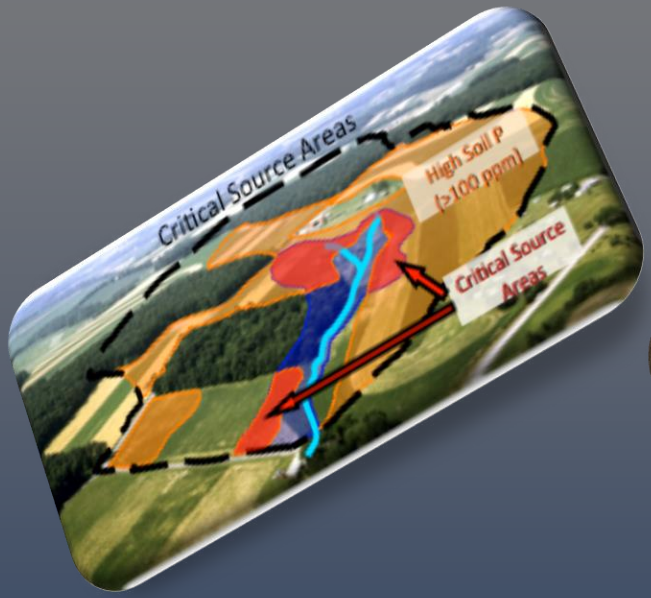
Chesapeake Bay 201 - Phosphorus

30 minutes of legacies, drainage and critical sources



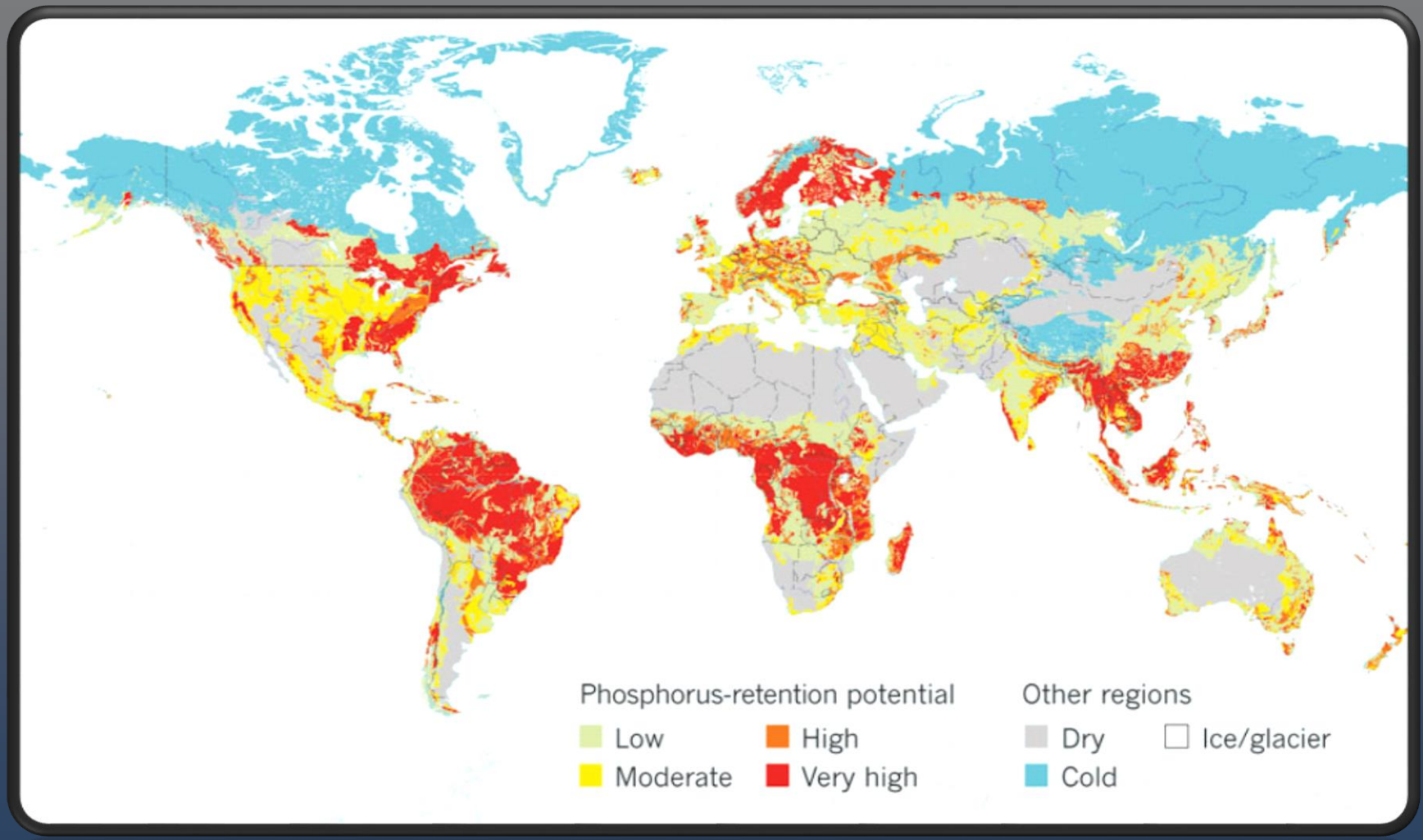
Pete Kleinman

USDA Agricultural Research Service

State College, PA 16802

P fertility

Many of the world's agricultural soils have high P binding potential

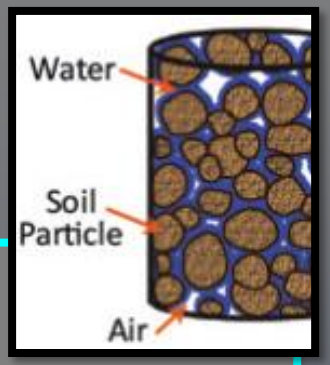


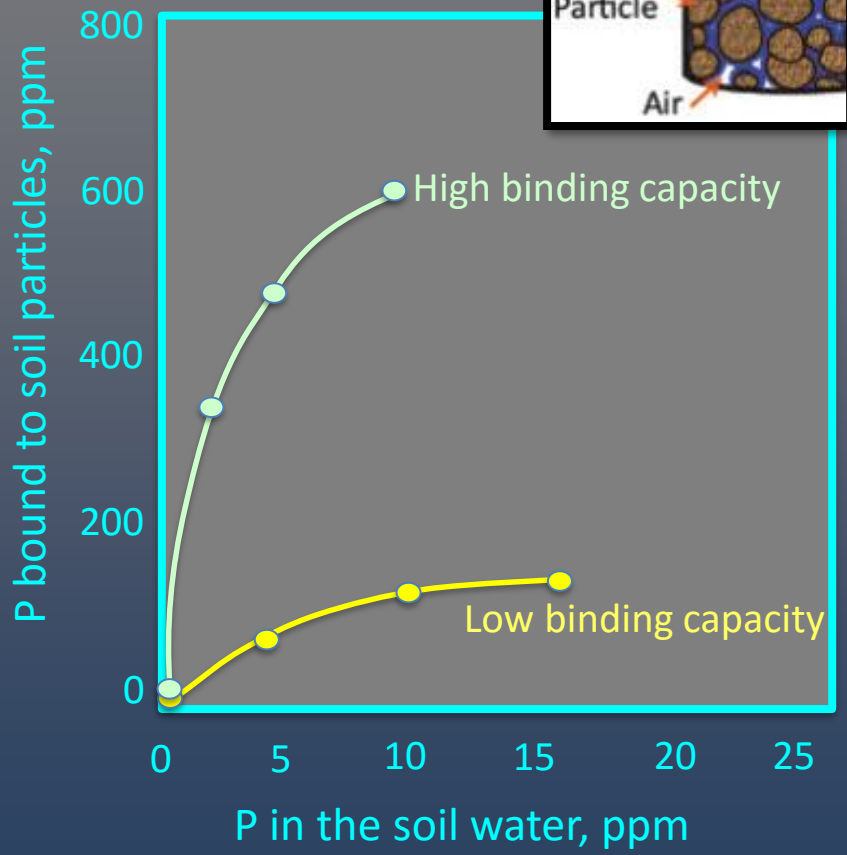
Kochian: Nature, 2012

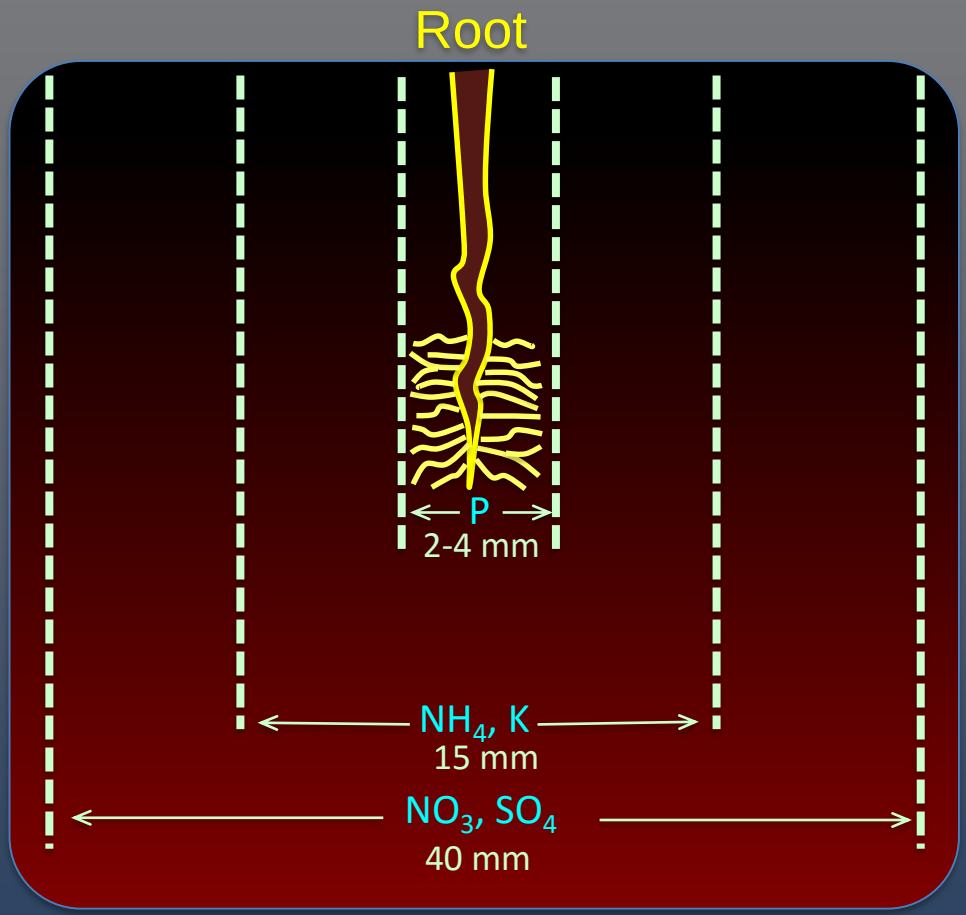
P fertility

Overcoming P binding

Most fertilizer P is bound by soil particles



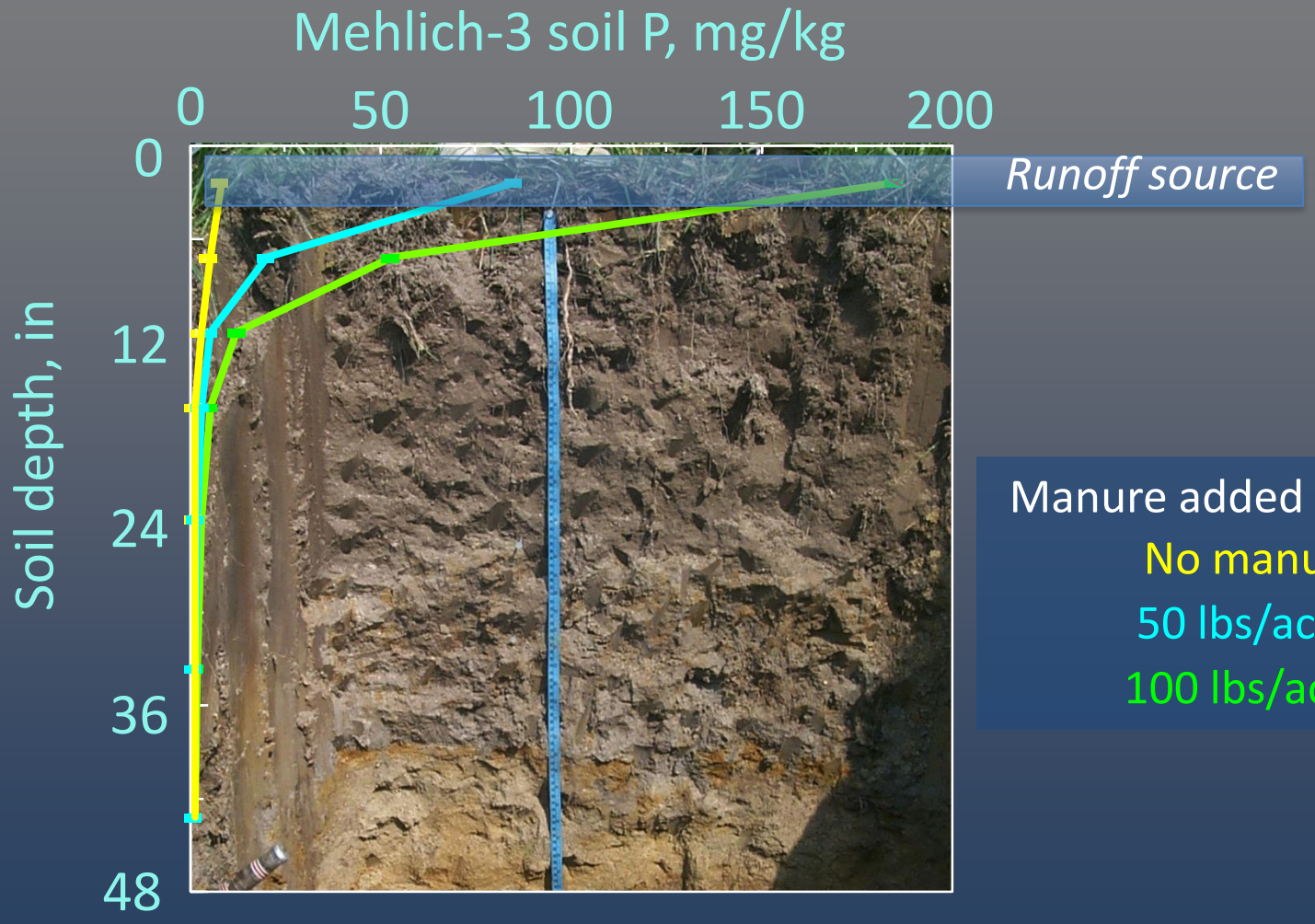




P fertility

Nearly all P sits near the surface

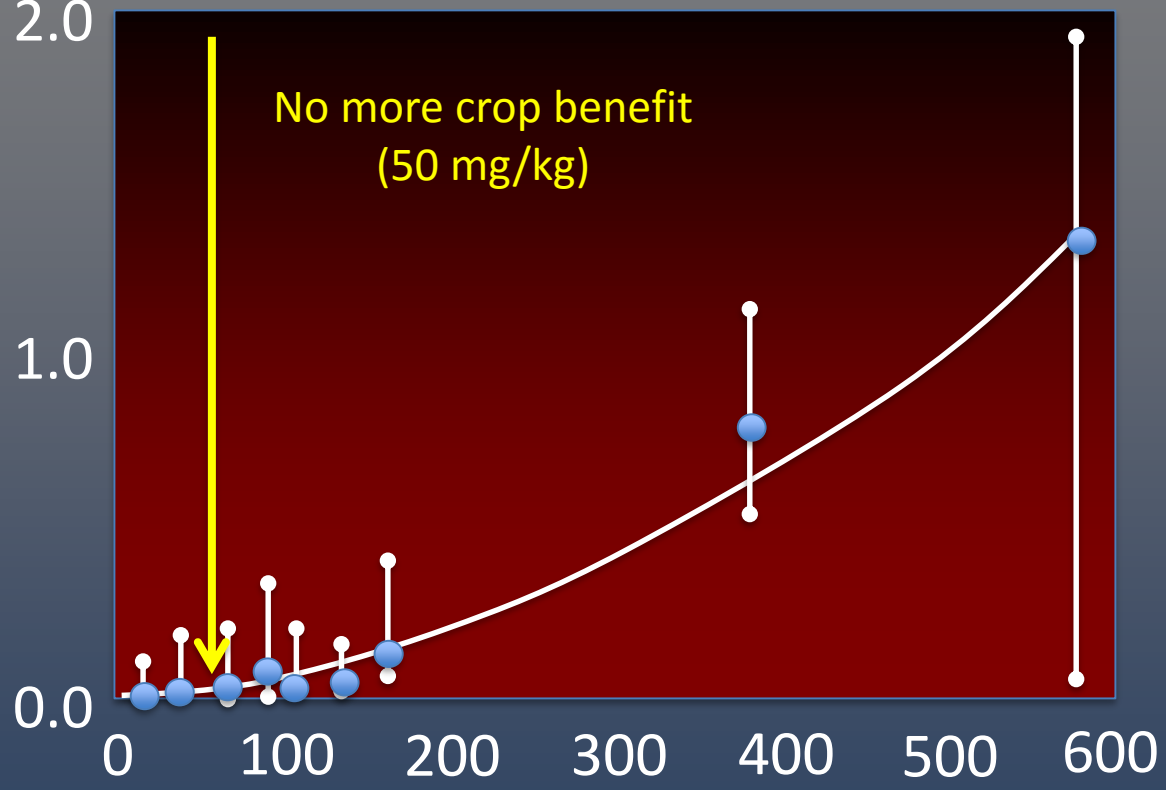
Particularly with no-till

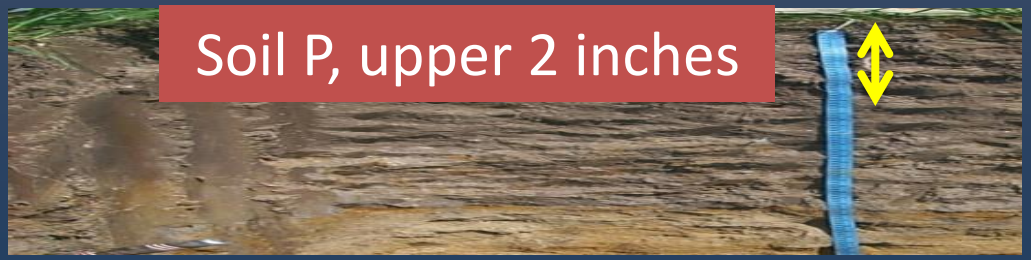


Sharpley and Smith: J. Environ. Qual., 1994

Dissolved P

More P in the soil, more P in runoff



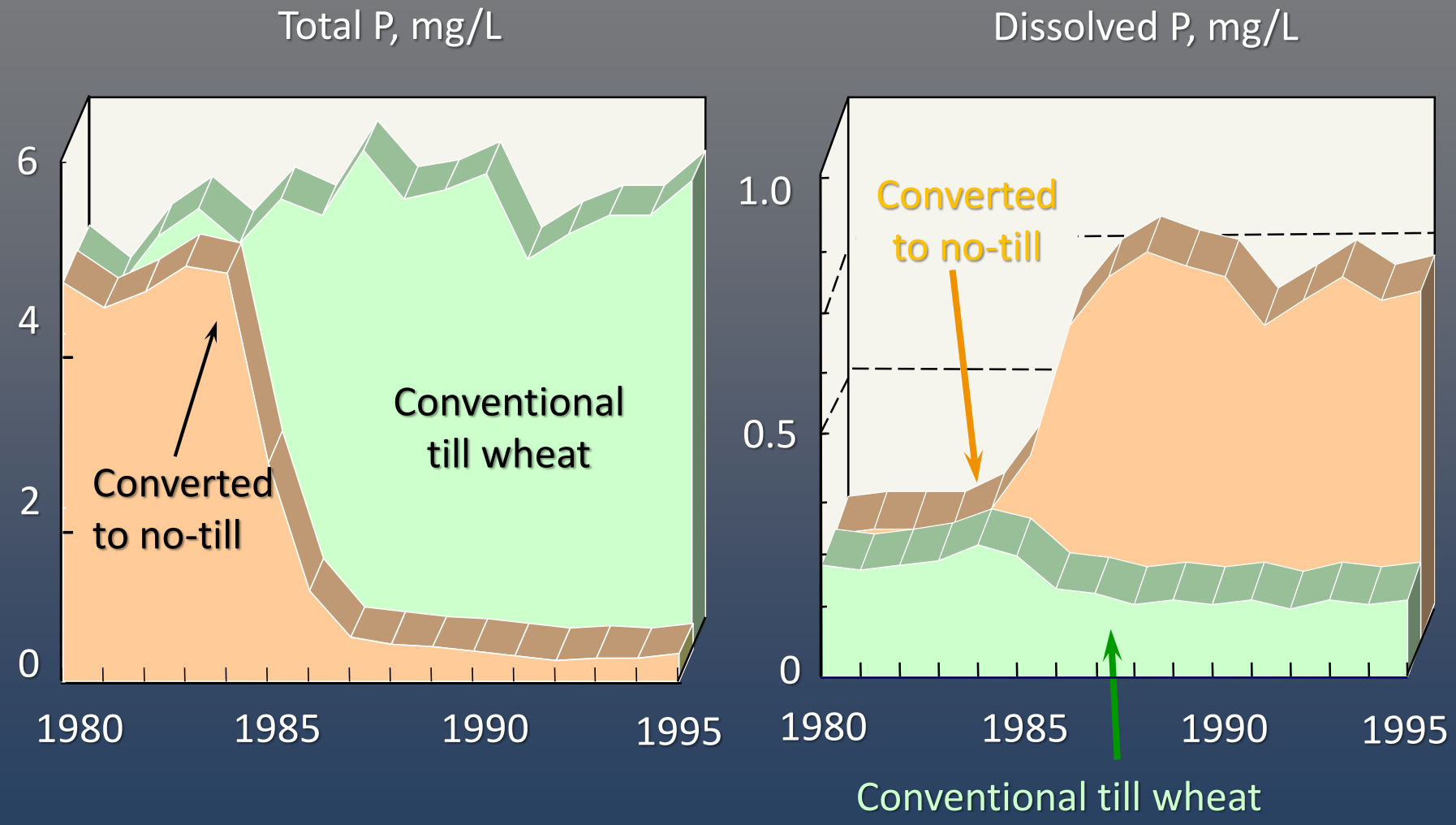


Source: King, USDA-ARS

Soil P

Conservation paradox

No-till reduced erosion by 95%



Sharpley & Smith, 1994 – El Reno, OK

Myths

P only moves with eroded soil particles – wrong

Management

Placement *Place fertilizer and manure into the soil where the roots can get to it and runoff cannot*

Rate *Keep application rates as low as possible*

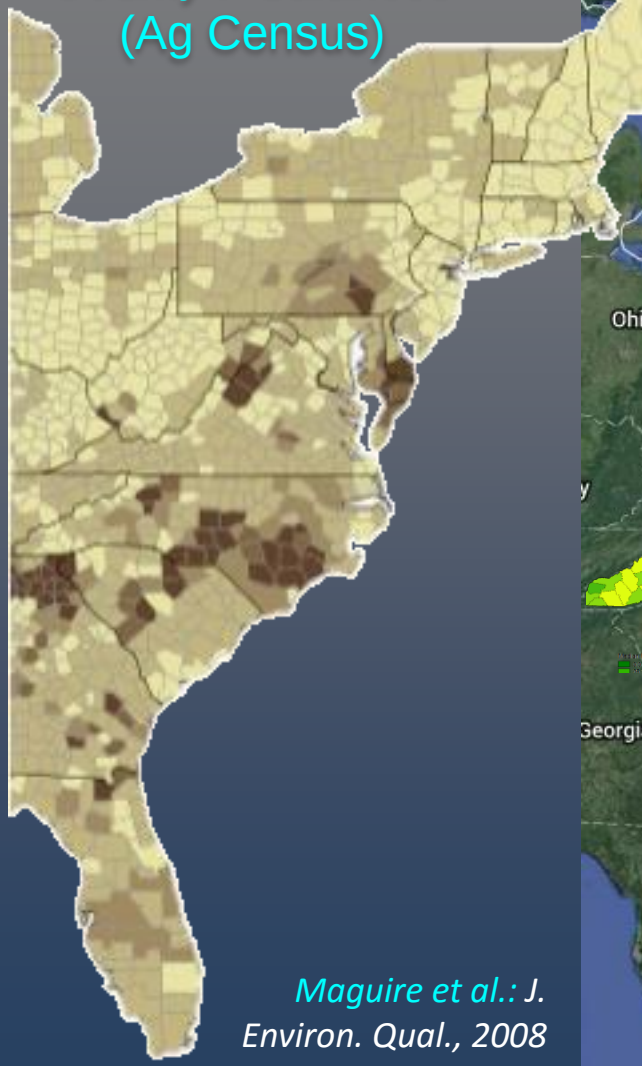
Strategy *Control erosion, but don't forget dissolved P*

Legacy P

Intensified and specialized farming systems

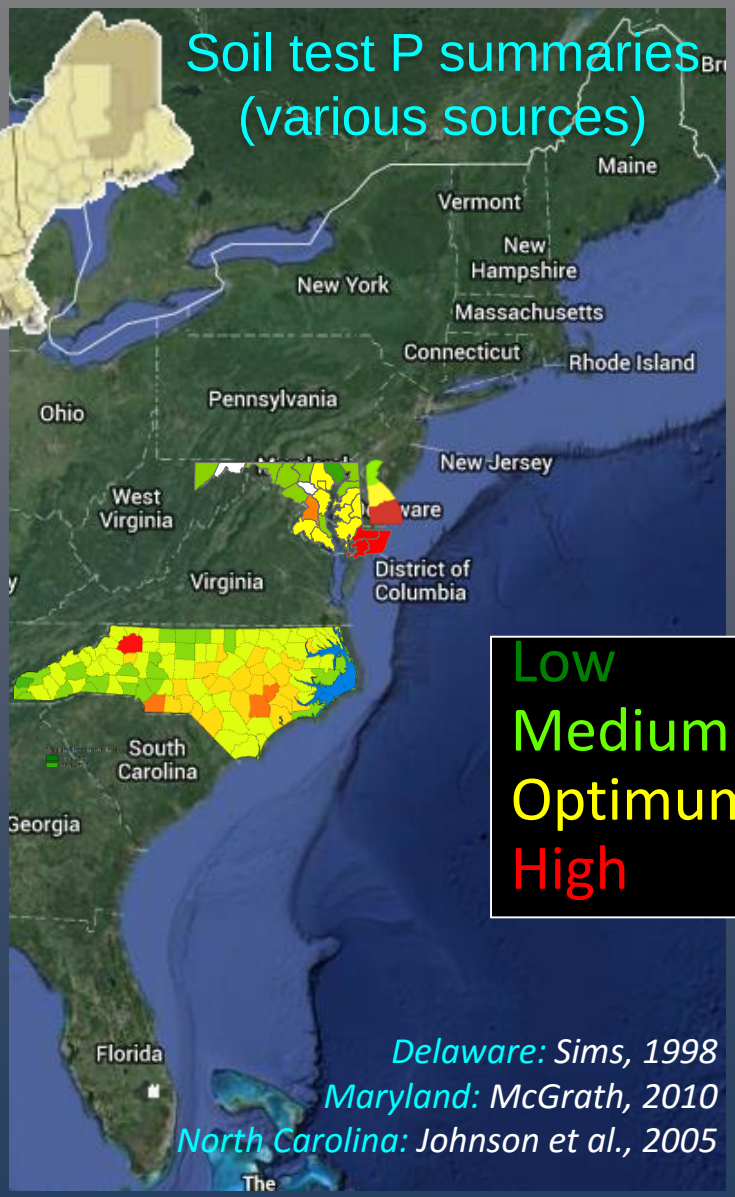
Disconnect between livestock production and soil P fertility objectives

County P balances (Ag Census)



Maguire et al.: J. Environ. Qual., 2008

Soil test P summaries (various sources)



Low
Medium
Optimum
High

Delaware: Sims, 1998
Maryland: McGrath, 2010
North Carolina: Johnson et al., 2005

Sims et al.: J. Environ. Qual., 1998

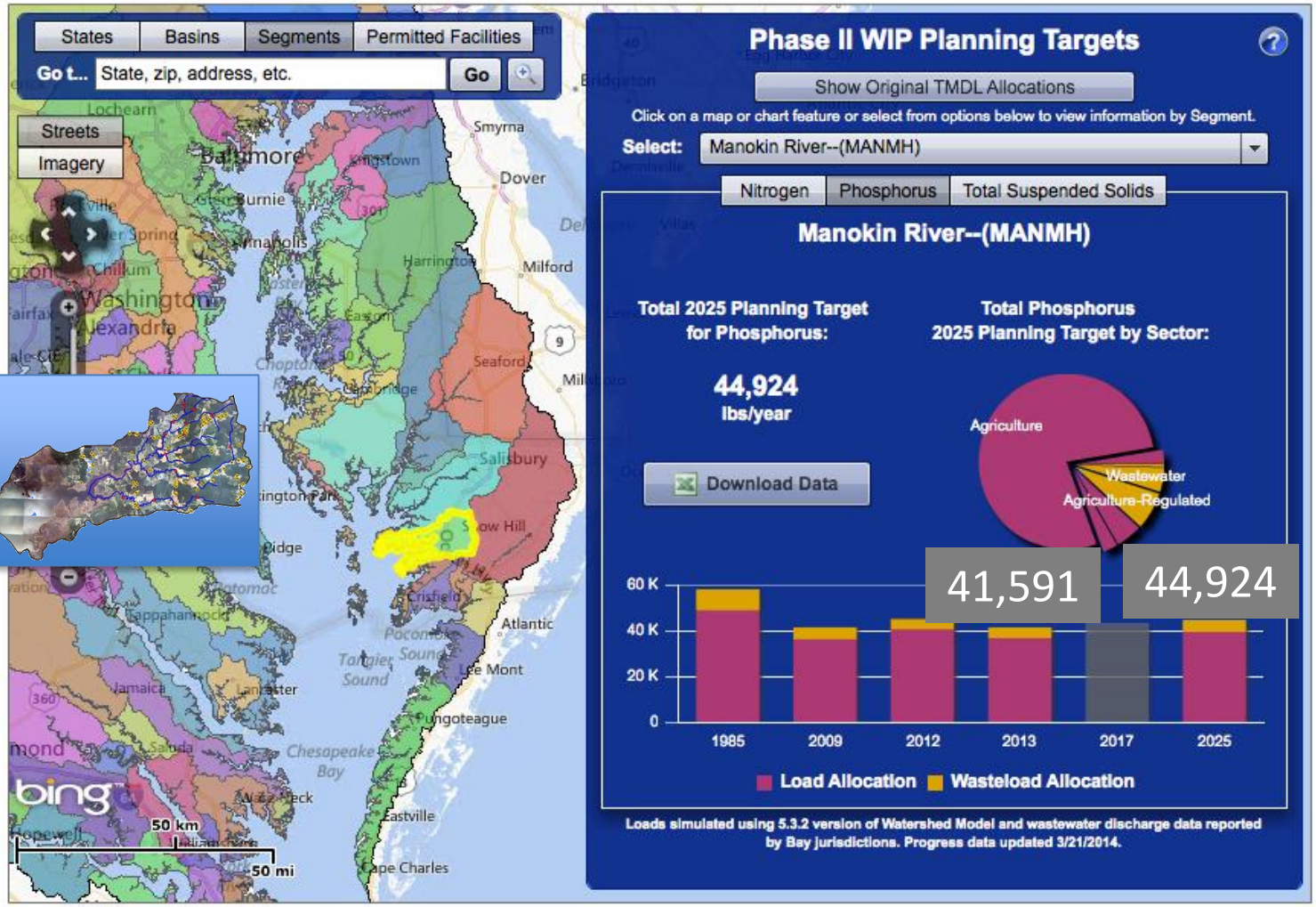
Manokin River
Legacy P and Artificial Drainage

ChesapeakeStat.net, verified April 1, 2014

Agriculture | TMDL Tracking | BMP Review | 2009-2011 Milestones | 2012-2013 Milestones

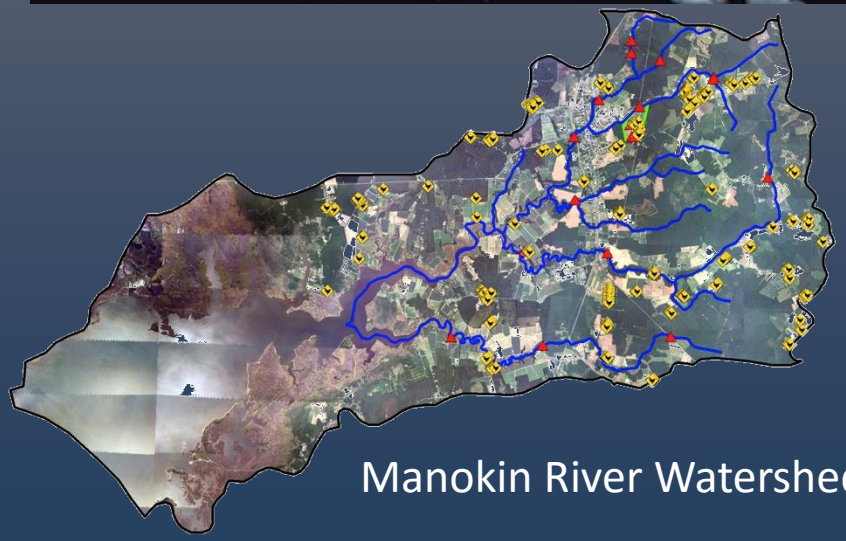
ake Bay TMDL Tracking and Accounting System

e Bay TMDL Tracking and Accounting System (BayTAS) was developed to inform EPA, the Bay Jurisdictions, and the ss in implementing the Bay Total Maximum Daily Load (Bay TMDL). BayTAS stores the TMDL allocations (based on the Watershed Model Phase 5.3.0 and tracks implementation progress (based on the Watershed Model Phase 5.3.2 and the jurisdictions' Phase II Watershed Implementation Plans (WIPs)). BayTAS data are displayed through the TMDL Tracker. Learn more about BayTAS and the terminology of the TMDL in the glossary found in Section 13 of the TMDL. Get answers to frequently asked questions about the Bay TMDL.



Legacy P and Artificial Drainage

Delmarva Fresh Chickens:
600 million birds, 800,000 tons litter

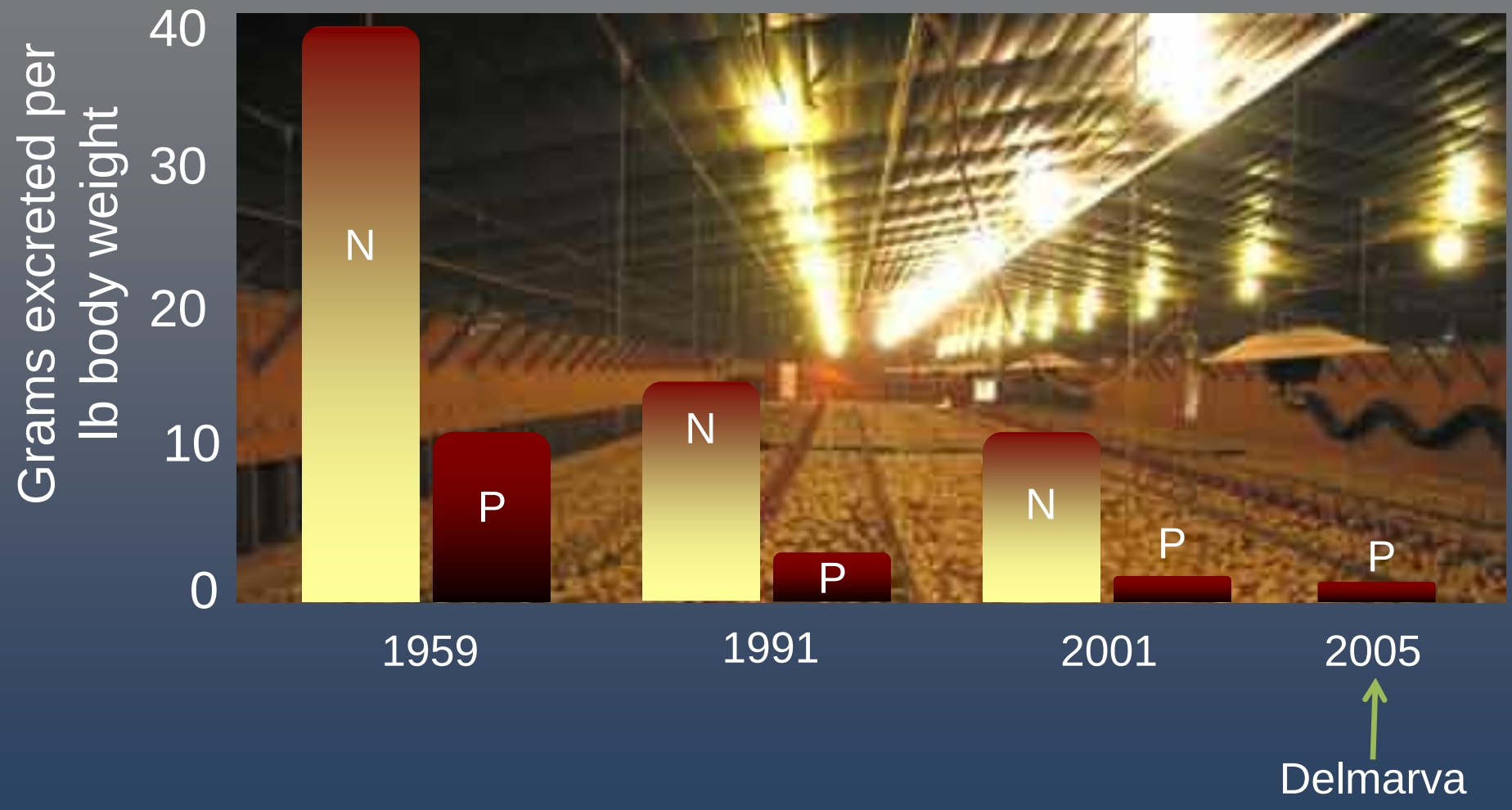


Manokin River Watershed

Feed efficiency

P excretion by broiler chickens

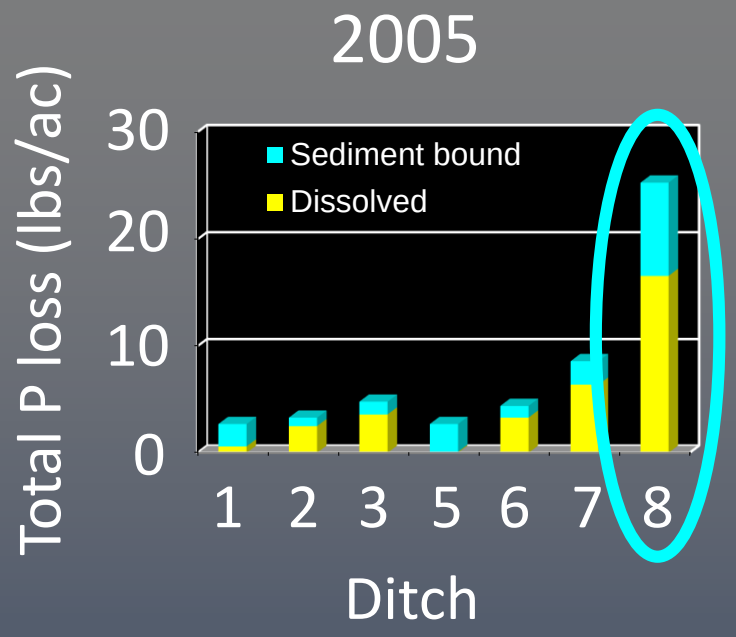
Historical and ongoing gains

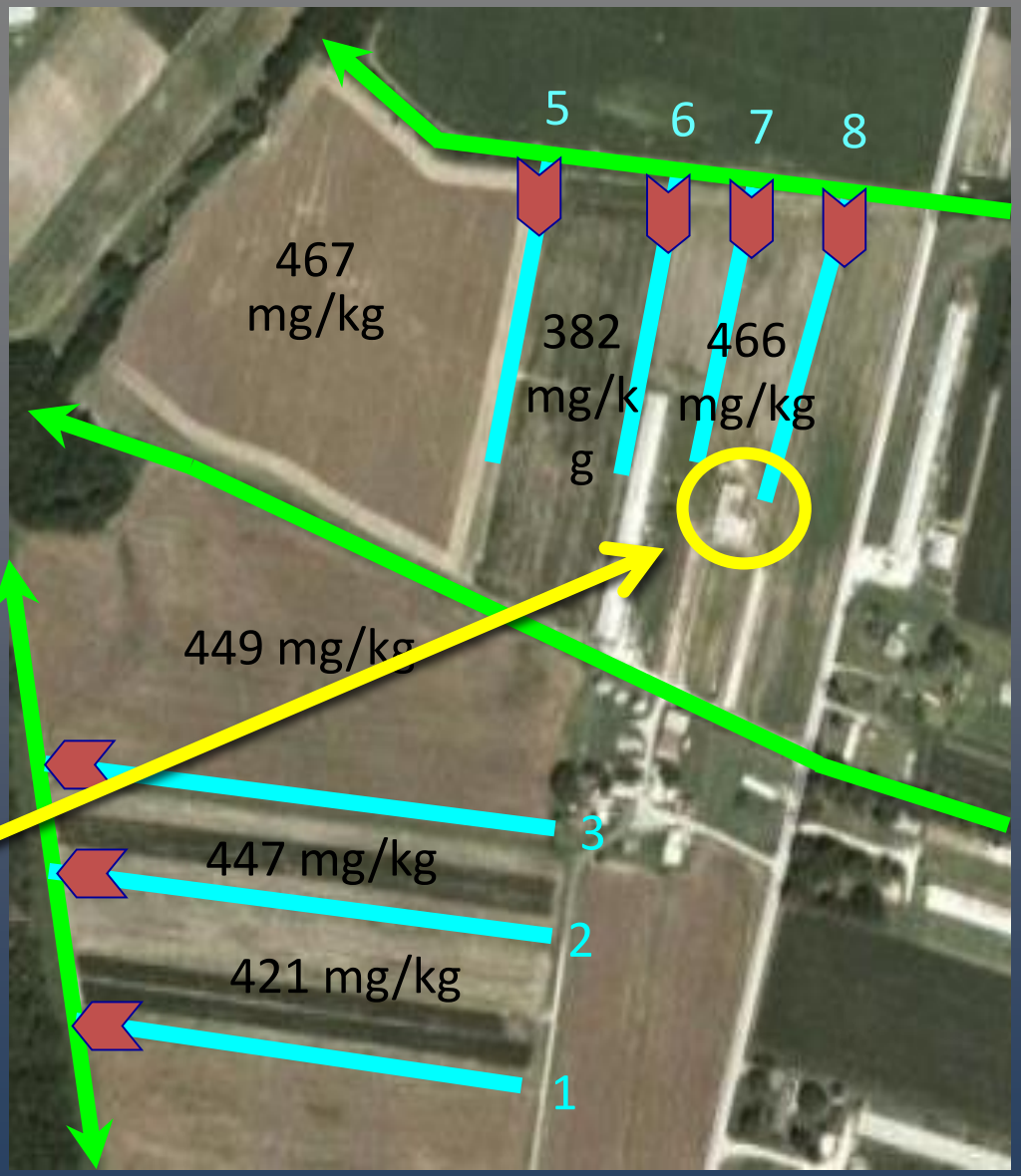


Adapted from Angel: *Univ. Maryland, 2009*

Drainage Ditches

Point and nonpoint sources of P





Kleinman et al., 2007 (J. Soil Water Conserv.)

Drainage Ditches

Clean it up! Infrastructure maintenance and barnyards

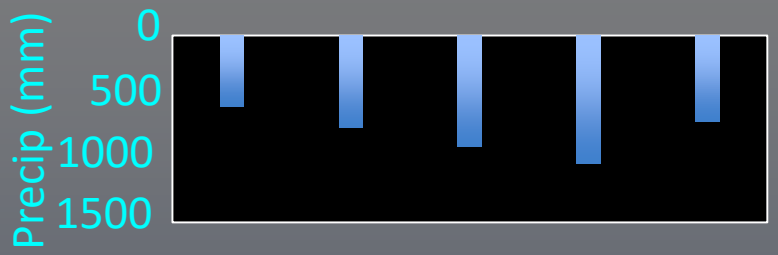
Here's a loafing area from one of the other Bay states

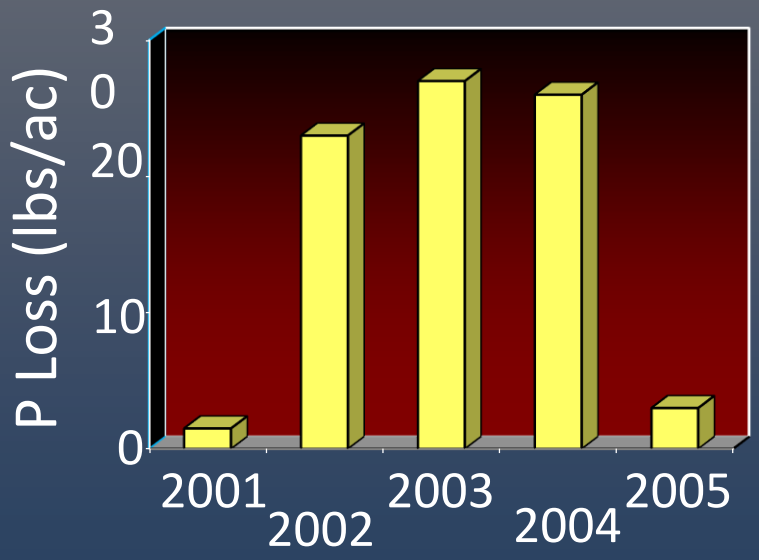
And this was installed with state subsidies as a BMP

Drainage Ditches

Connect legacy P sources with streams

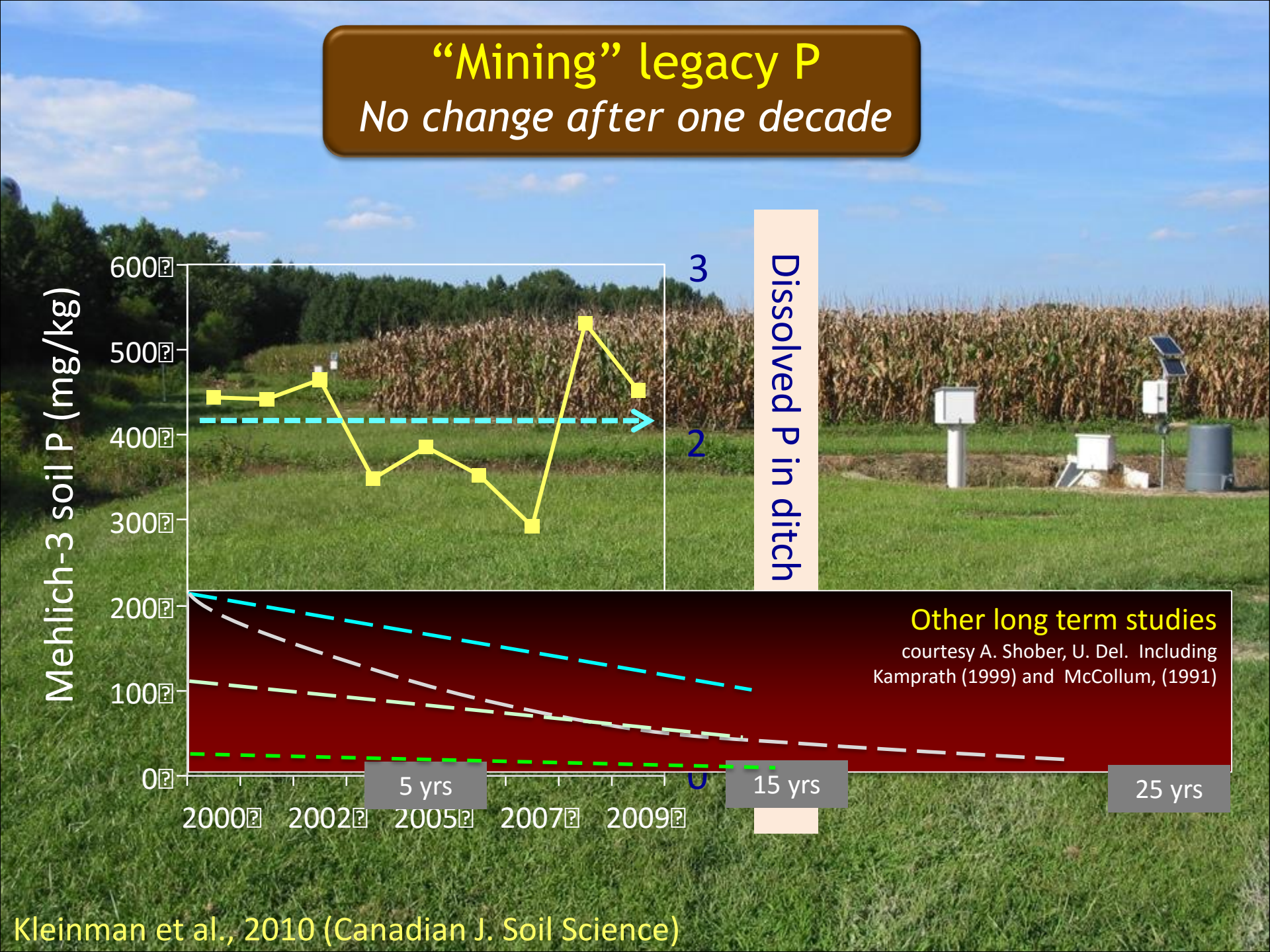
Flashy - drainage fluctuations can be enormous





Kleinman et al., 2007 (J. Soil and Water Conserv.)

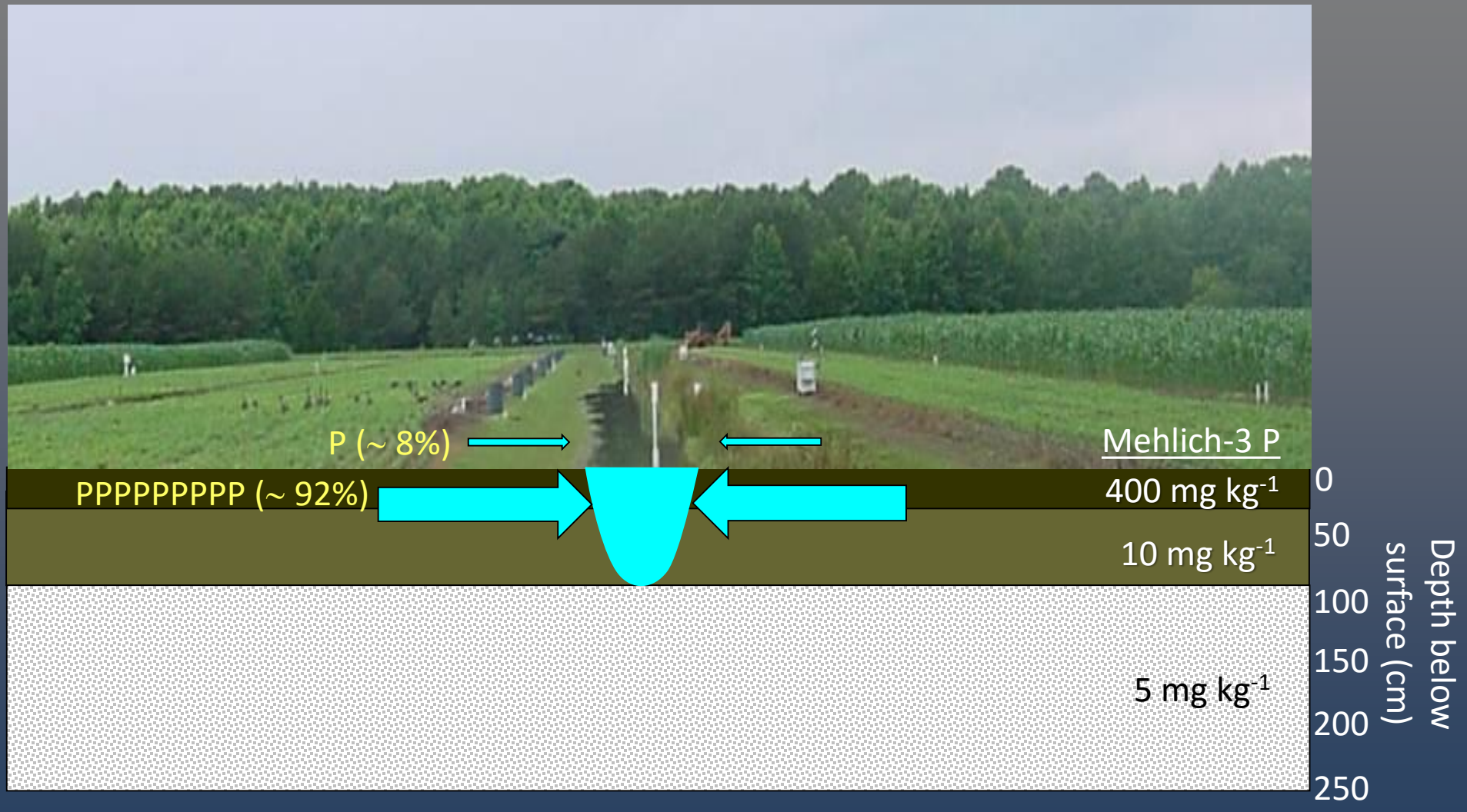
"Mining" legacy P
No change after one decade



Kleinman et al., 2010 (Canadian J. Soil Science)

Legacy P transfers to drainage ditches

Shallow groundwater is the primary pathway



Kleinman et al., 2007 (J. Soil Water Conserv.)

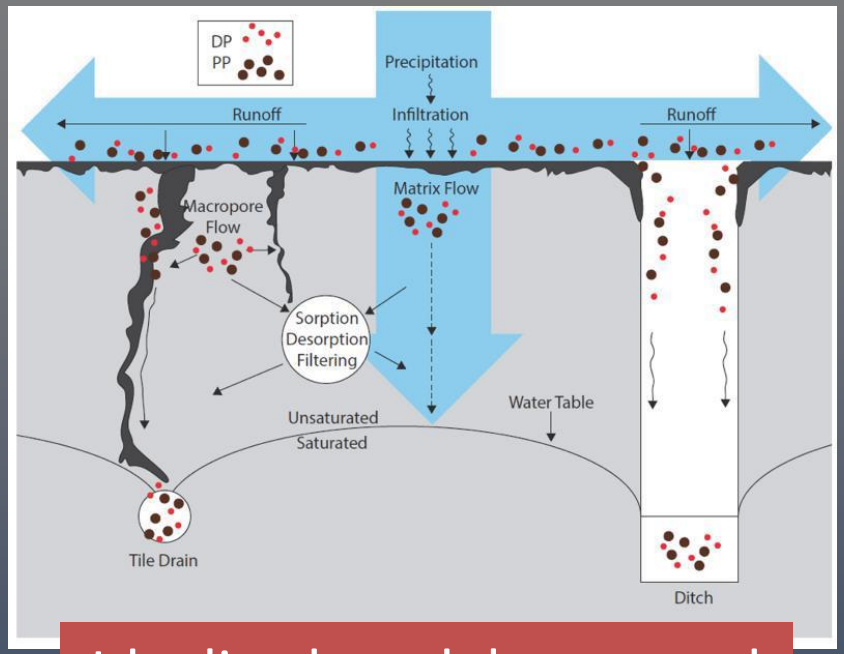
Phosphorus loss in ditch drainage

Greatest risk is in the near-ditch zone (within 5-10 m)

Kleinman et al., 2007 (J. Soil Water Conserv.)

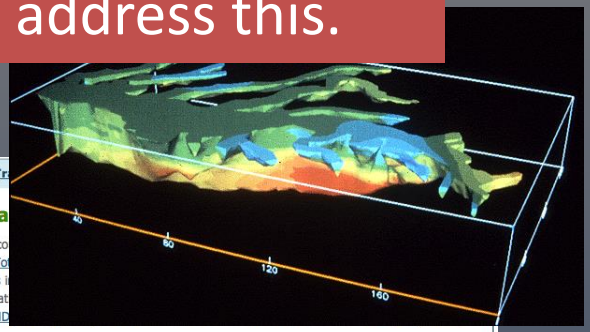
No model gets P in drainage water right

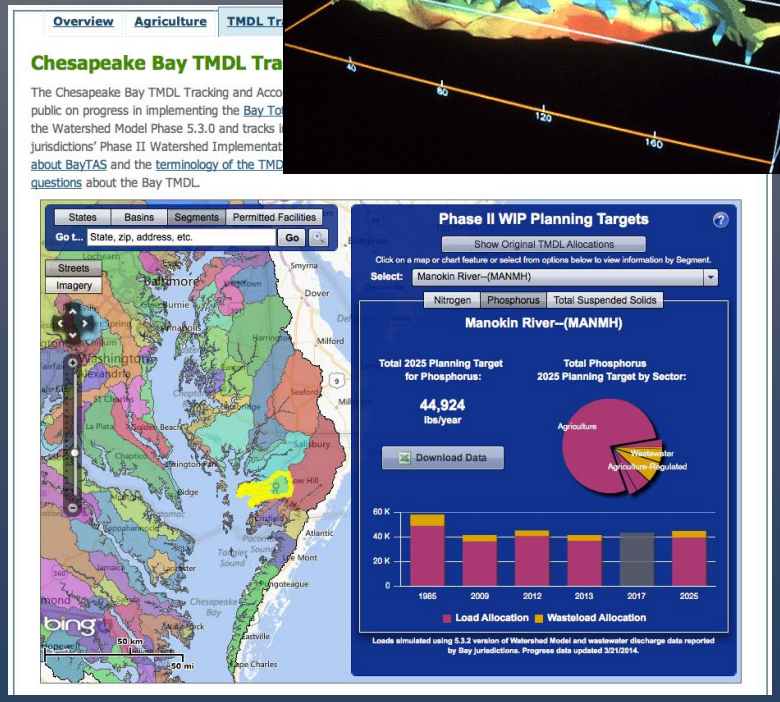
Journal of Environmental Quality, 2015



Idealized model proposed by Radcliffe et al. (2015) after their conclusion

The Bay Model is not alone. Hopefully version 6.0 will address this.





Legacy P Myths

We can quickly reverse 40+ years of soil P buildup – no, we must work to lower P in hydrologically connected areas

Management

Phyto-mining – extracting P with crops (takes time, but we can use deep rooted, high biomass crops)

Tillage – mixing surface and subsurface changes soil P quickly

Rate - Stop applying starter fertilizer and manure to high P soils that are hydrologically connected

P in drainage water myths

P doesn't move underground – wrong

P in drainage water can't be managed – wrong (its not easy)

Management – full court press

Drainage *Flow control structures and filter strategies*

<u>4R Nutrient stewardship</u>

Placement *Close contact with soil minimizes P in drainage water.*
Applying 1-3 m away from drains .
Don't let legacy P build up near ditches and tile drains.

Timing *Avoid periods before storm events and when soils are wet (can't store liquid manures) or dry (and cracked)*

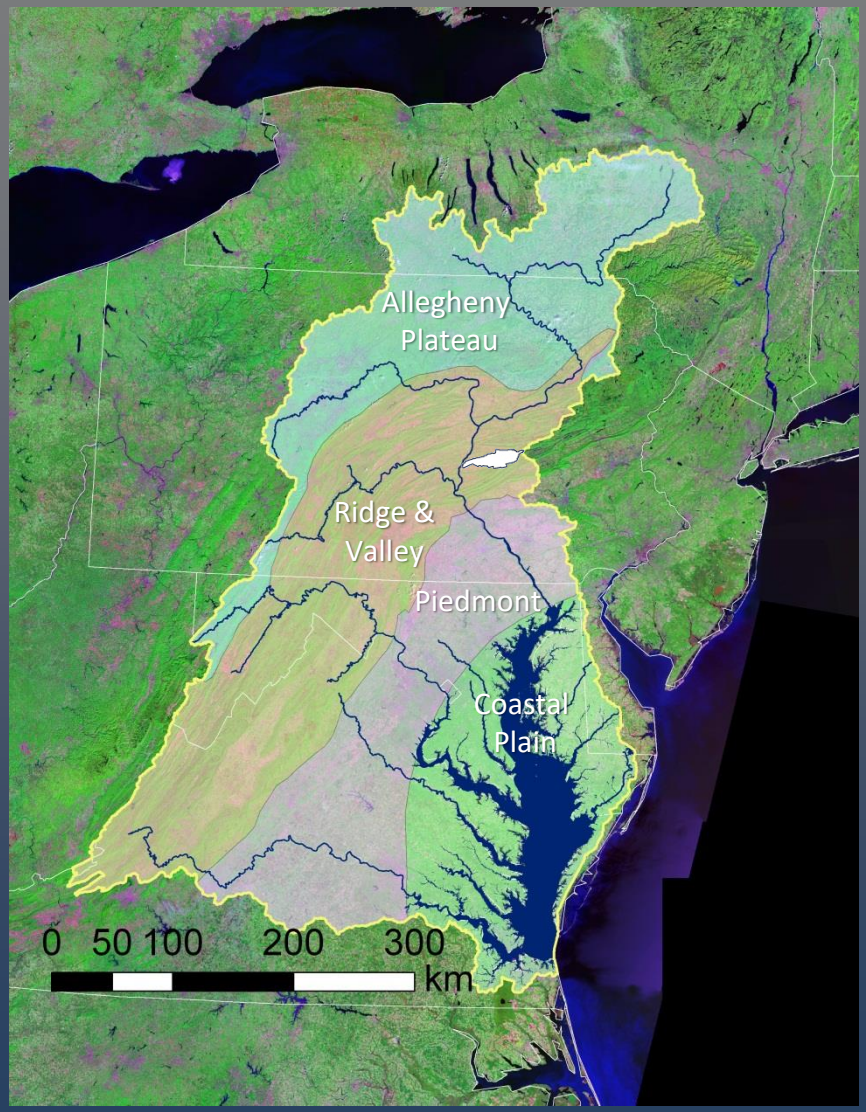
Rate *Keep application rates as low as possible*

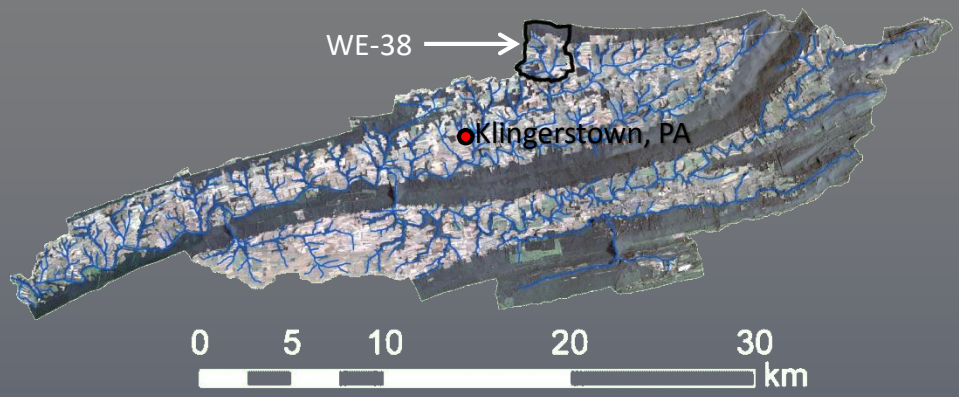
Form *Add amendments like alum to reduce P solubility*

Legacy P

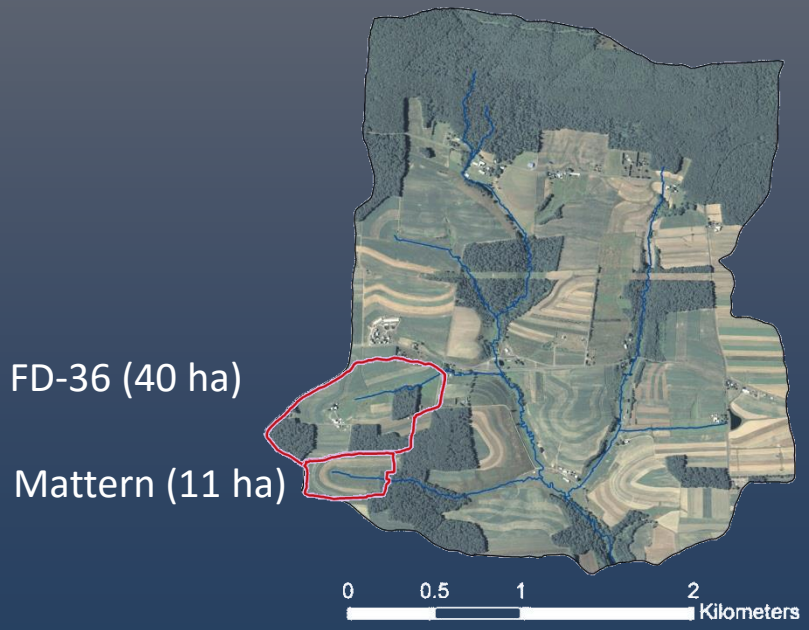
Big loads from little sources

Legacy P in the riparian area



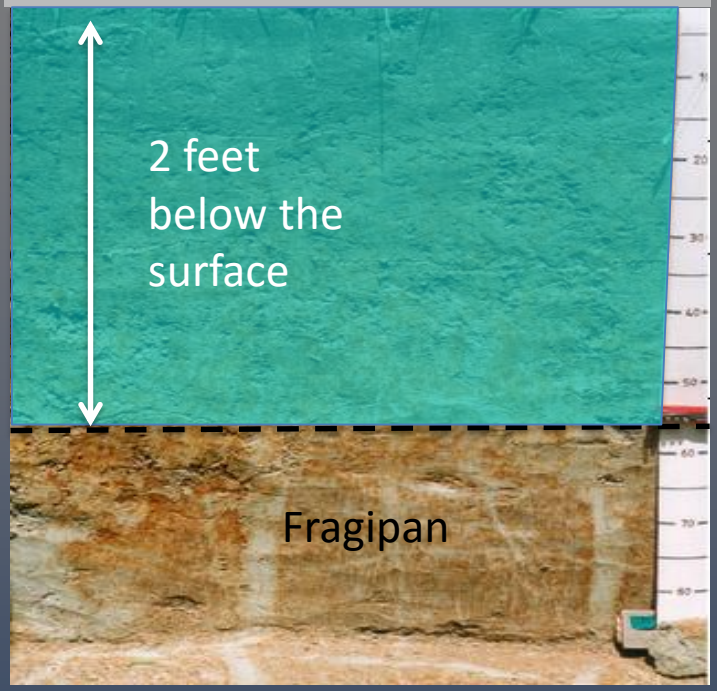


WE-38 Watershed (7.3 km^2)



Soil Science 1.0: The fragipan

Poorly-drained soil
fragipan



Relatively impermeable (seasonal perching of groundwater)

Well-drained soil
no fragipan

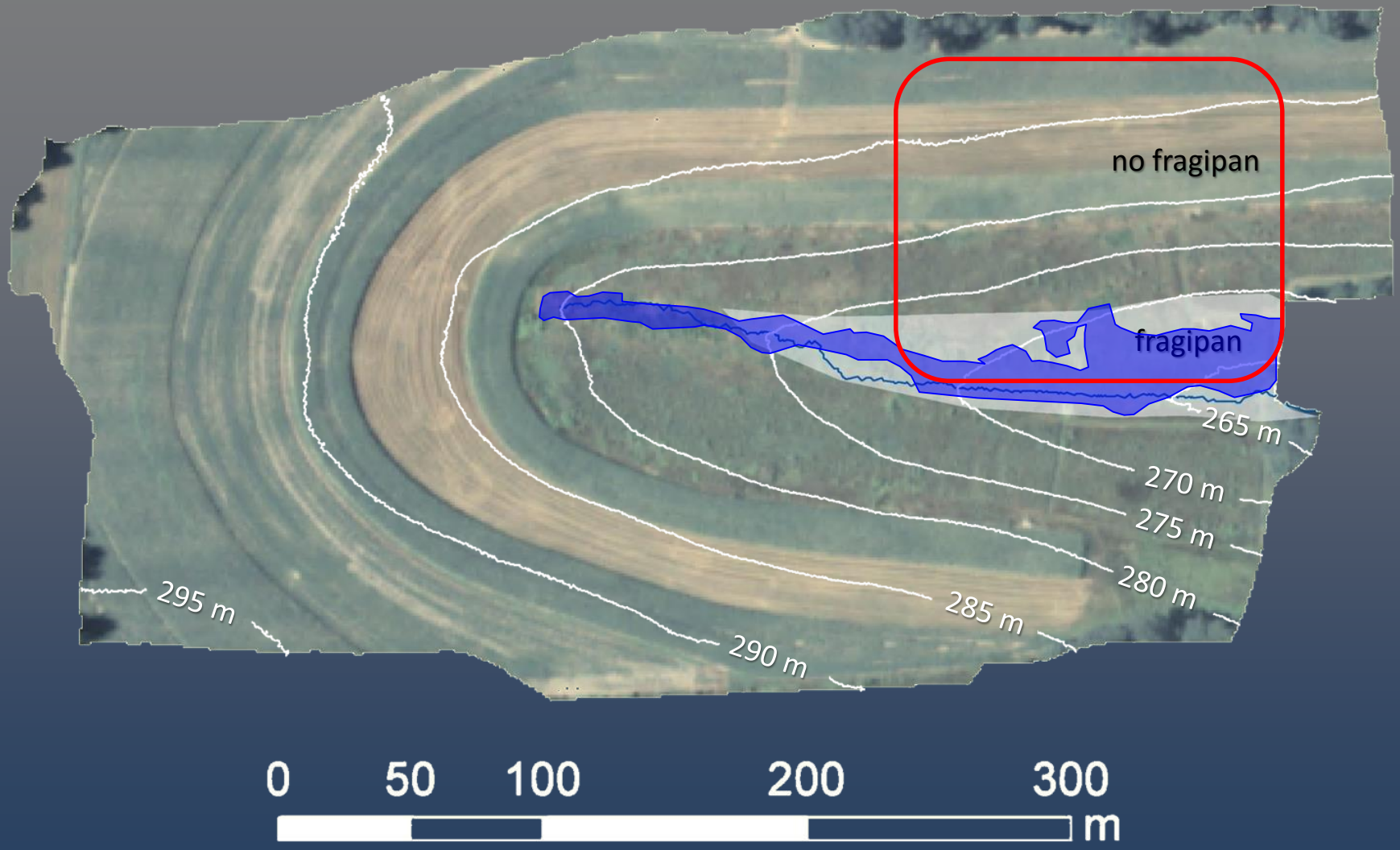
Rapid infiltration of rainfall and runoff

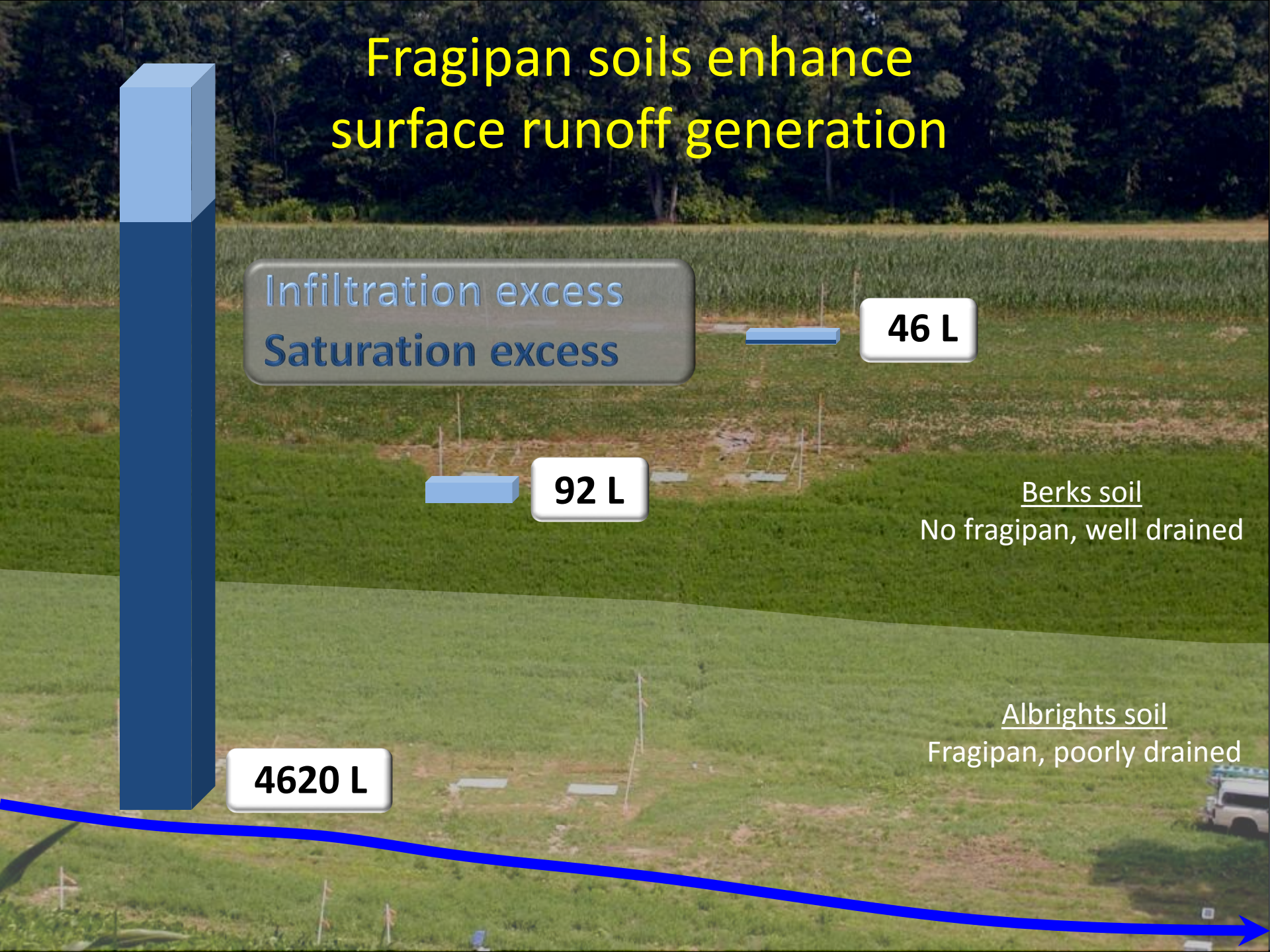
Fragipan soils and zones of saturation

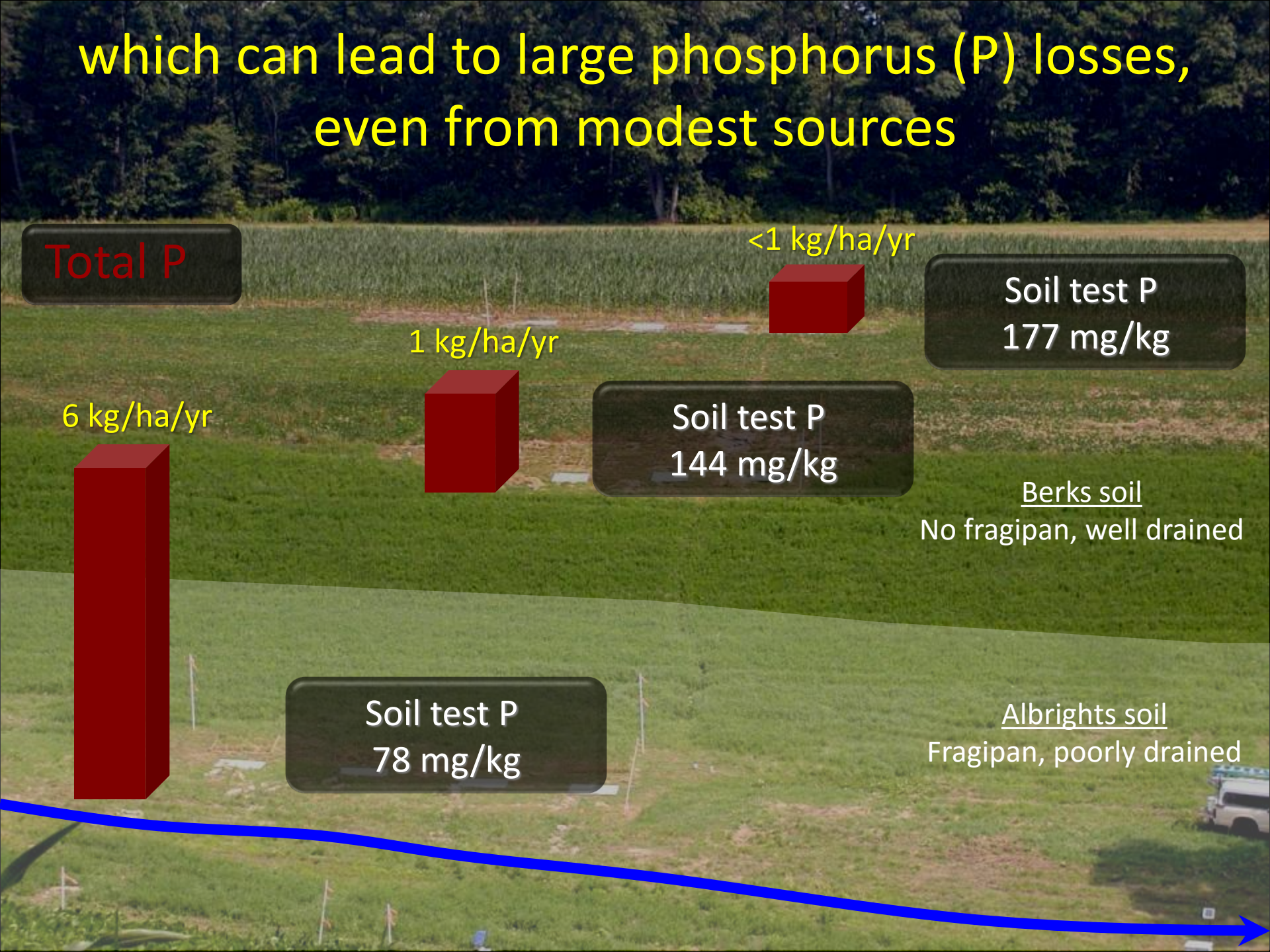
Late August 2003

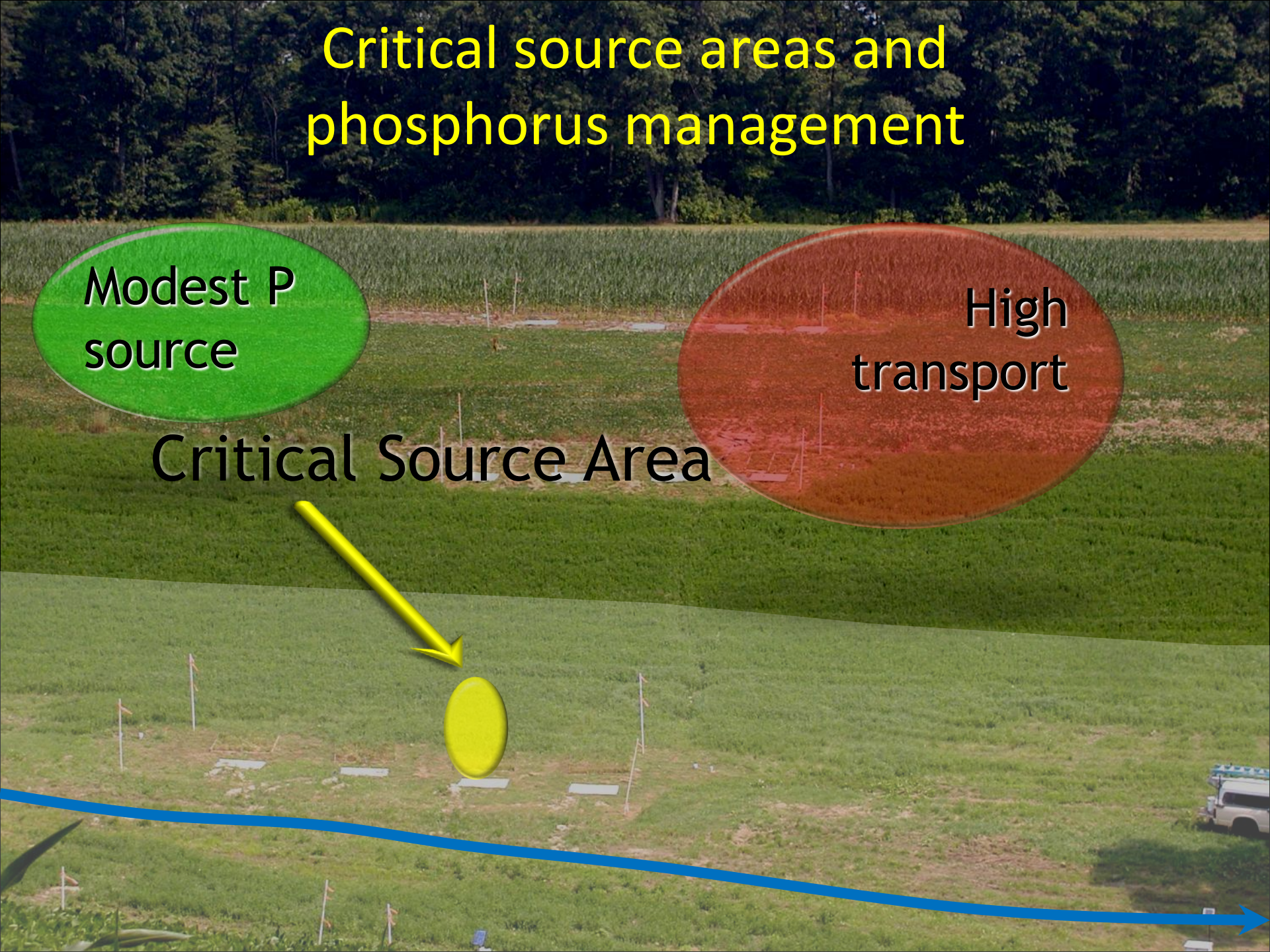
Fragipan soils and zones of saturation

Late October 2003

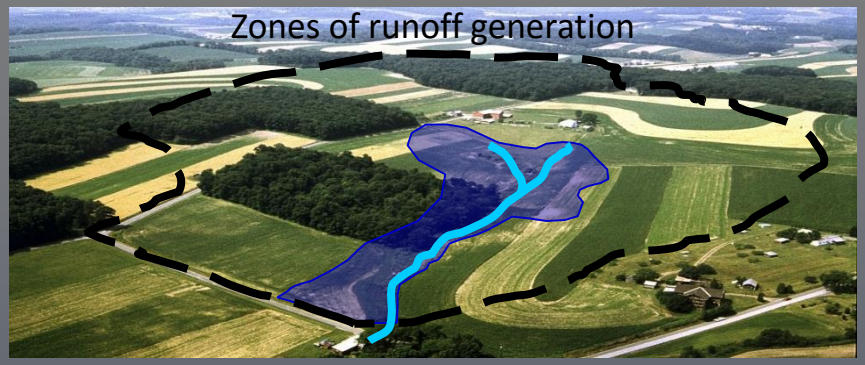


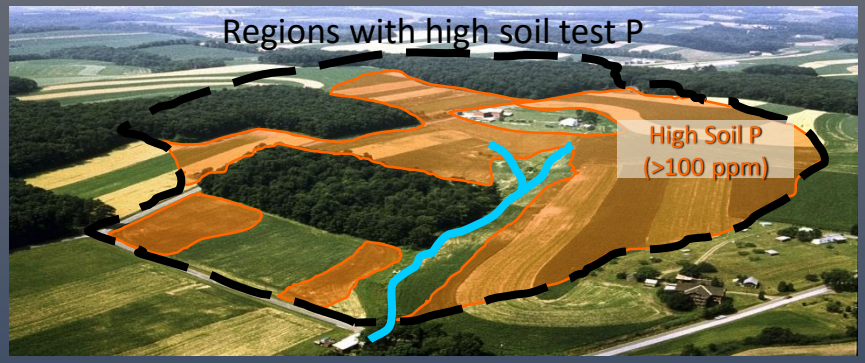

Fragipan soils enhance surface runoff generation
Infiltration excess
Saturation excess
46 L
92 L
4620 L
Berks soil
No fragipan, well drained
Albrights soil
Fragipan, poorly drained

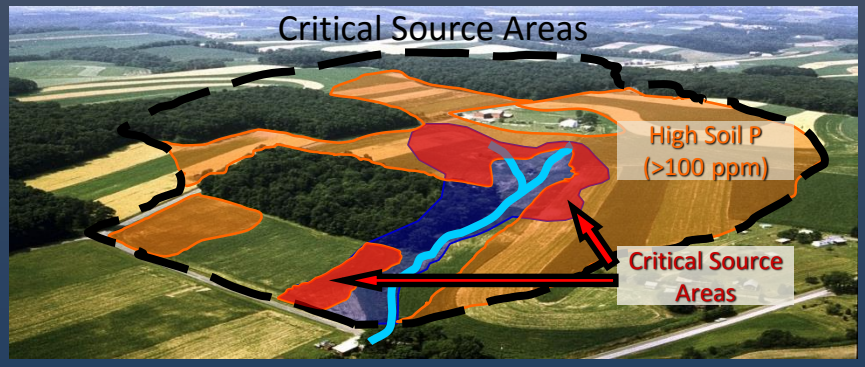

which can lead to large phosphorus (P) losses, even from modest sources
Total P
6 kg/ha/yr
Soil test P
78 mg/kg
1 kg/ha/yr
Soil test P
144 mg/kg
<1 kg/ha/yr
Soil test P
177 mg/kg
Berks soil
No fragipan, well drained
Albrights soil
Fragipan, poorly drained


Critical source areas and phosphorus management
Modest P source
High transport
Critical Source Area

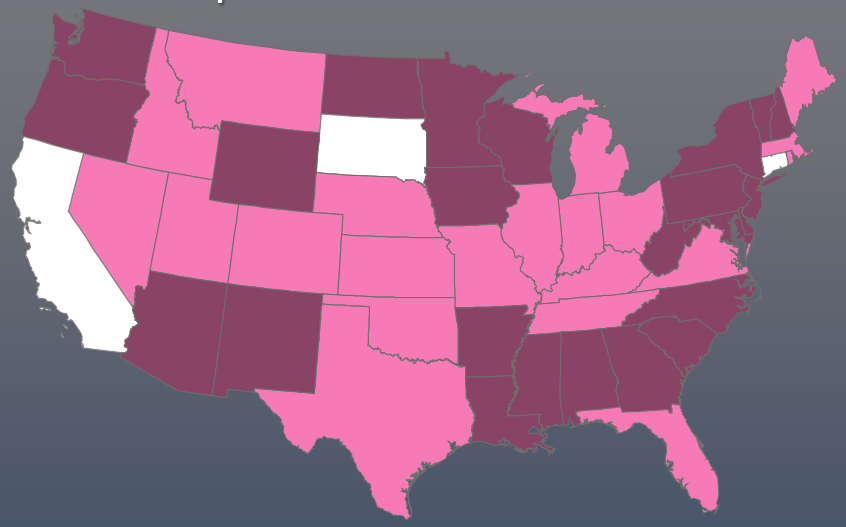
Identifying runoff prone soils is essential to the Phosphorus Index







Phosphorus Index is widely adopted in the United States



Phosphorus Index

Phosphorus Index and/or Environmental Phosphorus Threshold

Soil Test Crop Response

Critical source area myths

We can curtail runoff to stop P loss– in some cases, but not the typical cases in our region

Non-extractive buffers will work – need legacy P removal

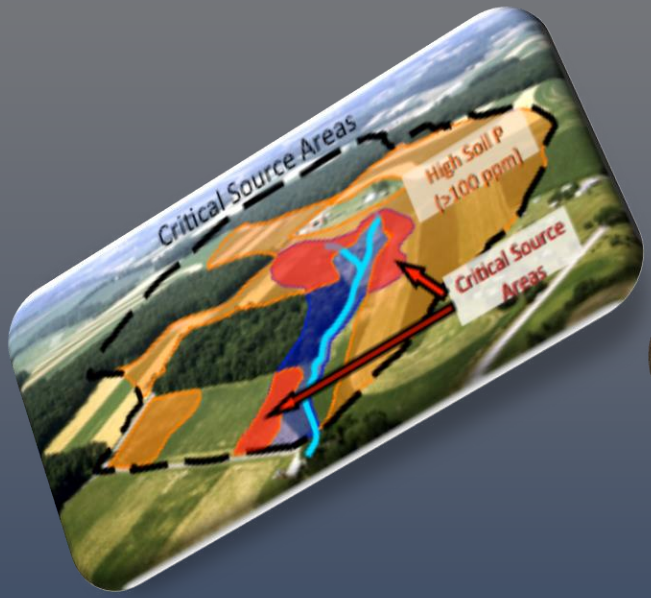
Management

Minimize legacy P – these areas should be at or below the agronomic optimum

P Index and setbacks - Improving over time

New forecasting technologies – currently being tested

Thank you



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