


Phosphorus Loading to Western Lake Erie: Trends and Sources



**Western Lake Erie Conference
Toledo Yacht Club
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Heidelberg College**

What are the trends in phosphorus export from northwestern Ohio watersheds draining into Lake Erie?

Particulate phosphorus?

phosphorus attached to suspended sediments

Decreases in annual loads to Lake Erie

Decreases have paralleled decreases in sediment loading


Dissolved reactive phosphorus?

a form of phosphorus in solution in water

Decreases between 1975-1994

Increases between 1994 - 2007

particularly important for Lake Erie



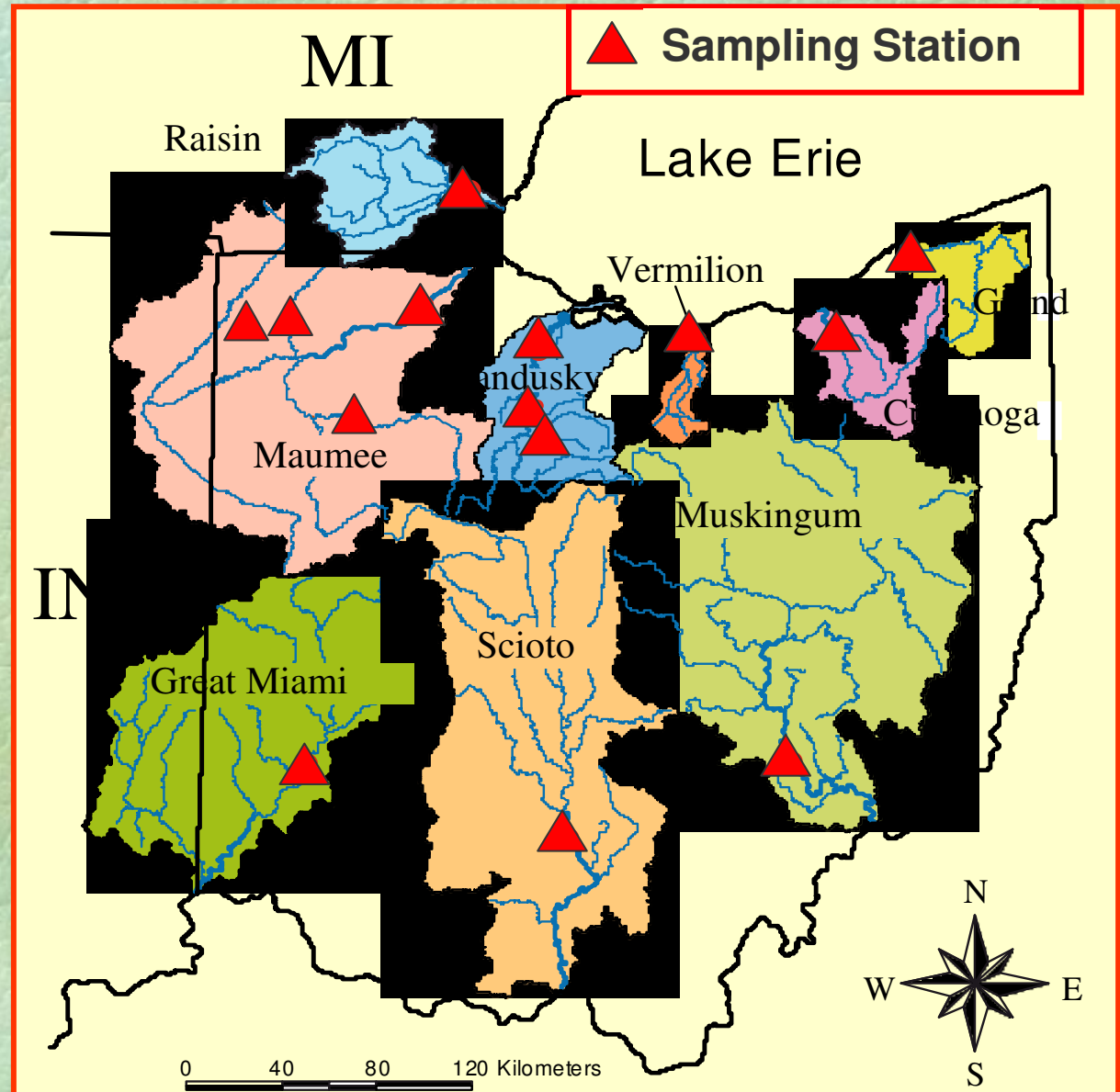
Let's look at the data --

Data from the Ohio Tributary Loading Program

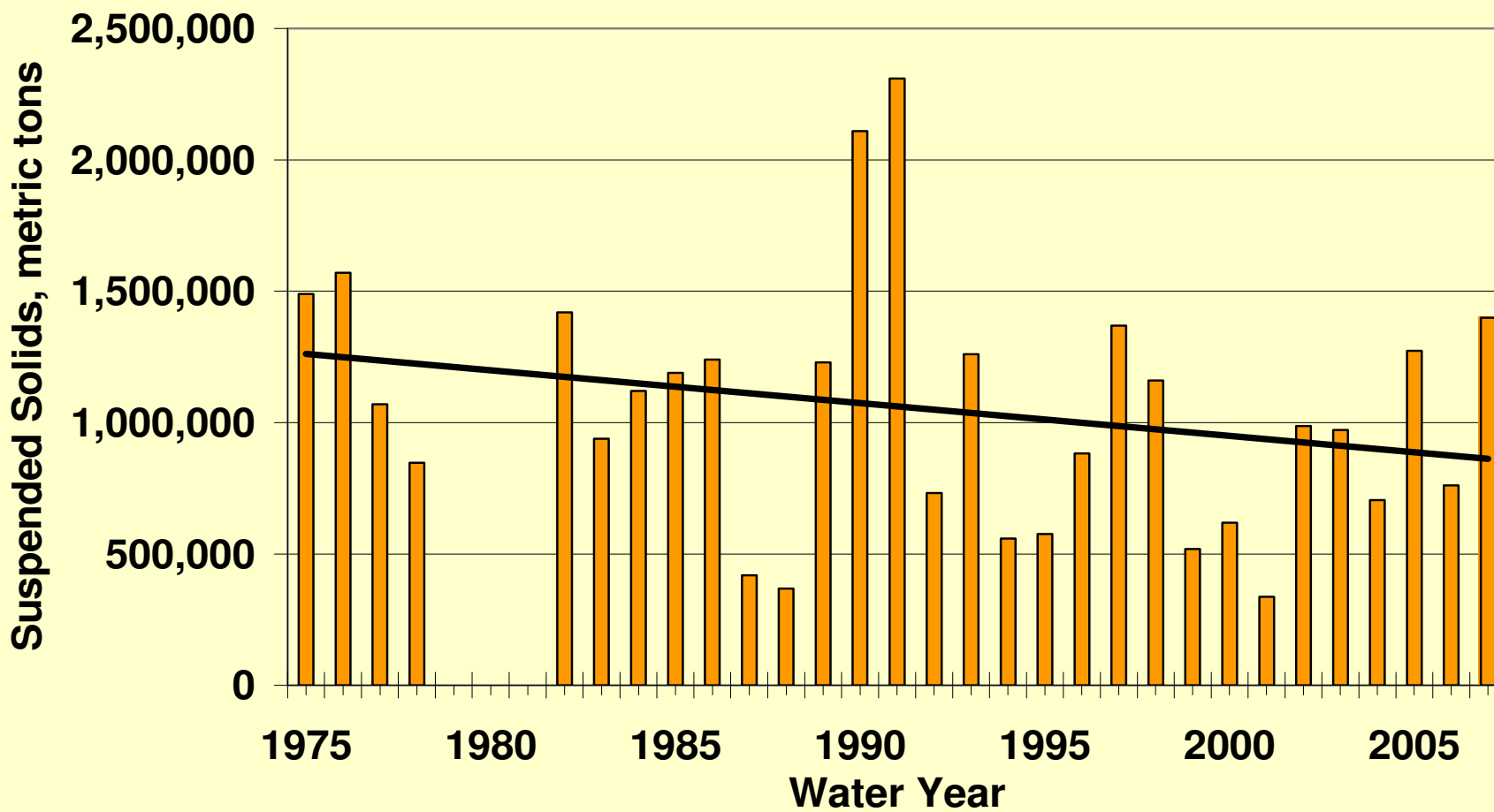
Program started
by Heidelberg College
in 1974 for
Lake Erie tributaries

Currently
automatic sampler
collections
at 12 U.S.
Geological Survey
Stream Gages

Major support from
the Ohio Department
Of Natural Resources,
Division of Soil and
Water
Conservation

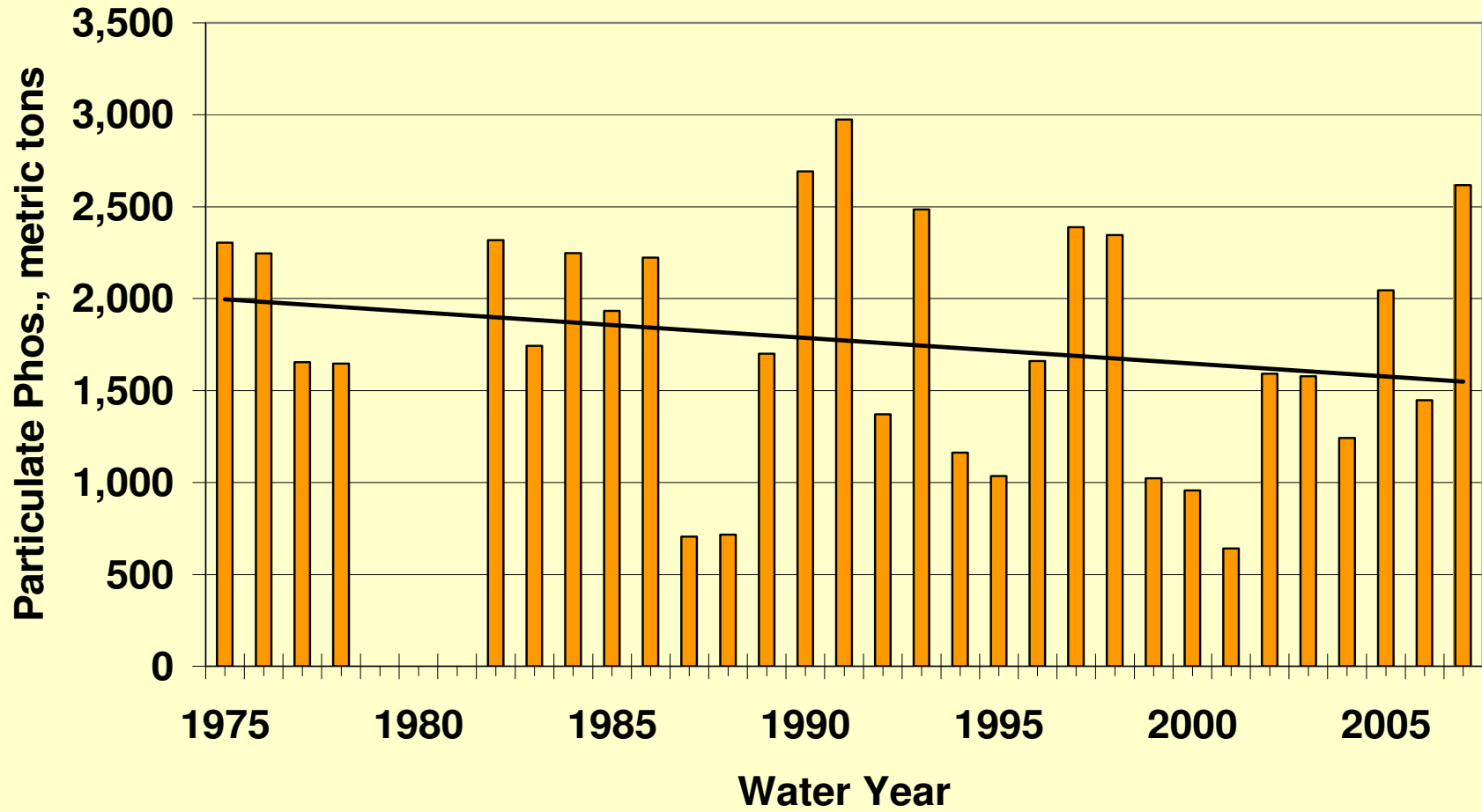


Maumee River, Suspended Solids Loads

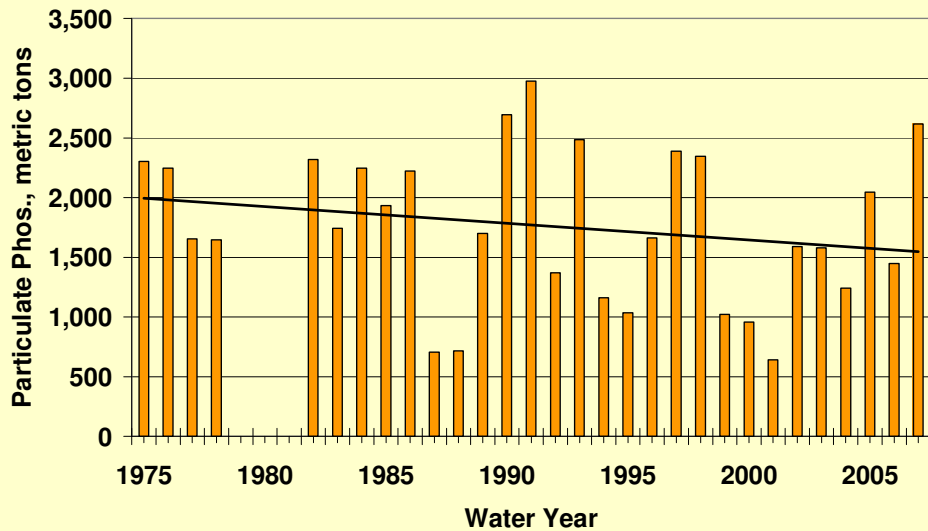


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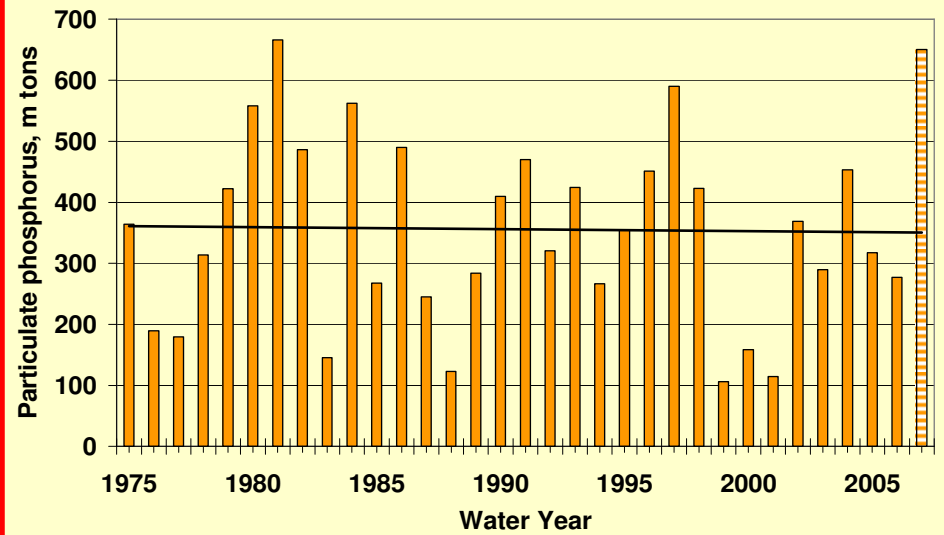
Maumee River, Particulate Phosphorus Loads



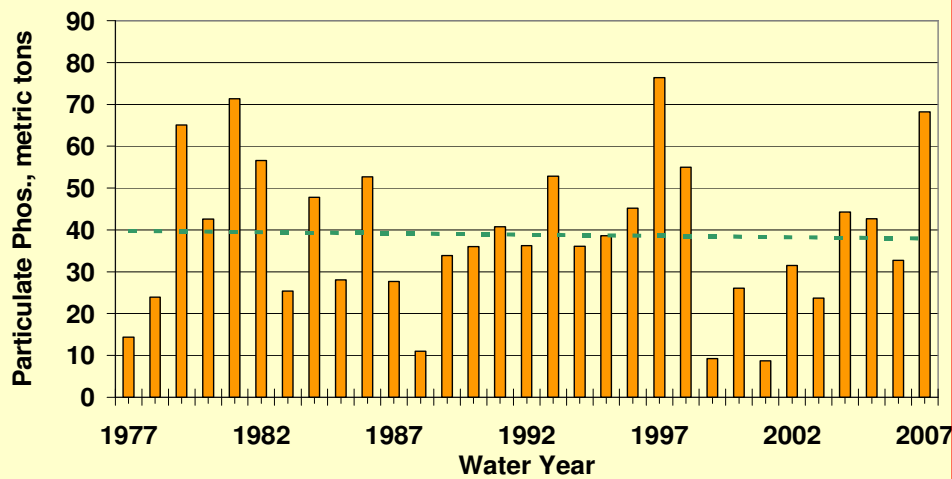
Maumee River, Particulate Phosphorus Loads



Sandusky River: Particulate Phosphorus Loading

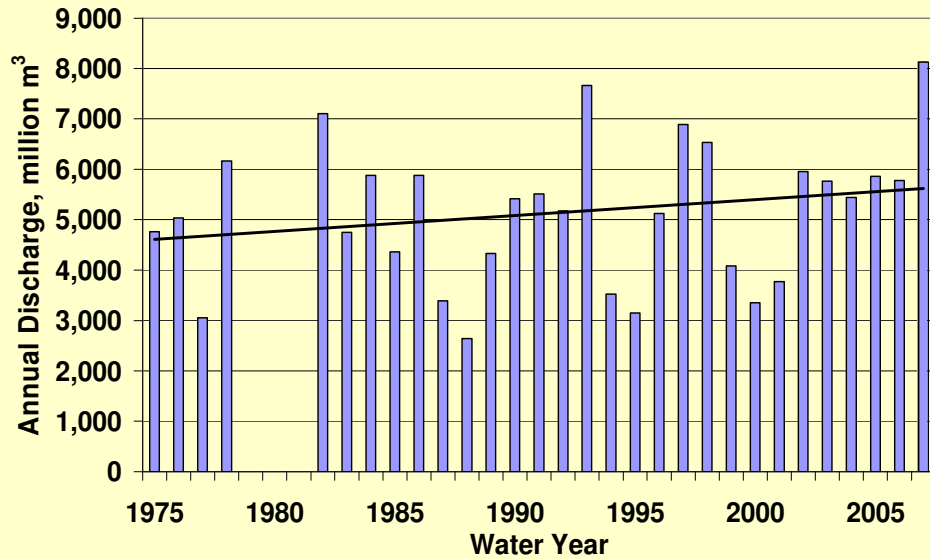


Honey Creek, Particulate Phosphorus Loads

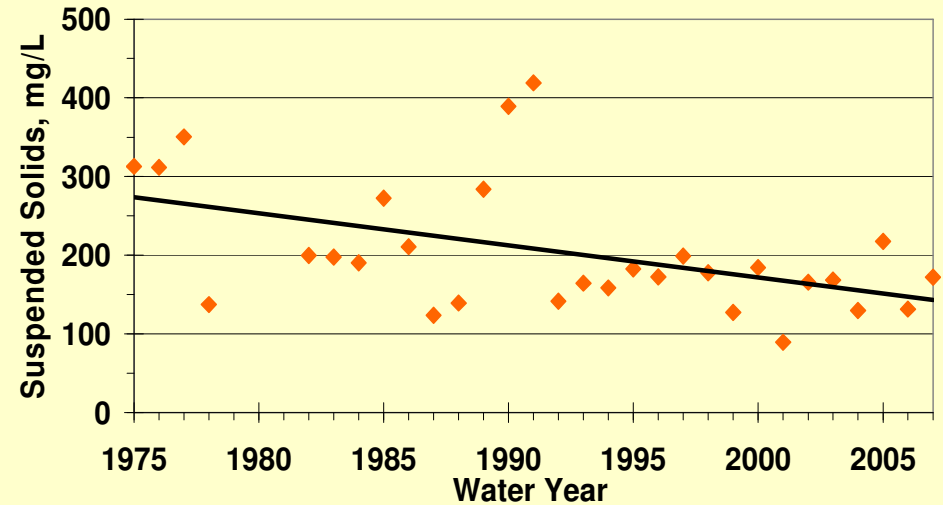


Decreases in loads of particulate phosphorus have occurred even though stream discharges have increased during the same period.

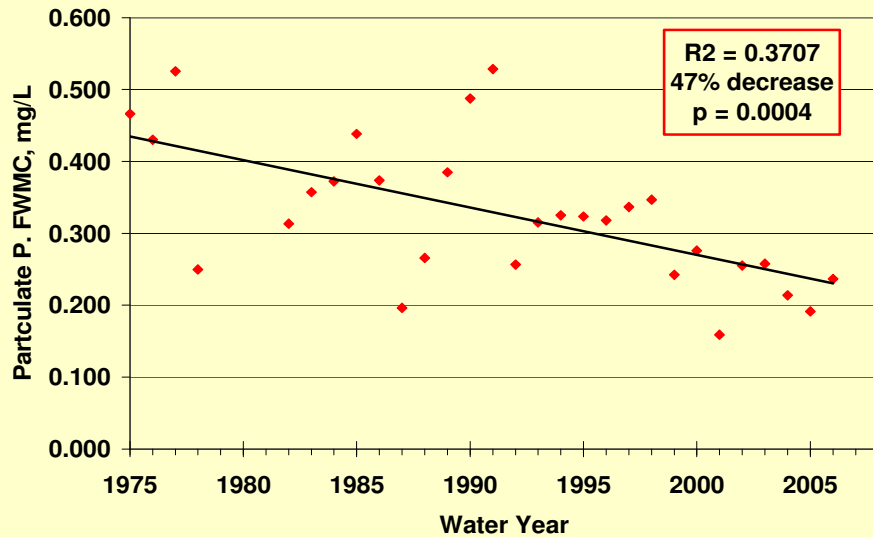
Maumee River, Annual Discharge



Maumee River, Flow weighted sediment concentrations

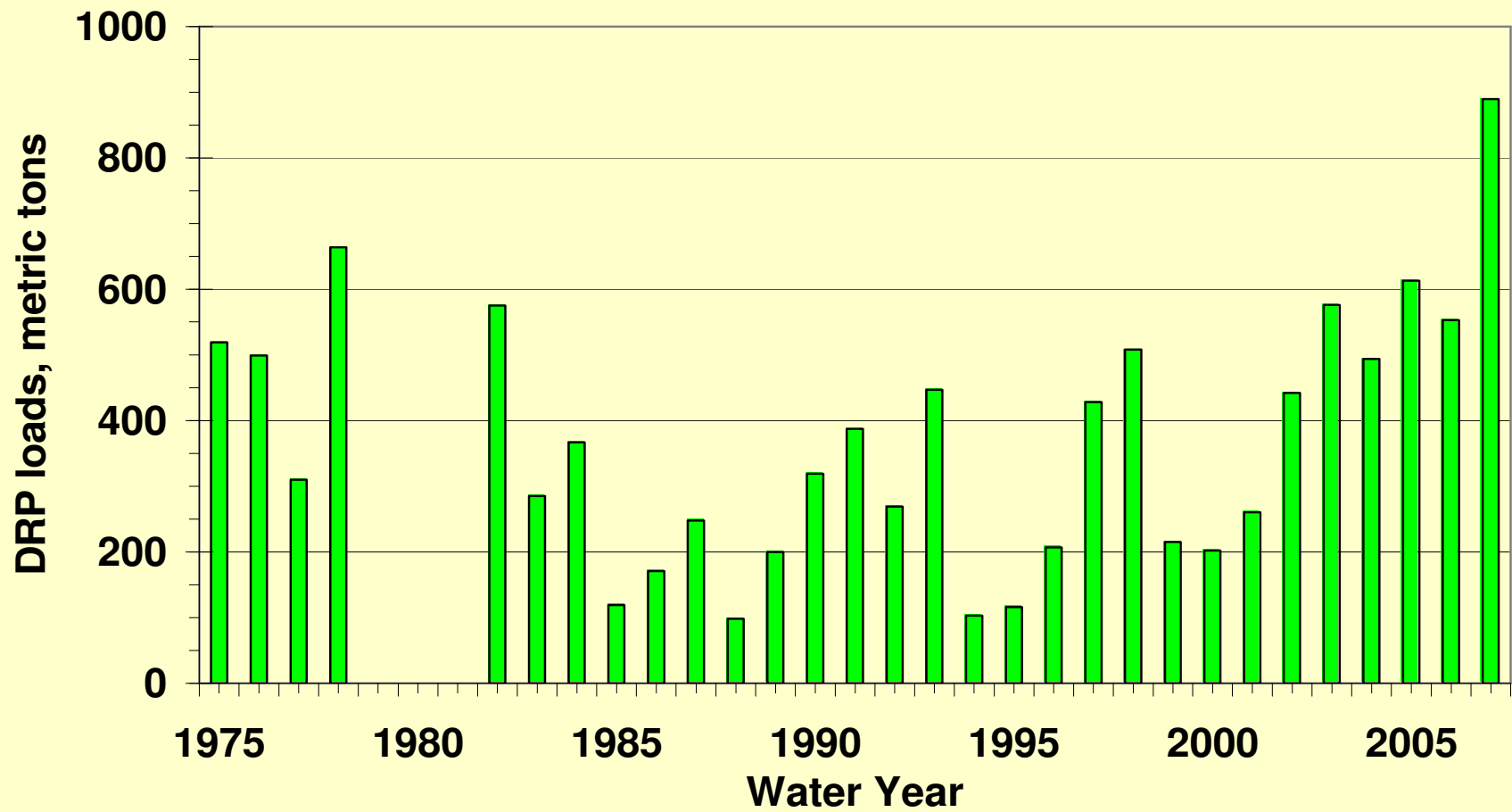


◆ Particulate P Flow Weighted Mean Concentration



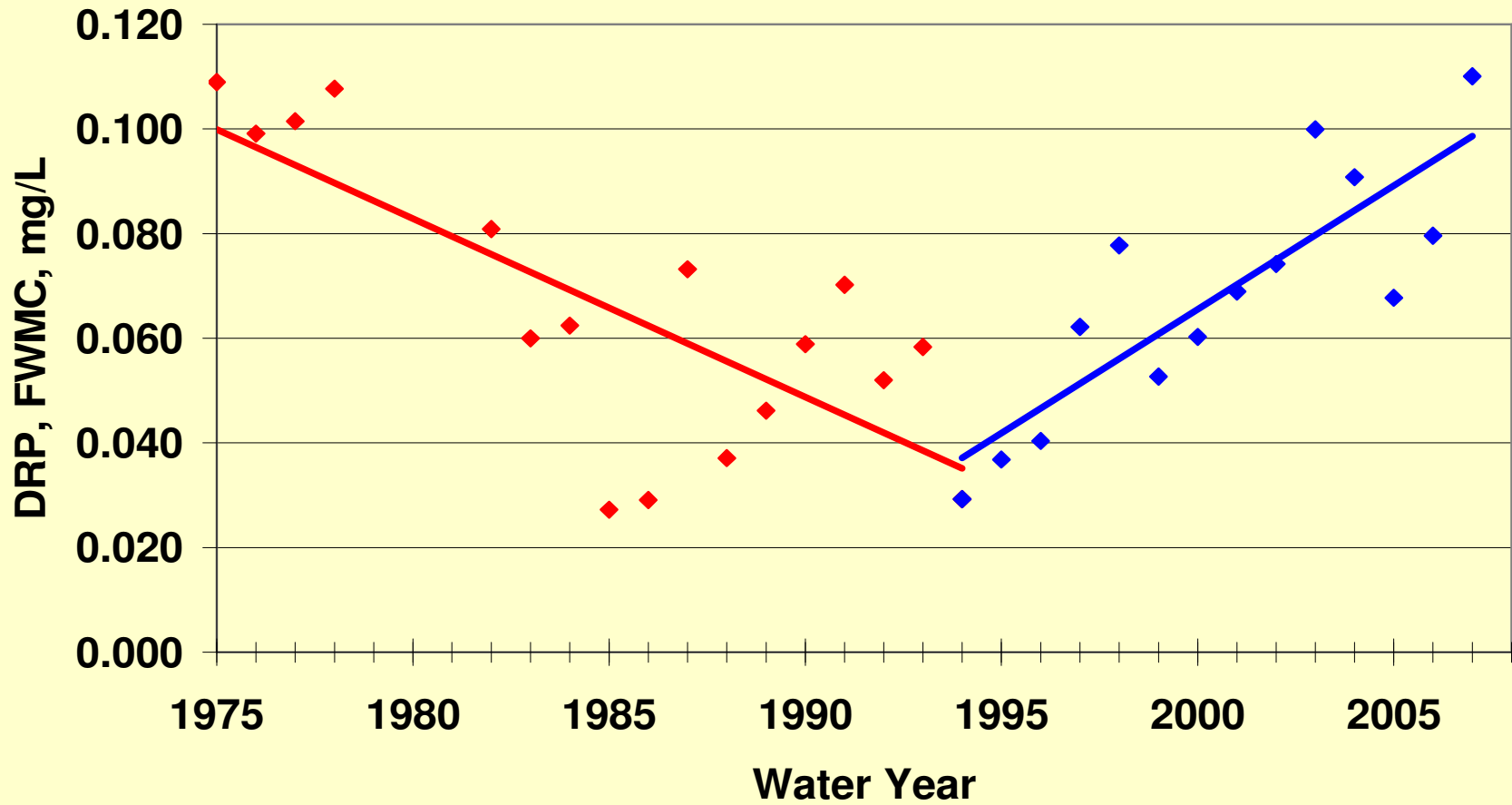
The decreases in concentrations of suspended solids and particulate phosphorus reflect the successes of the conservation tillage and buffer strip programs in northwestern Ohio.

Maumee River, Dissolved Reactive Phos. Loads

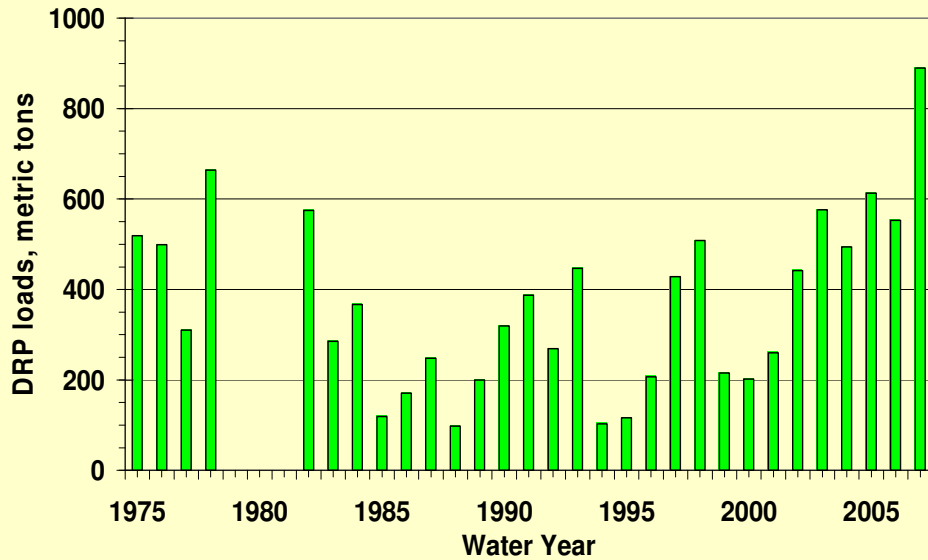


Maumee River, DRP, FWMC

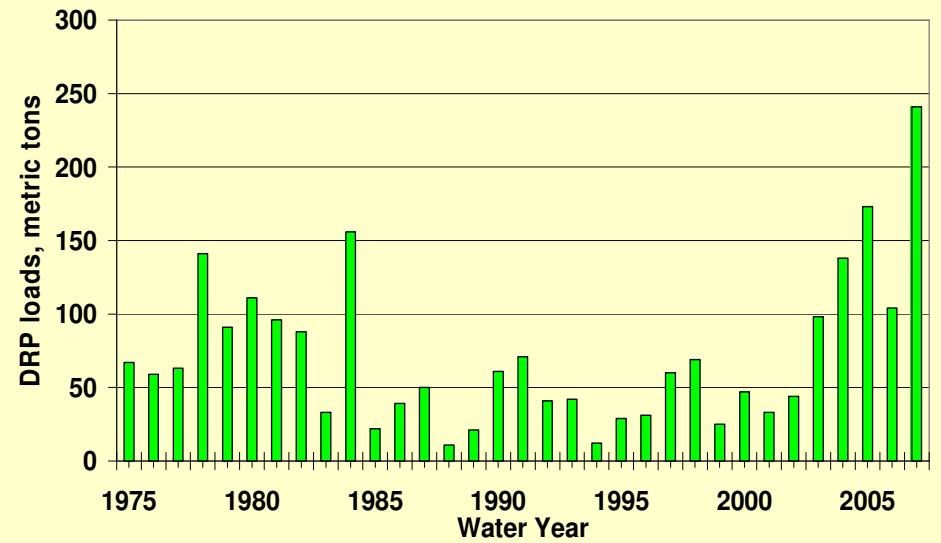
◆ 1975-1994 ◆ 1994-2007 — Linear (1975-1994) — Linear (1994-2007)



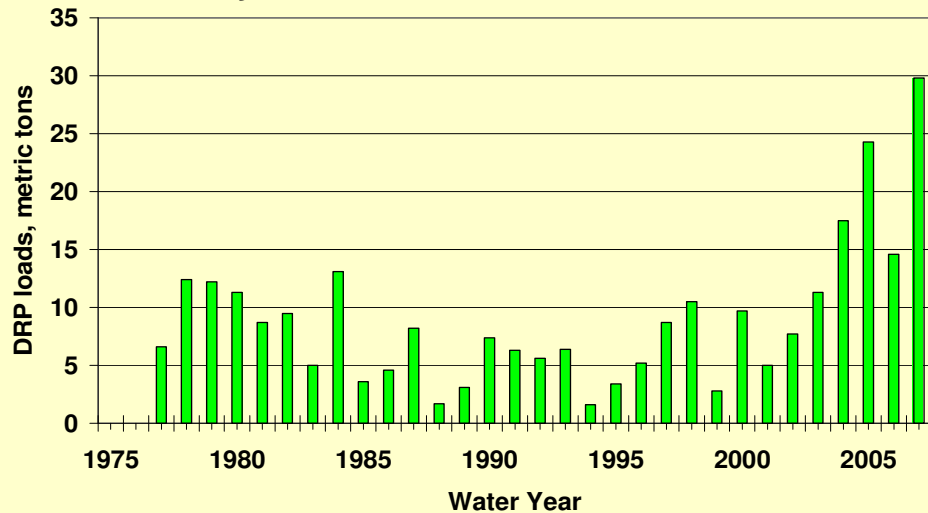
Maumee River, Dissolved Reactive Phos. Loads



Sandusky River, Dissolved Reactive Phos. Loads



Honey Creek, Dissolved Reactive Phos. Loads



How are the DRP loads delivered?

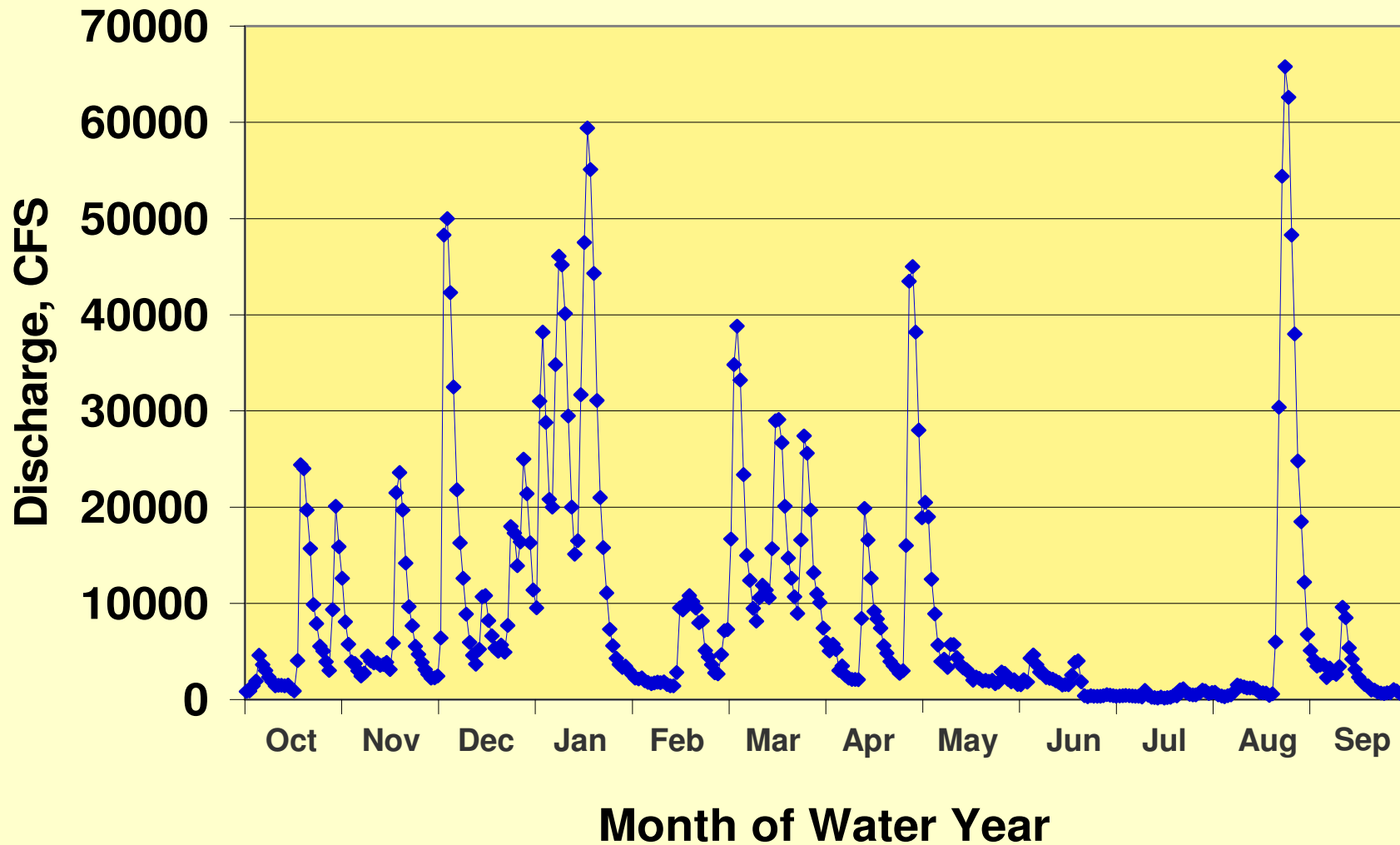
What is the source of the DRP?

Why are they increasing?

How can the loads be reduced?

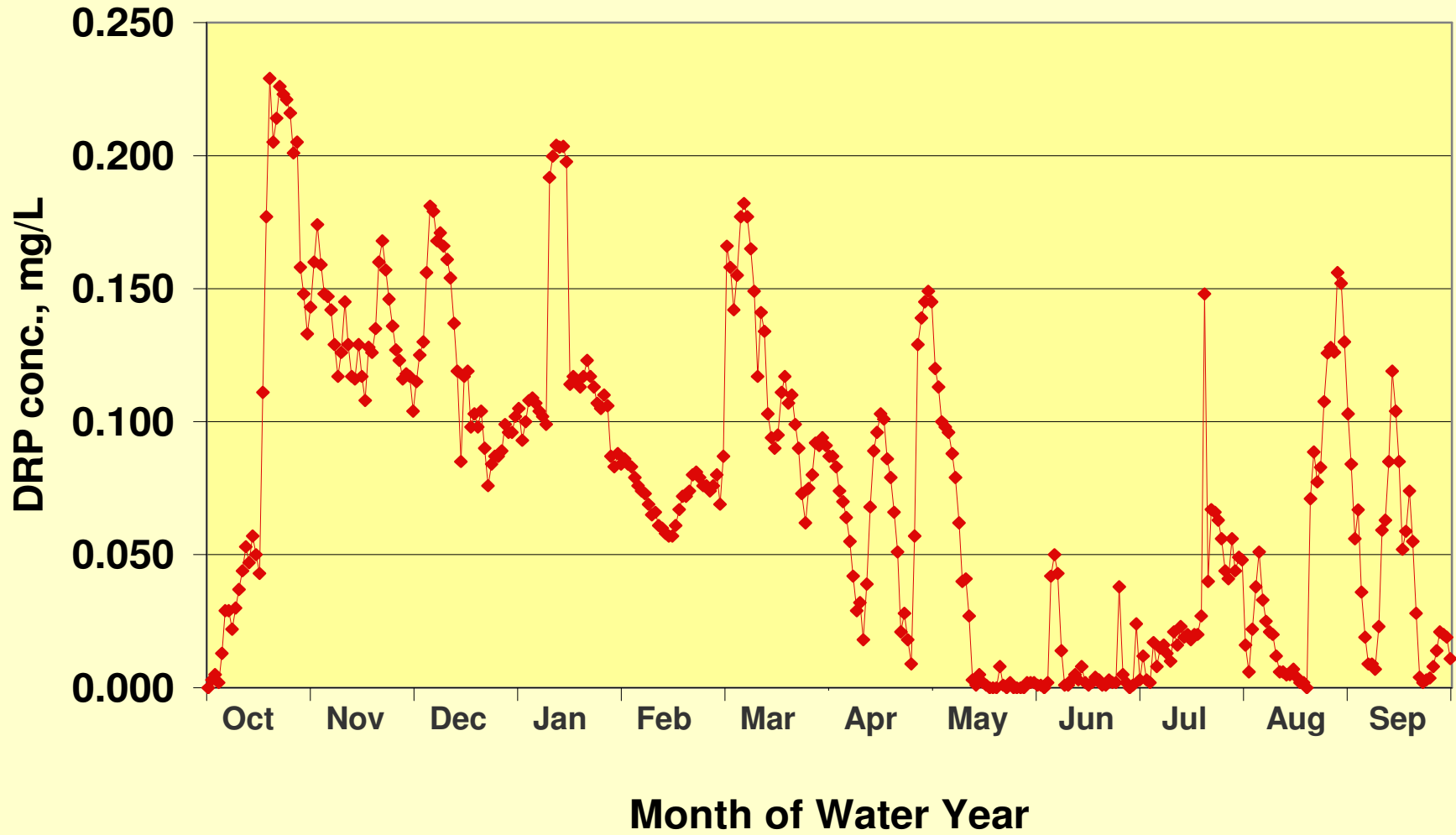
How are the DRP loads delivered?

Maumee River, Annual Hydrograph, 2007 Water Year



How are the DRP loads delivered?

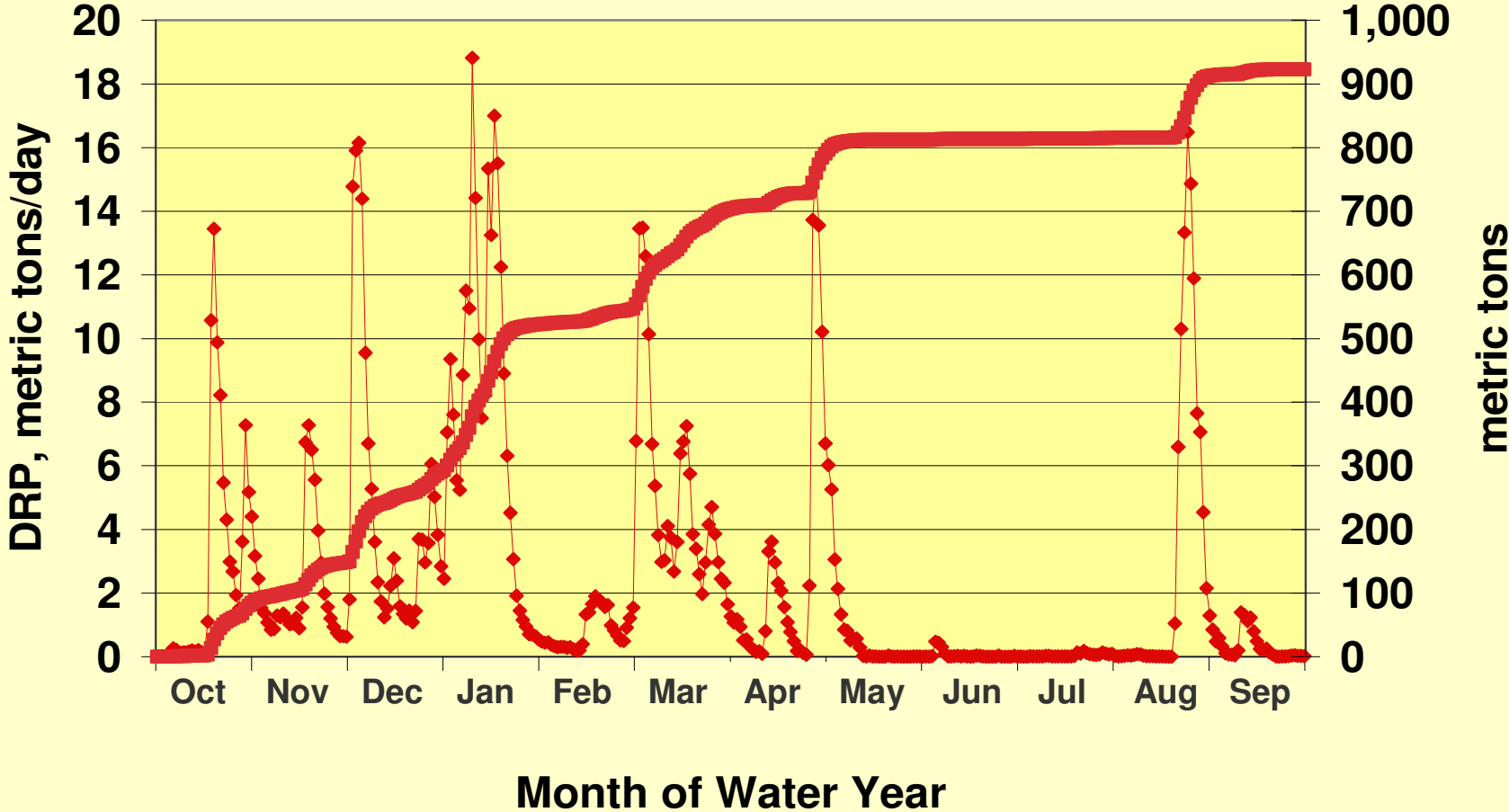
Maumee Dissolved Reactive Phosphorus Concentrations



How are the DRP loads delivered to Lake Erie?

Maumee River, DRPcumulative load, 2007 WY

<DRP loads are delivered to Lake Erie in storm event pulses>



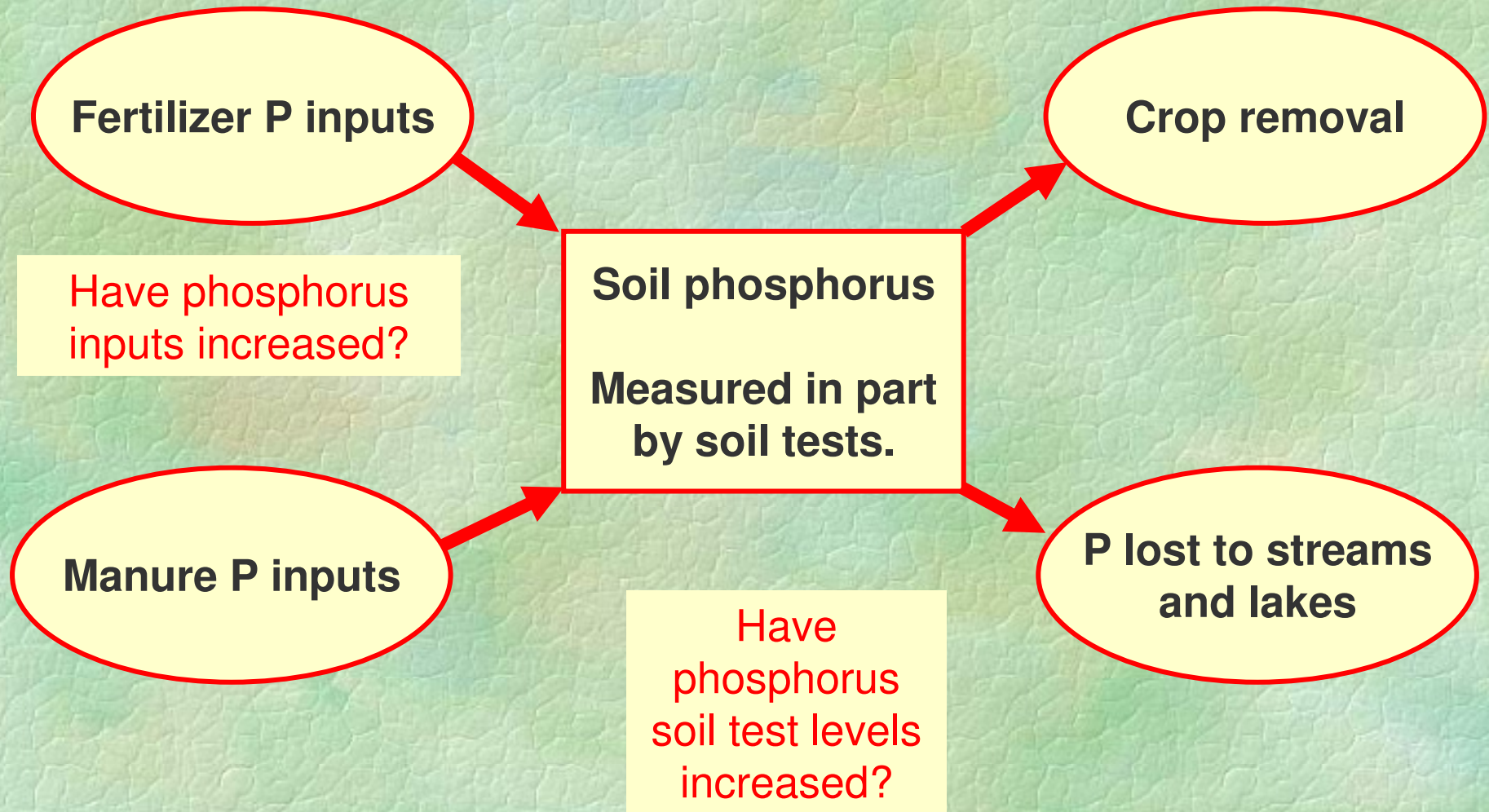
What is the source of the DRP?

Relative Contributions of point and nonpoint sources of phosphorus to total phosphorus export from NW Ohio watersheds

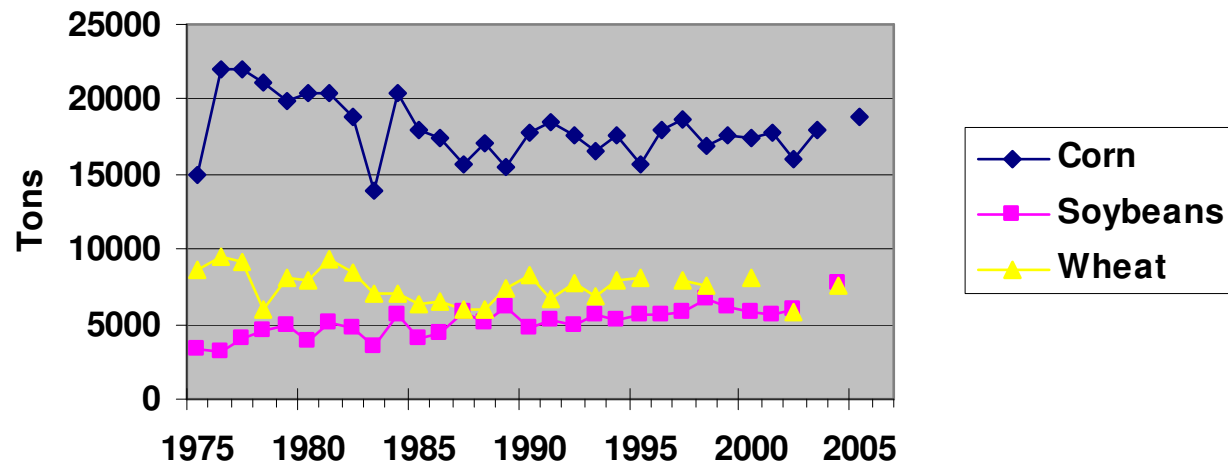
	Point Sources	Nonpoint Sources
Maumee River	7.5%	92.5%
Sandusky River	4.2%	95.8%
Honey Creek	3.0%	97.0%
Rock Creek	<1%	>99%

Row crop agriculture has to be the source of the increases in DRP loading to Lake Erie.

Why is dissolved phosphorus loading from agriculture increasing?



**Tons P/Yr applied to NW and NC Ohio crops
(NASS, USDA-ERS data)**



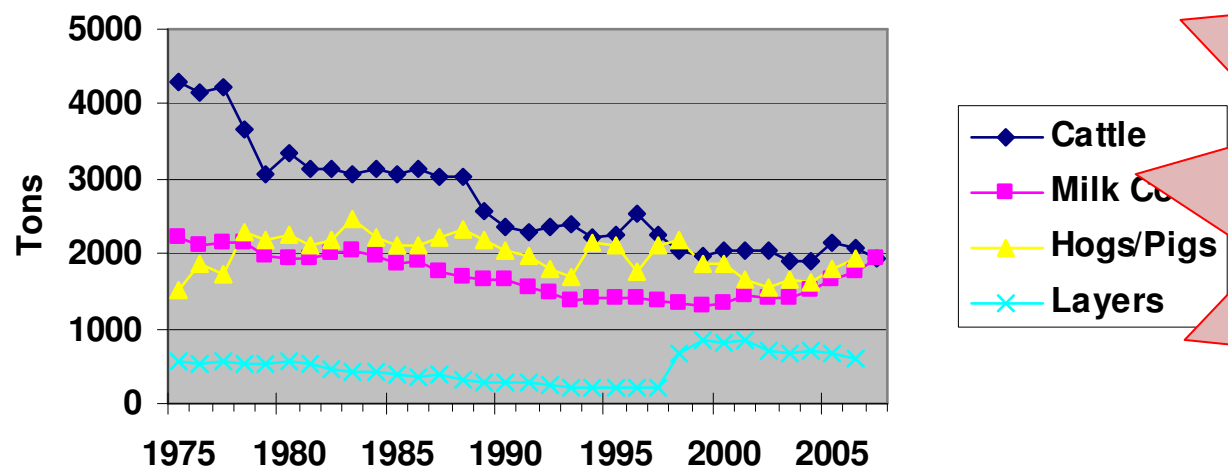
In 2002:

33,332 tons P applied

83% from commercial fertilizers

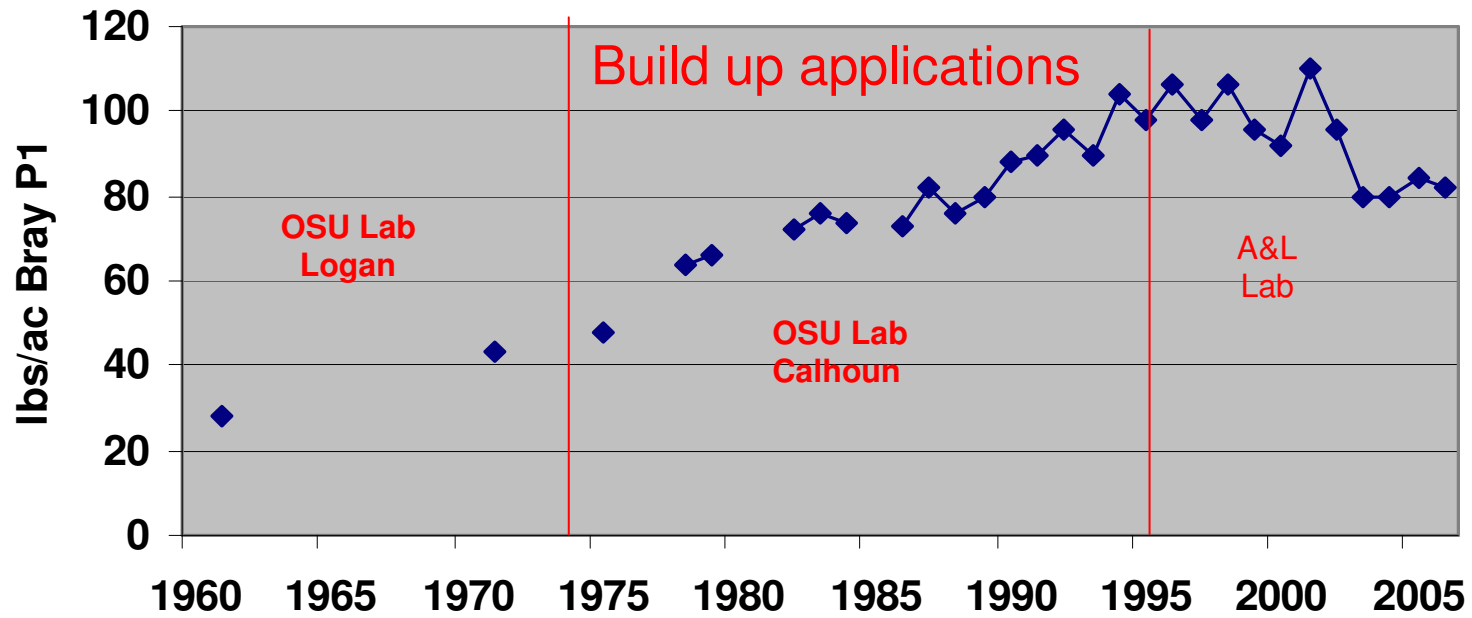
17% from manures

Tons P/Yr from livestock and layers in NW and NC Ohio (NASS, USDA-NRCS data)



Increasing phosphorus inputs do not appear to be a direct cause of increasing DRP export

Long term phosphorus soil test trends for NW Ohio

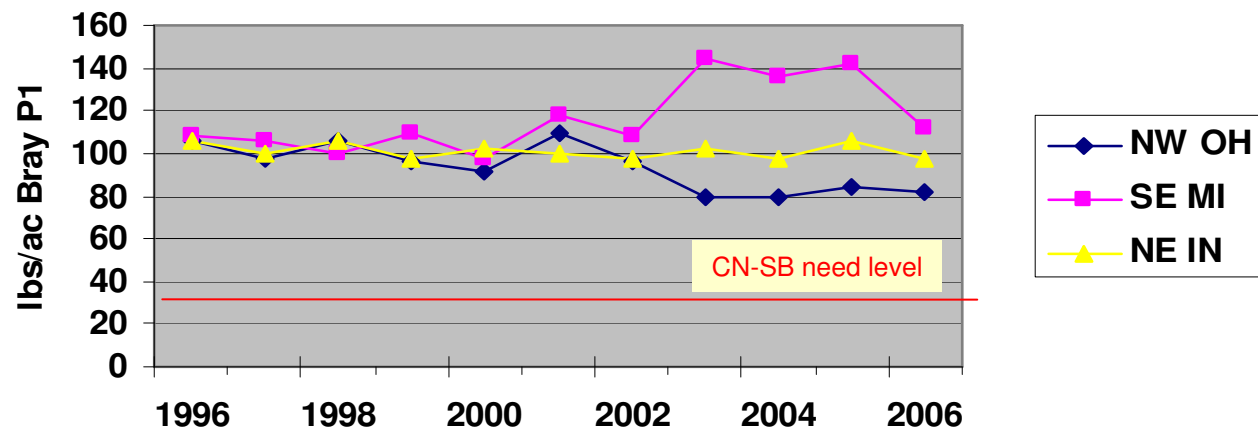


Soil test values don't show large increases from 1995 to present. Appear unlikely to be a direct cause of increased DRP export.

What are the likely causes of increased dissolved phosphorus runoff from cropland?

- 1. Some fields likely have excessively high phosphorus soil test values.**
- 2. Phosphorus stratification in soils under no-till and reduced till practices.**
- 3. Increasing usage of fall and winter broadcasting of fertilizers and surface applications of manures.**
- 4. Increasing amounts of surface runoff from fields (less water infiltration during storms events).**

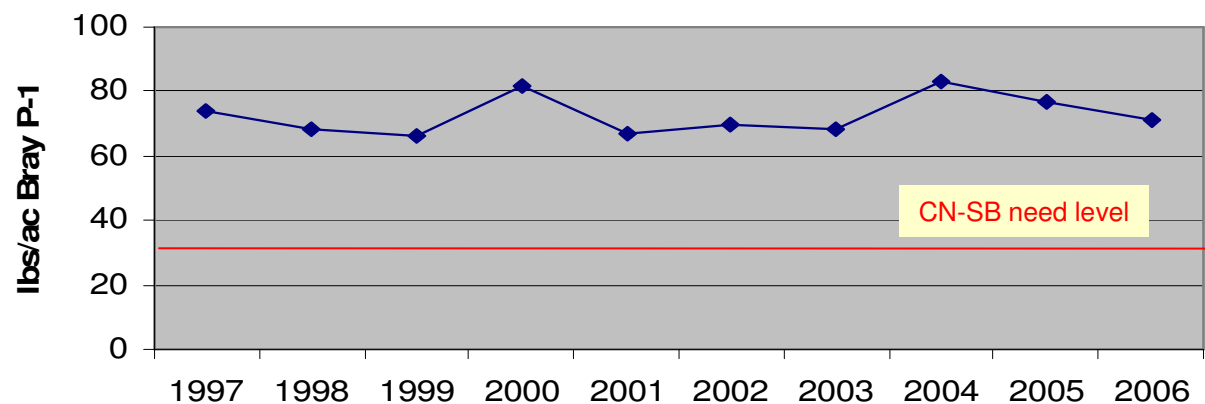
Phosphorus Soil Test Trends (A&L Great Lakes Laboratory, Inc.)



Average soil test values are well above crop needs for optimum yields.

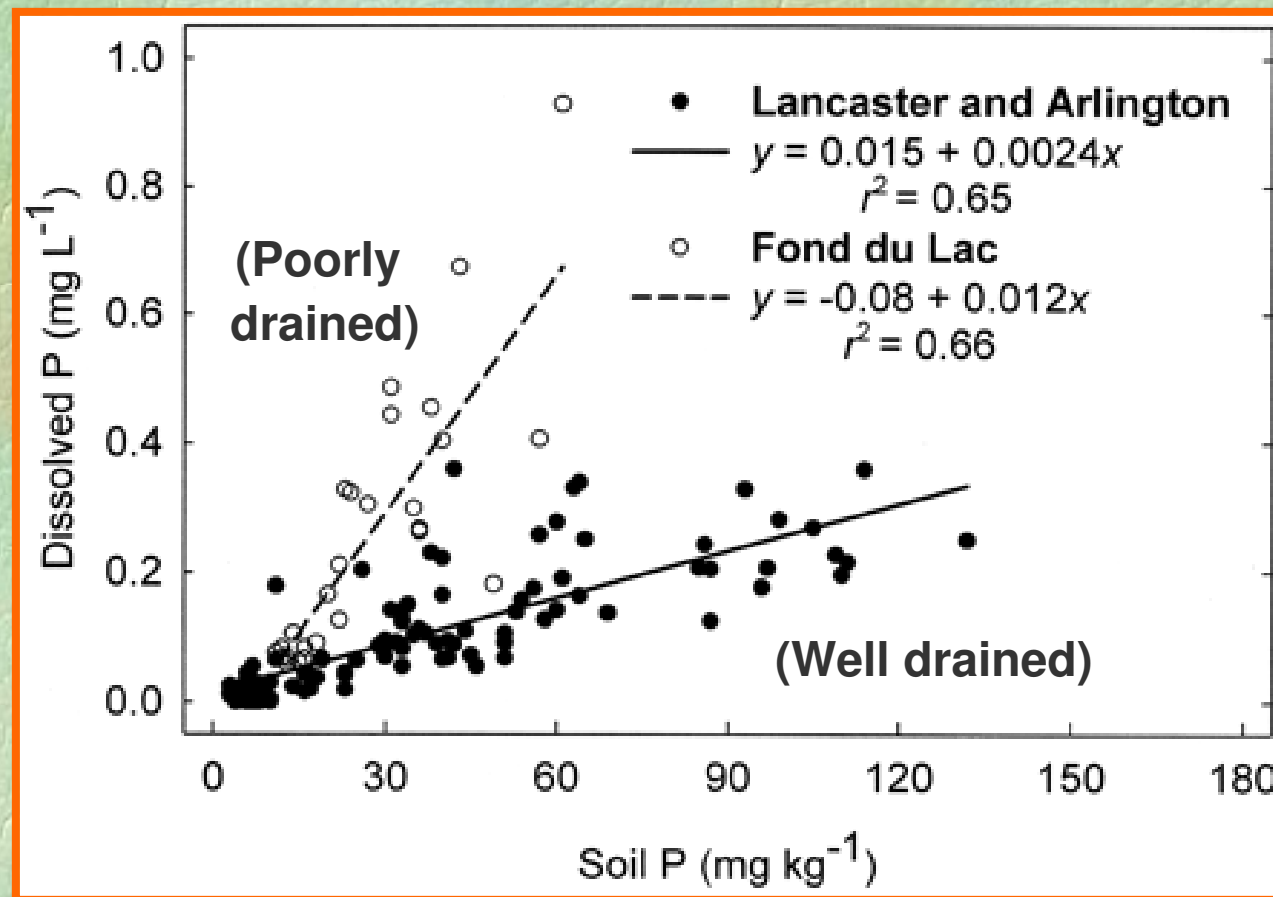
Soil testing is done immediately prior to fertilizer or manure applications and represents the low point in phosphorus levels in the soil.

Maumee/Sandusky Phosphorus Soil Test Trends (Spectrum Analytic Lab)

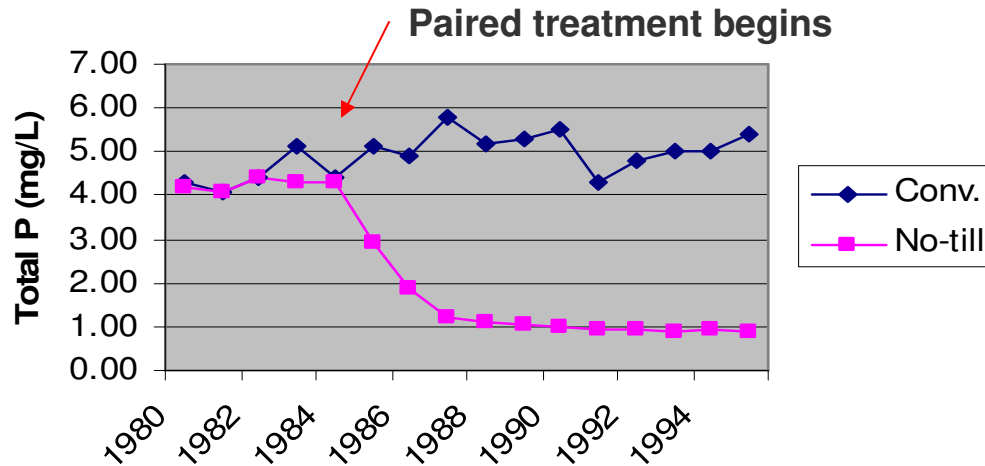


Many farmers don't use soil testing.

Under conservation tillage and for a given soil test P, DP concentrations are greater in runoff from more poorly drained soils. (Andraski and Bundy. 2003. U of Wisc.)



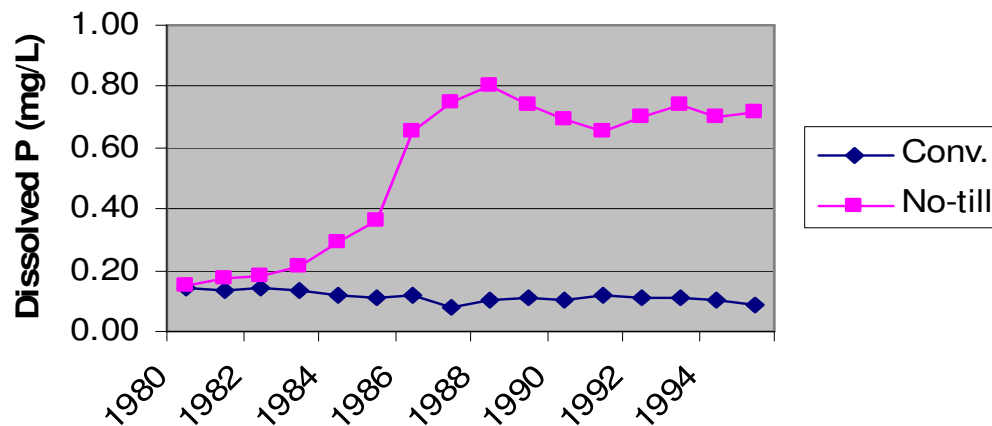
Mean Annual TP in Runoff as a Function of Tillage Management



Reducing tillage can decrease TP in runoff ...

Why does no-till increase DRP runoff?

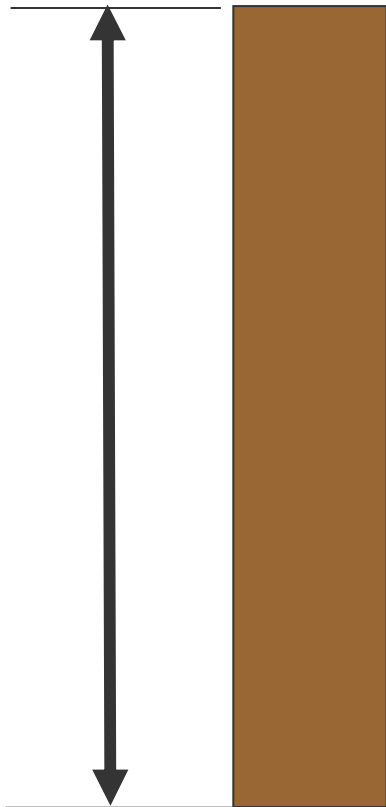
Mean Annual DP in Runoff as a Function of Tillage Management



...but it can increase DP in runoff.

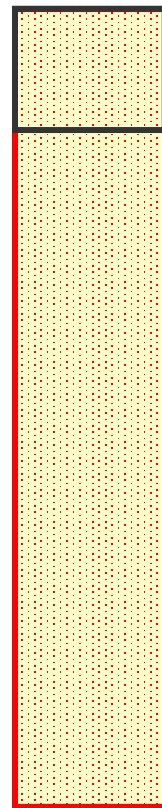
(Sims and Kleinman. 2006. Phosphorus.)

Soil surface



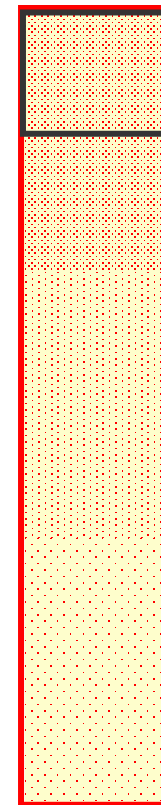
8 inch depth

**Conventional tillage
(soil inversion)**



**~ Uniform
phosphorus
distribution in soil**

**No-till & reduced till
(no soil inversion)**



**Stratified phosphorus
distribution in soil
Highest at soil surface**

**Phos. runoff
proportional to
P conc. in
upper inch of
soil**

**Very different
phosphorus
conc. In runoff**

**~Same
standard soil
test results**

Standard soil testing

Soil surface

Stratified soil testing (uncommon in Ohio)

0 – 8 inches

0 – 2 inch

2 – 8 inch

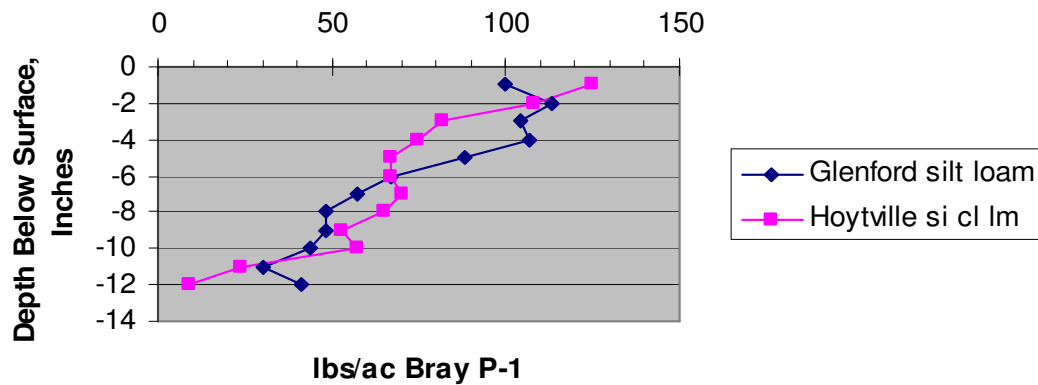
8 inch depth

Great Lakes
Protection
Fund Grant for
extensive
stratified soil
testing in the
Sandusky
Watershed.

- Standard soil test results used for fertilizer recommendations
- Less useful for phosphorus runoff estimates

- Possible advantages for nutrient management
- More useful for phosphorus runoff estimates

**Phosphorus Stratification After 20 Years of No-till,
Sandusky County, OH**

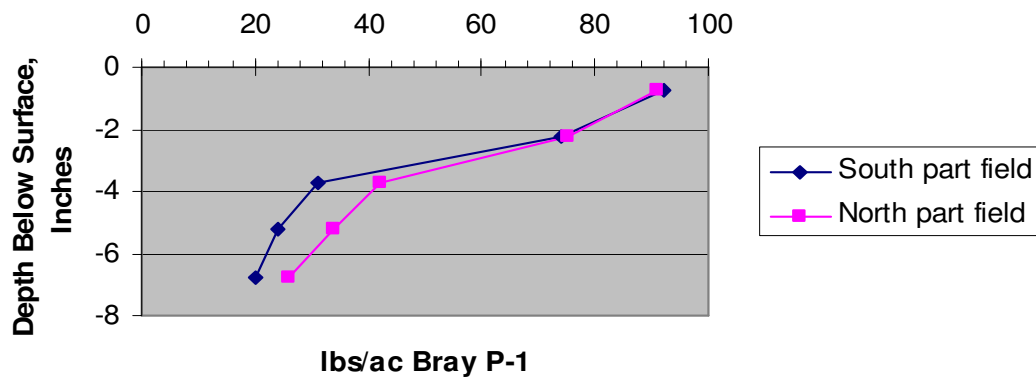


Standard 8 inch soil test:

Glenford 86 lbs/ac
Hoytville 82 lbs/ac

Jerry Cunningham, CCA
Country Spring
Farmers Co-op.

**Phosphorus Stratification After 20 Years of No-till on a
Blount silt loam, Seneca County, OH**



Standard 8 inch soil test:

South field 48 lbs/ac
North field 54 lbs/ac

Bill McKibben, CCA
Logan Labs

Fertilizer application methods

Incorporation into upper soil strata

Broadcast onto soil surface, often in fall winter.

Fertilizer is cheaper in the fall.

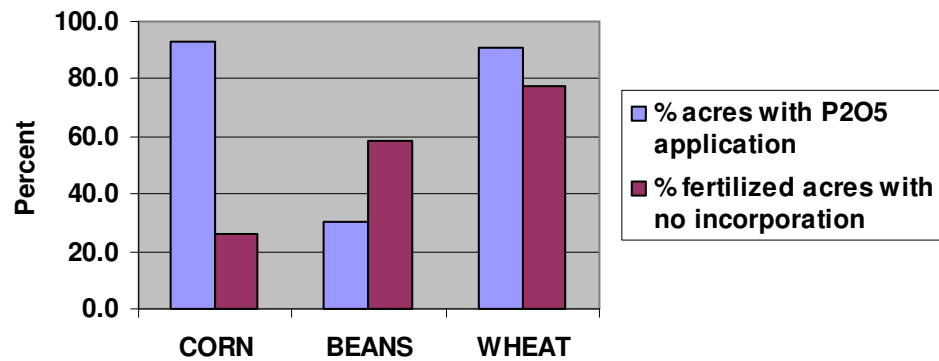
More convenient for farmers.

...but up to 45% of broadcast phosphorus fertilizer can be lost to runoff.

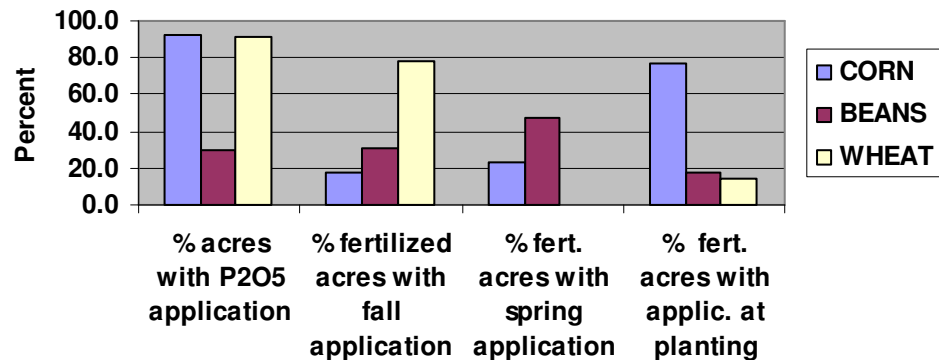
More common with no-till and reduced till practices.

What about method and timing of P₂O₅ fertilizer application for corn, soybeans and wheat in Ohio?

Average percents (1996-2005): P₂O₅ application methods (USDA-ERS)



Average percents (1996-2005): timing of P₂O₅ applications (USDA-ERS)



Value of nutrients that moved past the monitoring stations on the Maumee and Sandusky Rivers during the 2007 Water Year, based on current fertilizer costs. (Current costs: N fertilizer-\$1,200 per ton as N, P fertilizer-\$2,500 per ton as P.

Nutrient	Maumee R.	Sandusky R.
Nitrate-N	\$37,560,000	\$8,196,000
Organic-N + ammonia-N	\$19,920,000	\$3,744,000
Dissolved Phosphorus	\$2,225,000	\$602,500
Particulate Phosphorus	\$6,875,000	\$1,795,000
<u>Total</u>	<u>\$66,580,000</u>	<u>\$14,337,500</u>

What farmers can do to reduce dissolved phosphorus in runoff?

1. **SOIL TEST!!!** Include 0 to 2 inch depth samples in no-till or very reduced tillage situations.
2. Read and study the phosphorus section of the Tri-State Fertility Guide. See Figure 1 and understand “critical level”, “maintenance limit”, “soil test P buildup, maintenance and drawdown ranges”.
3. Where soil test P values are above the “maintenance limit” for crop yield goals, follow the “drawdown” recommendations for P_2O_5 needs, if any.
4. Avoid surface broadcast applications of P_2O_5 unless incorporated by some form of tillage. Options, too, are injection or banding.
5. Avoid fertilizer or manure applications on frozen soils or before intense rain storm events.
6. Manure test to quantify P nutrient value; then match manure application rate with crop needs.

What farmers can do to reduce dissolved phosphorus in runoff?

- 7. Add phytase enzymes to feed to enhance P nutrient utilization by hogs and chickens.**
- 8. Use manure or soil amendments like aluminum or ferrous sulfate to stabilize dissolved phosphorus.**
- 9. Use upland grass or tree buffers to permit greater infiltration of dissolved phosphorus in runoff.**
- 10. Establish winter cover where growing roots can retain dissolved phosphorus in fields.**
- 11. Where 0 to 2 inch soil test P levels are very high (two times the “maintenance limit” for corn and soybeans or 120 lbs/ac Bray P1), consider a one time inversion of the soil profile; then resume conservation tillage methods.**

Questions