Chesapeake Bay Goal Line 2025

October 6, 2010

Phosphorus Transport in Maryland Coastal Plain Watersheds: What We Know After 25 Years

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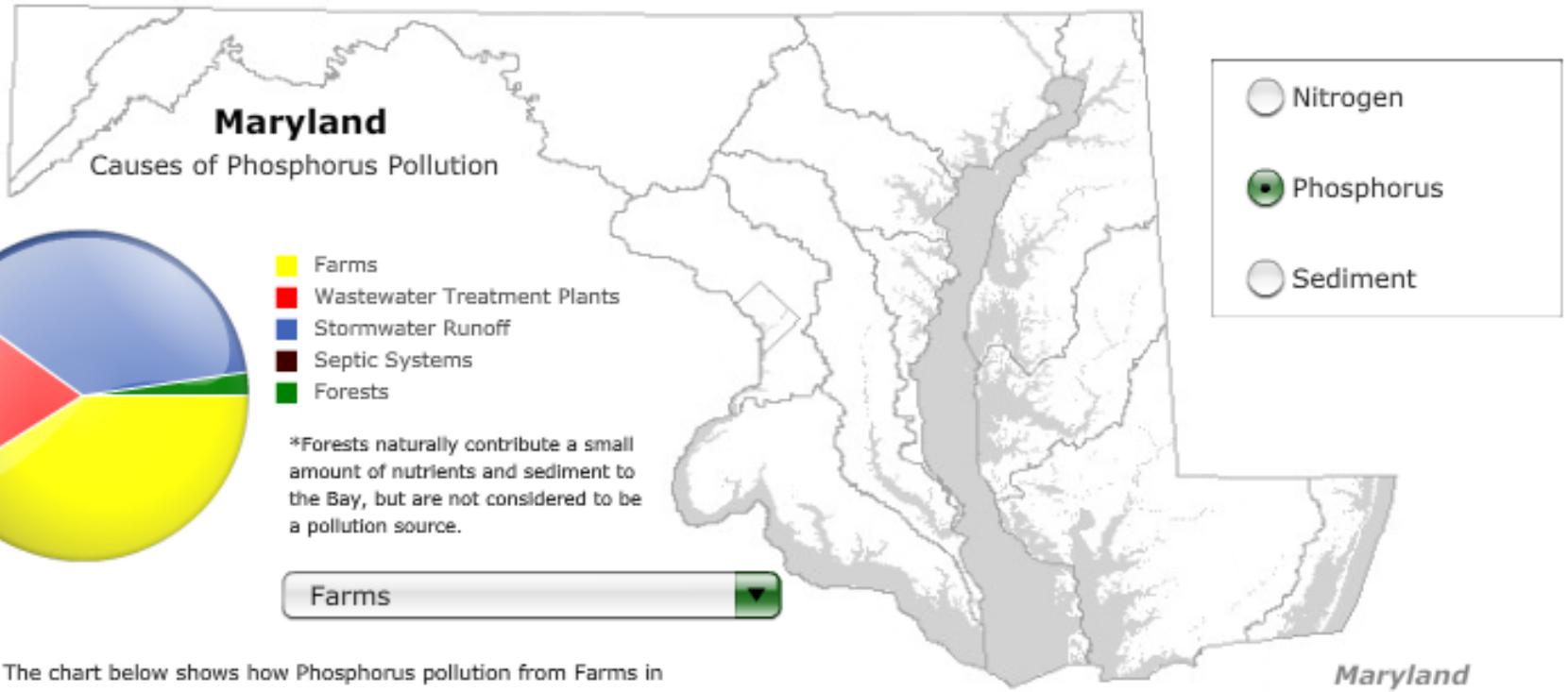
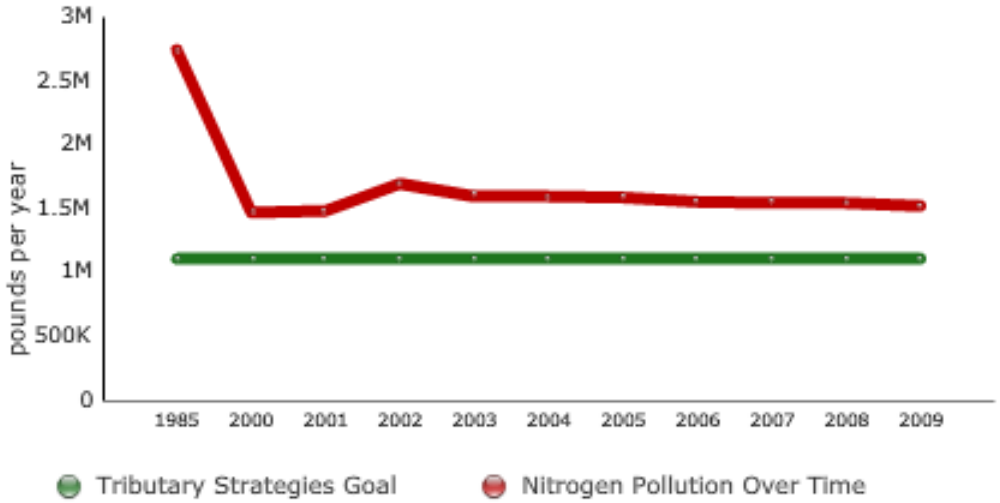
Causes of the Problems

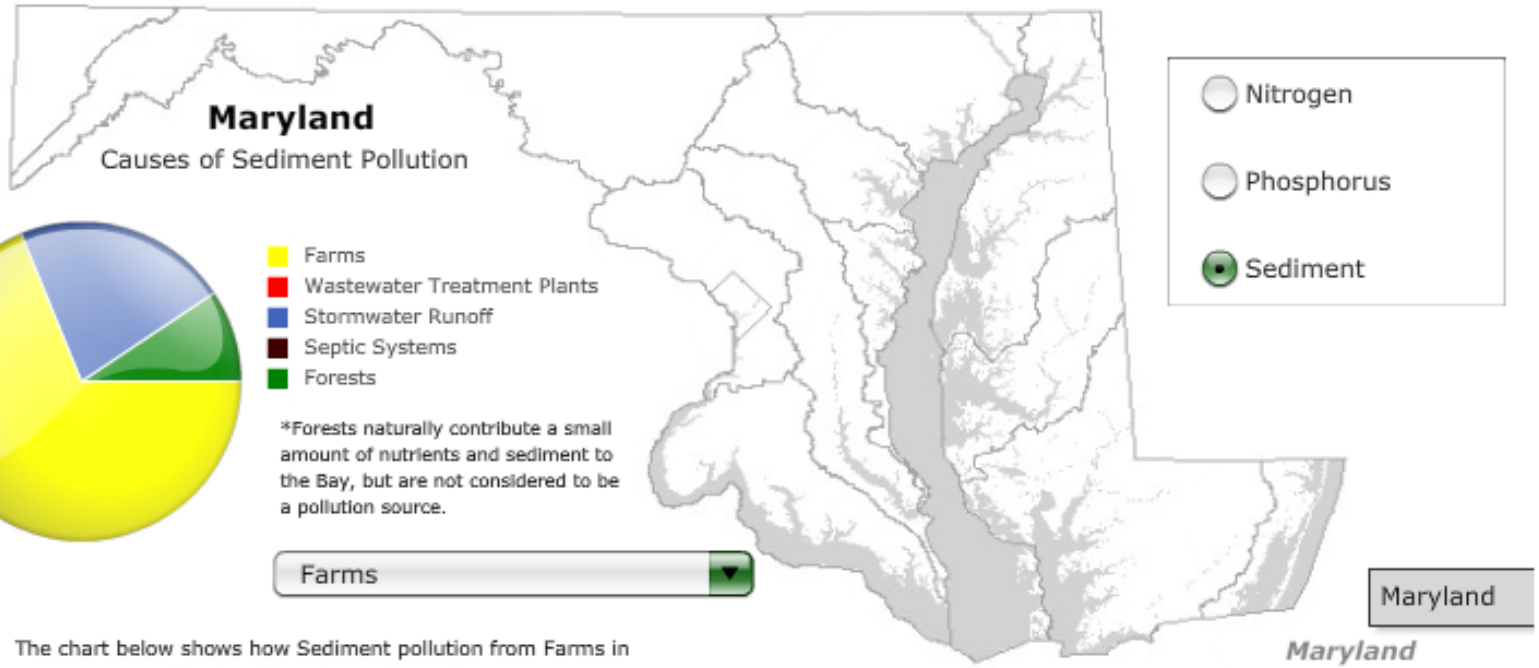


The chart below shows how Phosphorus pollution from Farms in Maryland has changed over time.

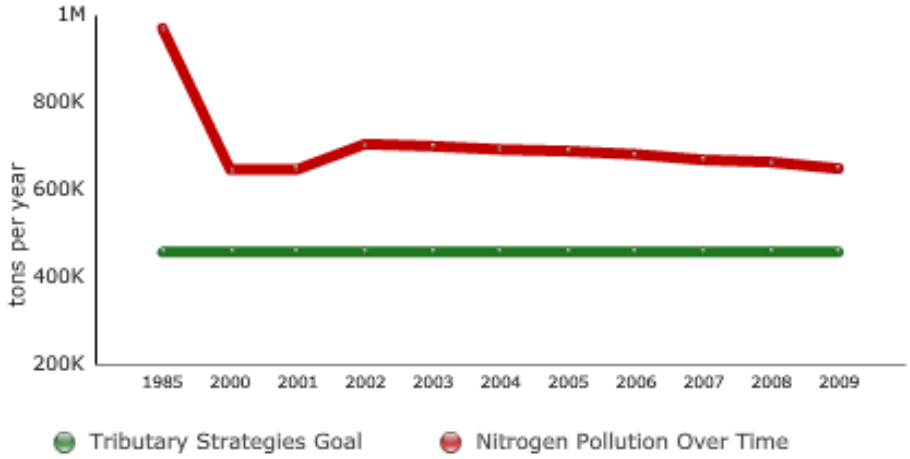


Phosphorus pollution fuels the growth of algae, creating dense, harmful algae blooms that rob the Chesapeake Bay's aquatic life of needed sunlight and oxygen. Phosphorus often attaches to soil and sediment particles on land, entering the Bay many years later when stream banks erode or rainwater washes it into streams, rivers and the Bay. Sources of phosphorus pollution include fertilizers from farmlands, lawns and golf courses; eroding soil & sediment from stream banks in urban and suburban neighborhoods; animal manure from farms; and wastewater from industrial facilities and sewage treatment plants.

Causes of the Problems

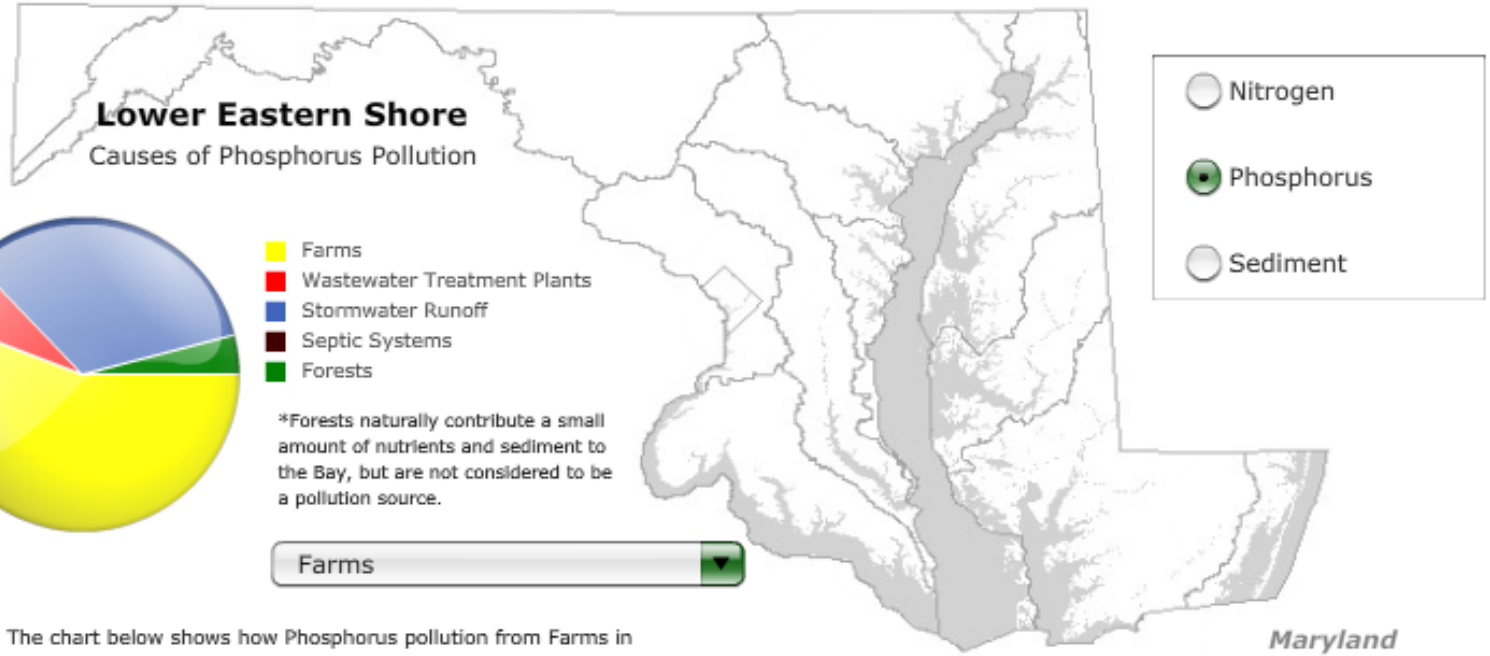


The chart below shows how Sediment pollution from Farms in Maryland has changed over time.

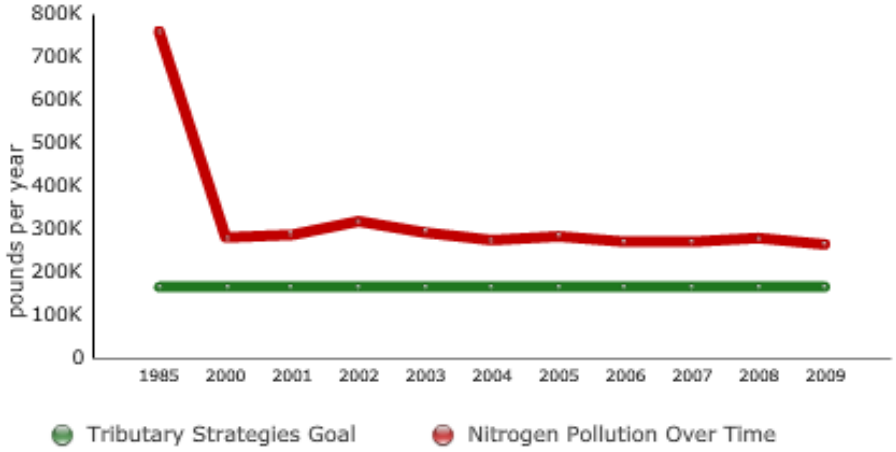


Excess sediments -- dirt, clay, silt and sand – hurt the Bay's water quality by blocking the sunlight needed by underwater plants and grasses. Without enough sunlight, these underwater grasses are not able to grow and provide habitat for young fish and blue crabs. In addition to blocking sunlight, sediment pollution can also carry nutrient and chemical contaminates into the bay, and smother oysters, underwater grasses and other bottom-dwelling creatures. Landscape changes, like development of forests and farmland, increase sediment pollution into the Chesapeake Bay.As trees and plants are removed on construction sites during development and stream banks erode due to increased stormwater flows in urban and suburban communities, rainwater carries sediment from the land into the Bay.

Causes of the Problems



The chart below shows how Phosphorus pollution from Farms in Lower Eastern Shore has changed over time.



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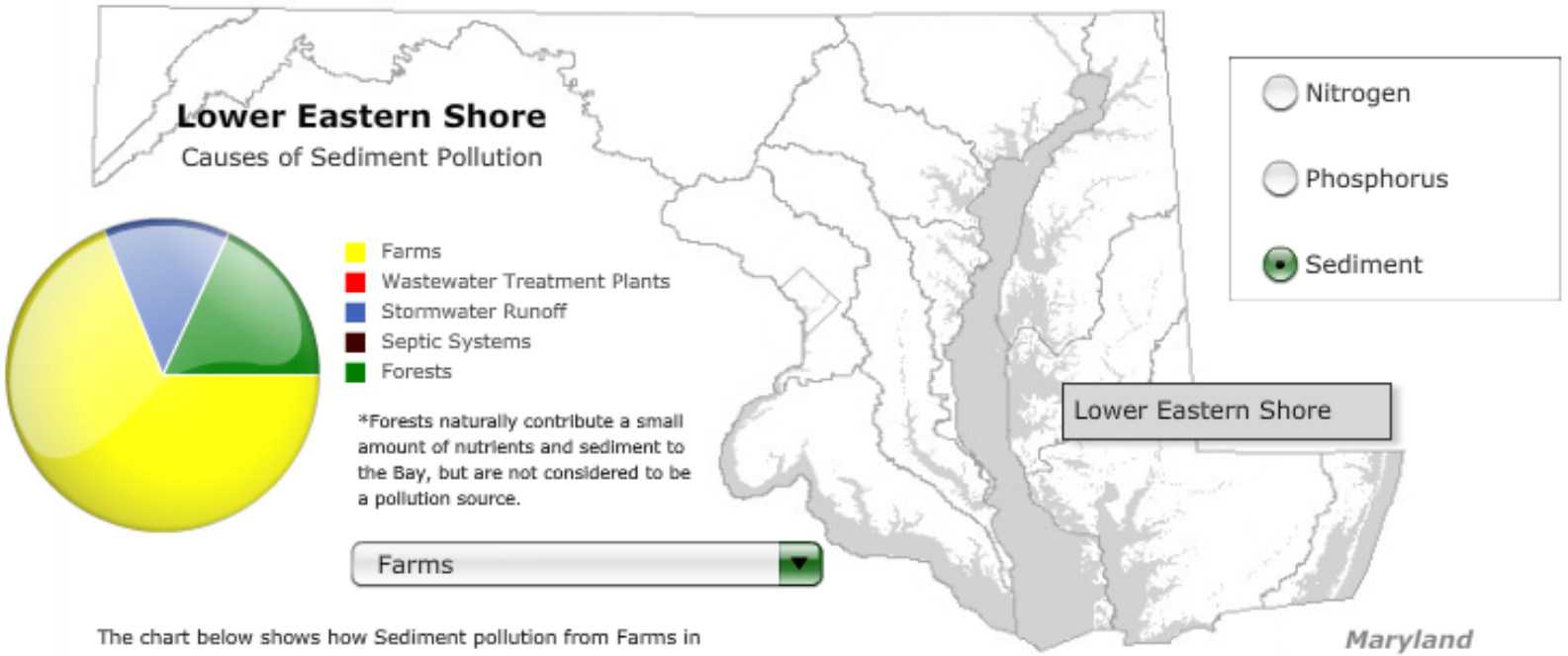
Causes of the Problems



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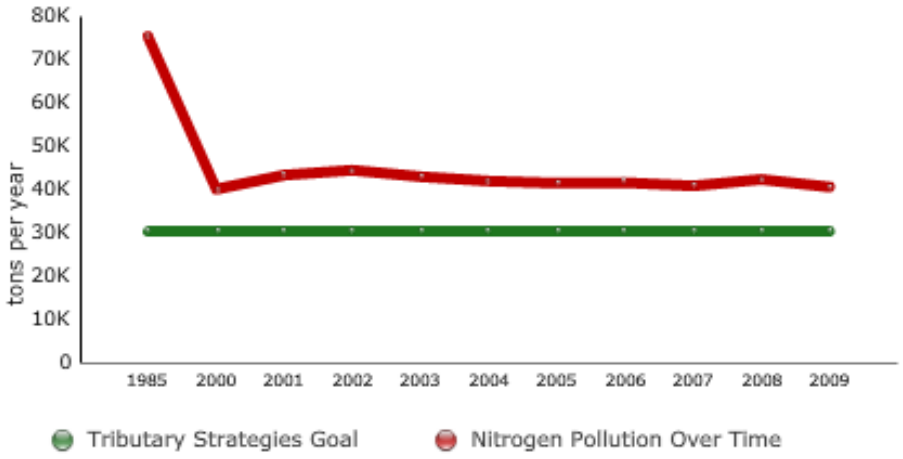

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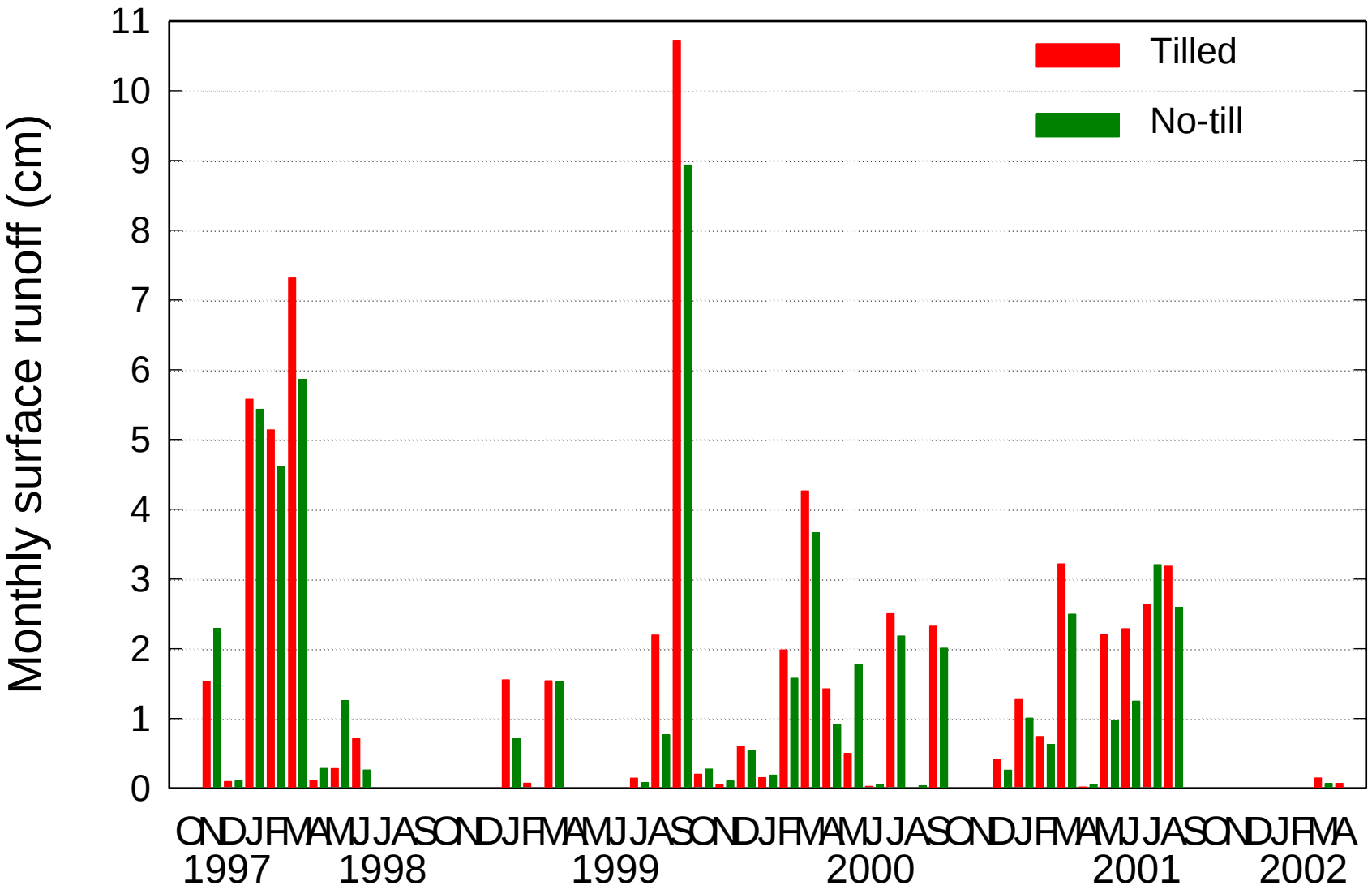
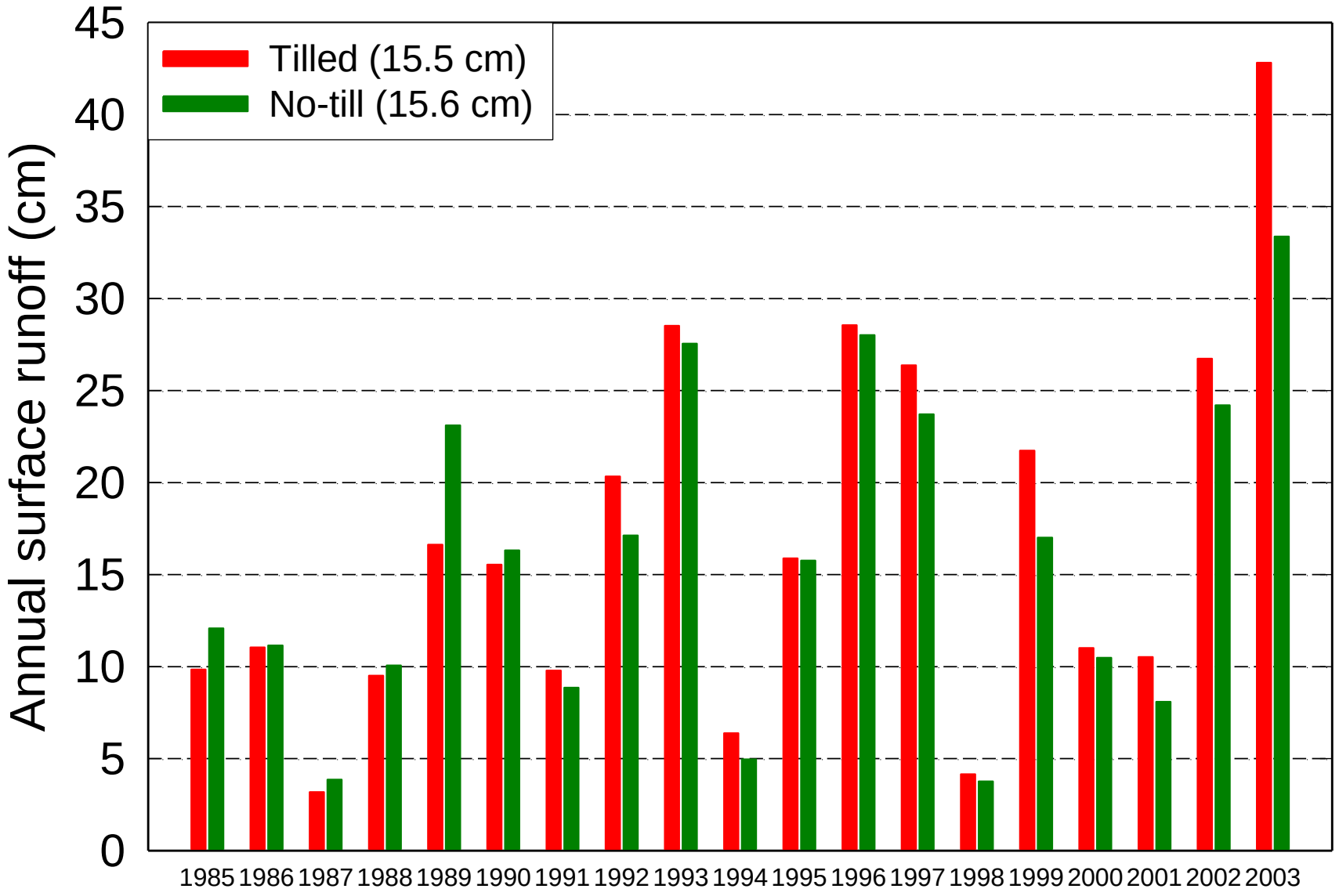
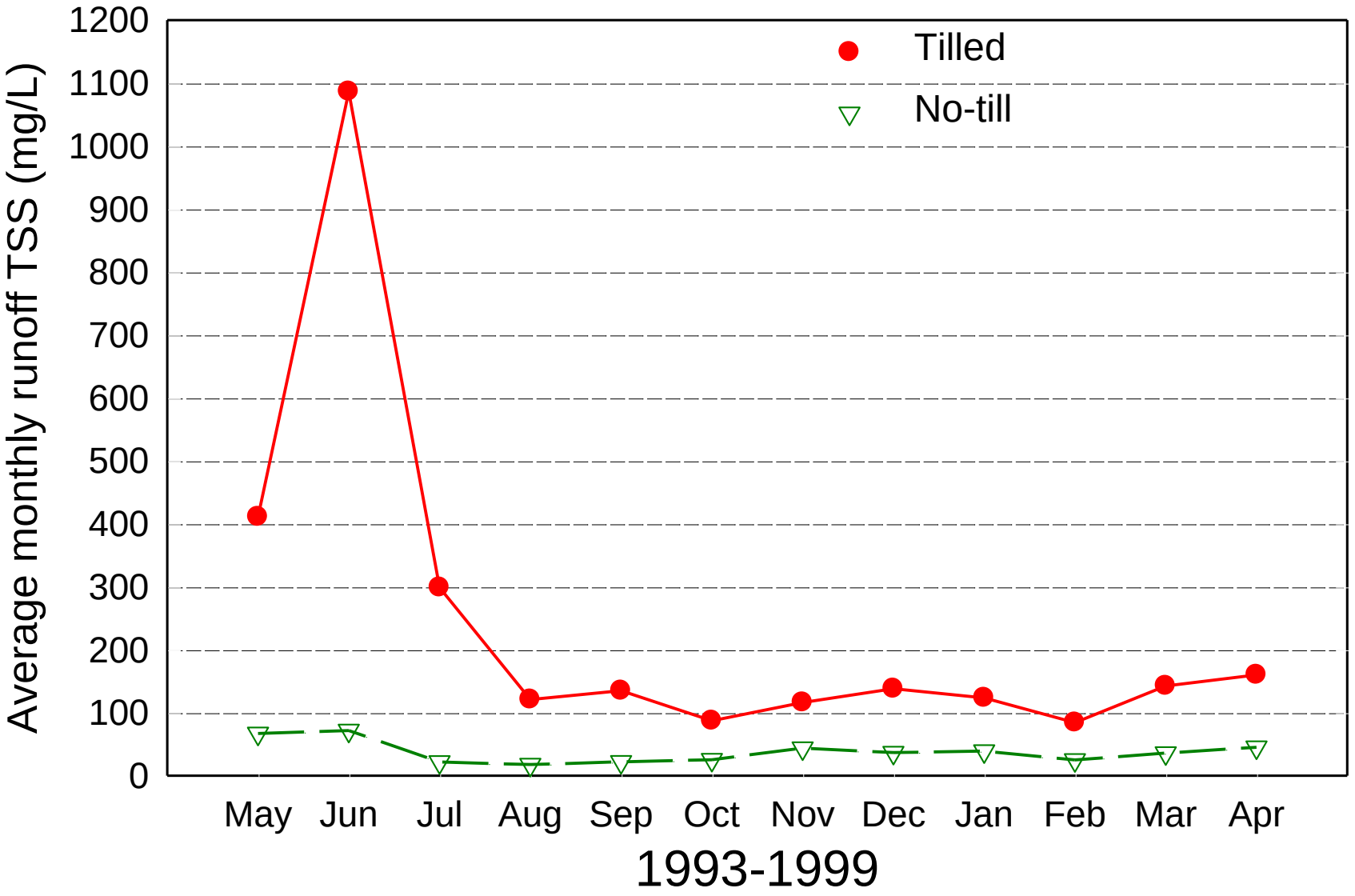
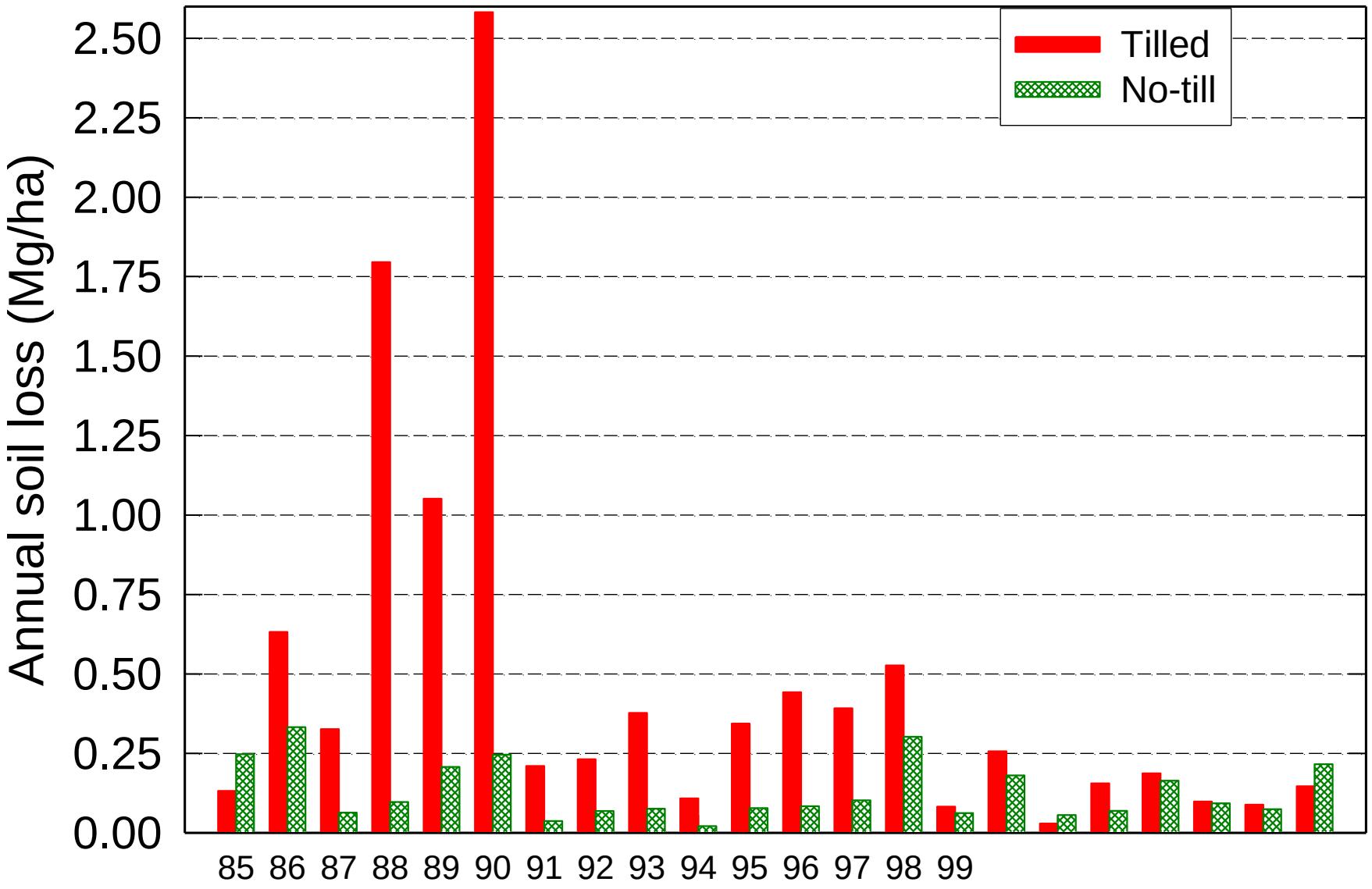
Watershed Management

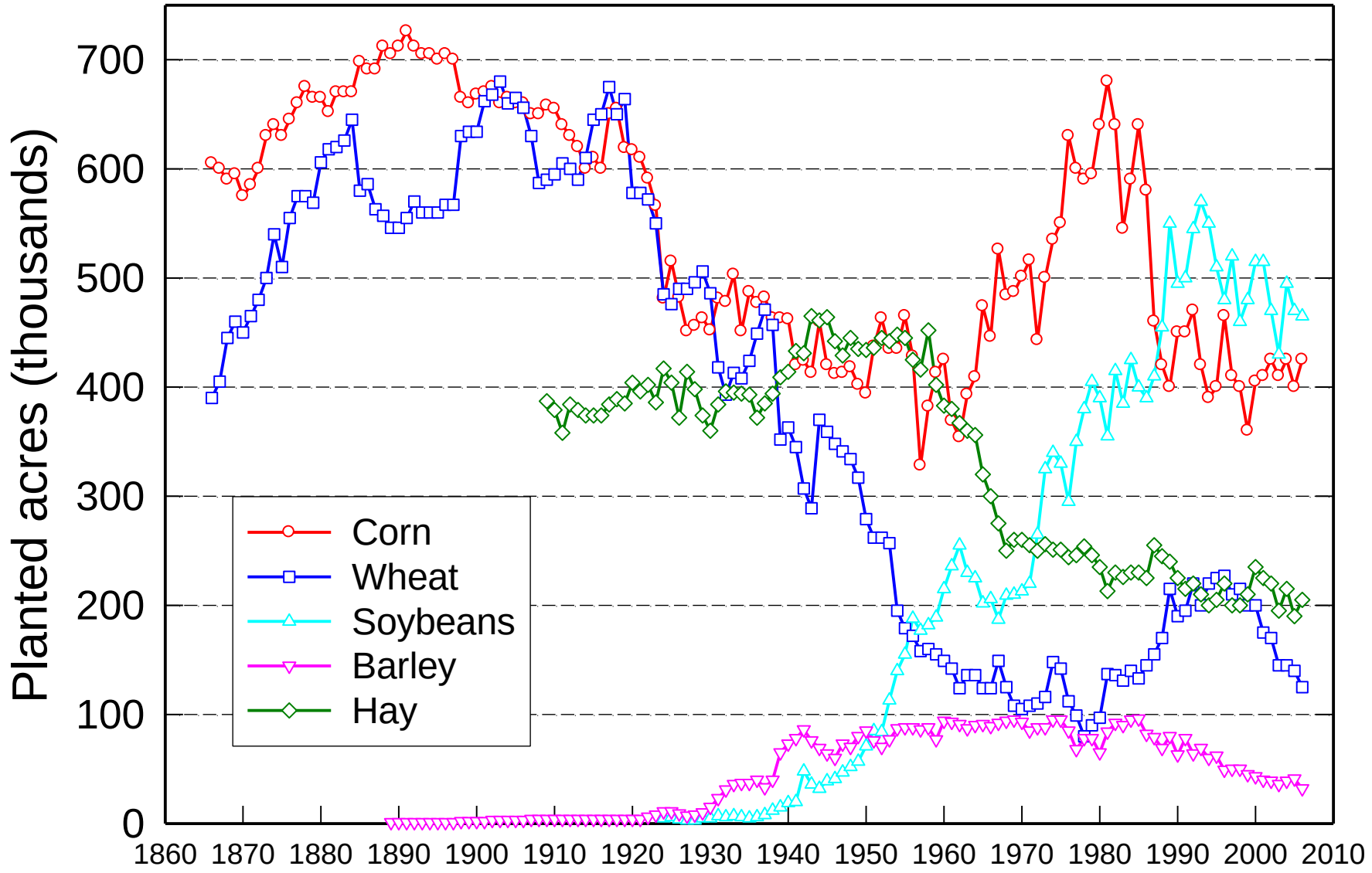
- 1985-97 continuous corn, CT/NT
- 1988-97 rye winter cover crops
- 1990 installed grass waterways
- 1994-97 No P applications
- 1998-2003 corn/wheat/dc soybean
- 1998-2003 CT/NT poultry litter
- 2004-07 surface/subsurface N
- 2008-09 NT/turbotill poultry litter


Monthly surface runoff (cm)
0
1
2
3
4
5
6
7
8
9
10
11
Tilled
No-till
O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A
1997
1998
1999
2000
2001
2002

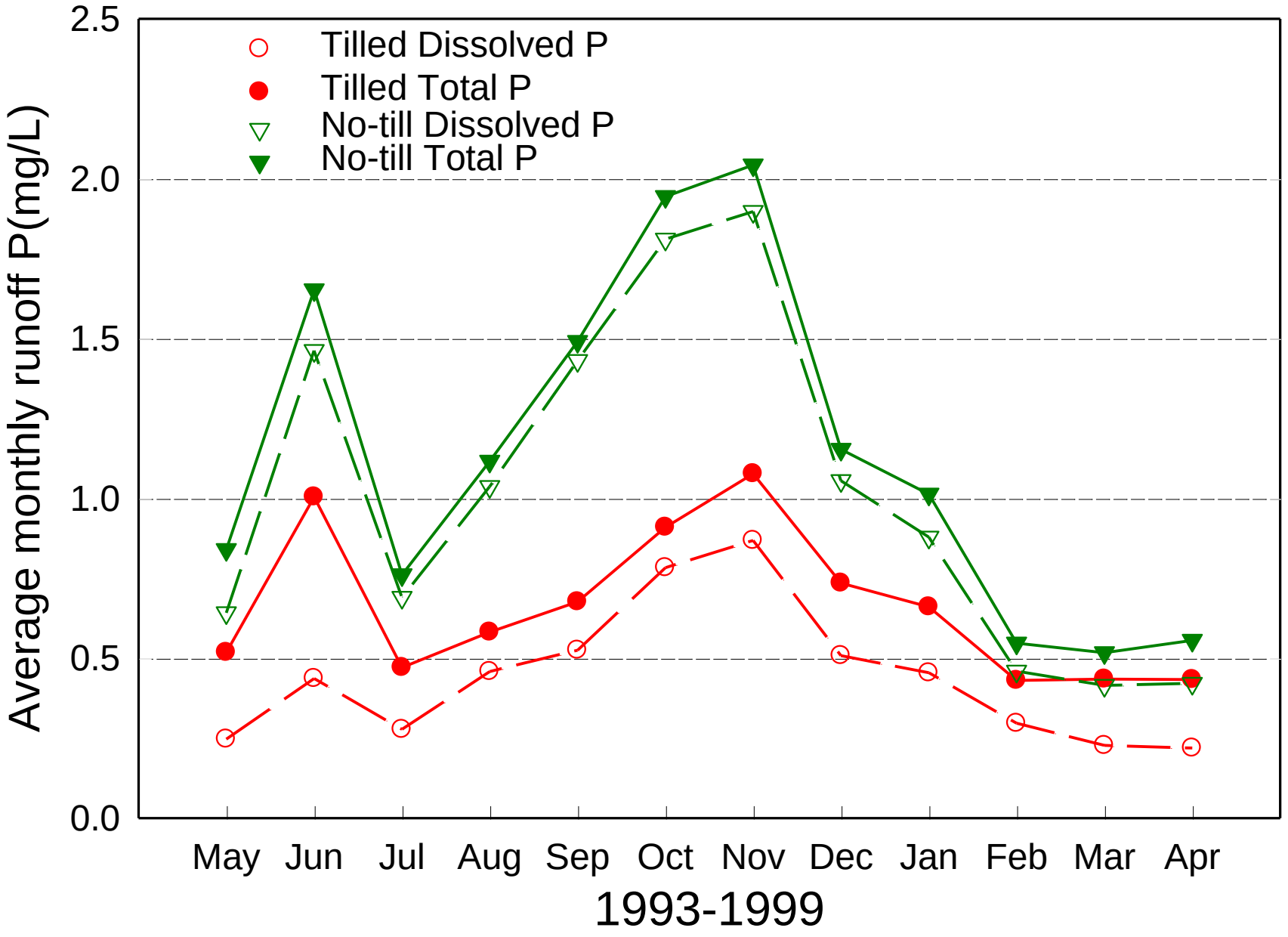

Tilled (15.5 cm)
No-till (15.6 cm)
Annual surface runoff (cm)
0
5
10
15
20
25
30
35
40
45
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003

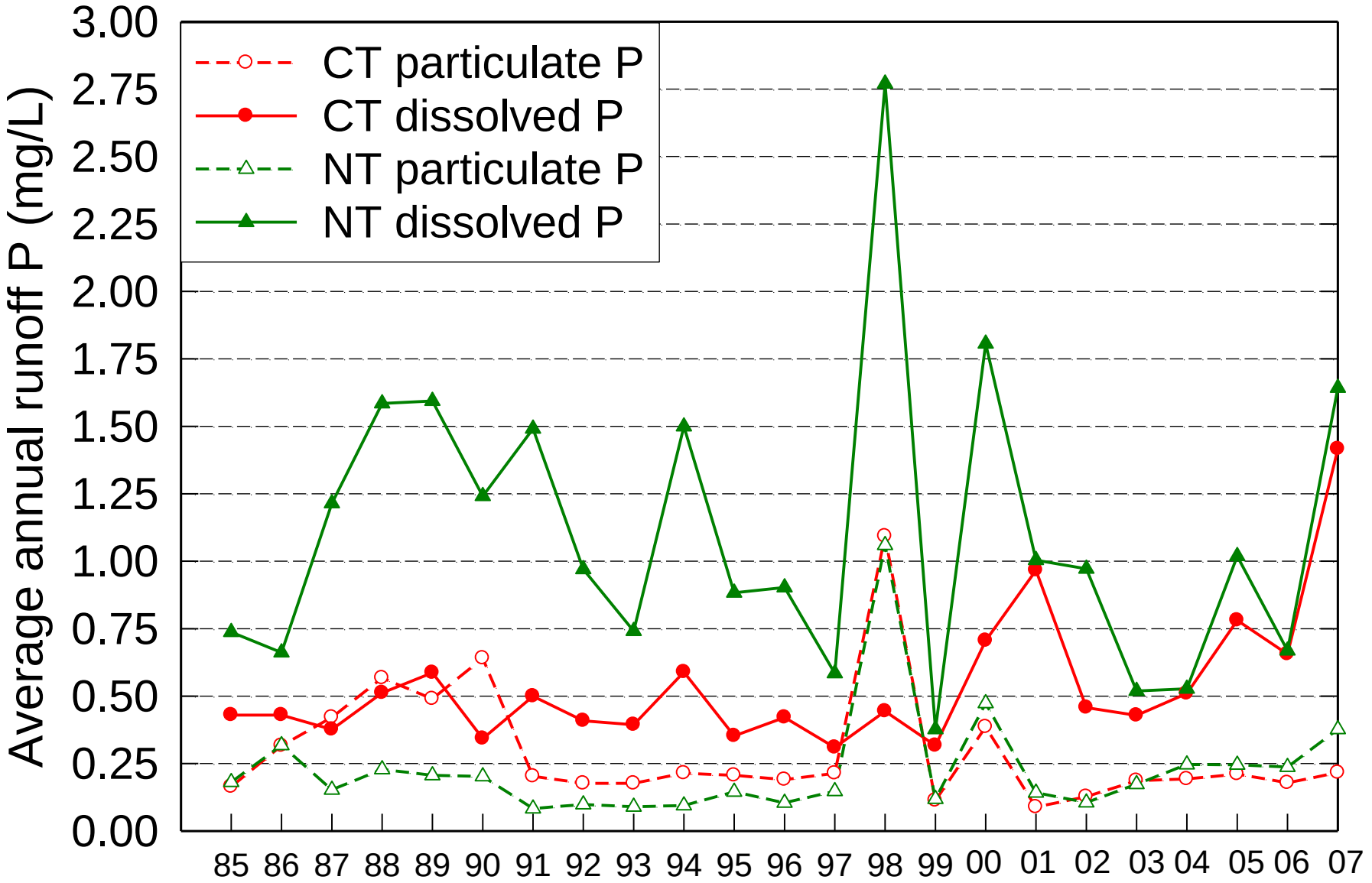

Average monthly runoff TSS (mg/L)
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
Tilled
No-till
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
1993-1999

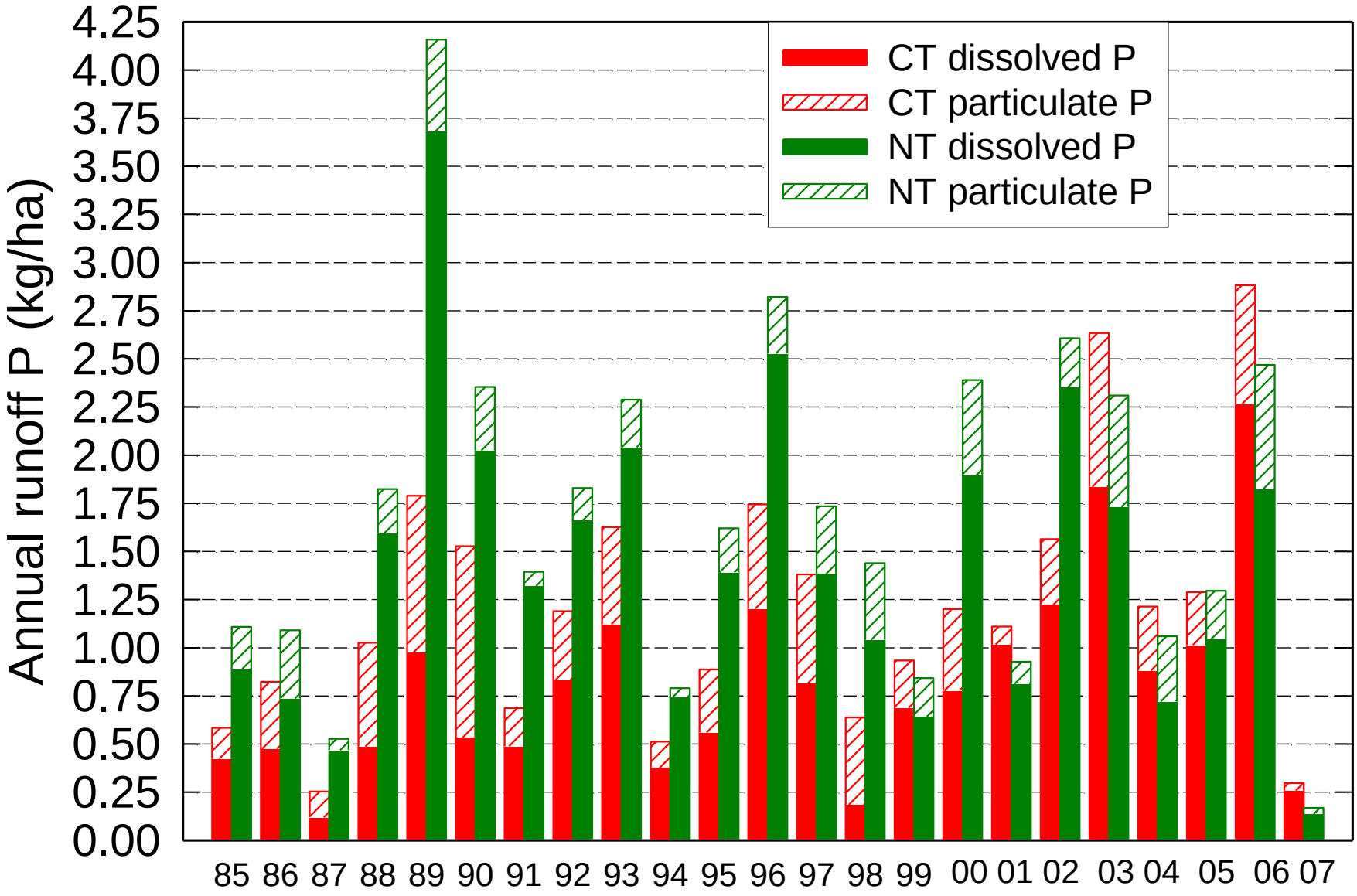

Annual soil loss (Mg/ha)
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
Tilled
No-till
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99

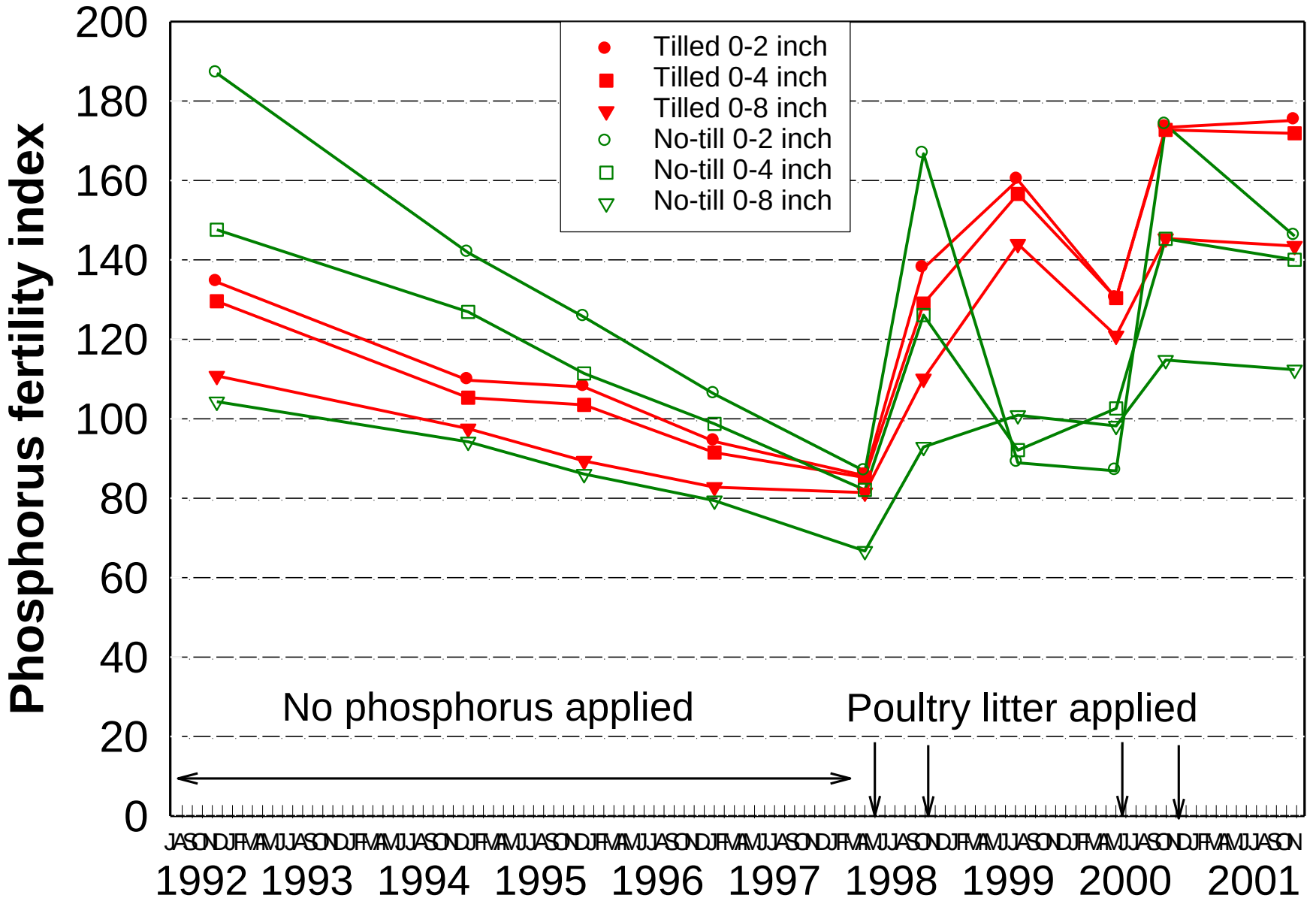

Planted acres (thousands)
700
600
500
400
300
200
100
0
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Corn
Wheat
Soybeans
Barley
Hay

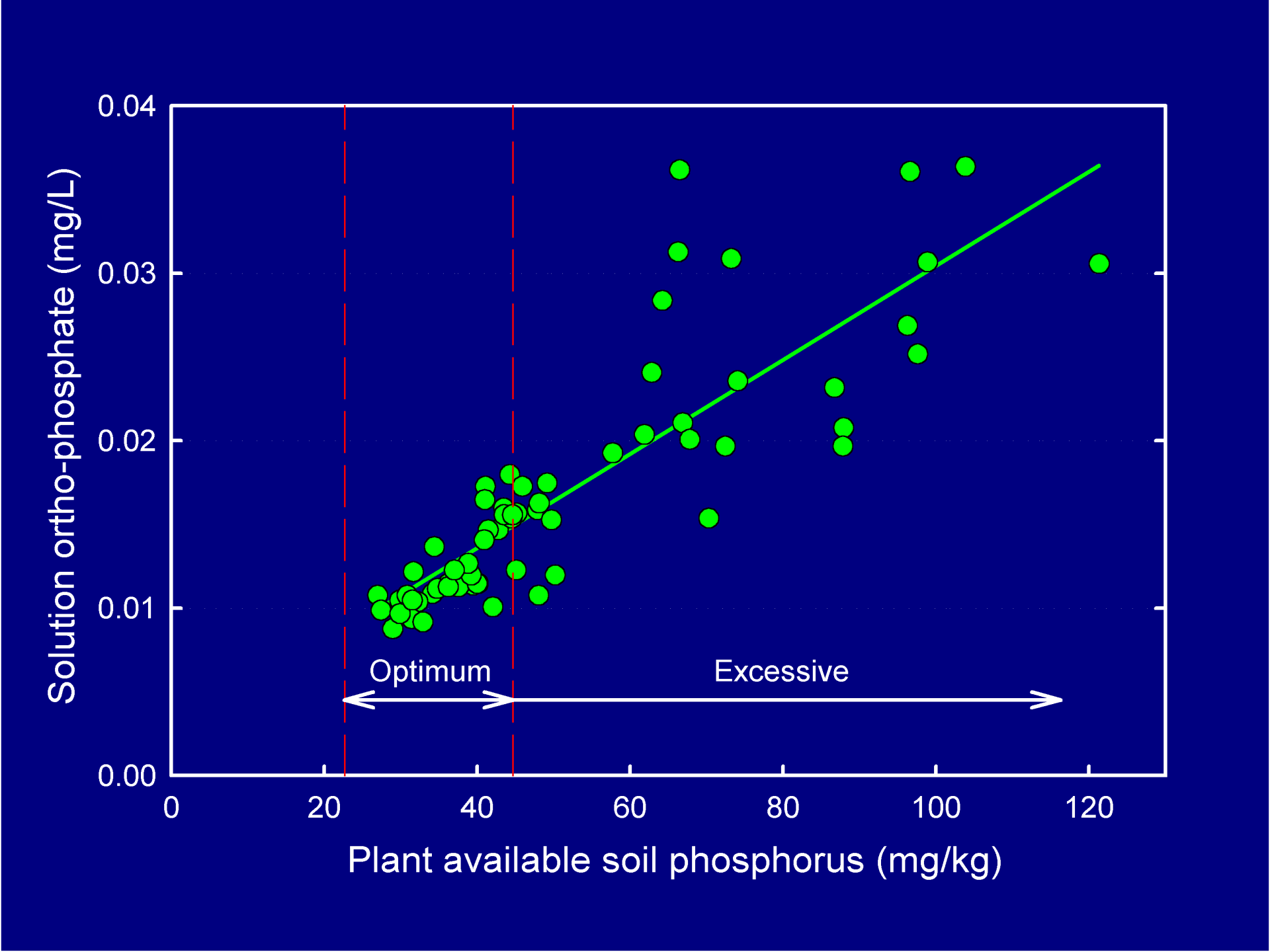
Unfortunately, erosion control did not translate into phosphorus control.


Tilled Dissolved P
Tilled Total P
No-till Dissolved P
No-till Total P
Average monthly runoff P(mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
1993-1999


Average annual runoff P (mg/L)
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
CT particulate P
CT dissolved P
NT particulate P
NT dissolved P
85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07

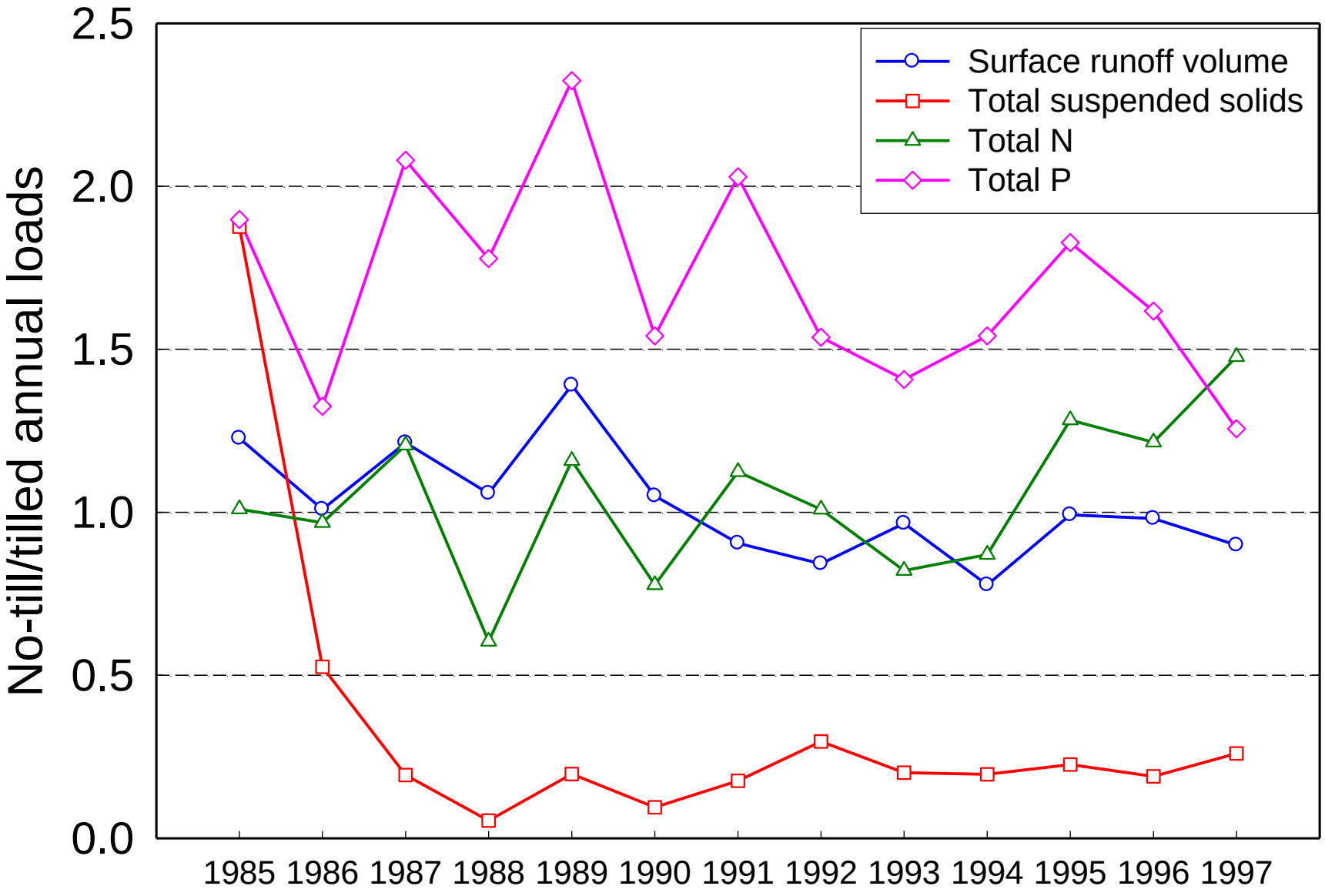

Annual runoff P (kg/ha)
4.25
4.00
3.75
3.50
3.25
3.00
2.75
2.50
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
CT dissolved P
CT particulate P
NT dissolved P
NT particulate P
85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07

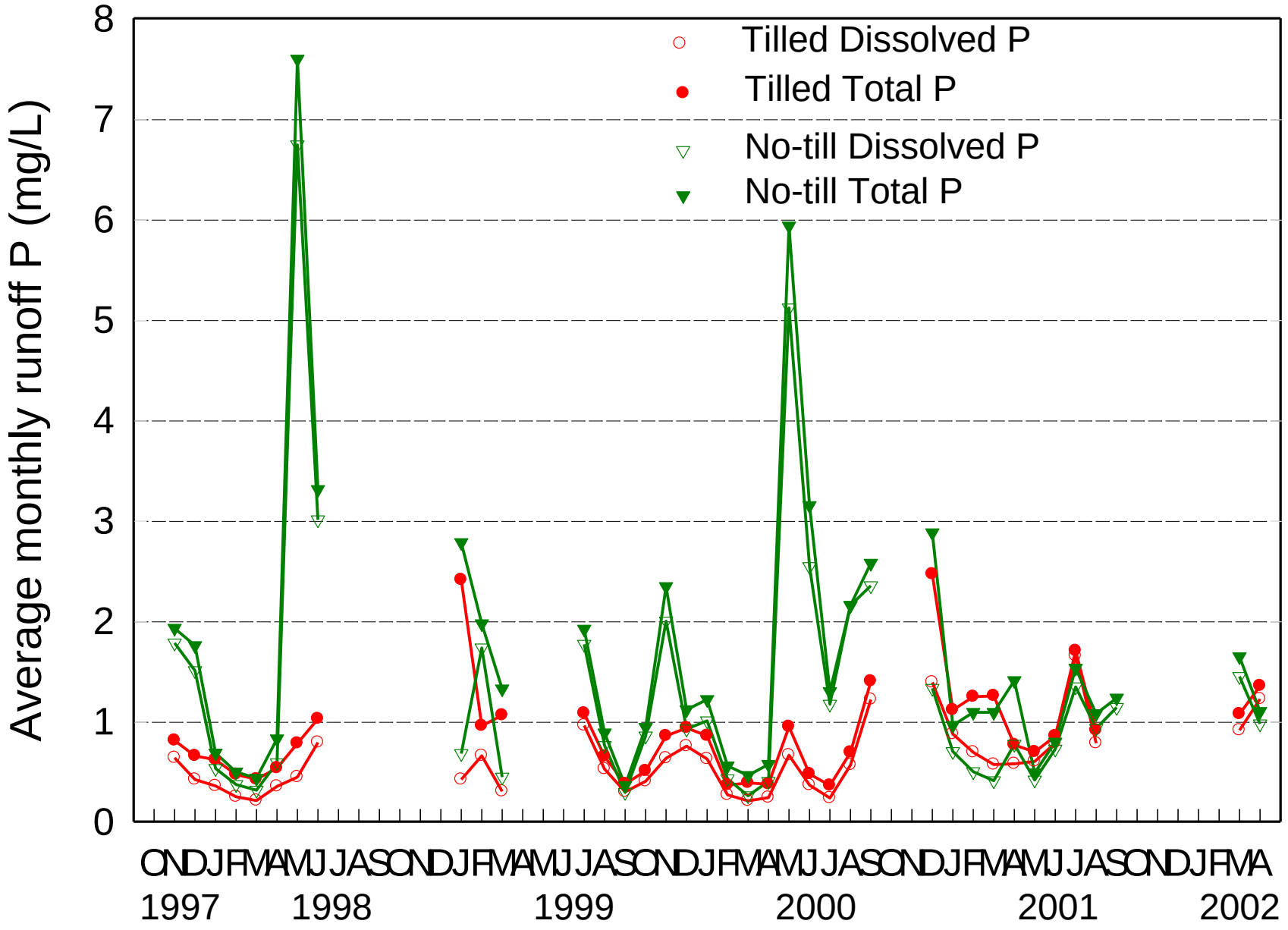

Phosphorus fertility index
200
180
160
140
120
100
80
60
40
20
0
Tilled 0-2 inch
Tilled 0-4 inch
Tilled 0-8 inch
No-till 0-2 inch
No-till 0-4 inch
No-till 0-8 inch
No phosphorus applied
Poultry litter applied
JASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASONDJFMAMJJASON
1992 1993 1994 1995 1996 1997 1998 1999 2000 2001


0.04
0.03
0.02
0.01
0.00
Solution ortho-phosphate (mg/L)
0
20
40
60
80
100
120
Plant available soil phosphorus (mg/kg)
Optimum
Excessive

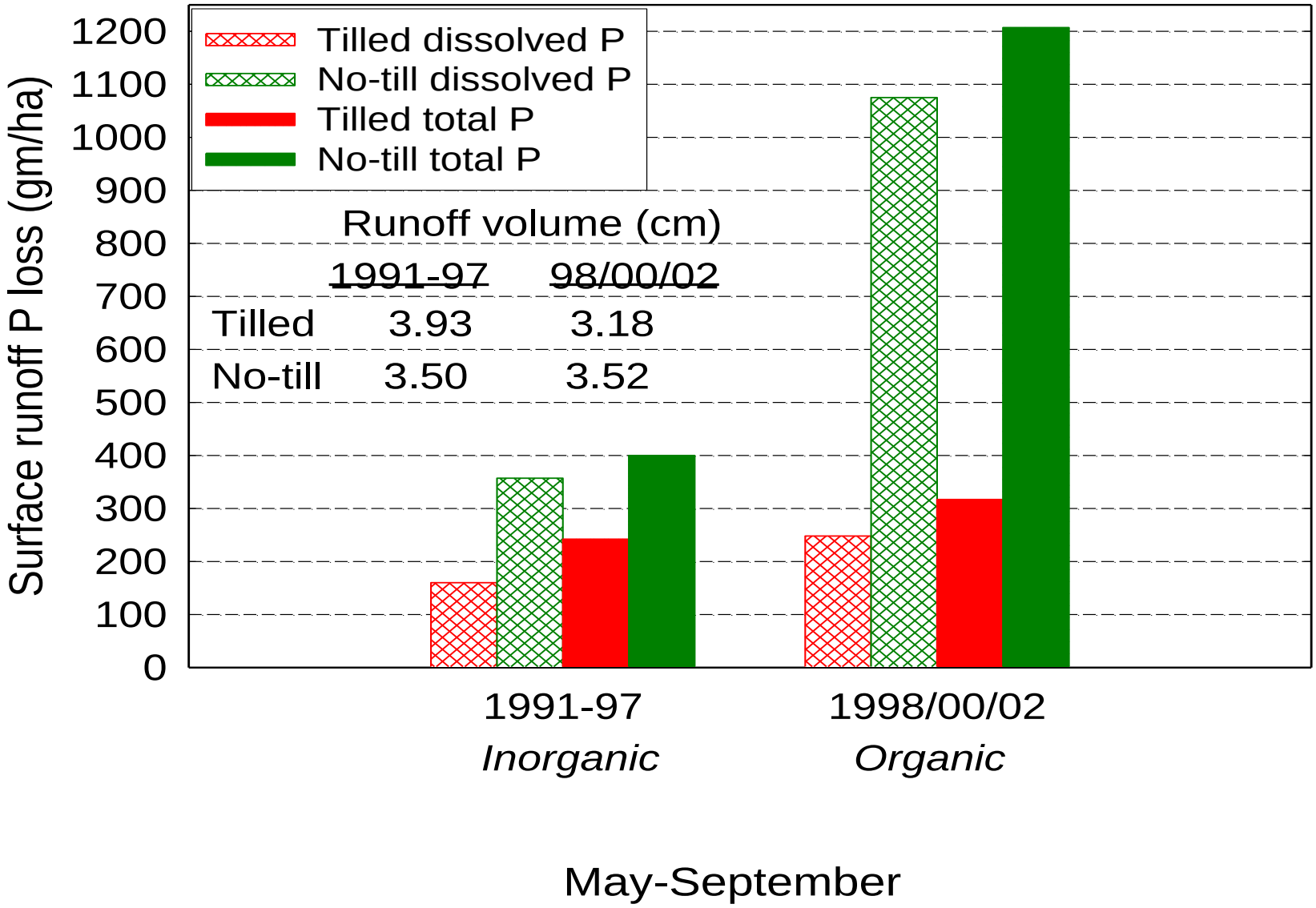
Sims et al. 2002 SSAJ

"We conclude that routine soil tests, such as Mehlich 3, can be an effective interim approach to guide environmentally based P recommendations for fertilizers, manures, biosolids and other P sources… Higher risks are clearly associated with M3-P values that are above the concentrations needed for economically optimum crop yields. "


No-till/tilled annual loads
2.5
2.0
1.5
1.0
0.5
0.0
1985 1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997
Surface runoff volume
Total suspended solids
Total N
Total P


Average monthly runoff P (mg/L)
0
1
2
3
4
5
6
7
8
Tilled Dissolved P
Tilled Total P
No-till Dissolved P
No-till Total P
O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A
1997
1998
1999
2000
2001
2002

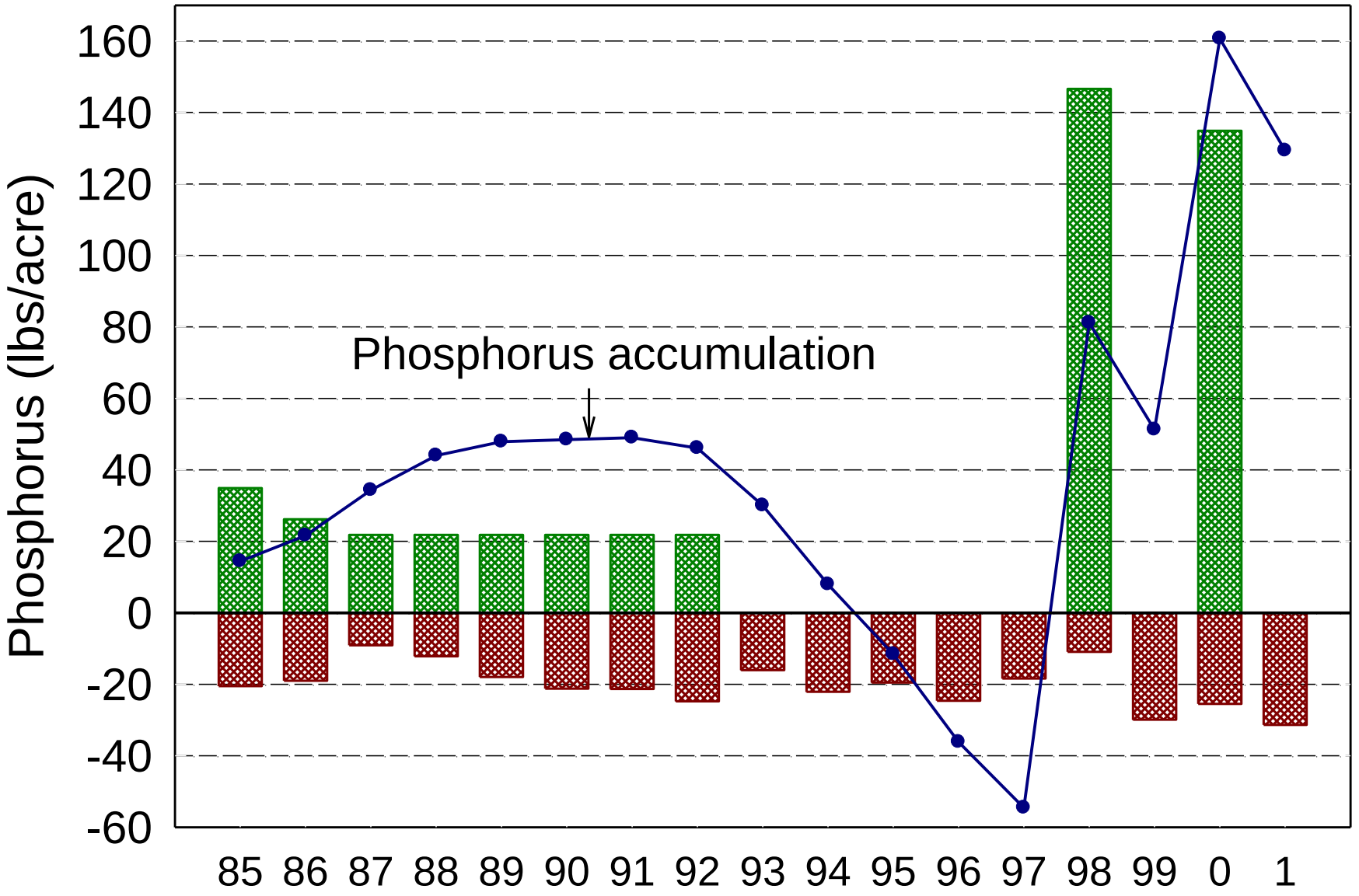
Effect of Tillage on P Losses



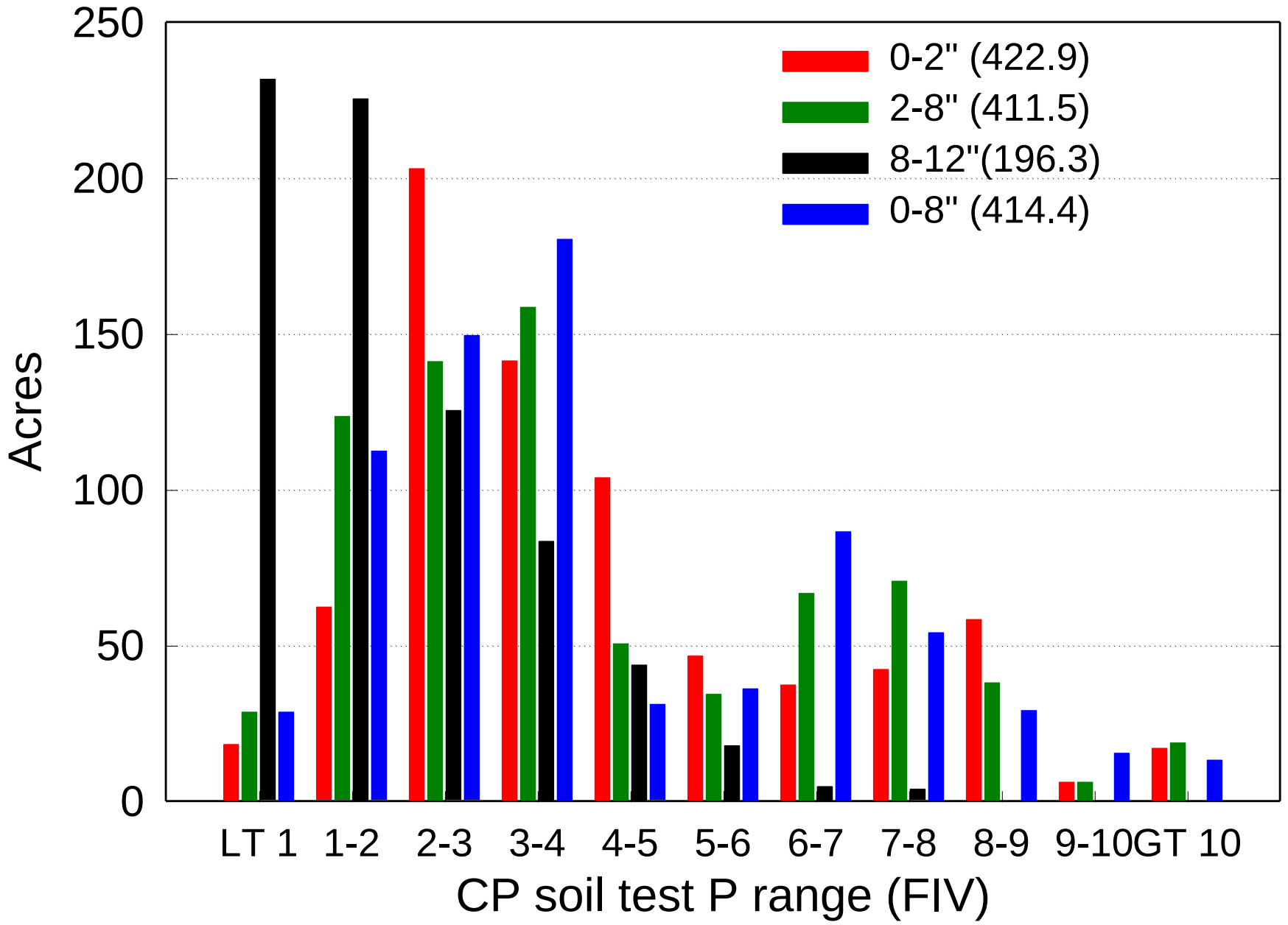
How P applications are managed is crucial to controlling P losses in surface runoff, independent of soil P levels.

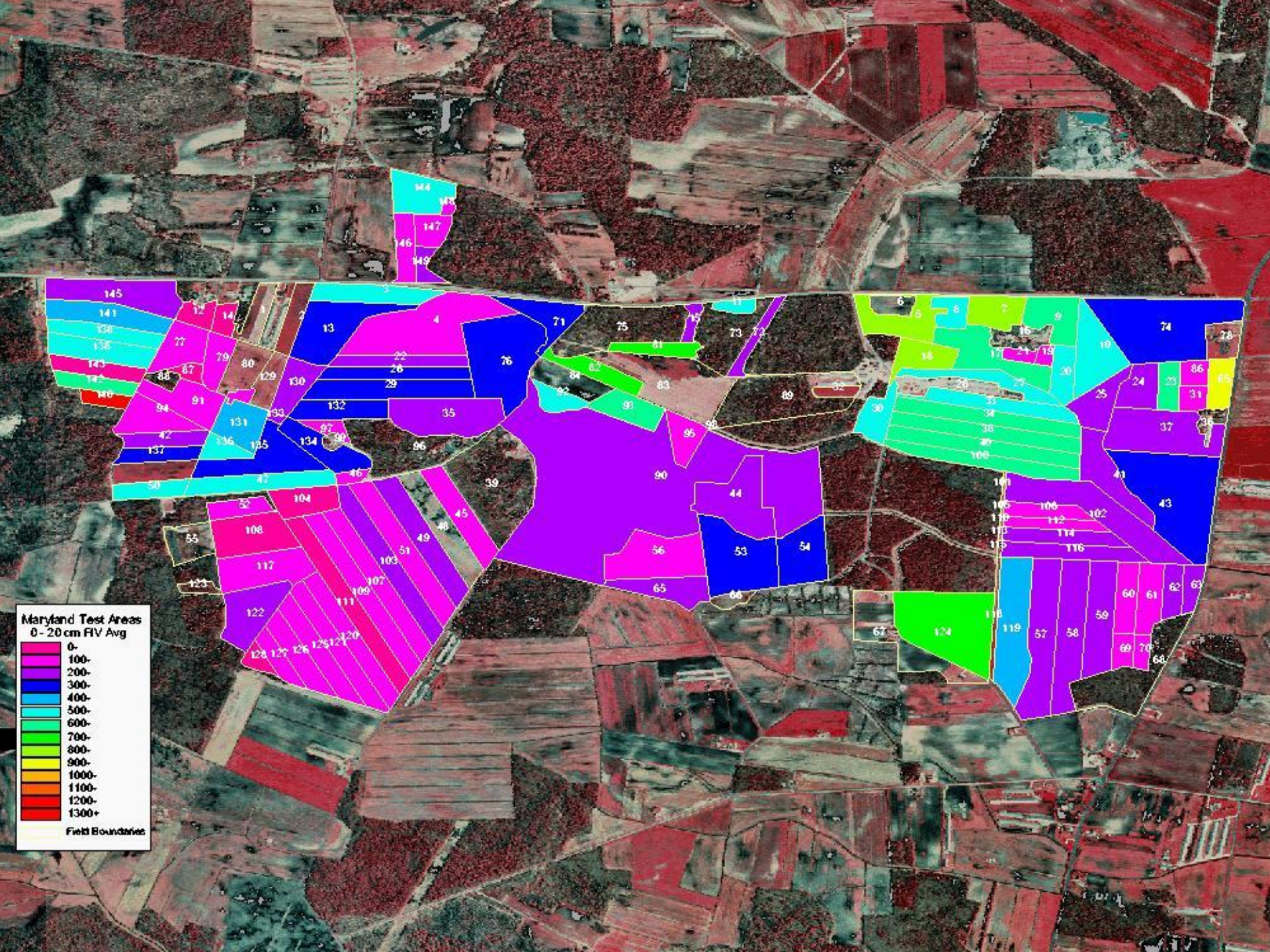
Pocomoke River Watershed

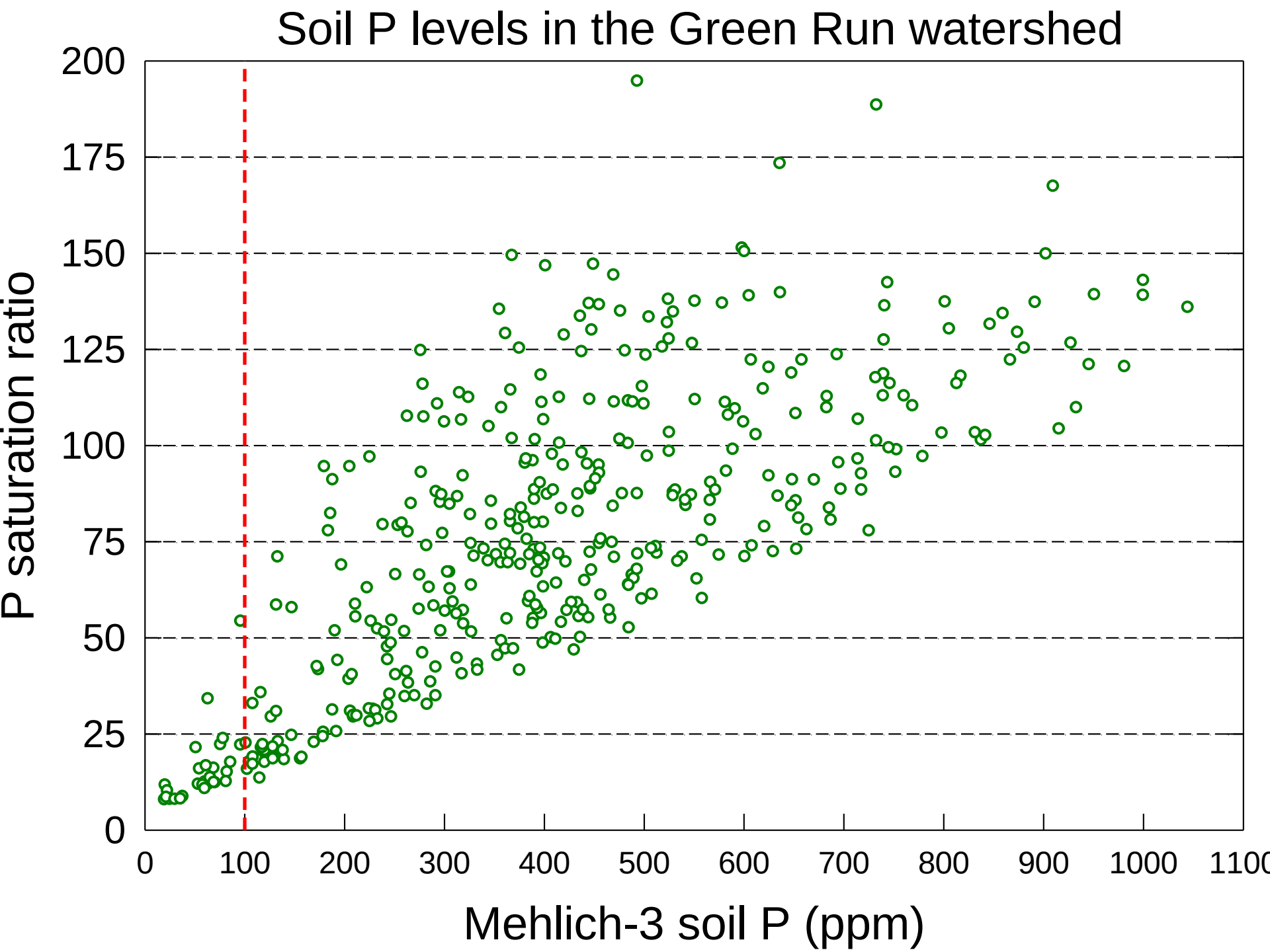
- 4 million lbs poultry litter P/year
- 100,000 acres cropland
- 40 lbs P/acre/year applied
- 20 lbs P/acre/year removed in harvested grain

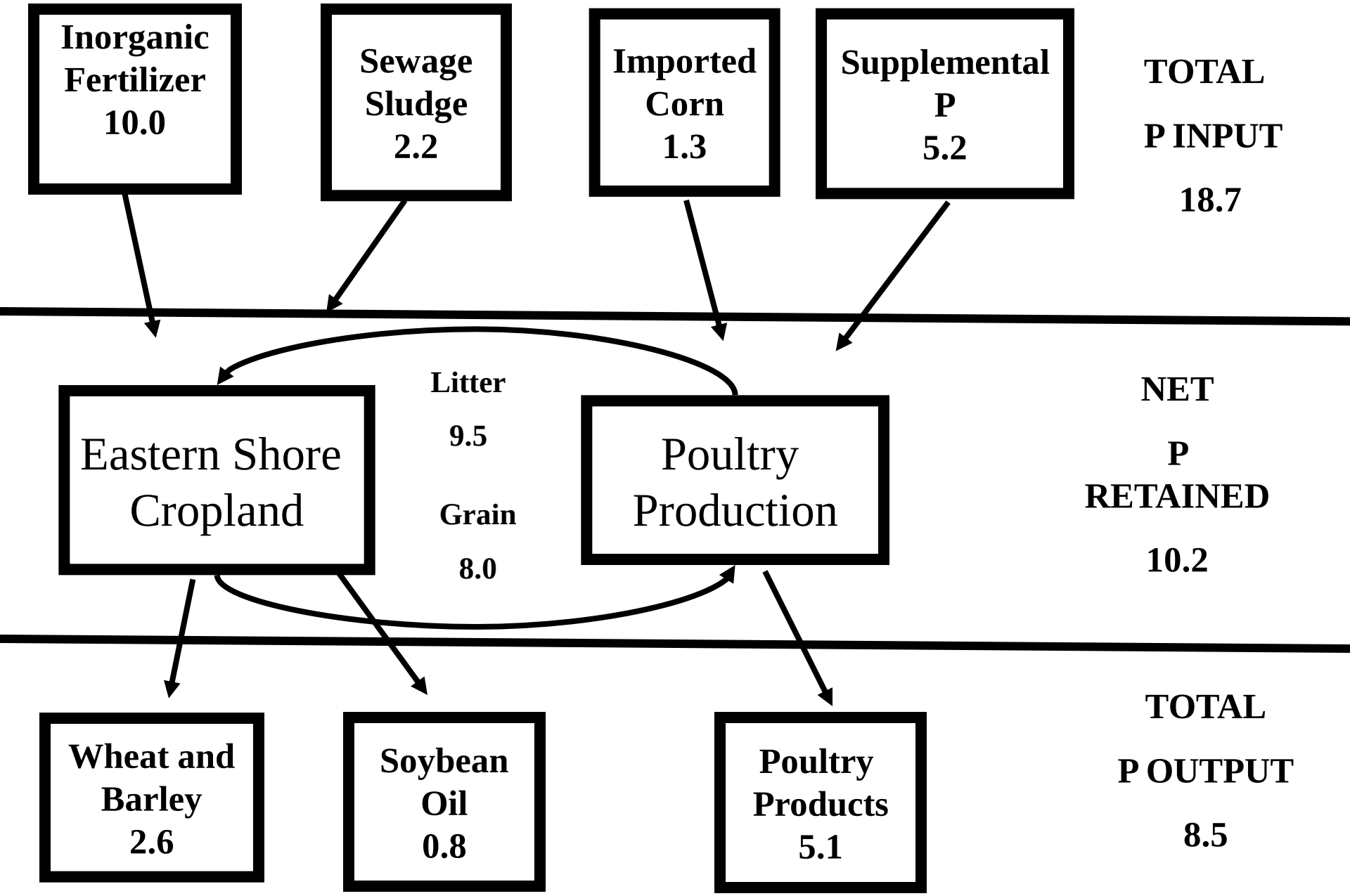

Phosphorus (lbs/acre)
160
140
120
100
80
60
40
20
0
-20
-40
-60
Phosphorus accumulation
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
0
1

Since the effort started to reduce nonpoint source nutrient loads in Maryland, the quantity of P stored in cropland in the Pocomoke River drainage basin increased by approximately 25 million pounds.

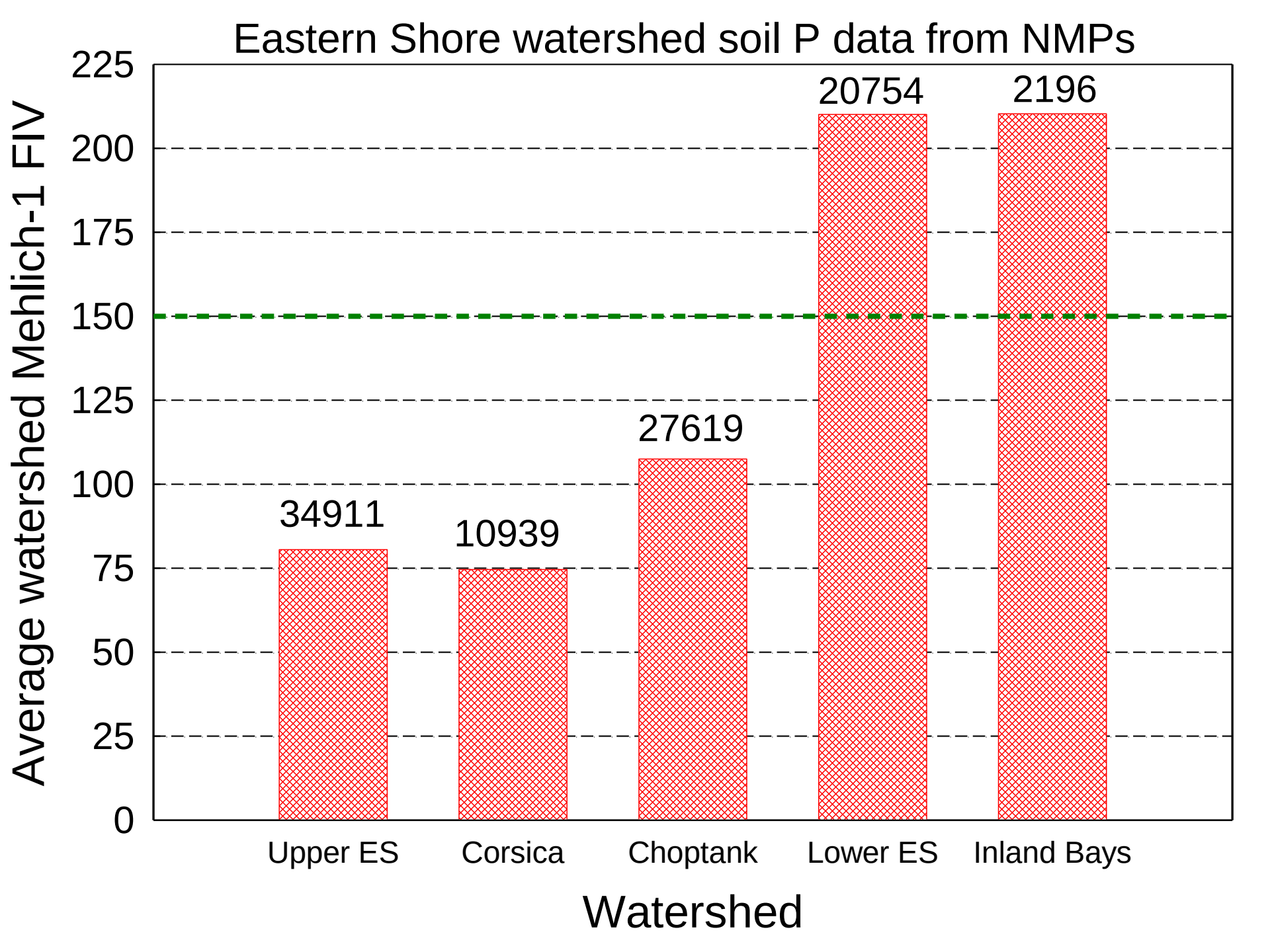

250
200
150
100
50
0
Acres
0-2" (422.9)
2-8" (411.5)
8-12"(196.3)
0-8" (414.4)
LT 1
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
9-10
GT 10
CP soil test P range (FIV)


Maryland Test Areas
0 - 20 cm PIV Avg
0-
100-
200-
300-
400-
500-
600-
700-
800-
900-
1000-
1100-
1200-
1300+
Field Boundaries


Soil P levels in the Green Run watershed
P saturation ratio
Mehlich-3 soil P (ppm)
0
25
50
75
100
125
150
175
200
0
100
200
300
400
500
600
700
800
900
1000
1100



Source: Kenneth Staver, Wye Research and Education Center


Eastern Shore watershed soil P data from NMPs
Average watershed Mehlich-1 FIV
225
200
175
150
125
100
75
50
25
0
34911
10939
27619
20754
2196
Upper ES
Corsica
Choptank
Lower ES
Inland Bays
Watershed

Where can we make progress?

- Erosion control still important,but
- Subsurface apply inorganic P
- Incorporate organic wastes
- Aim for “Optimum” soil FIV-budgets
- GPS/GIS based tracking of watershed soil P levels
- Buffers/ditch management

Agriculture and Phosphorus Management

The Chesapeake Bay

Edited by Andrew N. Sharpley

Concluding Remarks

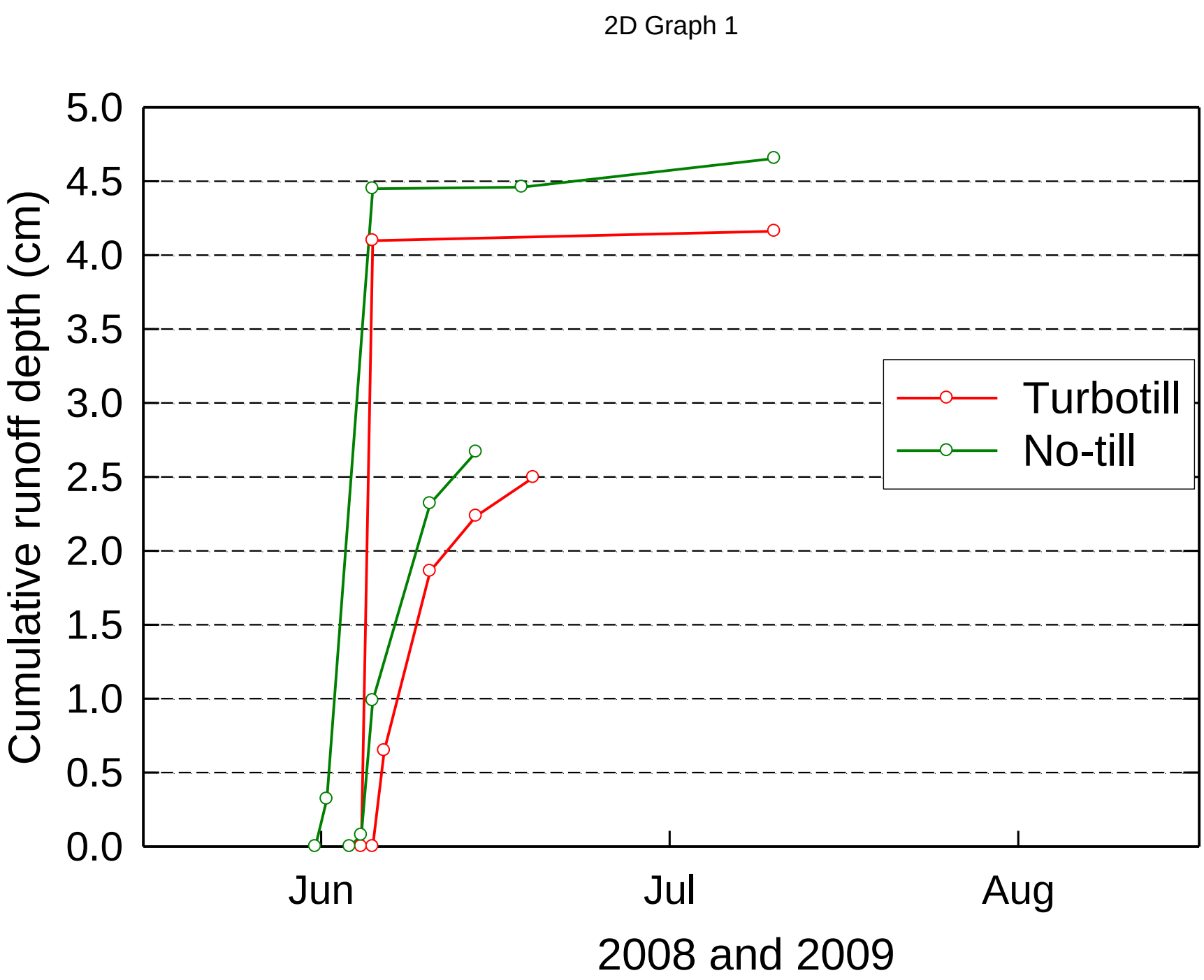
"The overall long-term goal of efforts to reduce P losses from agriculture to surface waters should aim to balance off-farm inputs of P in feed and fertilizer with P outputs as produce, along with managing soils in ways that retain nutrients and applied P resources."

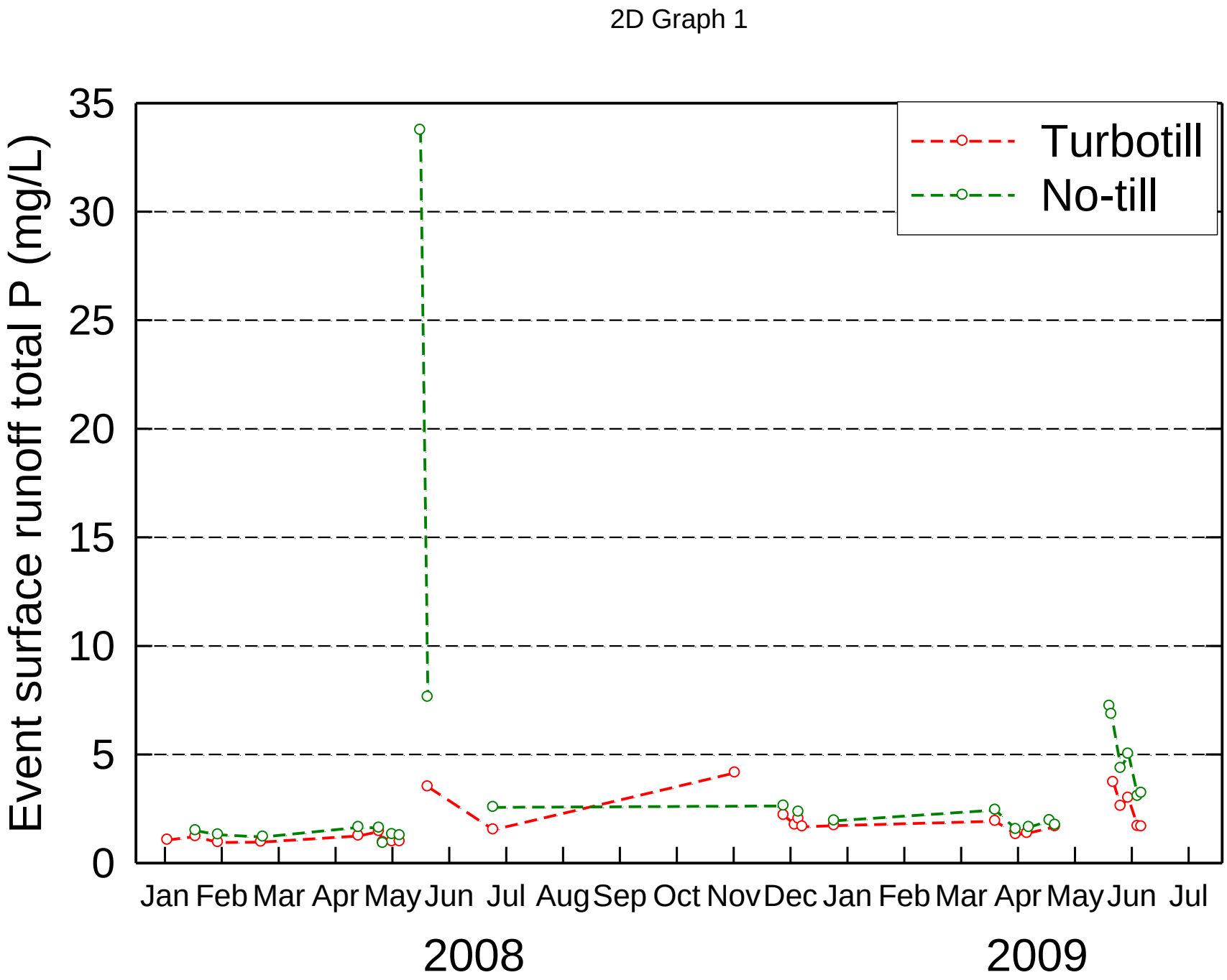

CASE IH

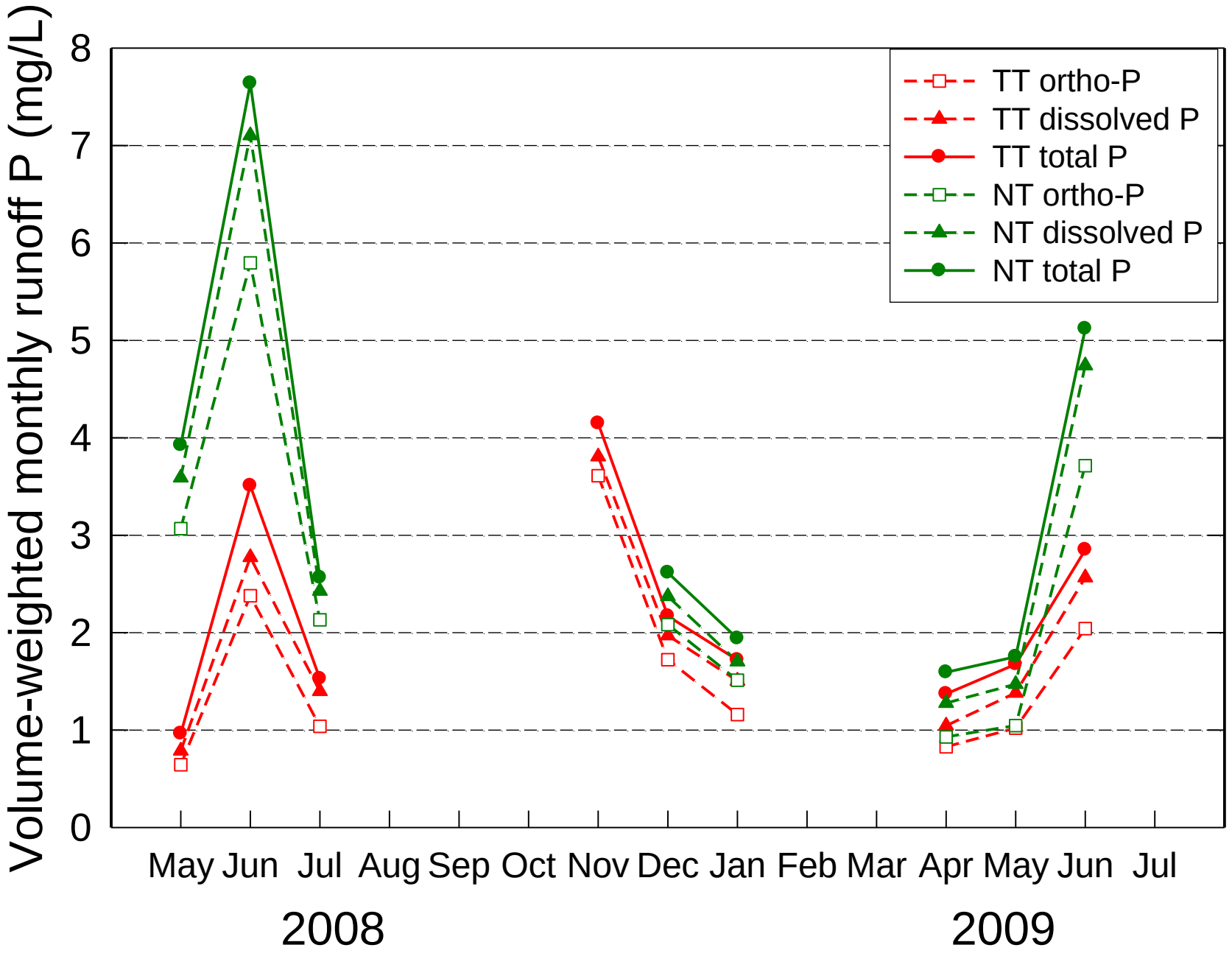
Forty Percent Nutrient Reduction Strategy for Choptank Watershed (1995)

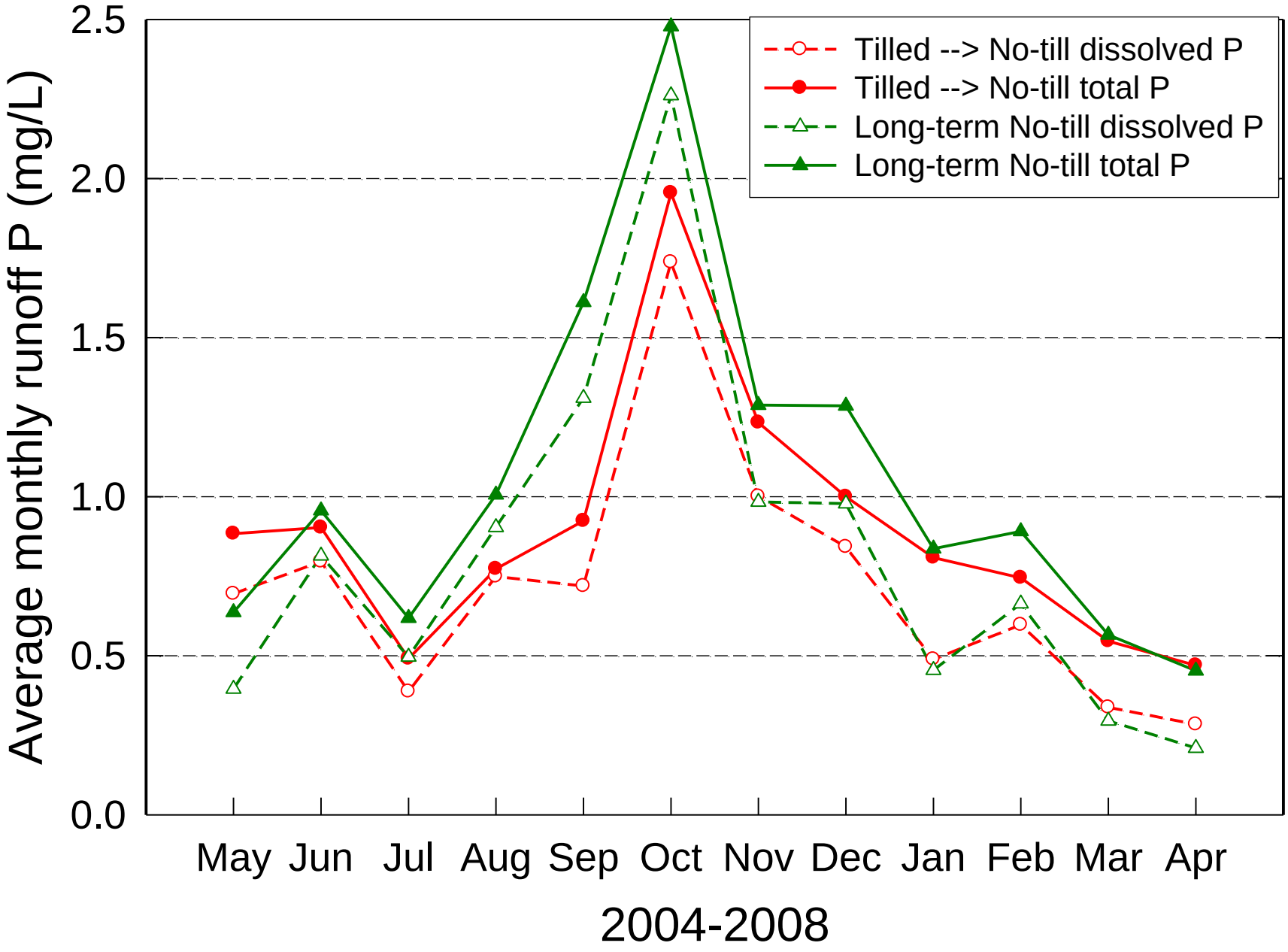
Practice	Coverage (acres)	N Load Reduction	P Load Reduction
Soil Cons./Water Quality Plan	35,893	73,222	6,820
Conservation Tillage	27,134	103,923	8,412
Nutr. Mngmt. – Fertilizer	129,806	192,113	7,788
Nutr. Mngmt – Organic	20,443	90,768	3,680
Cover Crops	50,586	437,063	8,094

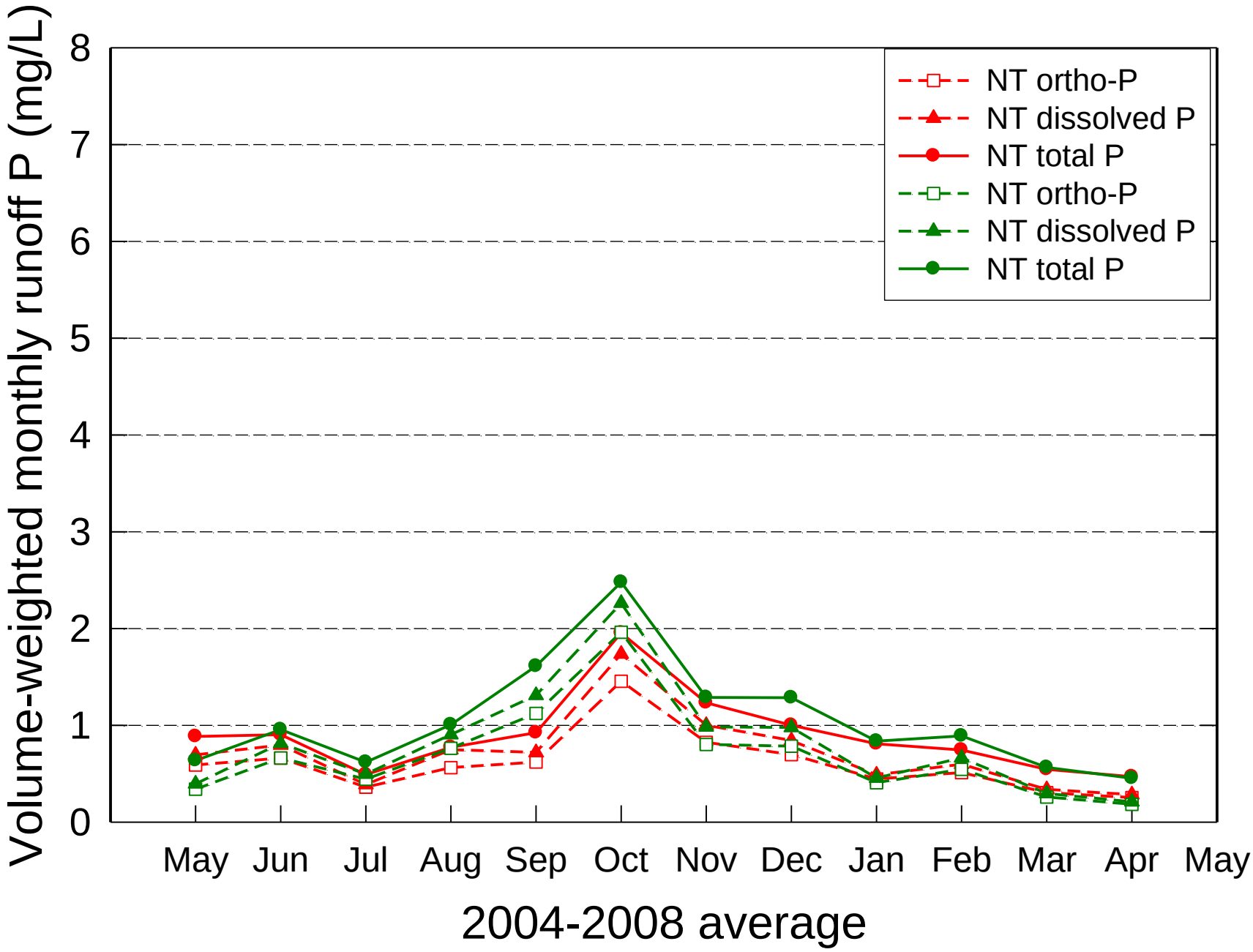
What worked?

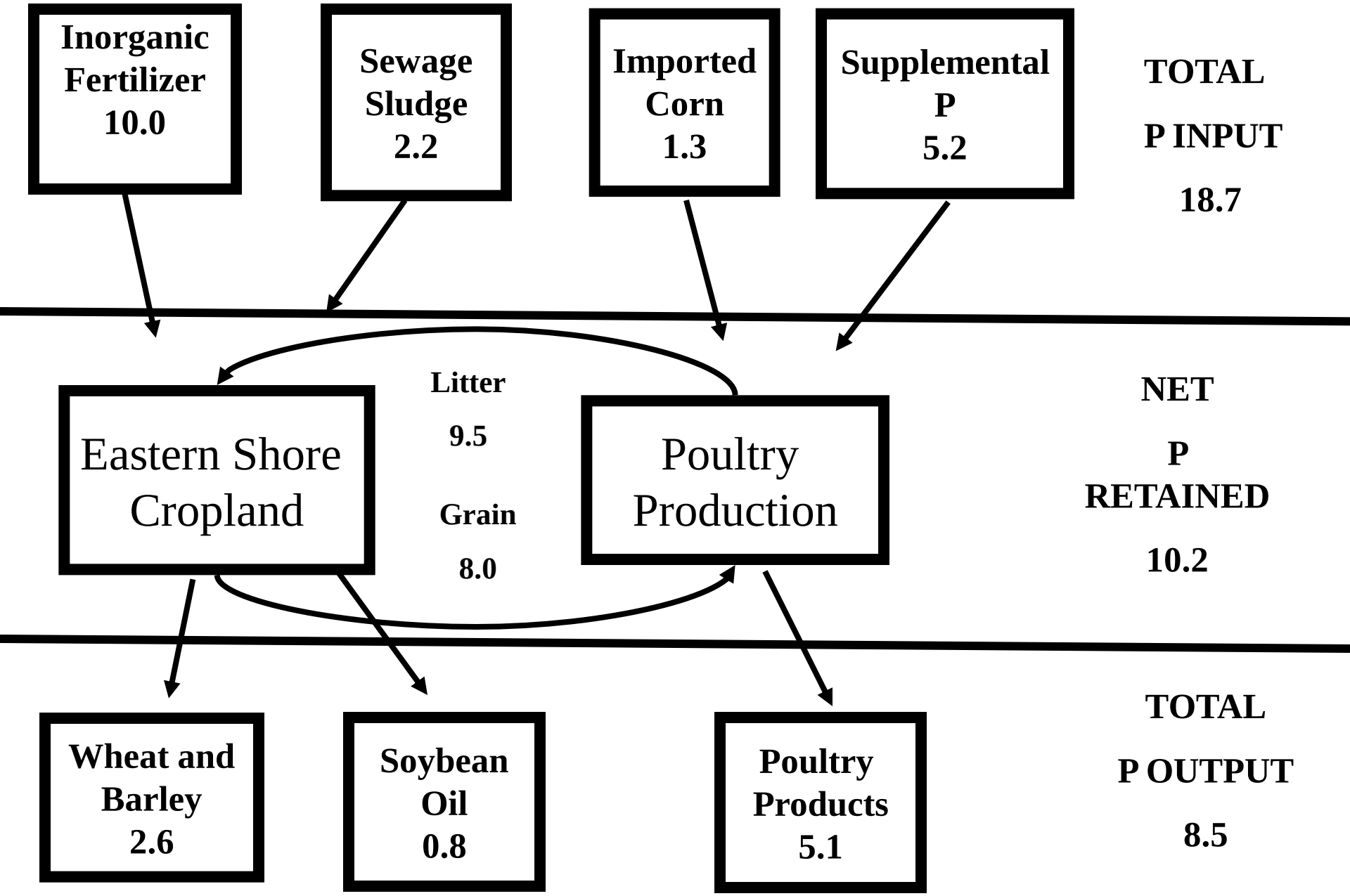

2D Graph 1
Cumulative runoff depth (cm)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Jun
Jul
Aug
2008 and 2009
Turbotill
No-till


2D Graph 1
Event surface runoff total P (mg/L)
35
30
25
20
15
10
5
0
Turbotill
No-till
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul
2008
2009

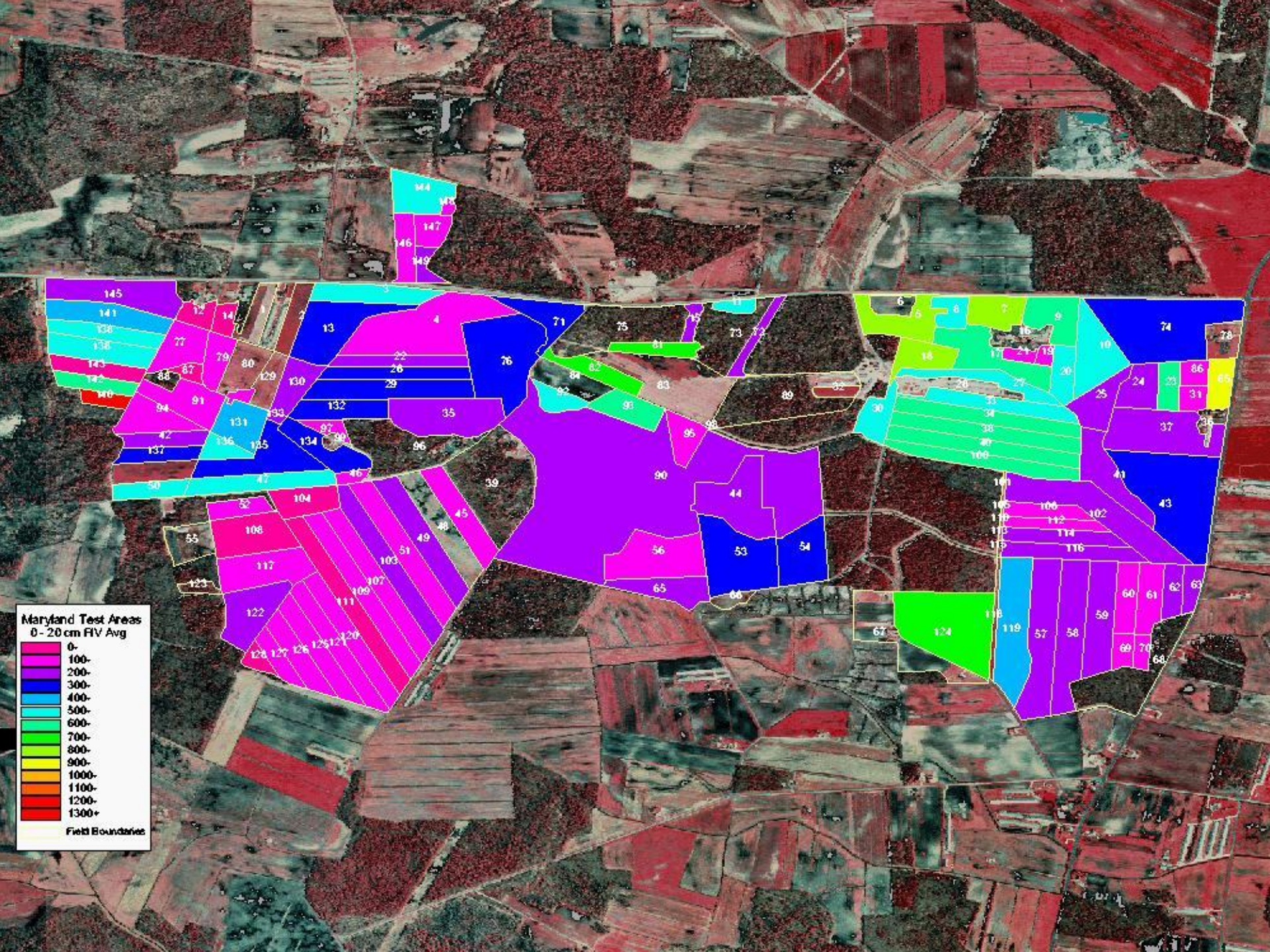

Volume-weighted monthly runoff P (mg/L)
0
1
2
3
4
5
6
7
8
TT ortho-P
TT dissolved P
TT total P
NT ortho-P
NT dissolved P
NT total P
May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul
2008
2009

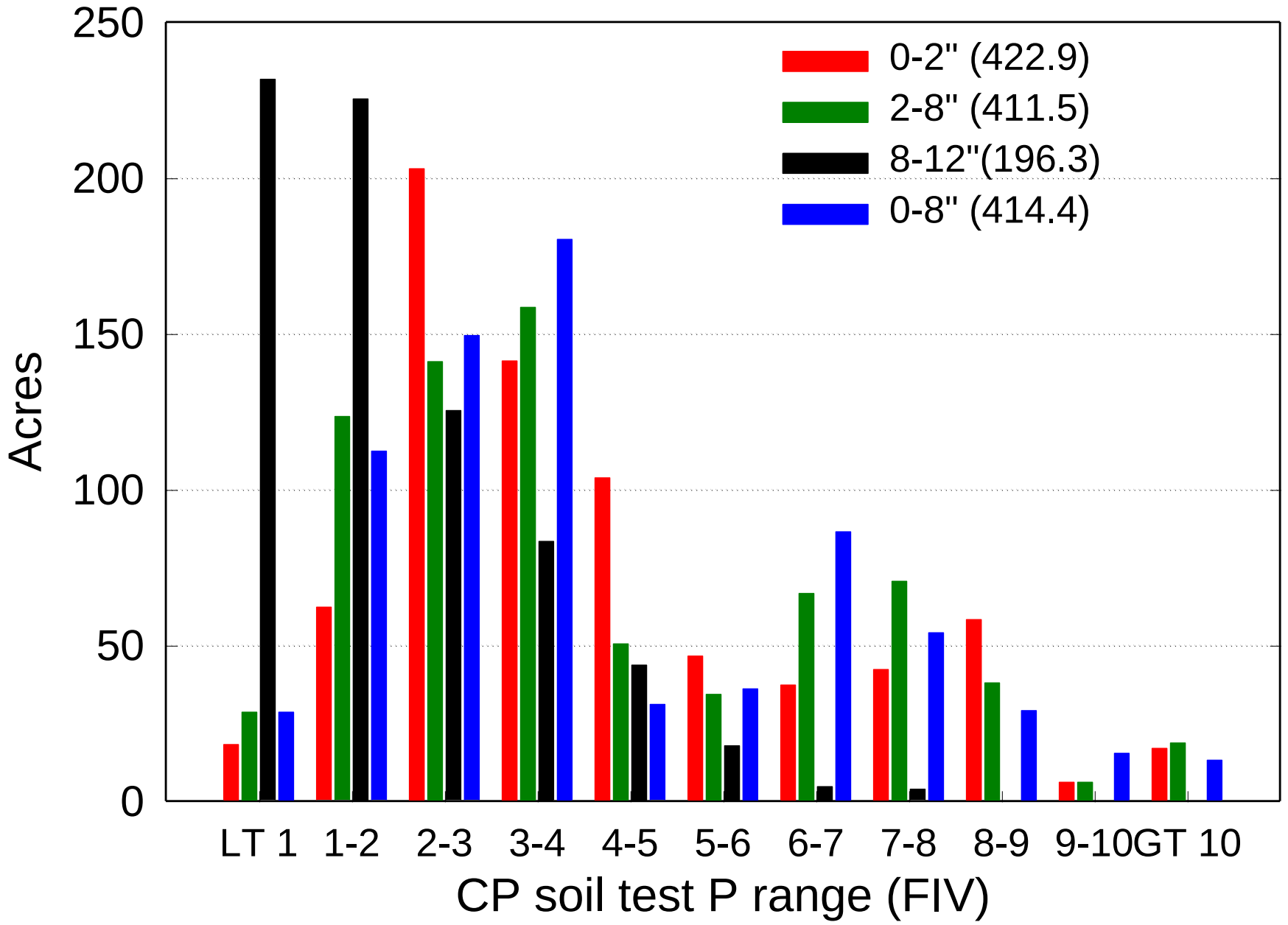

Average monthly runoff P (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
2004-2008
Tilled --> No-till dissolved P
Tilled --> No-till total P
Long-term No-till dissolved P
Long-term No-till total P

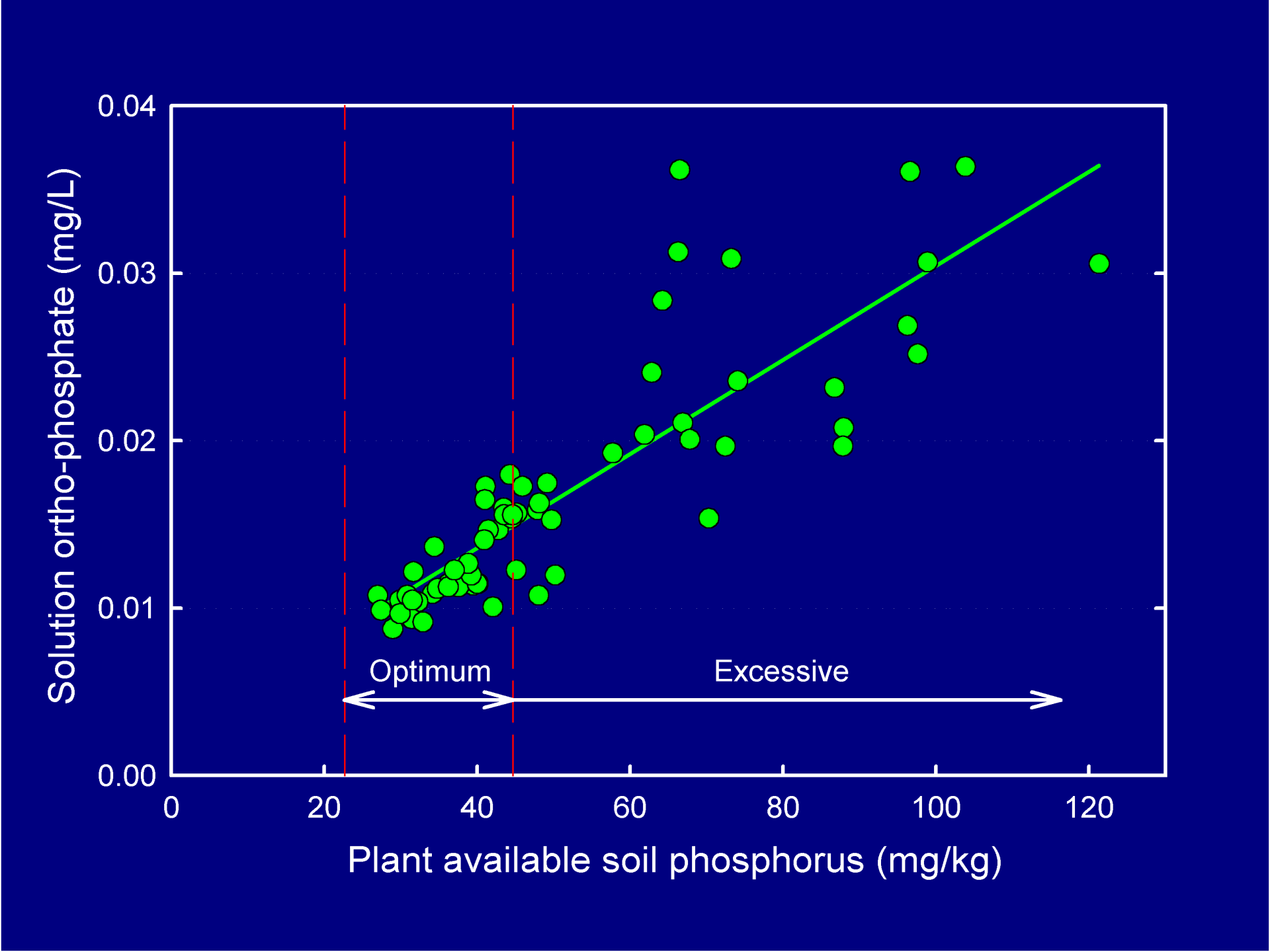

Volume-weighted monthly runoff P (mg/L)
0
1
2
3
4
5
6
7
8
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
2004-2008 average
NT ortho-P
NT dissolved P
NT total P
NT ortho-P
NT dissolved P
NT total P

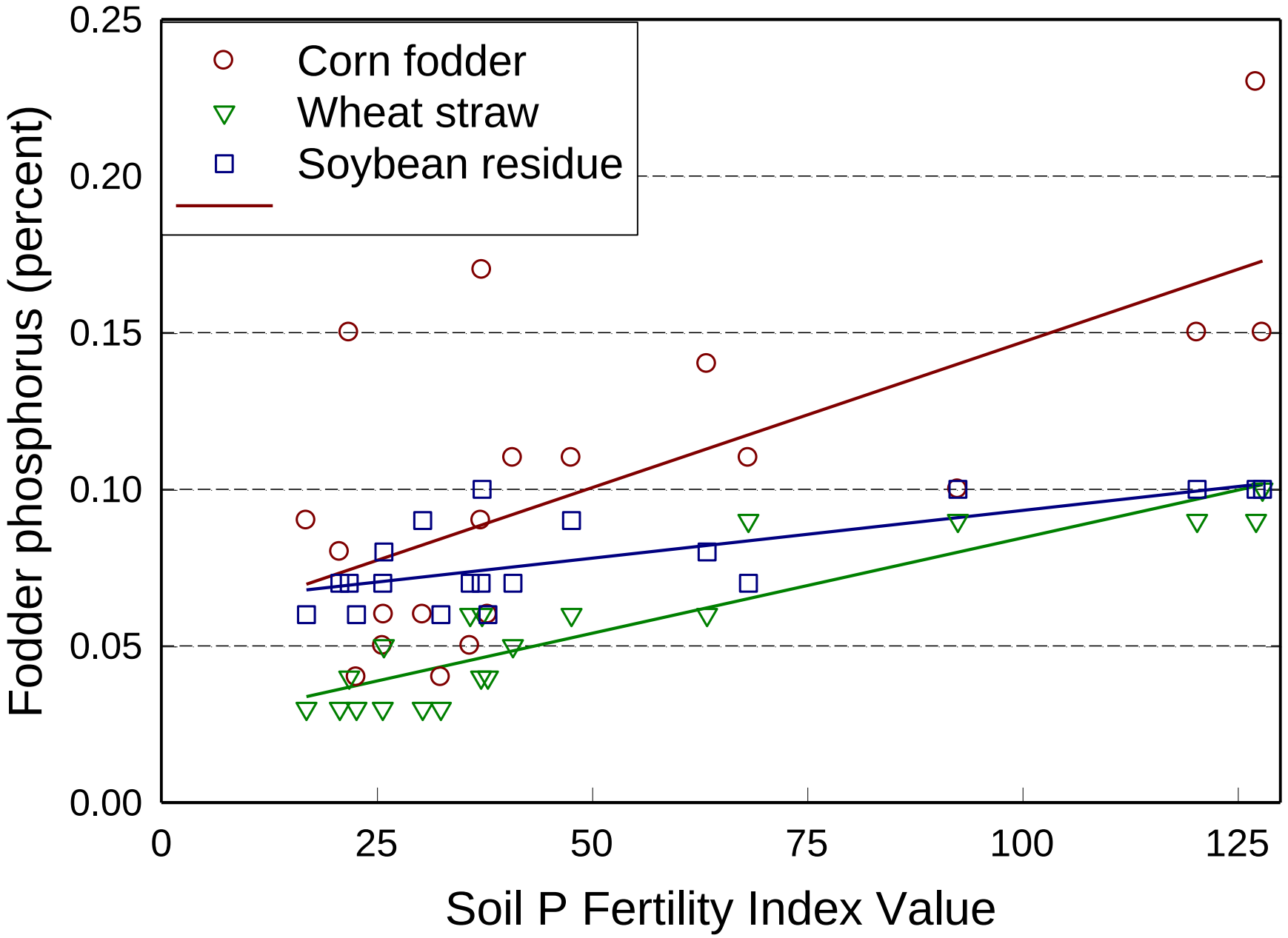


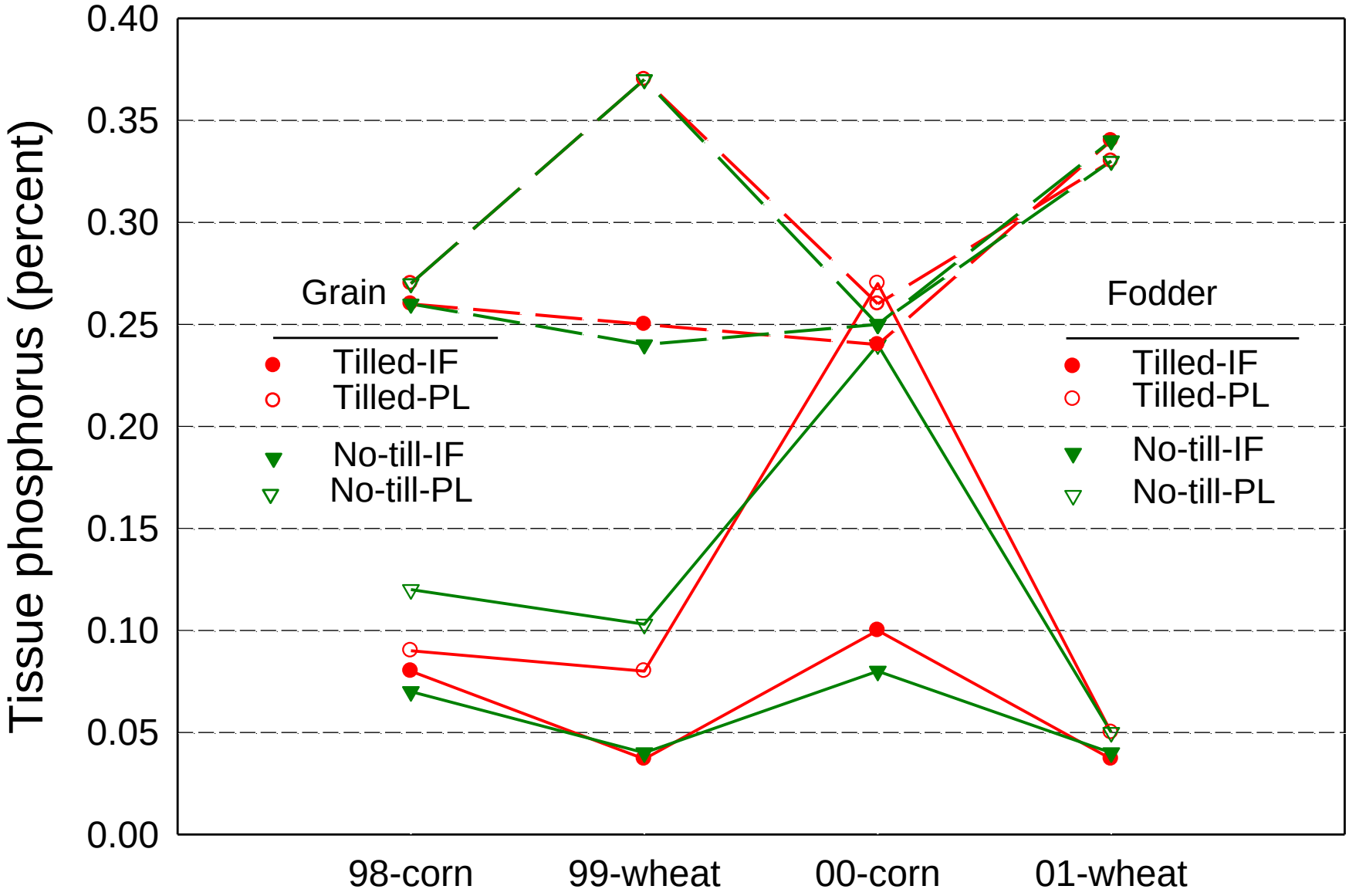
Source: Kenneth Staver, Wye Research and Education Center

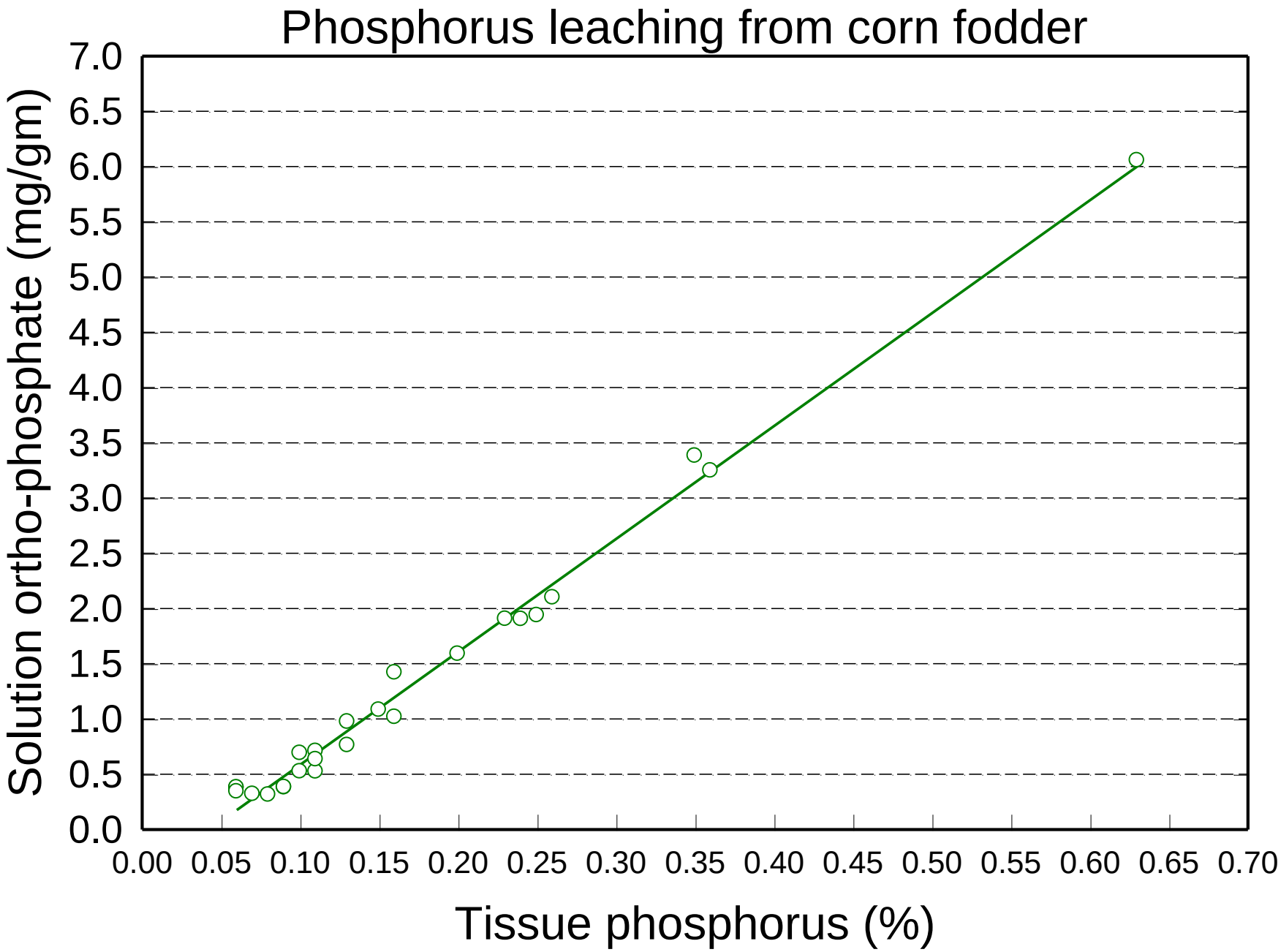

Maryland Test Areas
0 - 20 cm PIV Avg
0-
100-
200-
300-
400-
500-
600-
700-
800-
900-
1000-
1100-
1200-
1300+
Field Boundaries

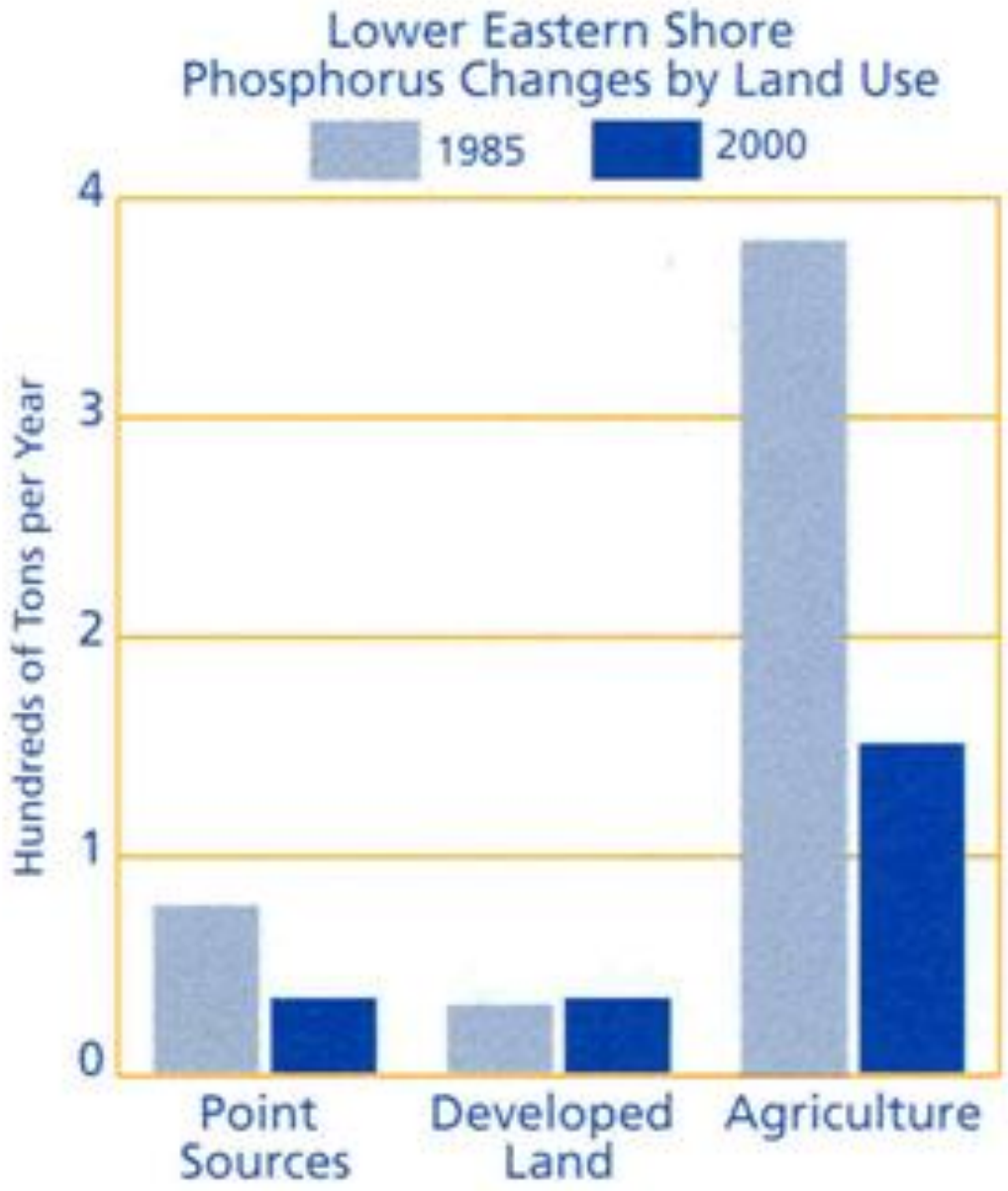

250
200
150
100
50
0
Acres
0-2" (422.9)
2-8" (411.5)
8-12"(196.3)
0-8" (414.4)
LT 1
1-2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
9-10
GT 10
CP soil test P range (FIV)

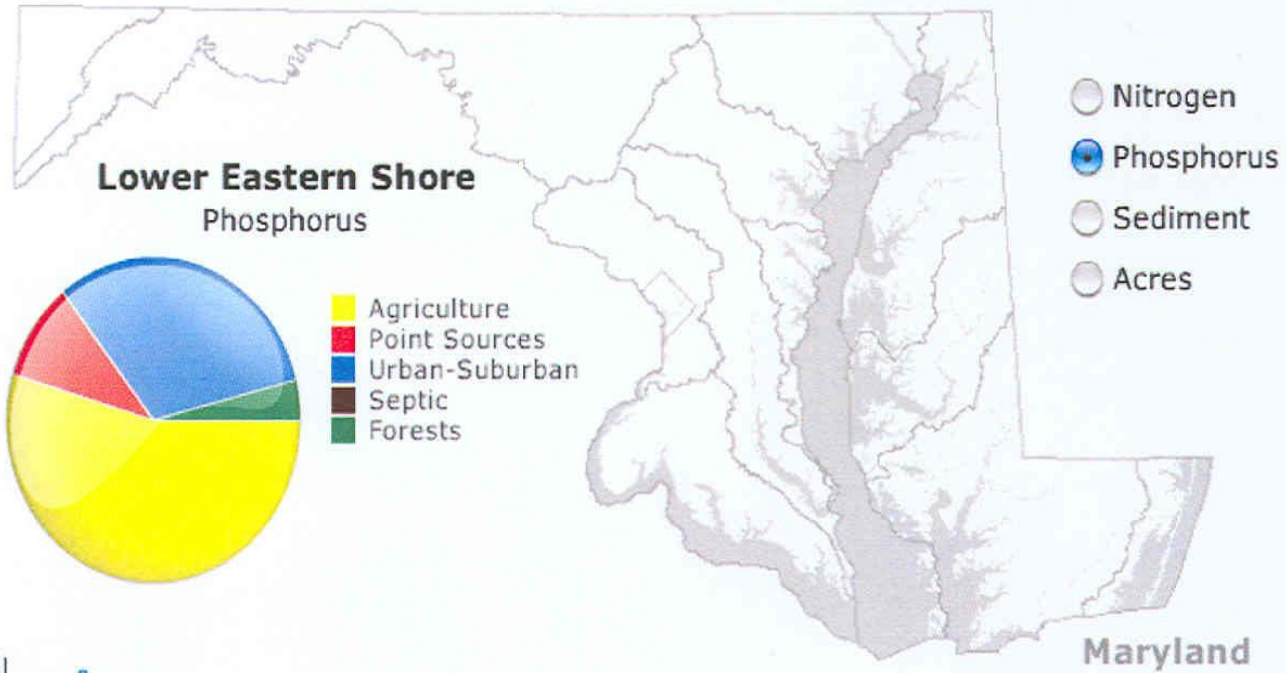

0.04
0.03
0.02
0.01
0.00
Solution ortho-phosphate (mg/L)
0
20
40
60
80
100
120
Plant available soil phosphorus (mg/kg)
Optimum
Excessive


Corn fodder
Wheat straw
Soybean residue
Fodder phosphorus (percent)
0.25
0.20
0.15
0.10
0.05
0.00
0
25
50
75
100
125
Soil P Fertility Index Value

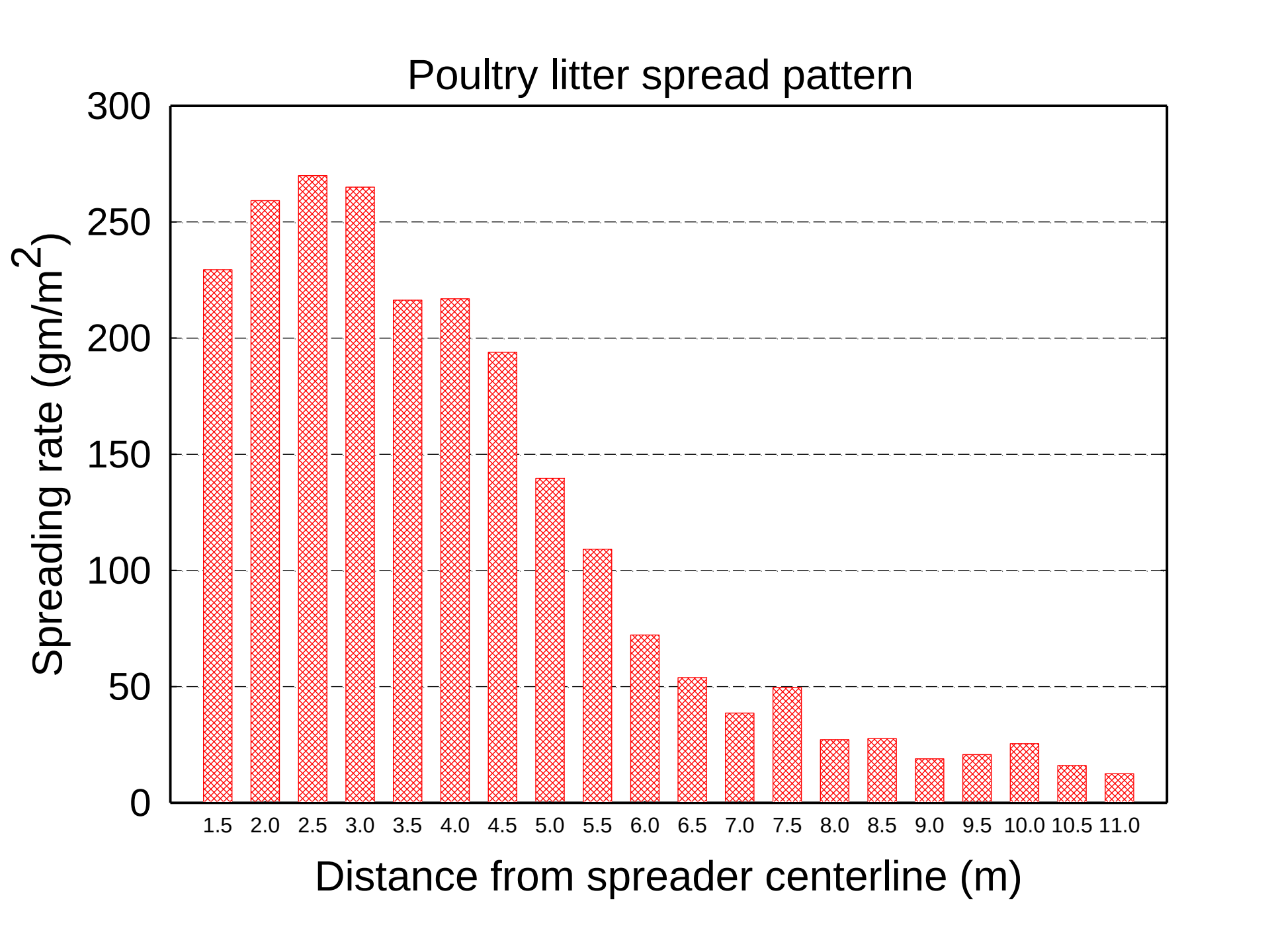

Tissue phosphorus (percent)
0.40
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
98-corn
99-wheat
00-corn
01-wheat
Grain
Tilled-IF
Tilled-PL
No-till-IF
No-till-PL
Fodder
Tilled-IF
Tilled-PL
No-till-IF
No-till-PL

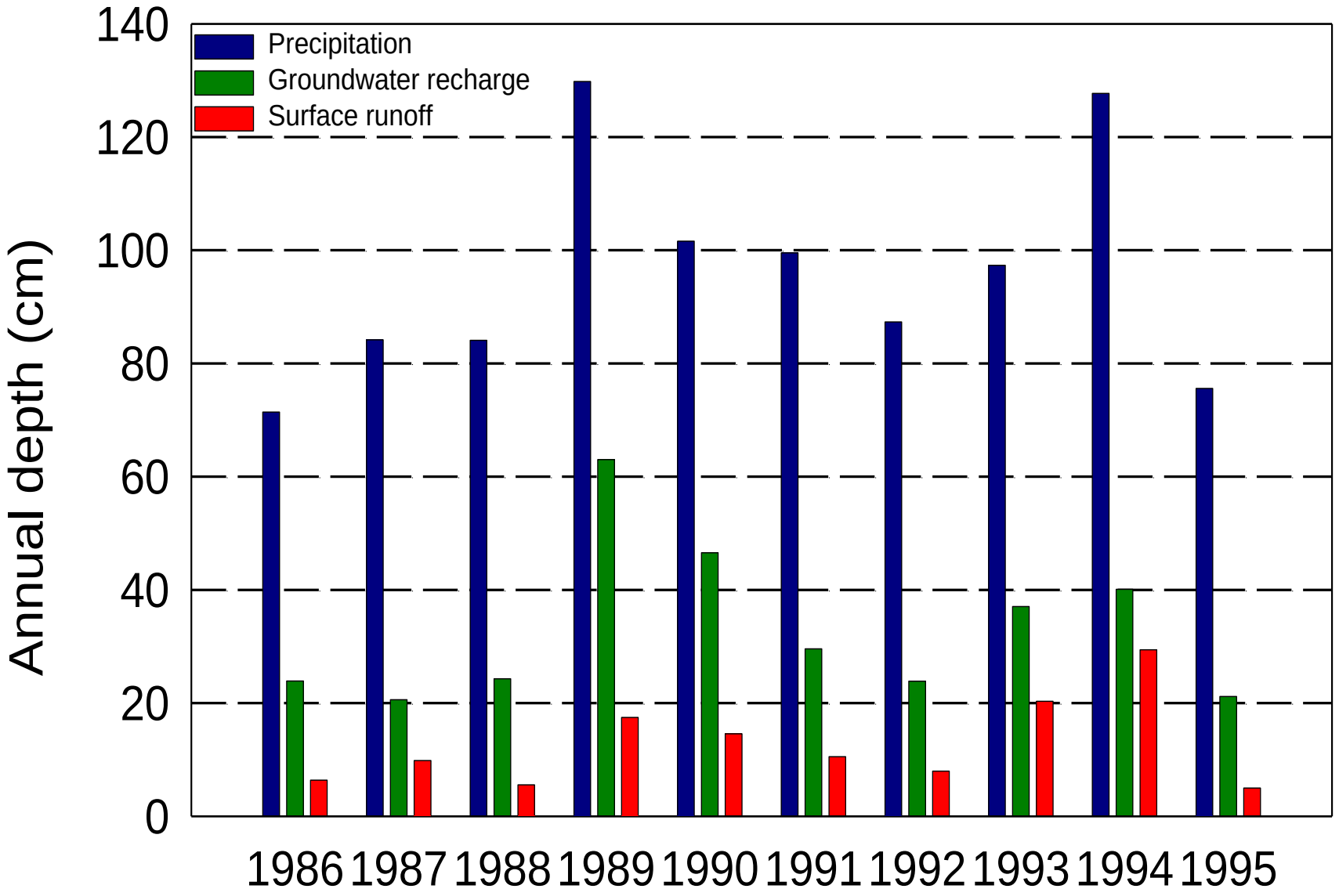

Phosphorus leaching from corn fodder
Solution ortho-phosphate (mg/gm)
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.00 0.05 0.10 0.15 0.20 0.25 0.30 0.35 0.40 0.45 0.50 0.55 0.60 0.65 0.70
Tissue phosphorus (%)

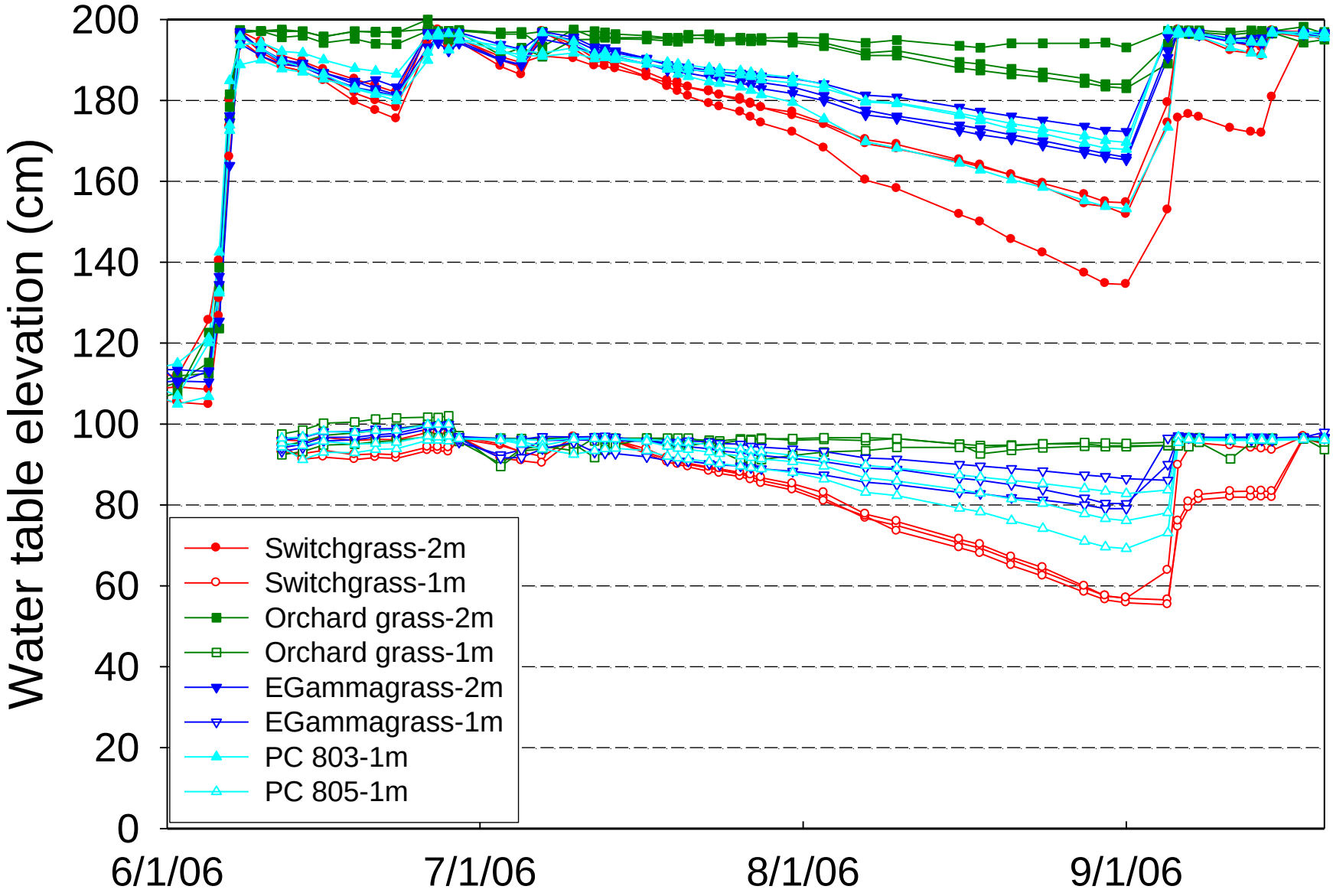

Lower Eastern Shore
Phosphorus Changes by Land Use
1985
2000
Hundreds of Tons per Year
4
3
2
1
0
Point Sources
Developed Land
Agriculture

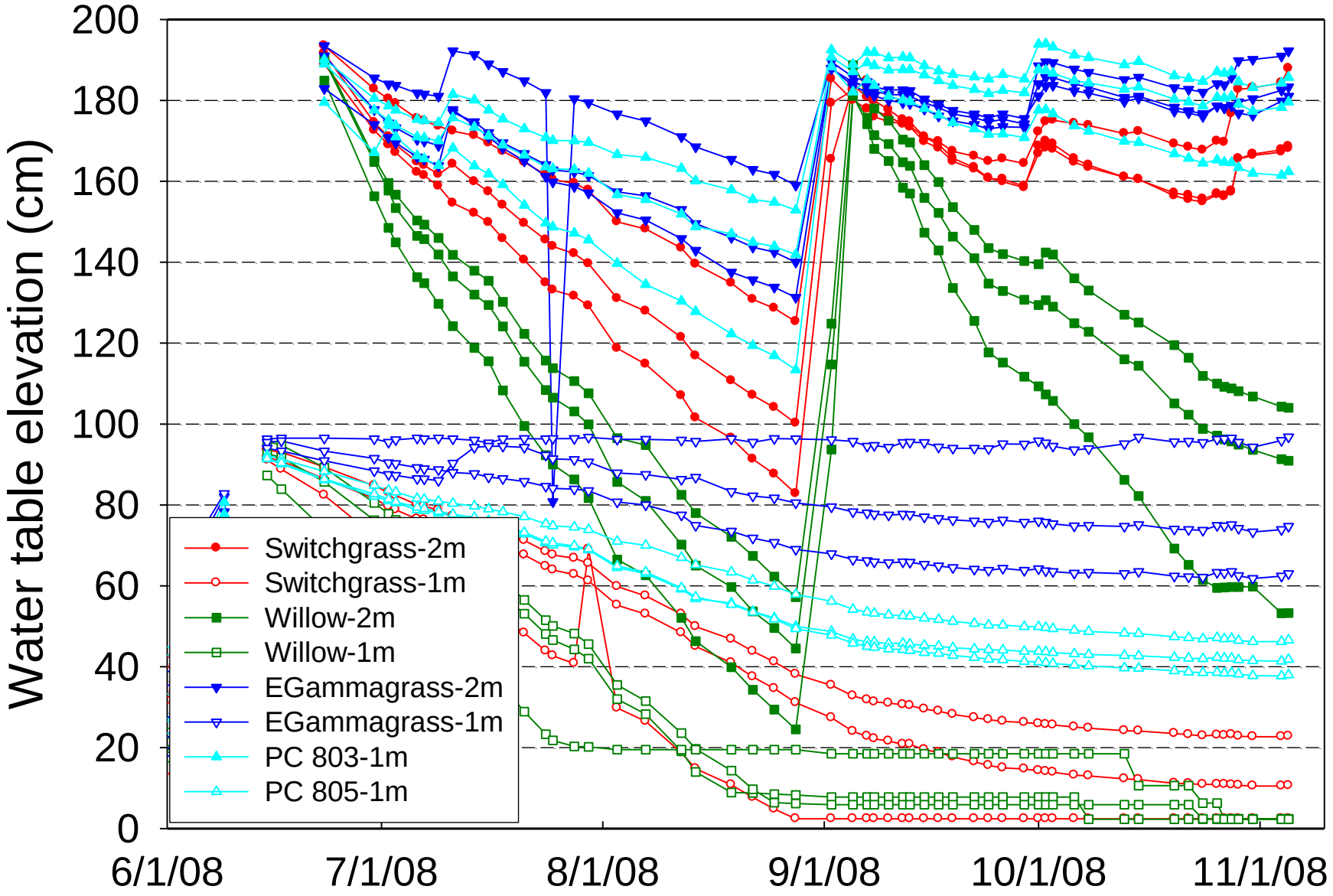


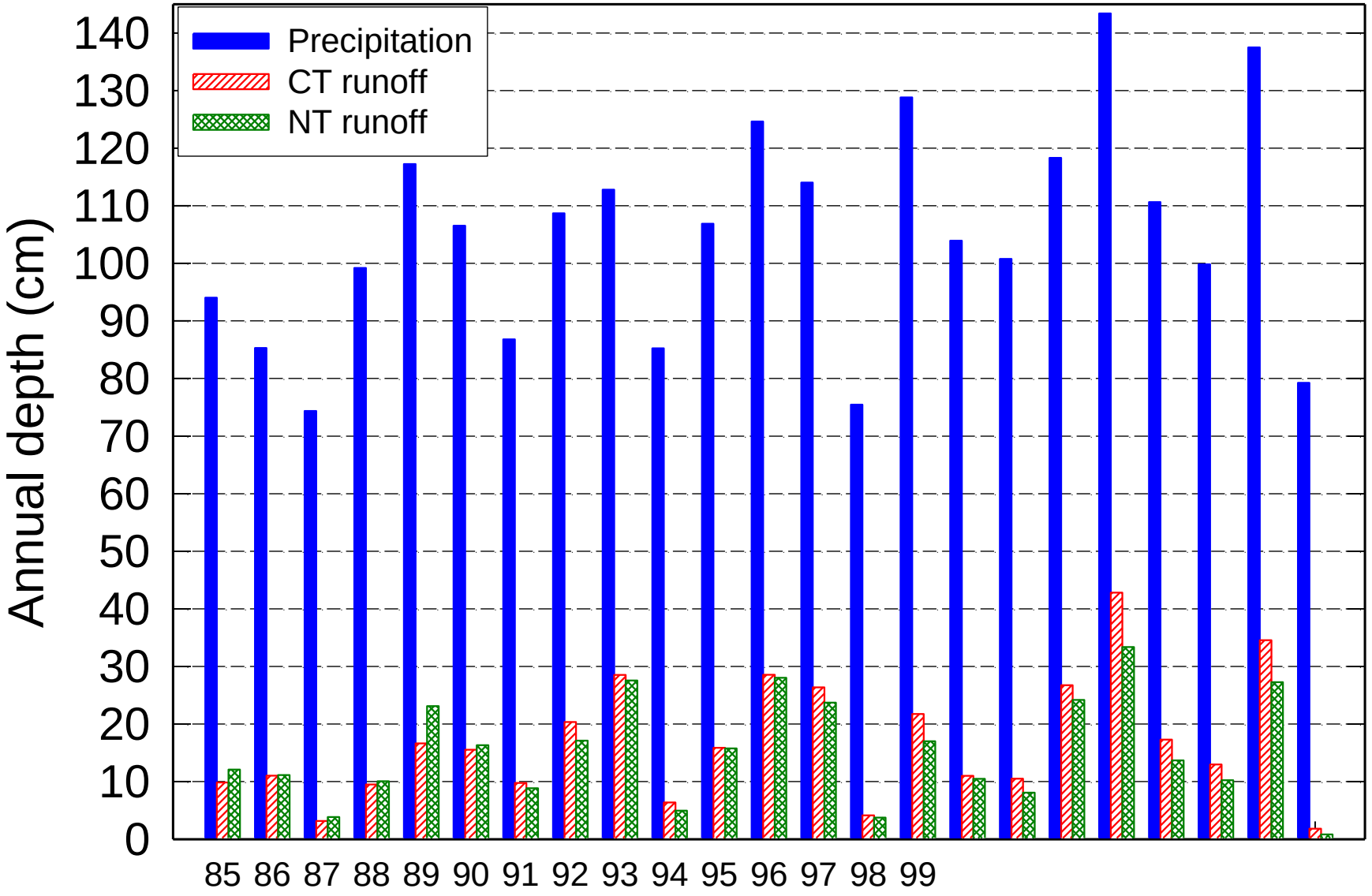
Phosphorus: The primary nutrients polluting the Chesapeake Bay are nitrogen and phosphorous. High amounts of these nutrients increase the growth of algae. Algae become so abundant that the color of the water turns brownish or greenish. Sunlight is blocked from reaching other plants. When the algae die and decompose, oxygen dissolved in the water is used. Often, so much oxygen is used by decomposing algae that fish and other animals must move to areas with more oxygen. Plants and animals that cannot move may die.


Poultry litter spread pattern
300
250
200
150
100
50
0
Spreading rate (gm/m2)
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
Distance from spreader centerline (m)

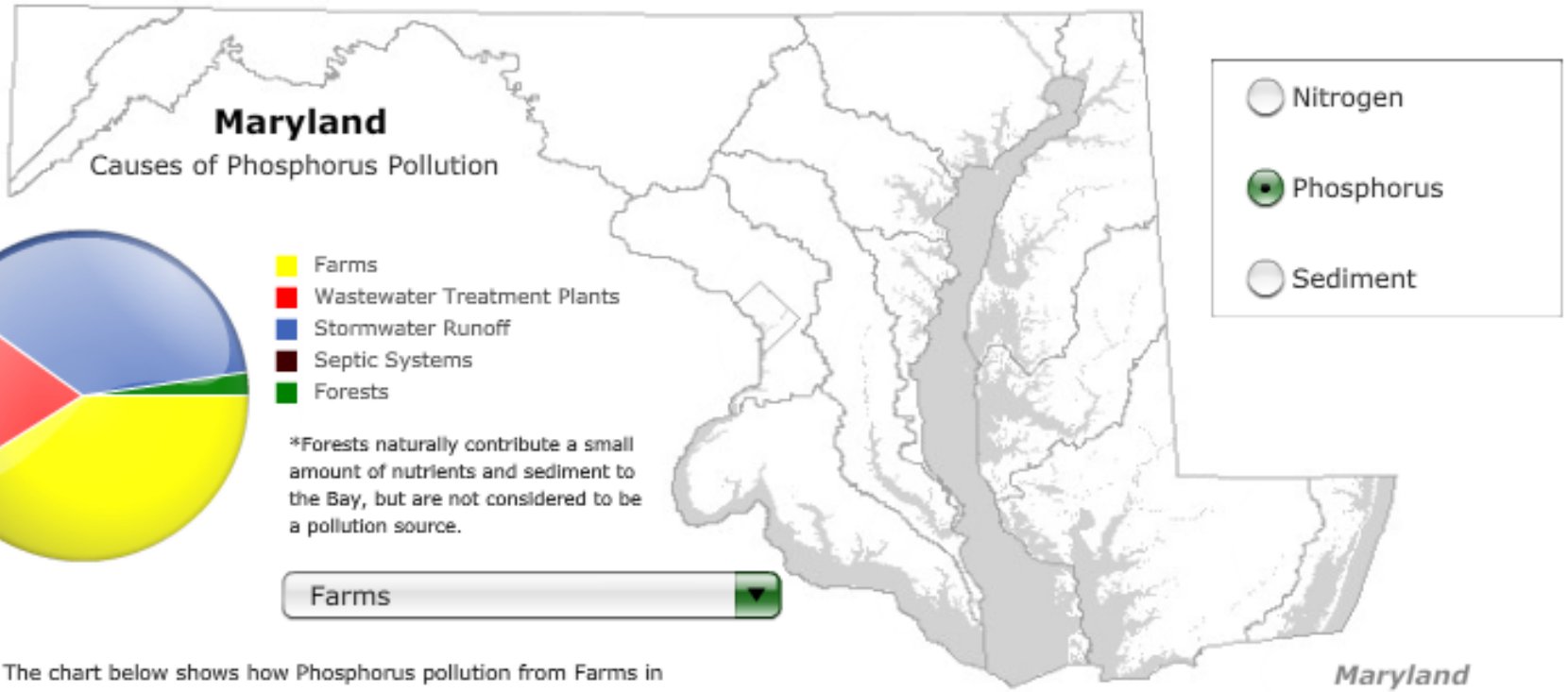

Precipitation
Groundwater recharge
Surface runoff
Annual depth (cm)
0
20
40
60
80
100
120
140
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995


Water table elevation (cm)
200
180
160
140
120
100
80
60
40
20
0
6/1/06
7/1/06
8/1/06
9/1/06
Switchgrass-2m
Switchgrass-1m
Orchard grass-2m
Orchard grass-1m
EGammagrass-2m
EGammagrass-1m
PC 803-1m
PC 805-1m

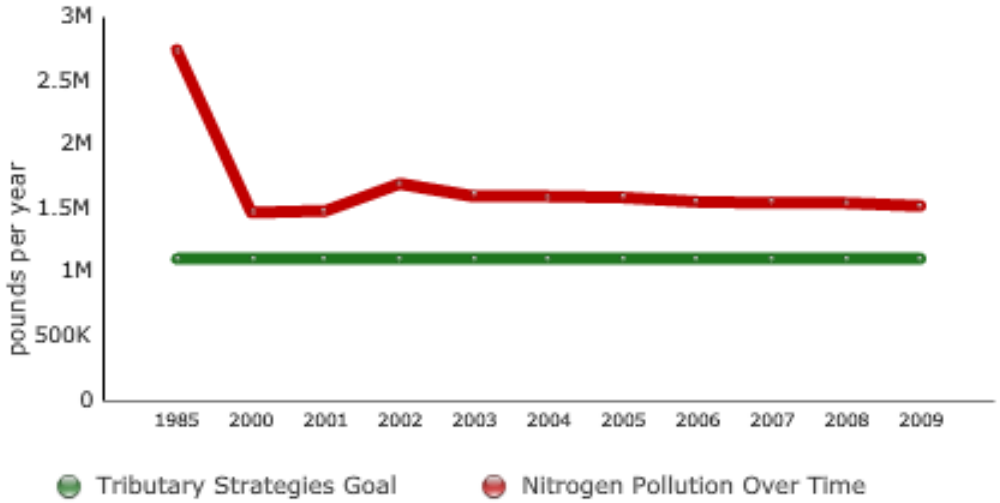

Water table elevation (cm)
200
180
160
140
120
100
80
60
40
20
0
6/1/08
7/1/08
8/1/08
9/1/08
10/1/08
11/1/08
Switchgrass-2m
Switchgrass-1m
Willow-2m
Willow-1m
EGammagrass-2m
EGammagrass-1m
PC 803-1m
PC 805-1m


Precipitation
CT runoff
NT runoff
Annual depth (cm)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99

Causes of the Problems

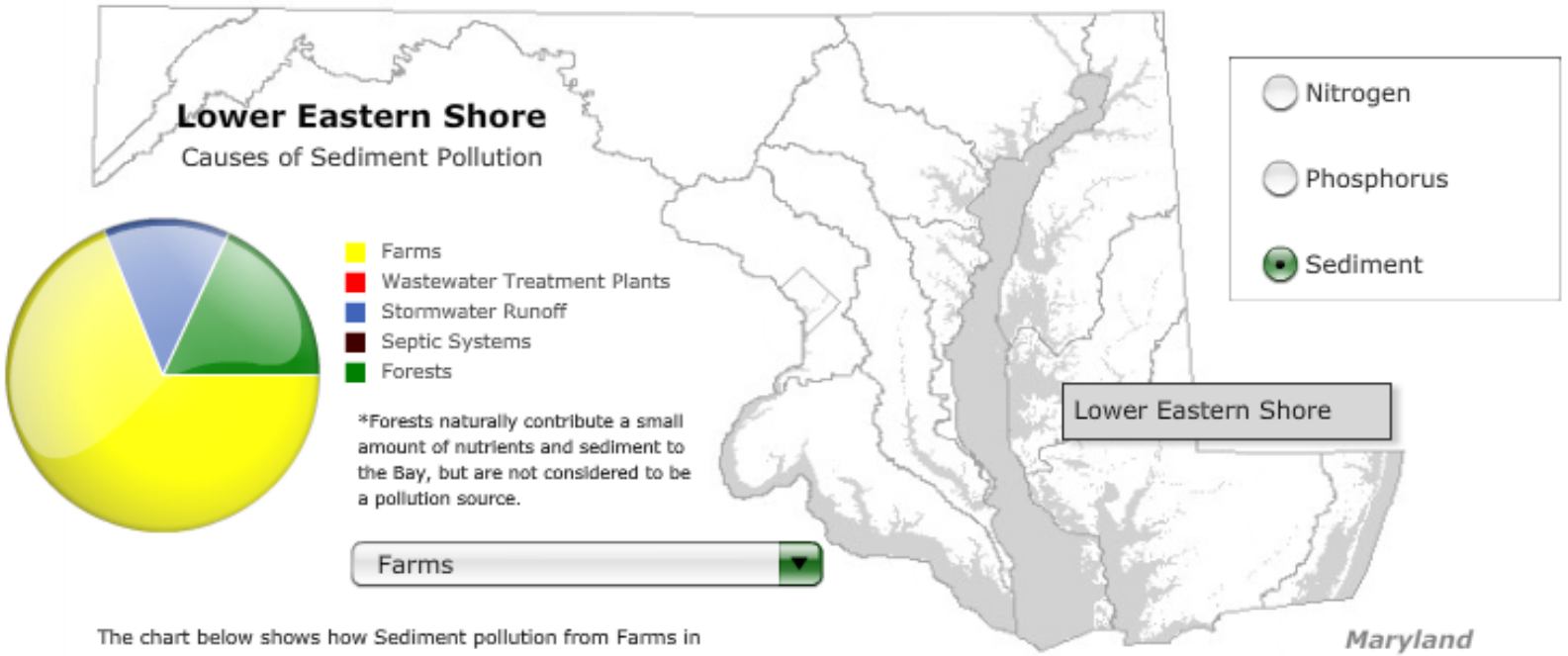


The chart below shows how Phosphorus pollution from Farms in Maryland has changed over time.

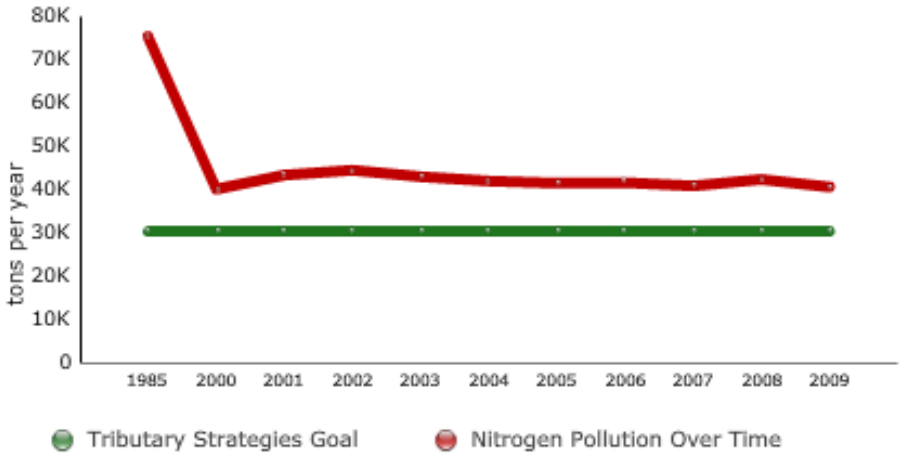


Phosphorus pollution fuels the growth of algae, creating dense, harmful algae blooms that rob the Chesapeake Bay's aquatic life of needed sunlight and oxygen. Phosphorus often attaches to soil and sediment particles on land, entering the Bay many years later when stream banks erode or rainwater washes it into streams, rivers and the Bay. Sources of phosphorus pollution include fertilizers from farmlands, lawns and golf courses; eroding soil & sediment from stream banks in urban and suburban neighborhoods; animal manure from farms; and wastewater from industrial facilities and sewage treatment plants.

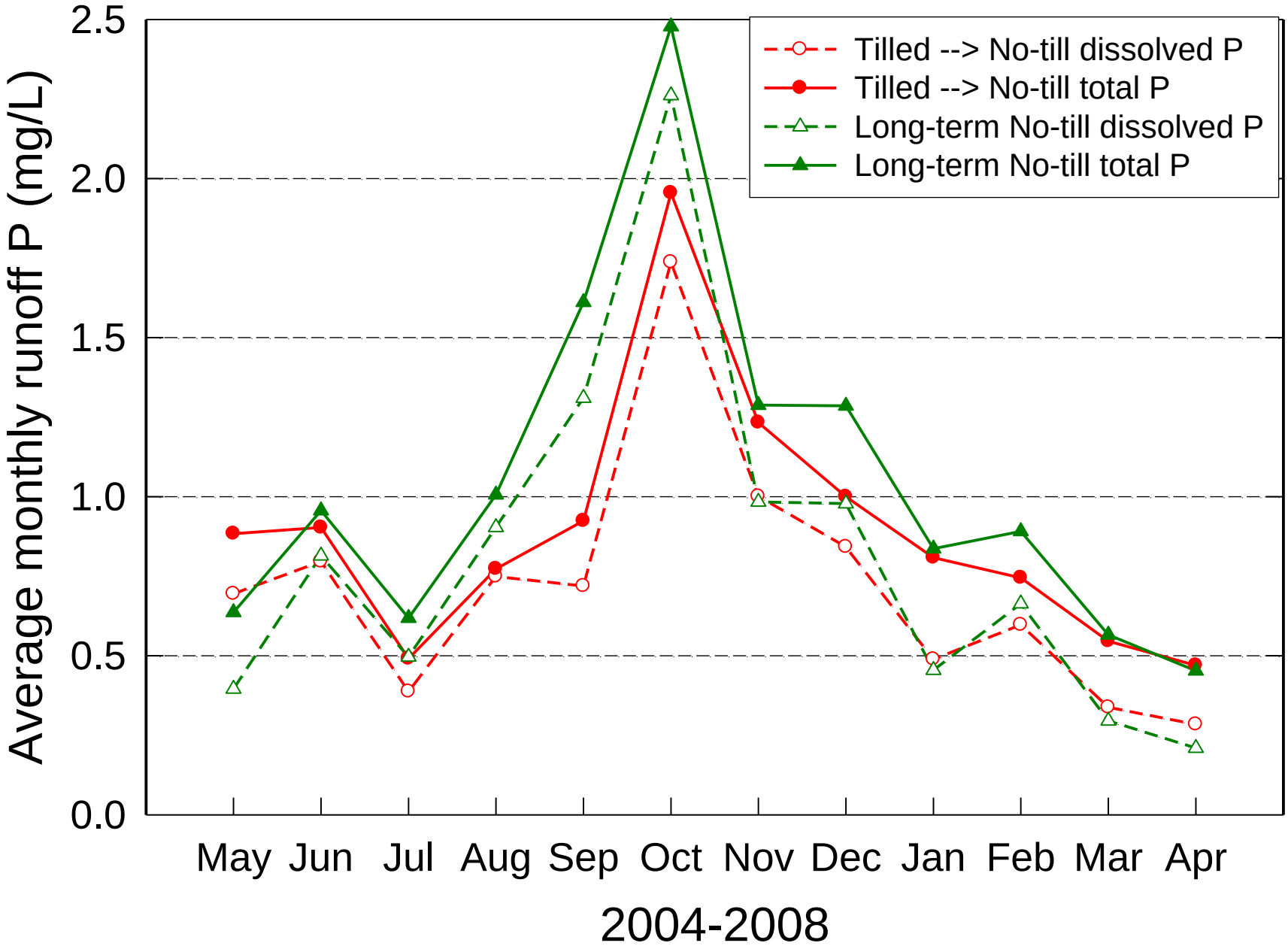
Causes of the Problems



The chart below shows how Sediment pollution from Farms in Lower Eastern Shore has changed over time.



Excess sediments -- dirt, clay, silt and sand – hurt the Bay's water quality by blocking the sunlight needed by underwater plants and grasses. Without enough sunlight, these underwater grasses are not able to grow and provide habitat for young fish and blue crabs. In addition to blocking sunlight, sediment pollution can also carry nutrient and chemical contaminates into the bay, and smother oysters, underwater grasses and other bottom-dwelling creatures. Landscape changes, like development of forests and farmland, increase sediment pollution into the Chesapeake Bay.As trees and plants are removed on construction sites during development and stream banks erode due to increased stormwater flows in urban and suburban communities, rainwater carries sediment from the land into the Bay.


Average monthly runoff P (mg/L)
2.5
2.0
1.5
1.0
0.5
0.0
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
2004-2008
Tilled --> No-till dissolved P
Tilled --> No-till total P
Long-term No-till dissolved P
Long-term No-till total P