Chesapeake Bay Goal Line 2025

October 5, 2010

Reducing Nitrogen Loss from Cropland in the Chesapeake Bay Watershed

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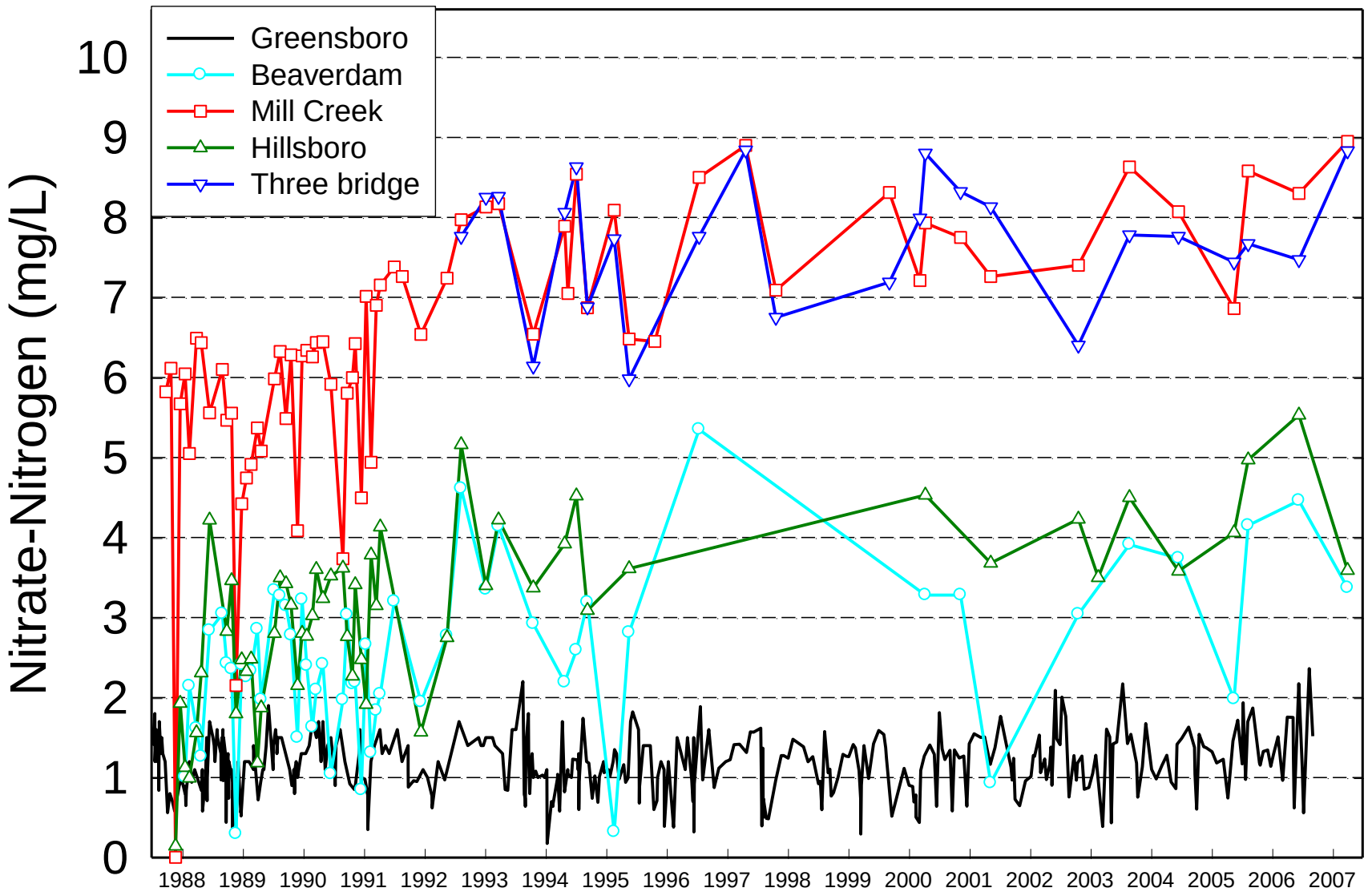
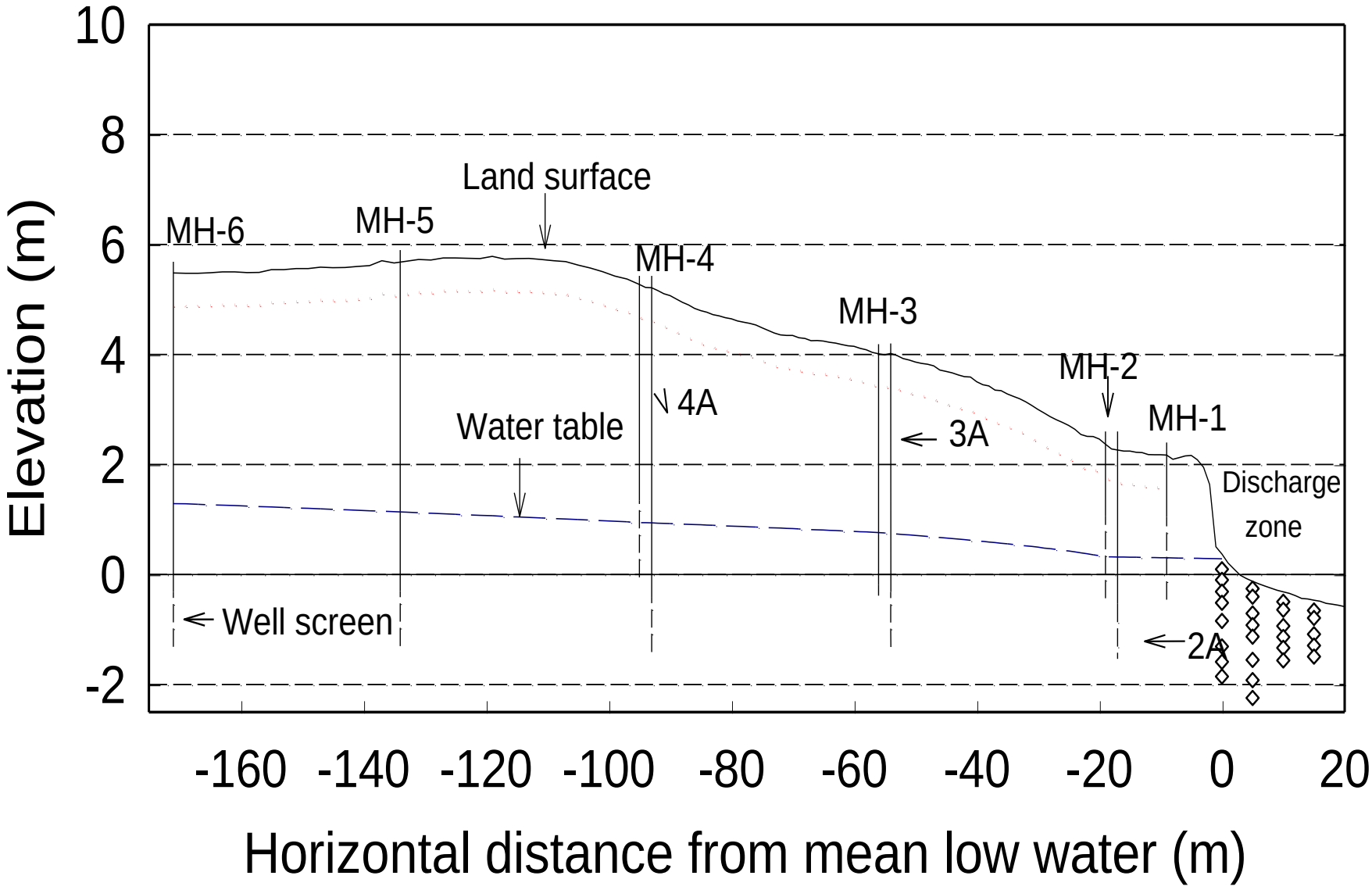

Greensboro
Beaverdam
Mill Creek
Hillsboro
Three bridge
Nitrate-Nitrogen (mg/L)
0
1
2
3
4
5
6
7
8
9
10
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007


10
8
6
4
2
0
-2
Elevation (m)
Land surface
MH-6
MH-5
MH-4
MH-3
MH-2
MH-1
4A
3A
2A
Water table
Discharge
zone
Well screen
-160
-140
-120
-100
-80
-60
-40
-20
0
20
Horizontal distance from mean low water (m)

Overall N Management

Objective : Supply crops with adequate quantities of plant available N for economic optimum yields while minimizing the potential for N losses in runoff and leachate.

Basic Fact #1

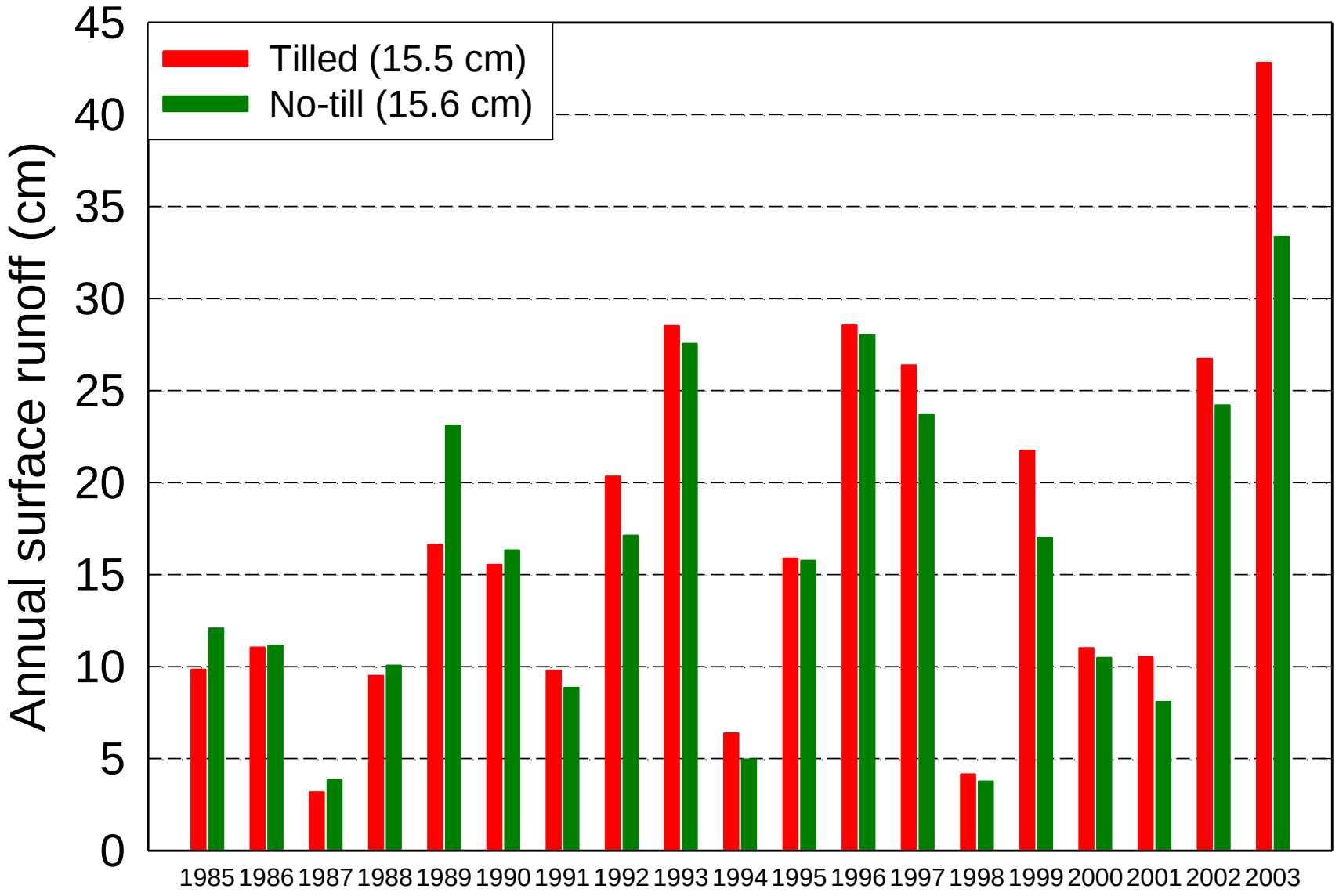
N losses occur when water leaving the crop field interacts with transportable forms of N.

N lost = concentration x volume.

Basic Fact #2

Volume = precipitation – evaporation

We have little ability to reduce the overall volume of water leaving crop fields although we do have some limited opportunities to affect how water leaves crop fields.


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

Basic Fact #3

Significant reductions in N losses will require reductions in the concentration of N in surface runoff or leachate.

Overall Strategy

Manage soil N so that levels of transportable forms are kept as low as possible while still meeting crop N needs. We want to reduce the potential for N loss.

Three aspects of soil N

1. Applications
2. Soil N cycle
3. Plant uptake

Applications

1. Rate
2. Timing
3. Placement

The big question on N rates

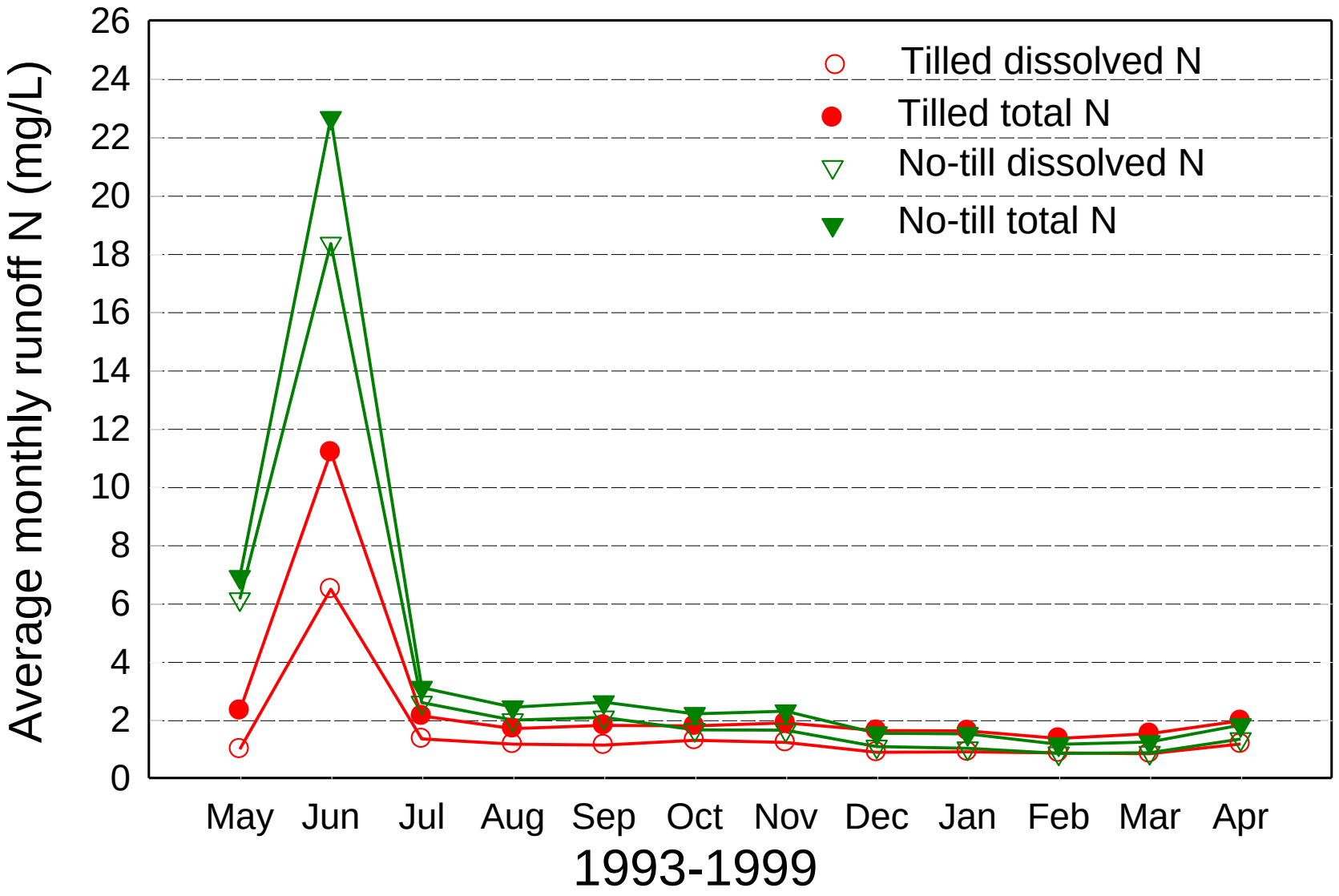
How have application rates changed? It is difficult to accurately project how N losses will change due to adjustments in N application rates without high quality pre- and post- data sets.

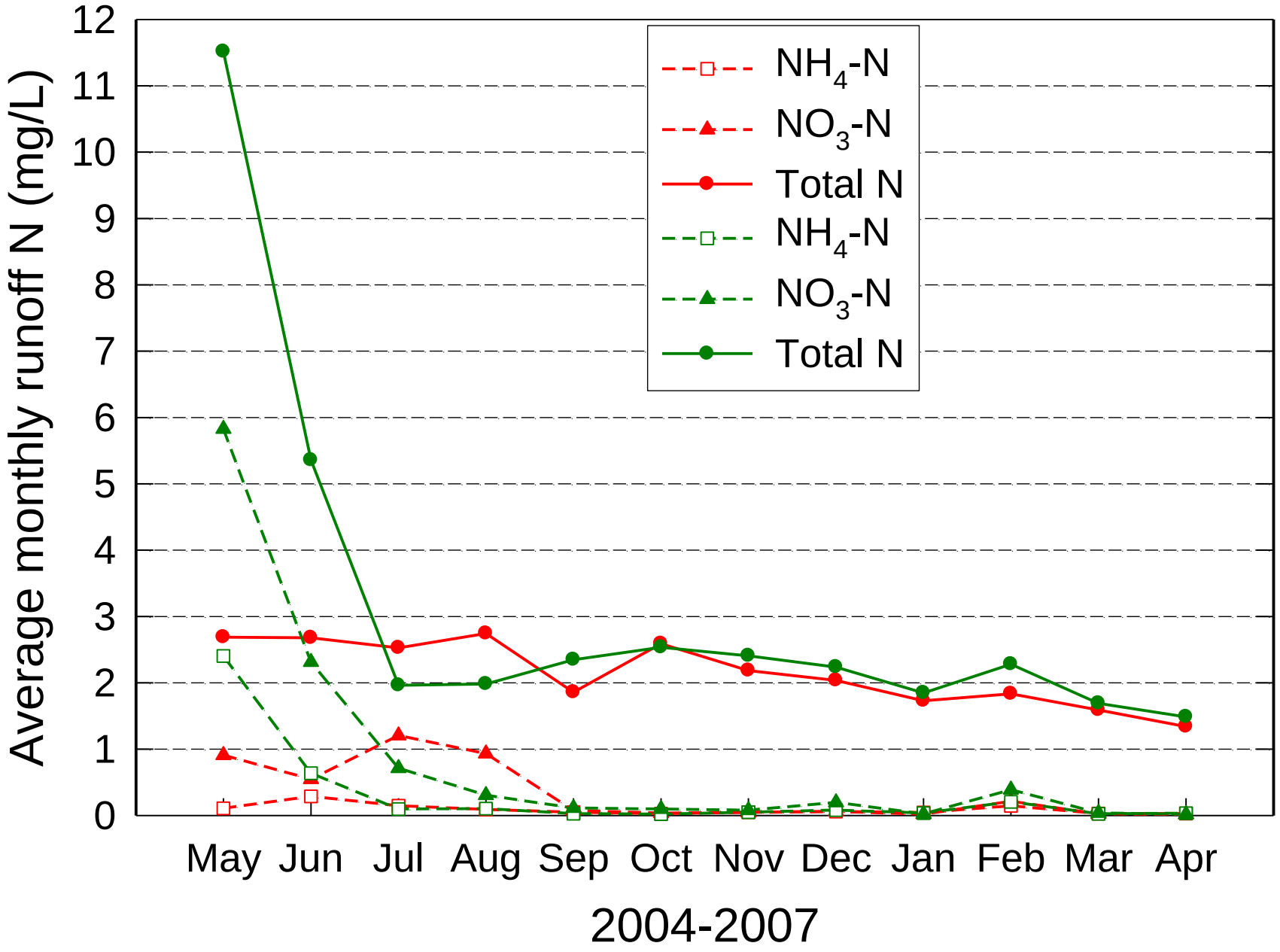
Timing objective

Synchronize the availability of N as closely as possible with crop N needs. Avoid preplant applications!

Placement objective

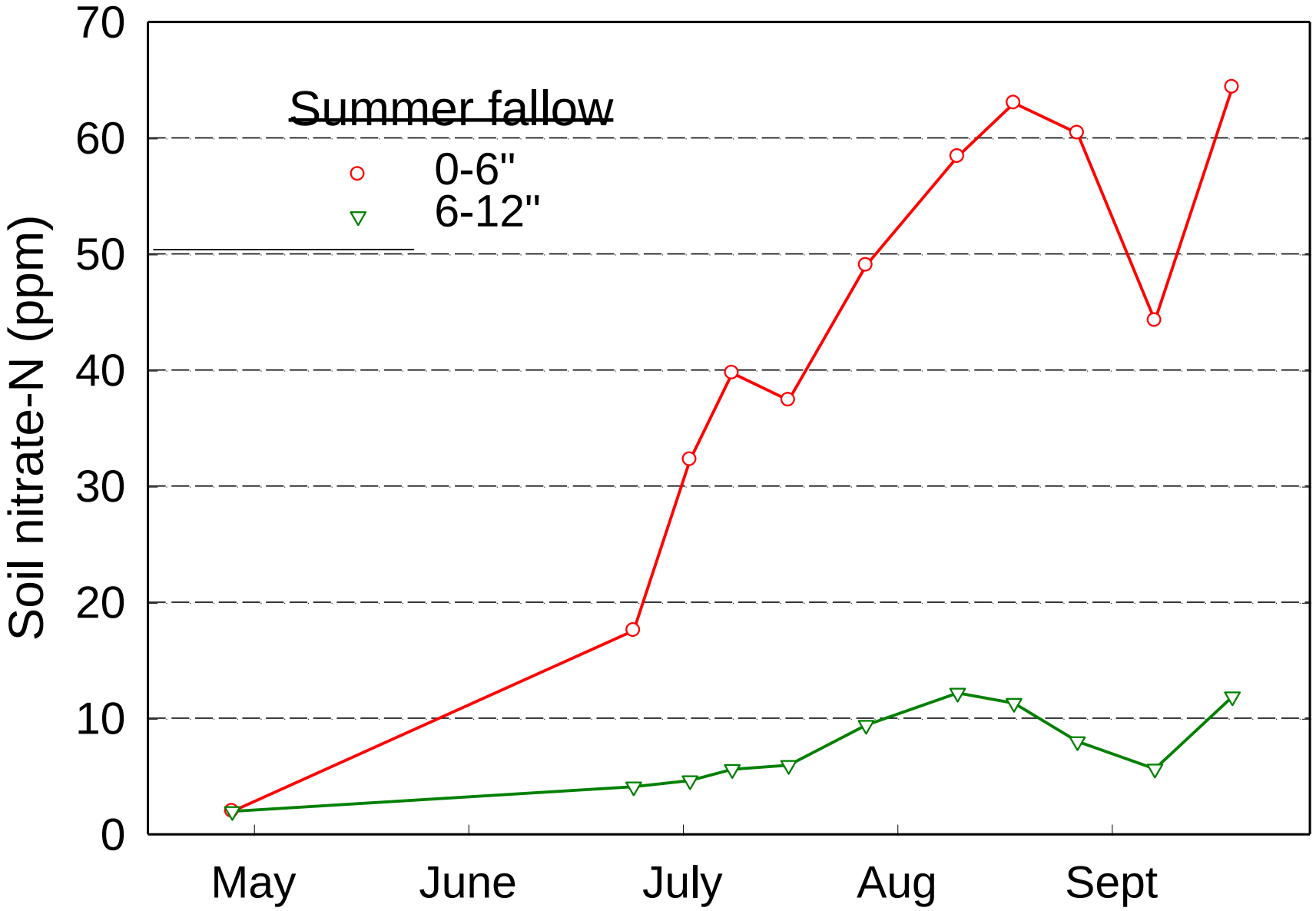
Minimize interaction of soluble N forms with surface runoff. Surface runoff N levels determined mostly by soluble N availability in the top 1” of soil.

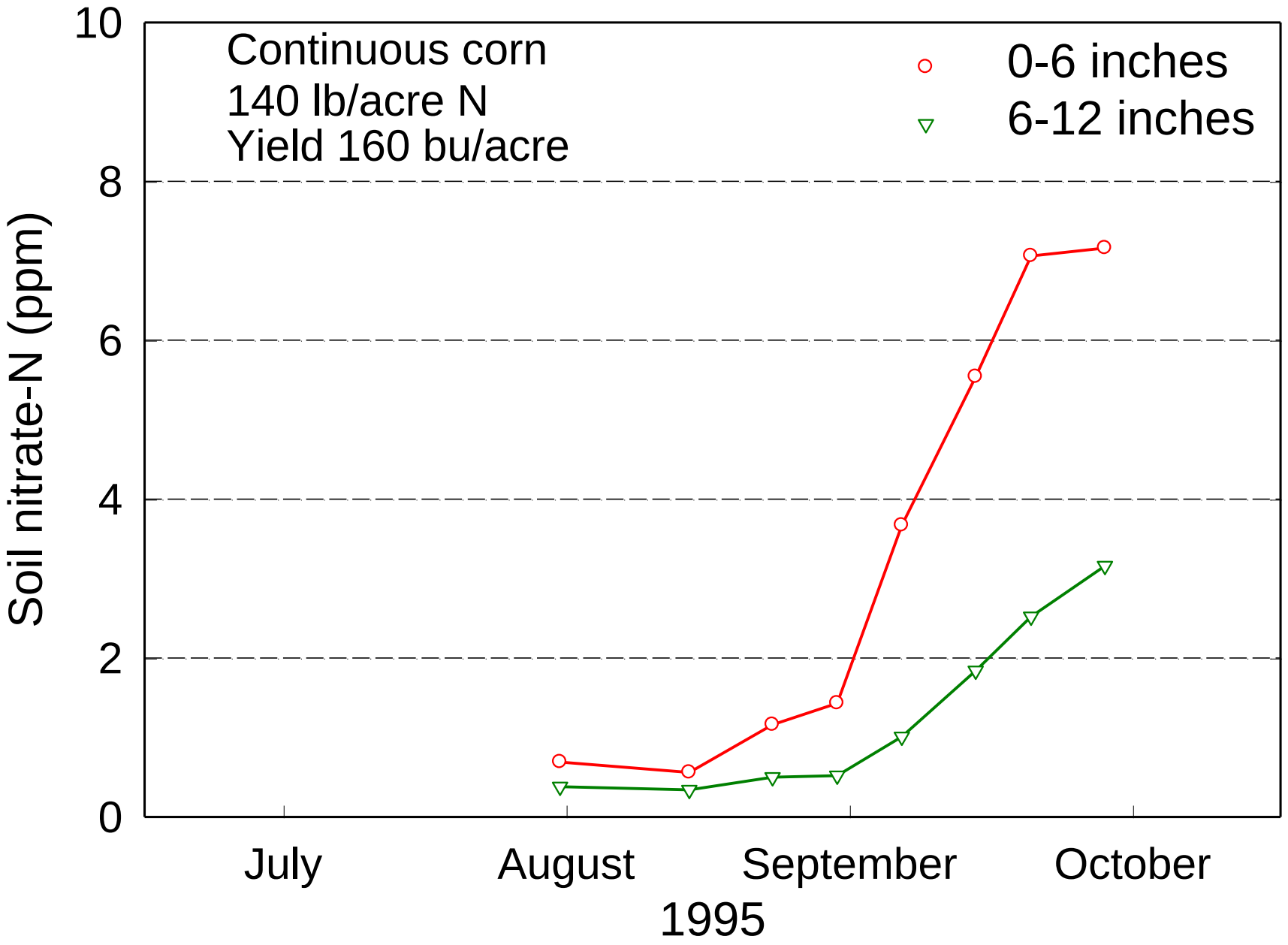

Average monthly runoff N (mg/L)
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Tilled dissolved N
Tilled total N
No-till dissolved N
No-till total N
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
1993-1999

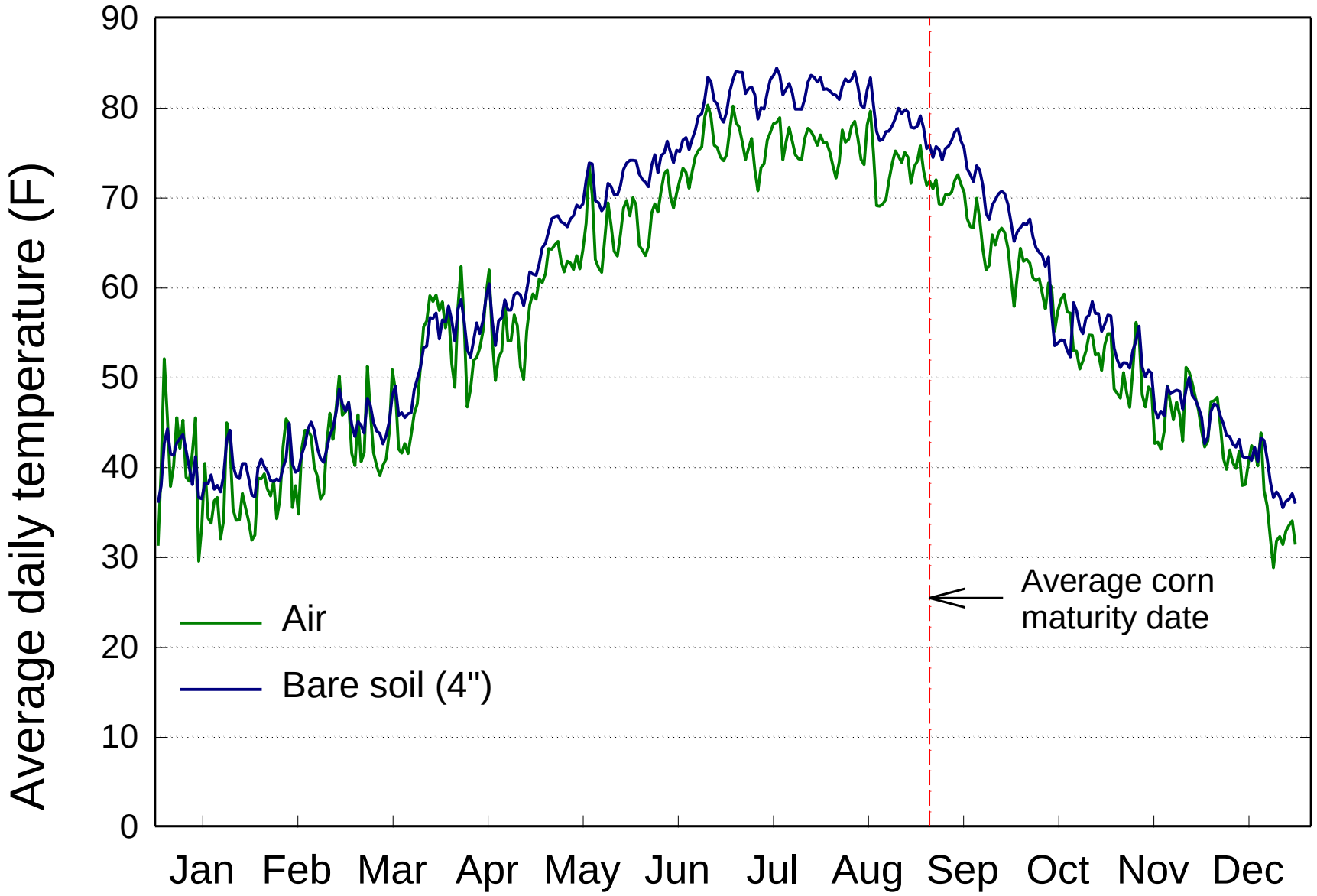

Average monthly runoff N (mg/L)
0
1
2
3
4
5
6
7
8
9
10
11
12
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
2004-2007
NH4-N
NO3-N
Total N
NH4-N
NO3-N
Total N

Soil N – It's not just applications!

When soil temperatures warm up, nitrate is released as soil microbes break down soil organic matter.

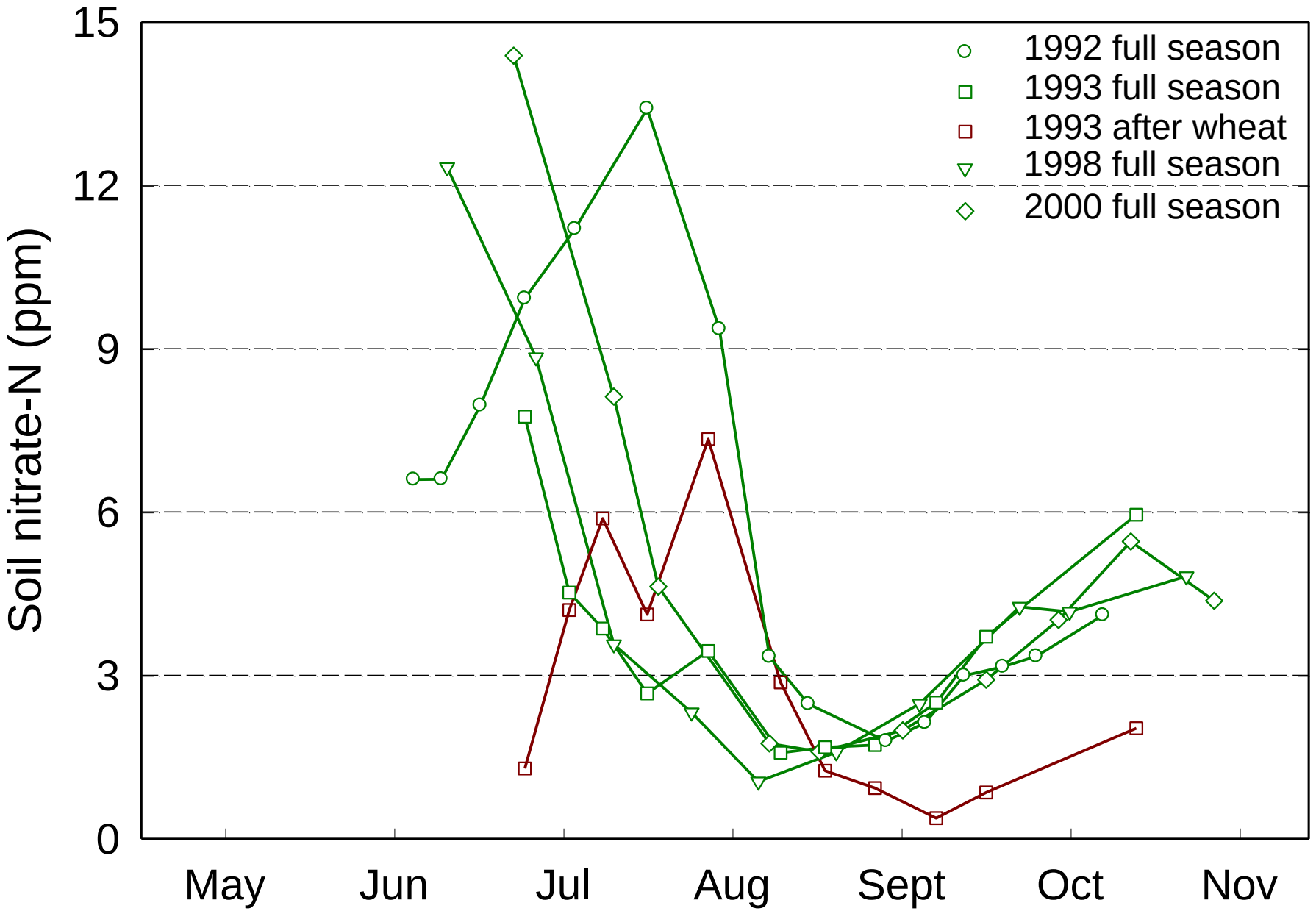

Summer fallow
0-6"
6-12"
Soil nitrate-N (ppm)
70
60
50
40
30
20
10
0
May
June
July
Aug
Sept

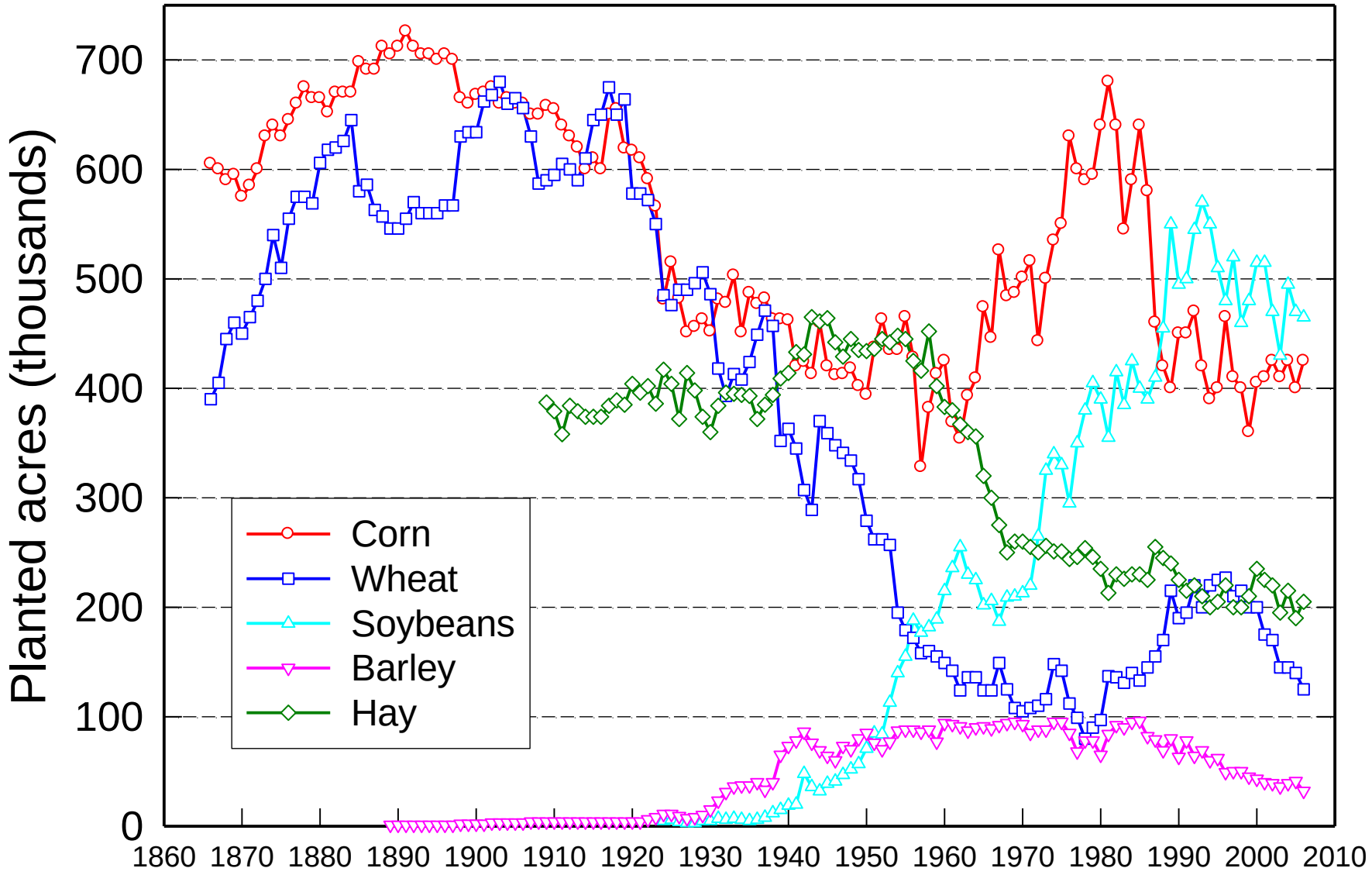

Continuous corn
140 lb/acre N
Yield 160 bu/acre
0-6 inches
6-12 inches
Soil nitrate-N (ppm)
10
8
6
4
2
0
July
August
September
October
1995

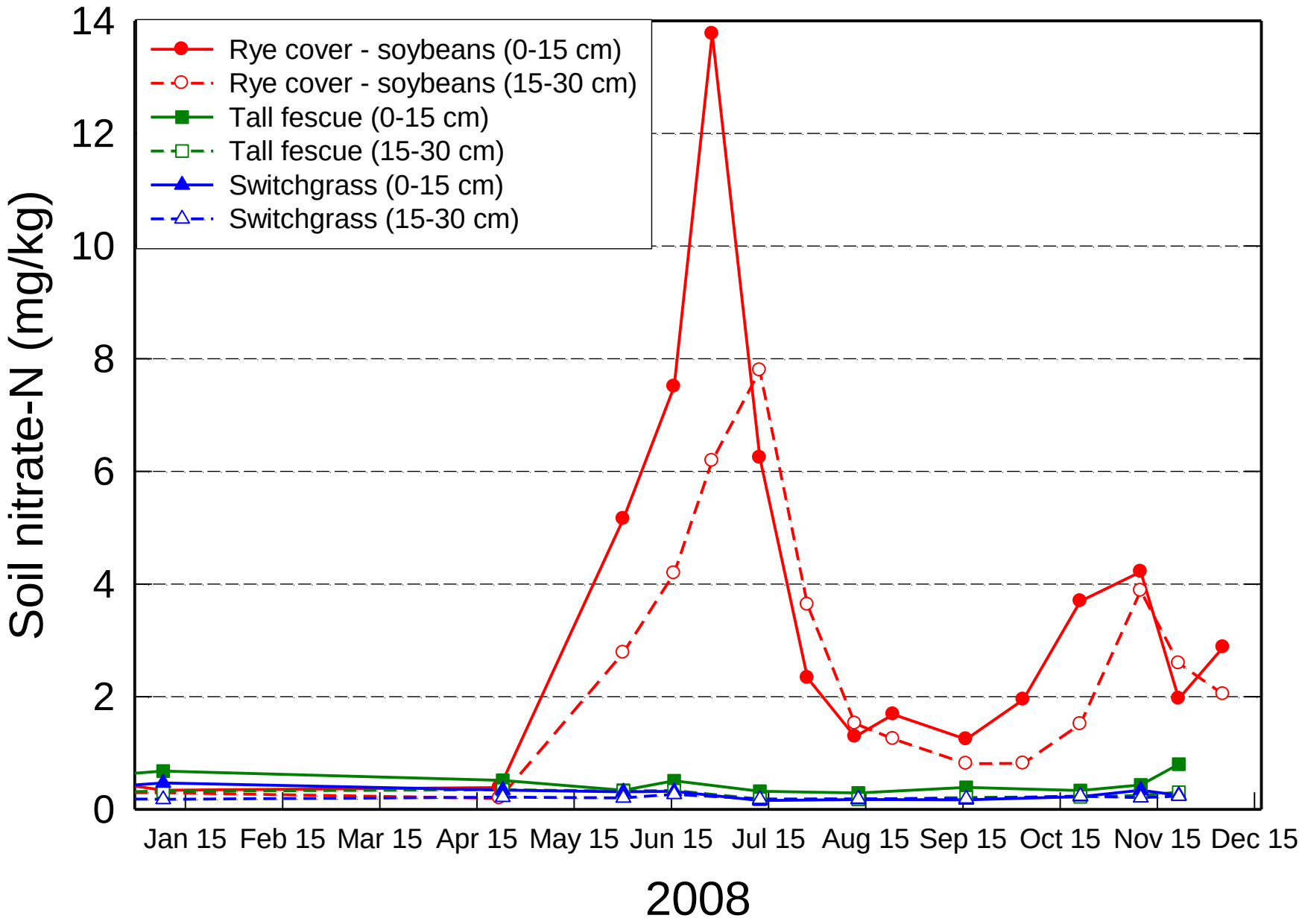

Average daily temperature (F)
90
80
70
60
50
40
30
20
10
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Air
Bare soil (4")
Average corn
maturity date

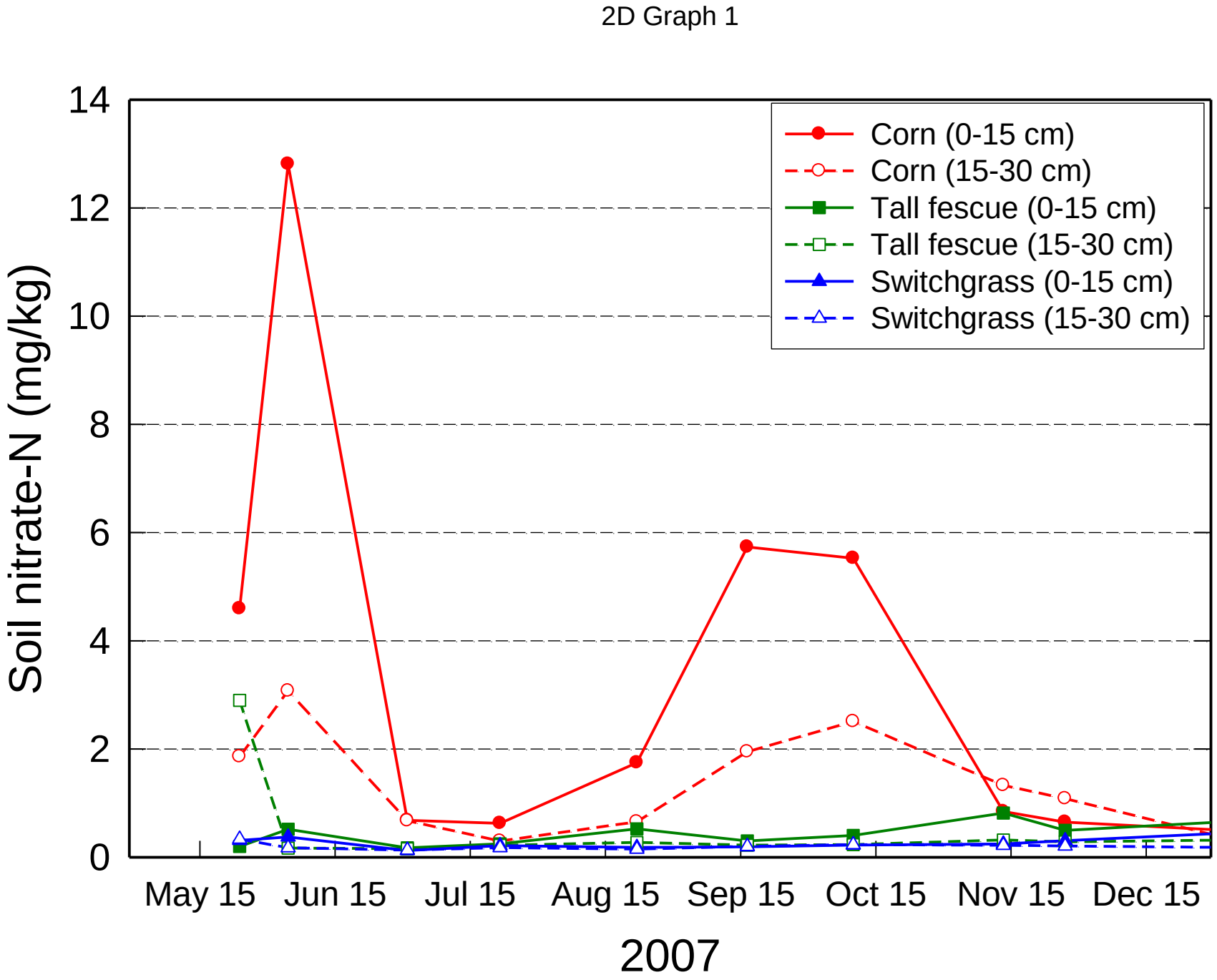
General Misconception

Nitrate in the root zone at the end of the growing season is a result of unused “residual fertilizer N”.


Soil nitrate-N (ppm)
15
12
9
6
3
0
May
Jun
Jul
Aug
Sept
Oct
Nov
1992 full season
1993 full season
1993 after wheat
1998 full season
2000 full season


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


2D Graph 1
Rye cover - soybeans (0-15 cm)
Rye cover - soybeans (15-30 cm)
Tall fescue (0-15 cm)
Tall fescue (15-30 cm)
Switchgrass (0-15 cm)
Switchgrass (15-30 cm)
Soil nitrate-N (mg/kg)
14
12
10
8
6
4
2
0
Jan 15
Feb 15
Mar 15
Apr 15
May 15
Jun 15
Jul 15
Aug 15
Sep 15
Oct 15
Nov 15
Dec 15
2008

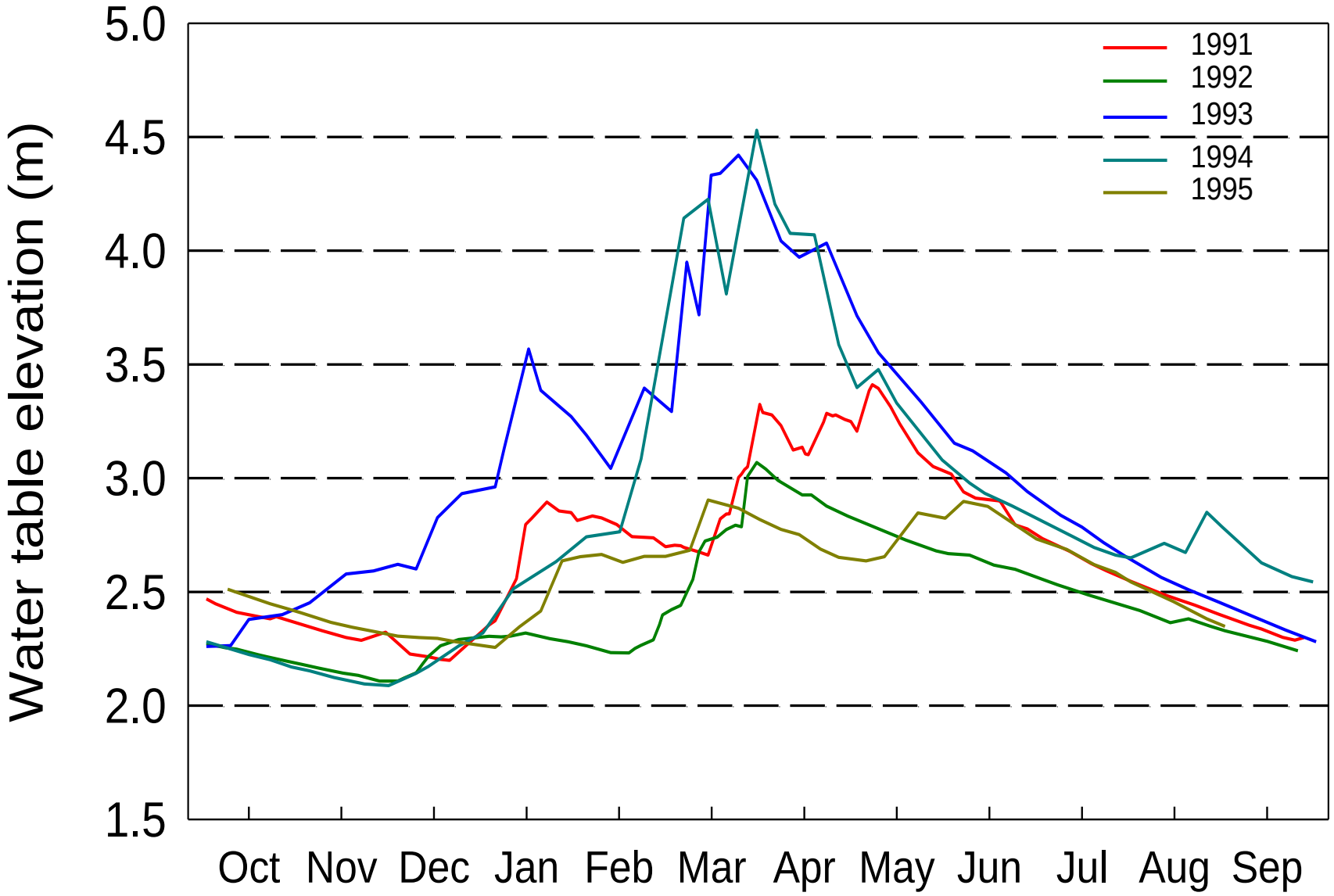

2D Graph 1
Soil nitrate-N (mg/kg)
14
12
10
8
6
4
2
0
May 15
Jun 15
Jul 15
Aug 15
Sep 15
Oct 15
Nov 15
Dec 15
2007
Corn (0-15 cm)
Corn (15-30 cm)
Tall fescue (0-15 cm)
Tall fescue (15-30 cm)
Switchgrass (0-15 cm)
Switchgrass (15-30 cm)

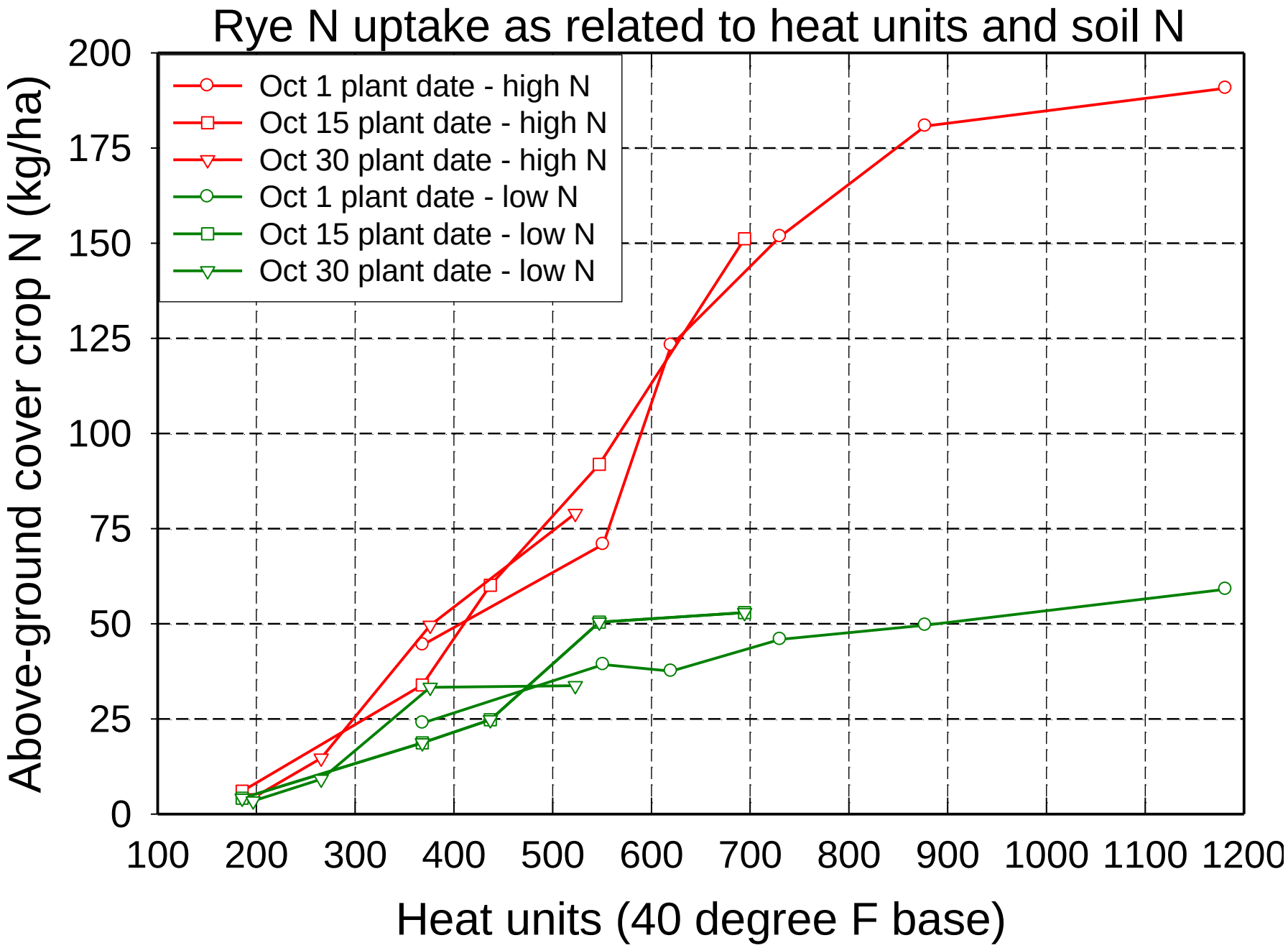
Three aspects of soil N

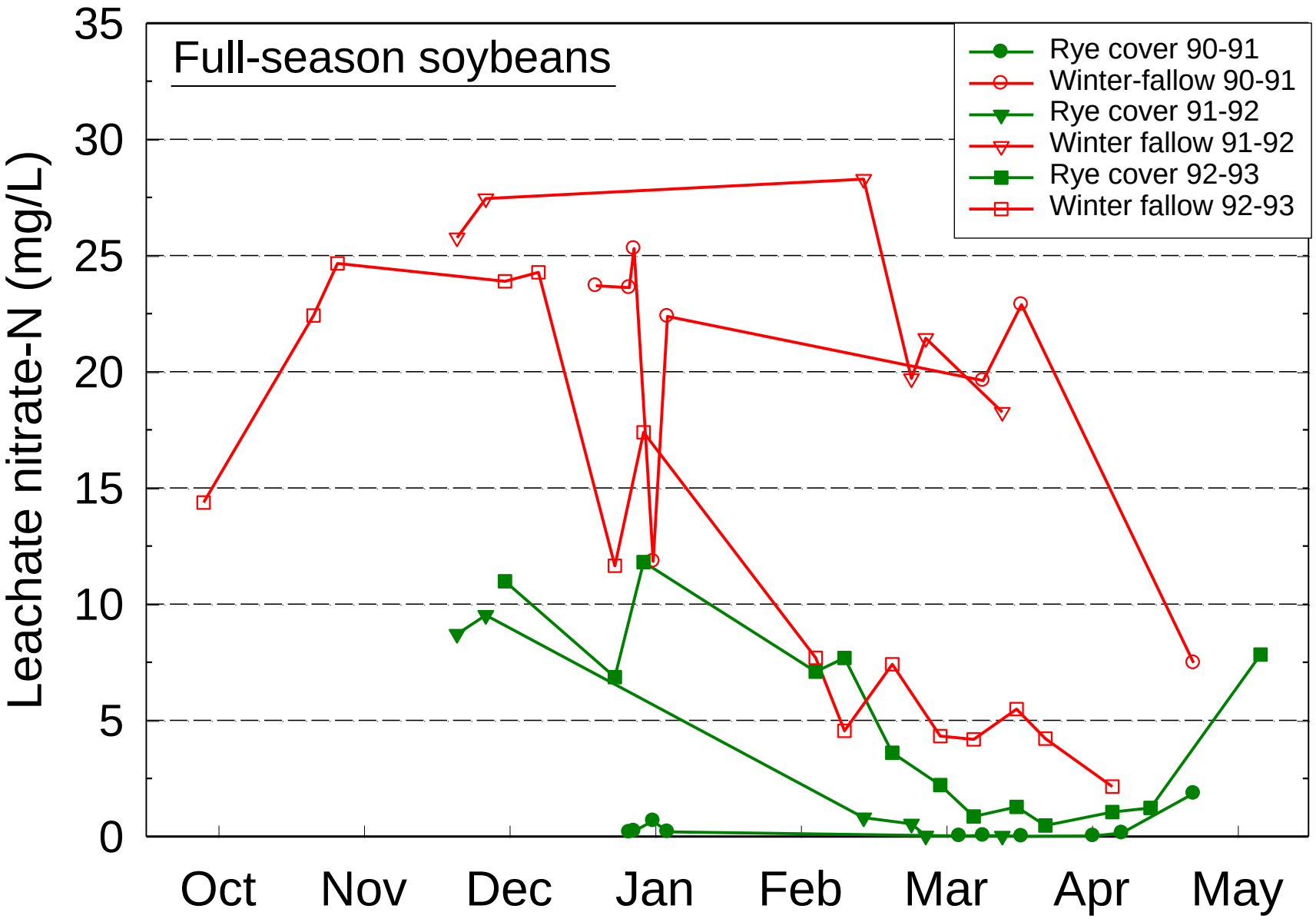
1. Applications
2. Soil N cycle
3. Plant uptake

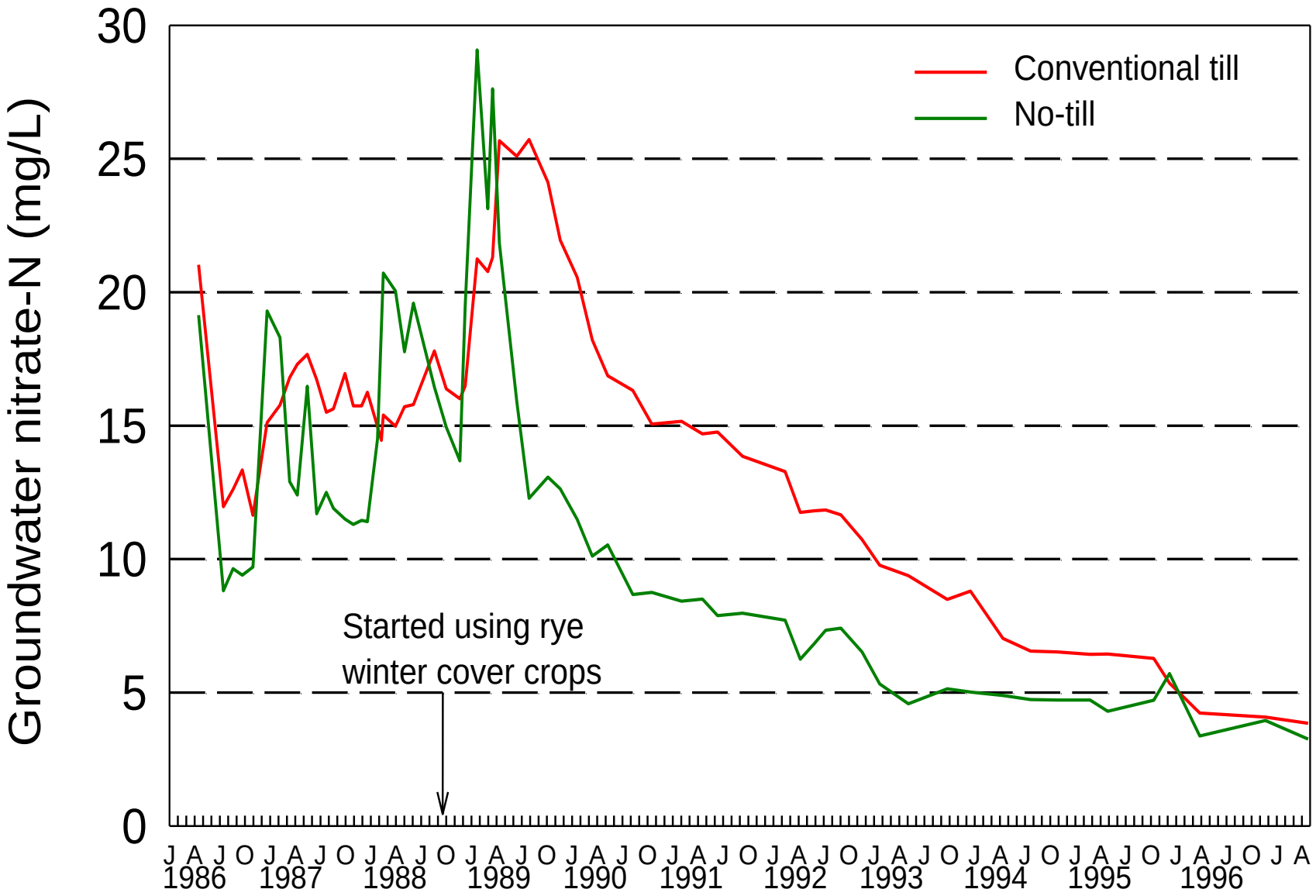
Plant N uptake objective

Keep plant N uptake capacity in place as much as possible both before and after summer annual crops. Make summer annual systems function like perennial systems.


Water table elevation (m)
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
1991
1992
1993
1994
1995

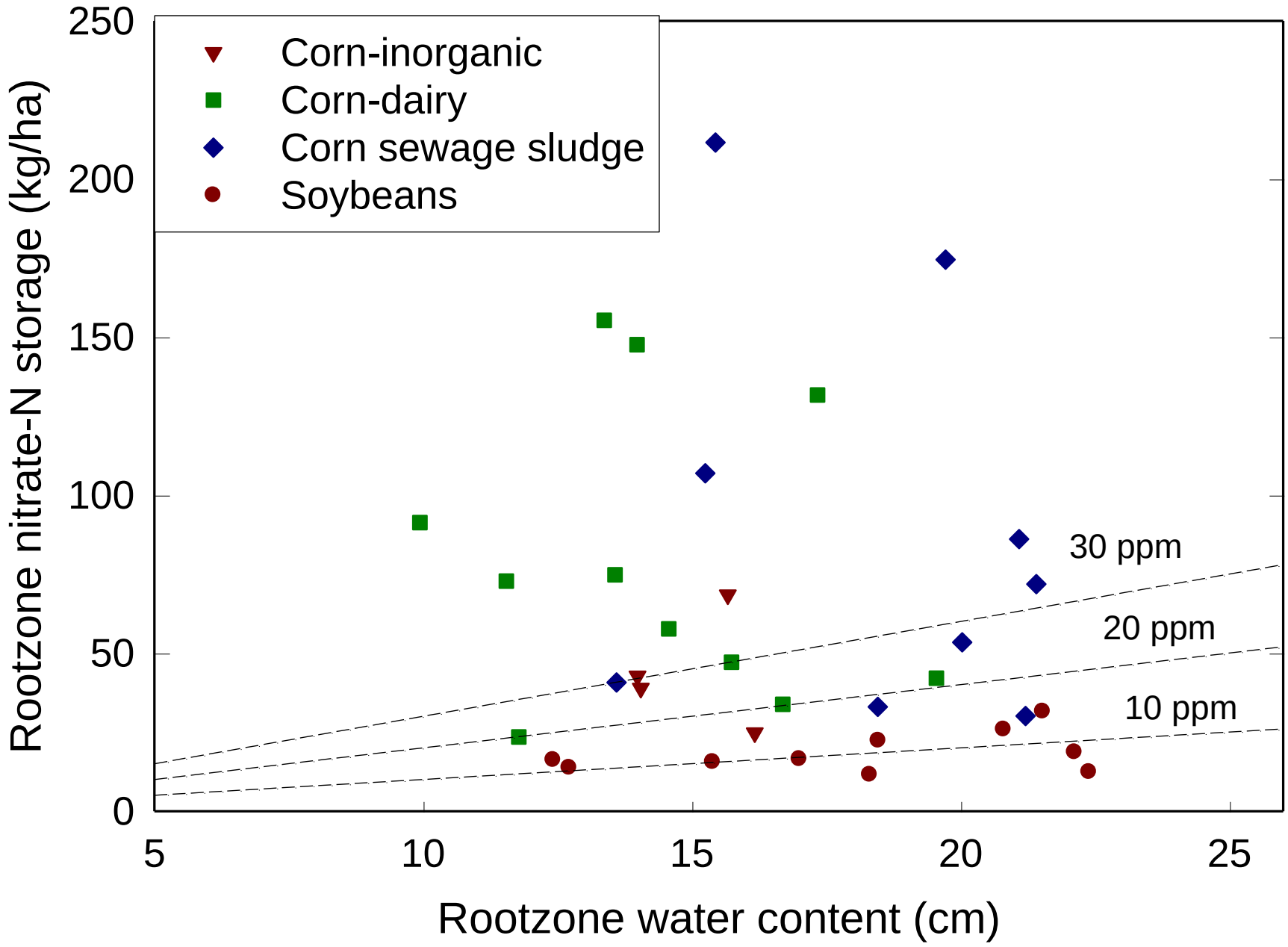

Rye N uptake as related to heat units and soil N
Above-ground cover crop N (kg/ha)
Heat units (40 degree F base)
Oct 1 plant date - high N
Oct 15 plant date - high N
Oct 30 plant date - high N
Oct 1 plant date - low N
Oct 15 plant date - low N
Oct 30 plant date - low N
0
25
50
75
100
125
150
175
200
100
200
300
400
500
600
700
800
900
1000
1100
1200

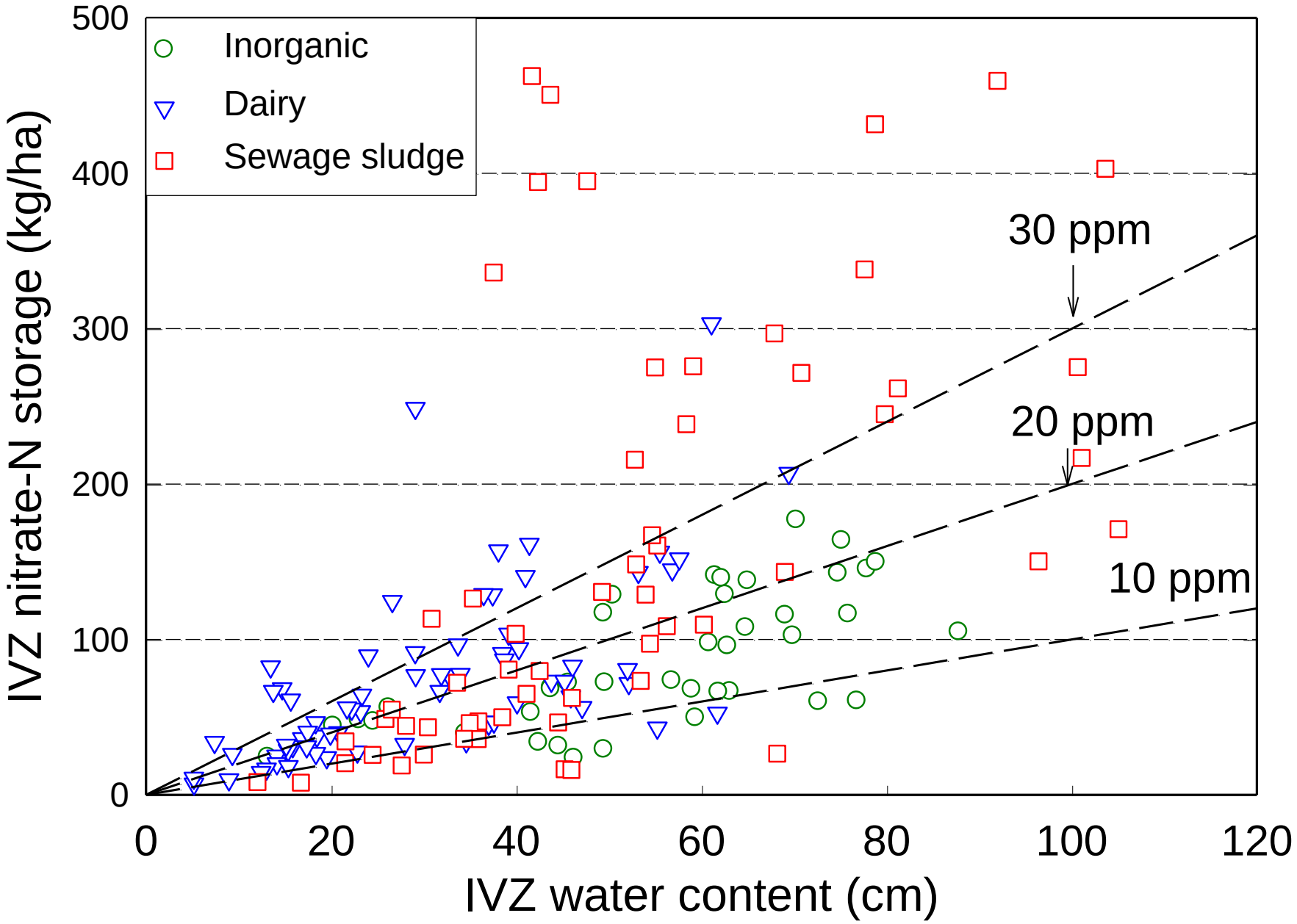

Full-season soybeans
Rye cover 90-91
Winter-fallow 90-91
Rye cover 91-92
Winter fallow 91-92
Rye cover 92-93
Winter fallow 92-93
Leachate nitrate-N (mg/L)
35
30
25
20
15
10
5
0
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May

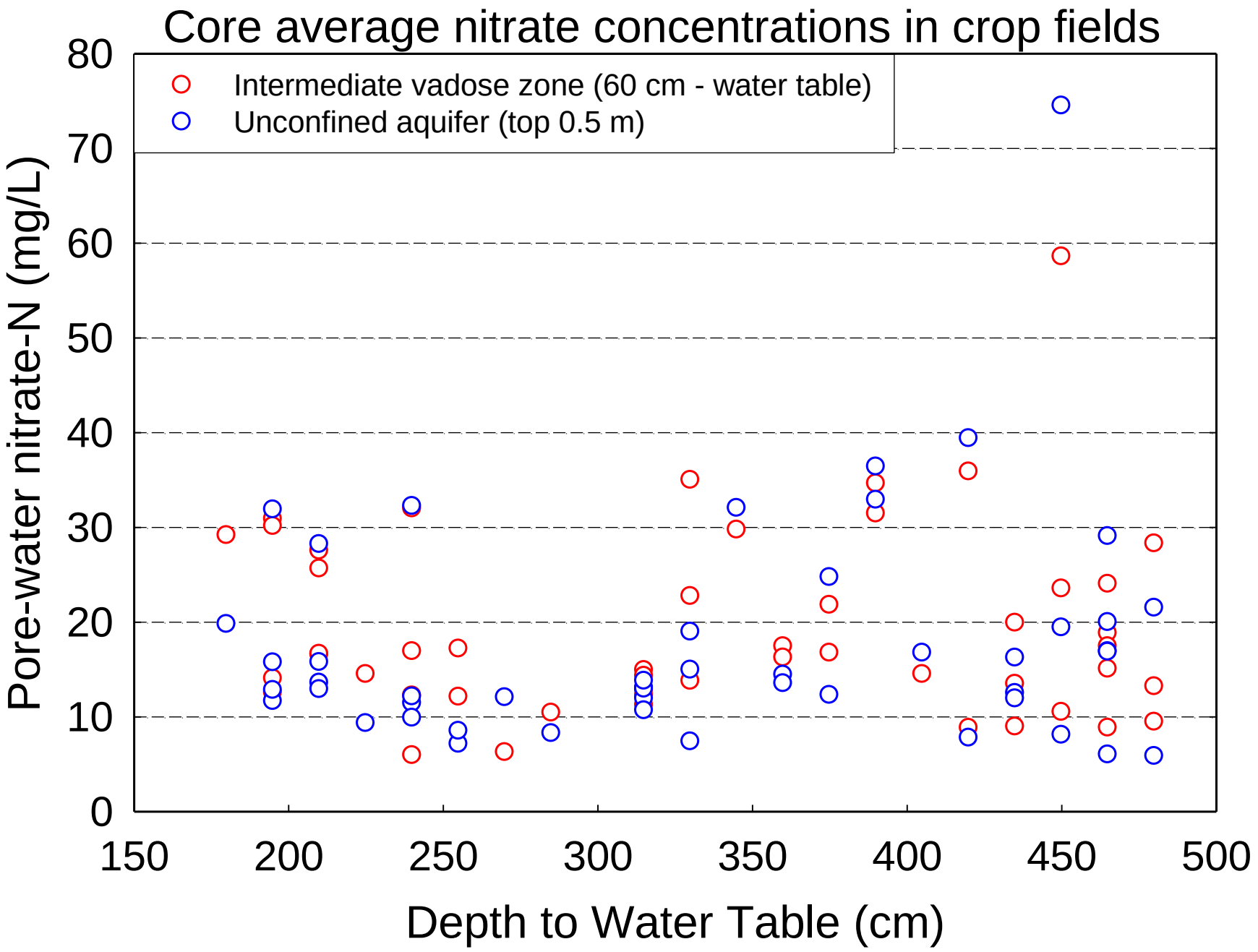

Groundwater nitrate-N (mg/L)
30
25
20
15
10
5
0
Conventional till
No-till
Started using rye
winter cover crops
J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A J O J A
1986 1987 1988 1989 1990 1991 1992 1993 1994 1995 1996

Where can we make progress?

- Rates- use all the tools and track changes to assess progress
- Timing-eliminate preplant inorganic N and split N applications
- Placement- Subsurface apply all soluble N sources
- Winter cover crops to clean up late season and early spring nitrate.
- Buffers-Use deep rooted perennials to intercept subsurface nitrate

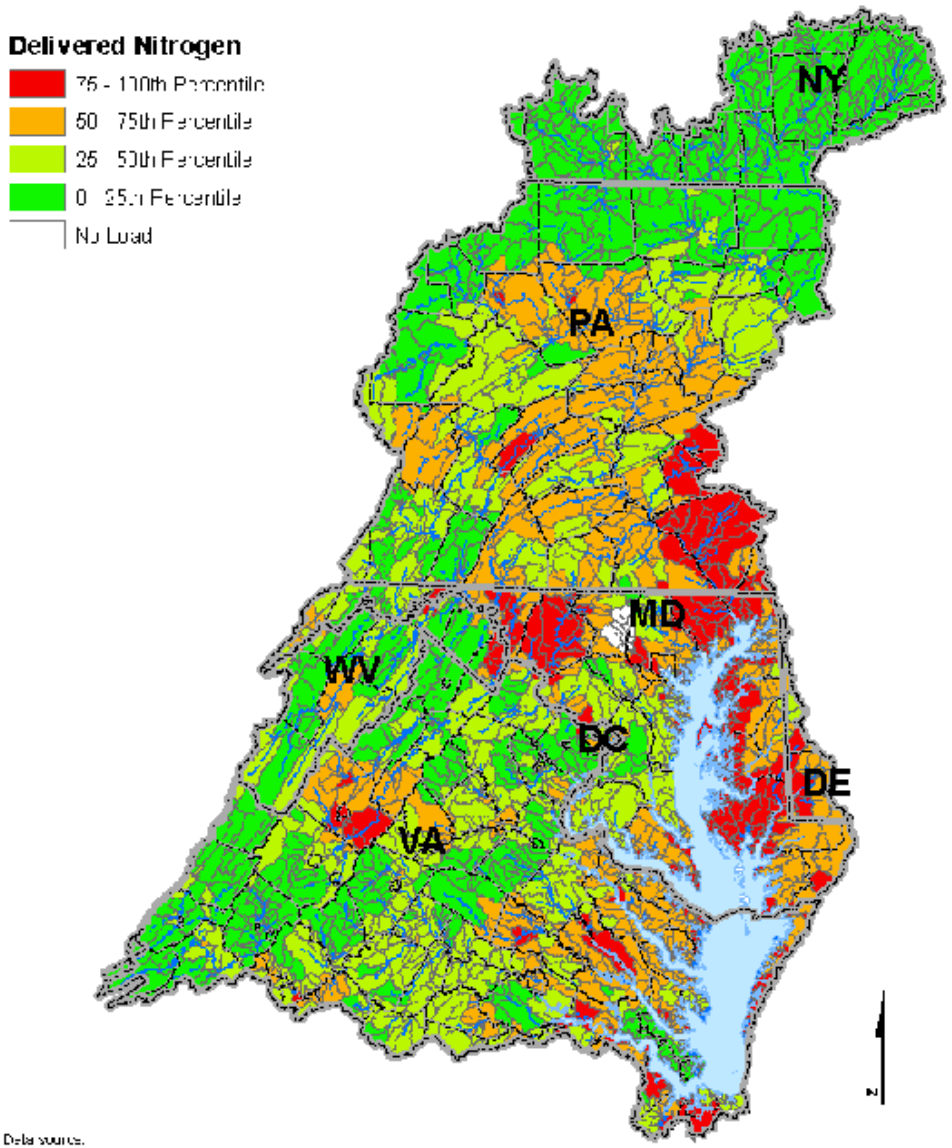

Corn-inorganic
Corn-dairy
Corn sewage sludge
Soybeans
30 ppm
20 ppm
10 ppm
Rootzone nitrate-N storage (kg/ha)
Rootzone water content (cm)
0
50
100
150
200
250
5
10
15
20
25


Inorganic
Dairy
Sewage sludge
30 ppm
20 ppm
10 ppm
IVZ nitrate-N storage (kg/ha)
IVZ water content (cm)
0
100
200
300
400
500
0
20
40
60
80
100
120


Core average nitrate concentrations in crop fields
Intermediate vadose zone (60 cm - water table)
Unconfined aquifer (top 0.5 m)
Pore-water nitrate-N (mg/L)
0
10
20
30
40
50
60
70
80
150
200
250
300
350
400
450
500
Depth to Water Table (cm)

Delivered Nitrogen

Loads per Agricultural Acres within the Chesapeake Bay Watershed

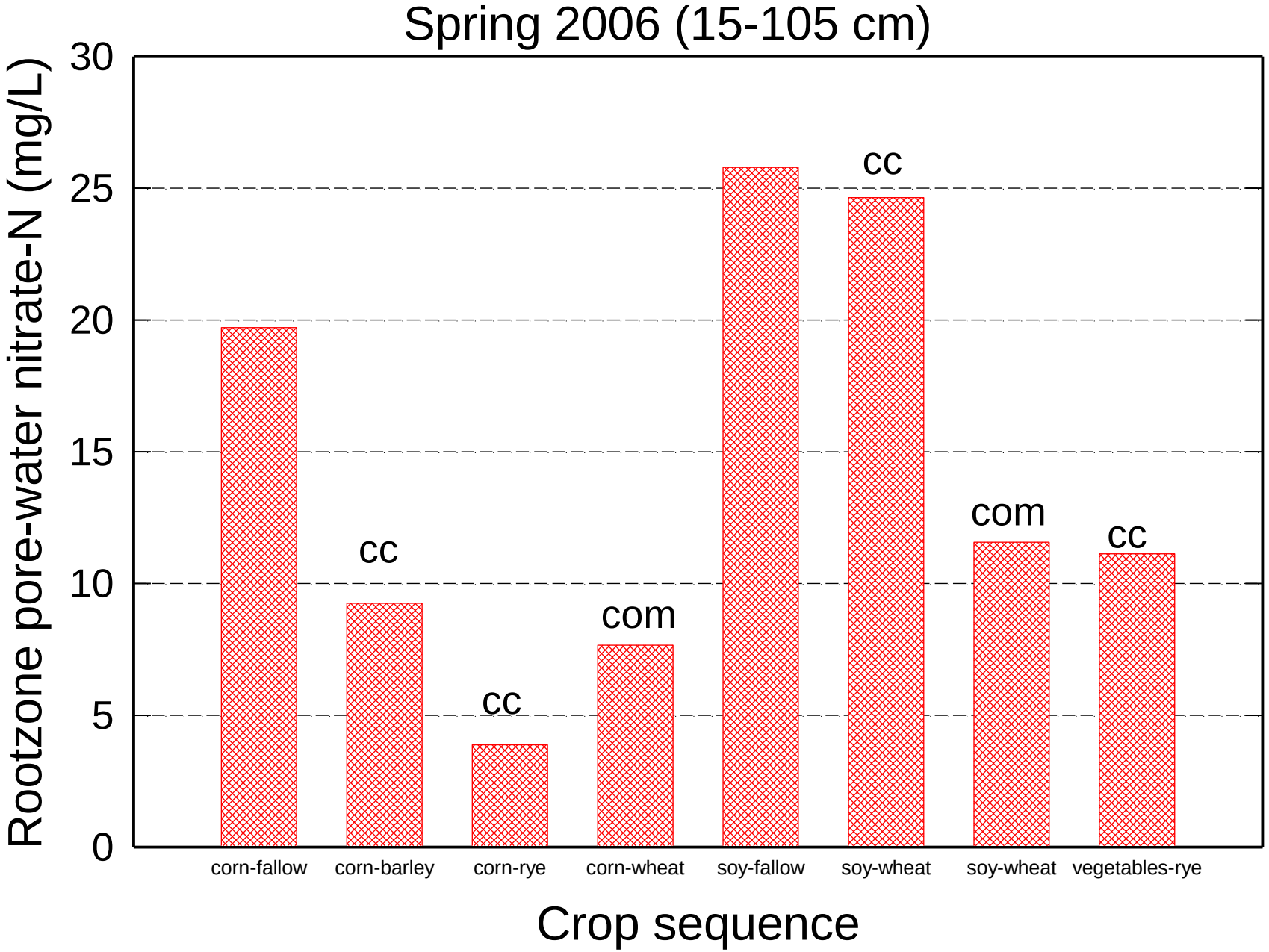


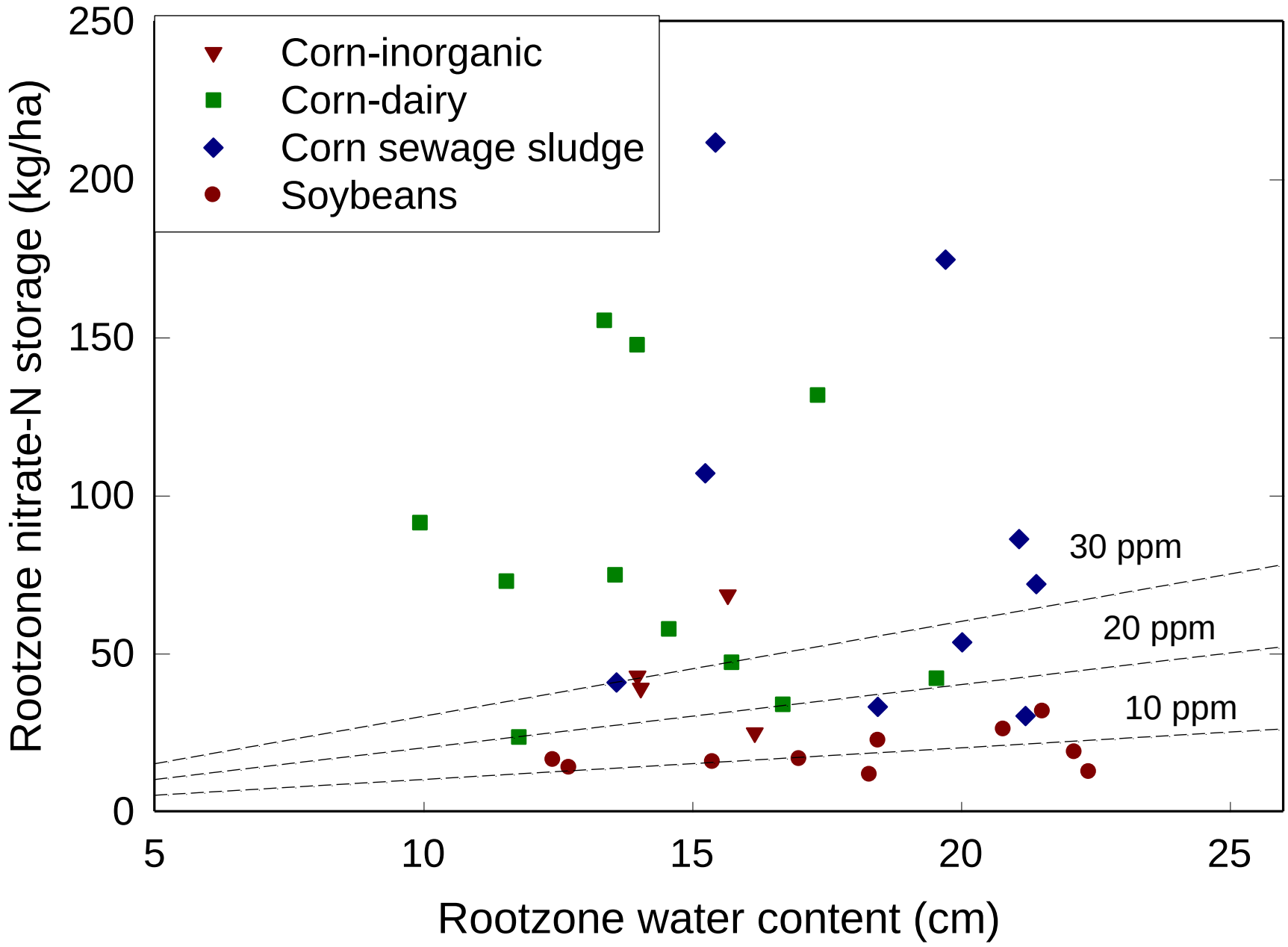
Data source:

USGS - 1997 SPARROW v. 3

Disclaimer: www.chesapeakebay.net/sparrow.htm

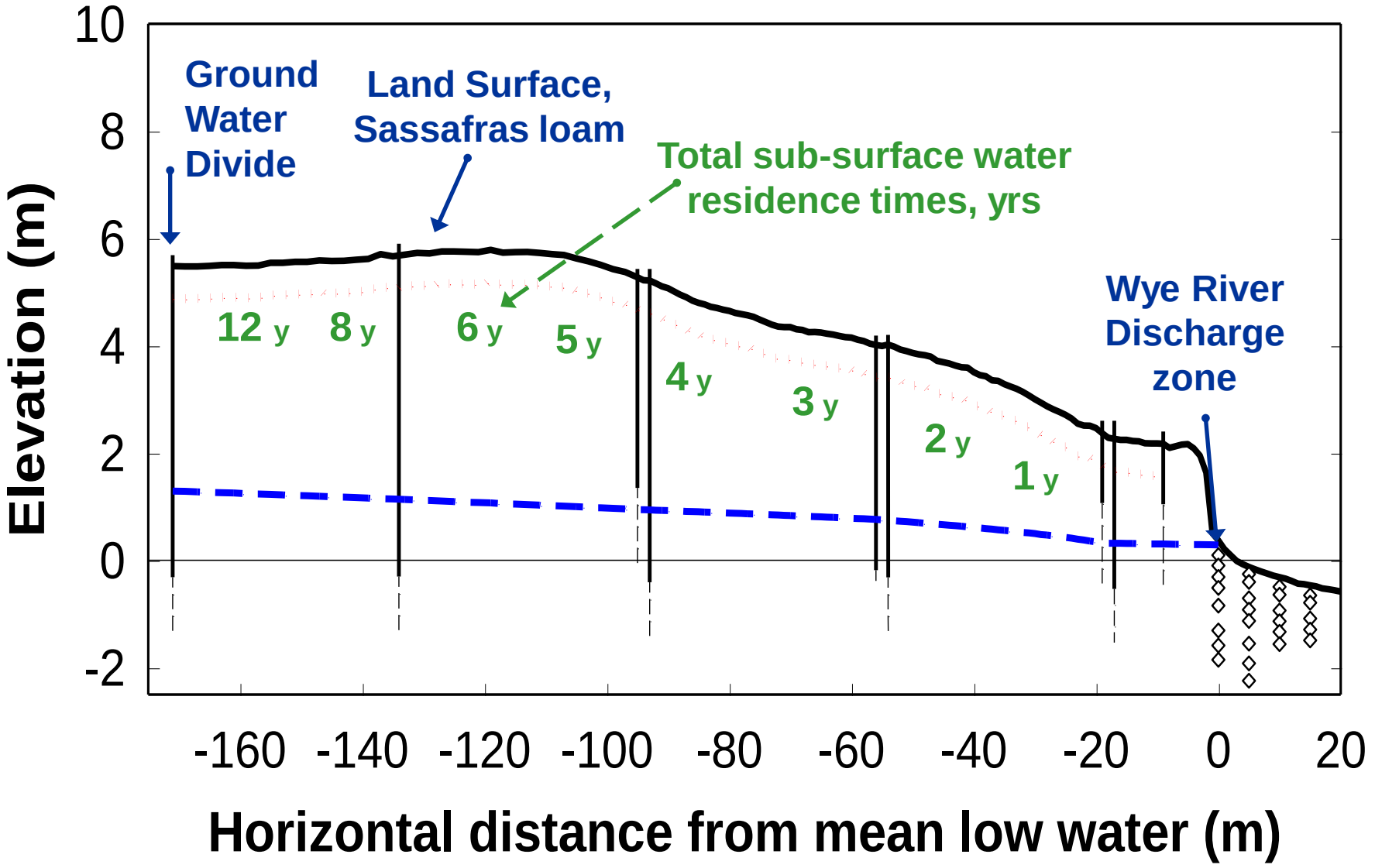
Created by JW, 05/17/2006

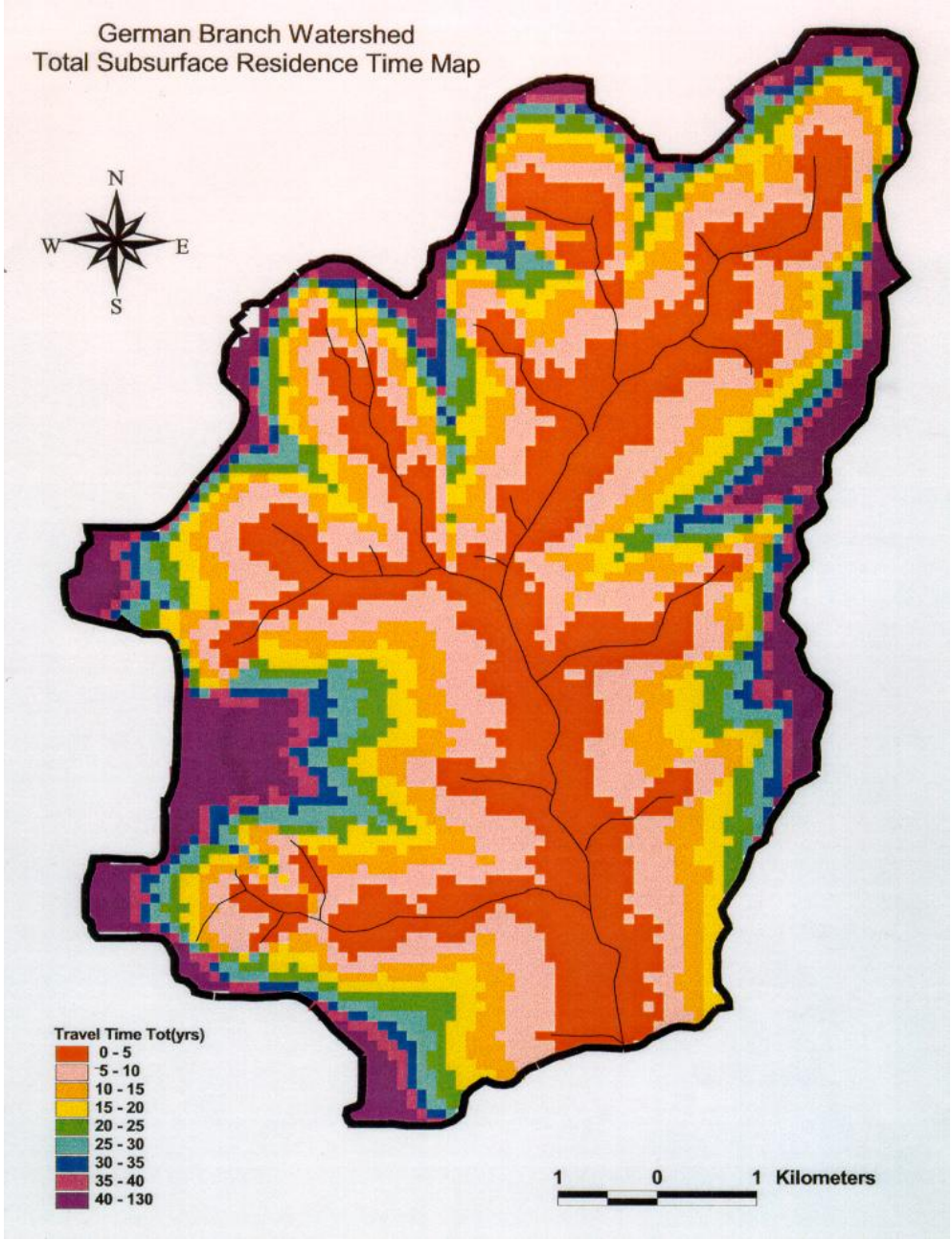

Spring 2006 (15-105 cm)
Rootzone pore-water nitrate-N (mg/L)
30
25
20
15
10
5
0
cc
cc
com
cc
com
cc
corn-fallow
corn-barley
corn-rye
corn-wheat
soy-fallow
soy-wheat
soy-wheat
vegetables-rye
Crop sequence


Corn-inorganic
Corn-dairy
Corn sewage sludge
Soybeans
30 ppm
20 ppm
10 ppm
Rootzone nitrate-N storage (kg/ha)
Rootzone water content (cm)
0
50
100
150
200
250
5
10
15
20
25

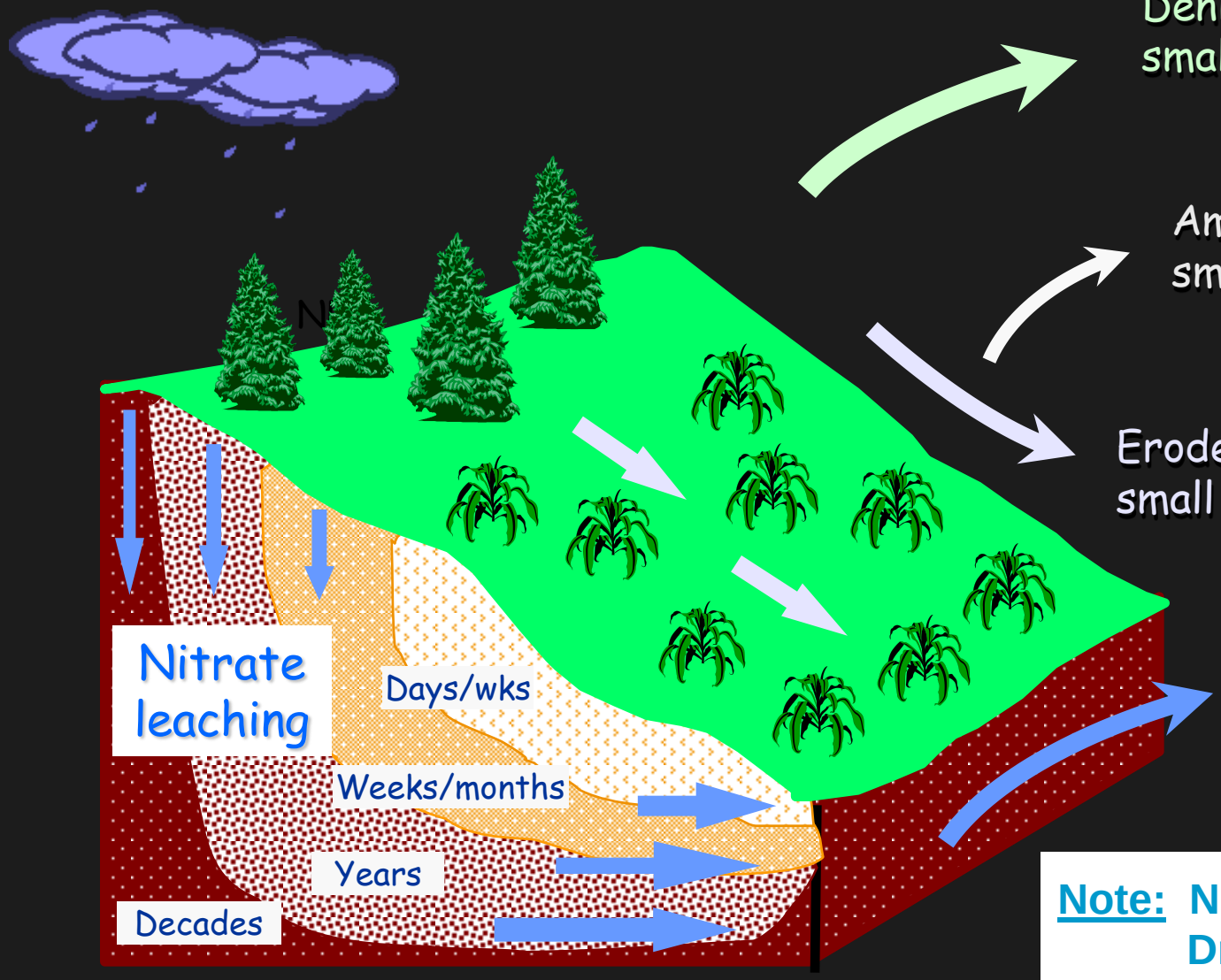
Can cover crops reduce nitrate losses over a landscape?

(Staver and Brinsfield, 2000, DNR Final Project Rpt.)




German Branch Watershed
Total Subsurface Residence Time Map
N
W
E
S
Travel Time Tot(yrs)
0 - 5
5 - 10
10 - 15
15 - 20
20 - 25
25 - 30
30 - 35
35 - 40
40 - 130
1
0
1
Kilometers

Where are the General "Leaks" in the Nitrogen Cycle?



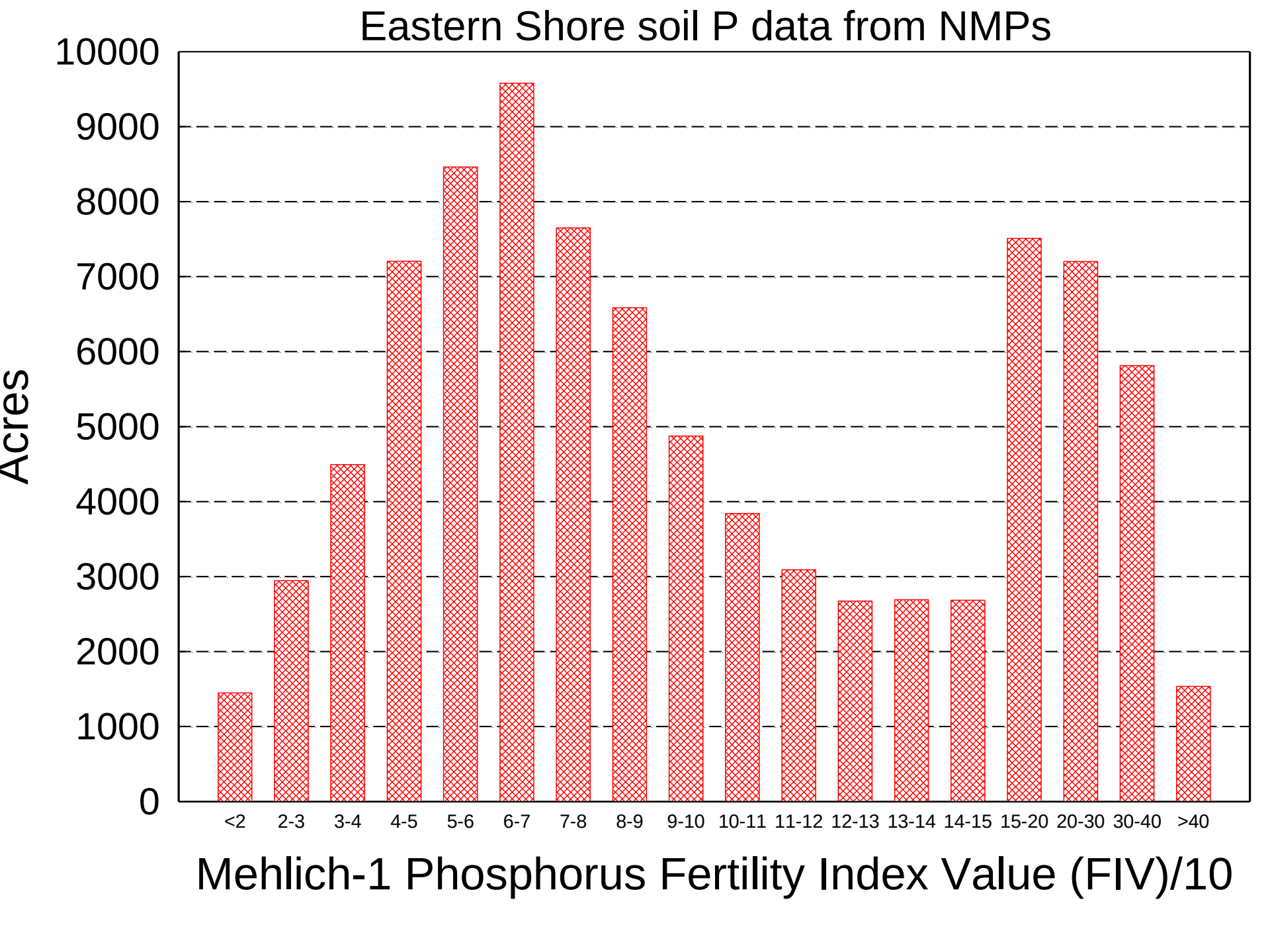
Denitrification losses:
small-moderate 10-20%

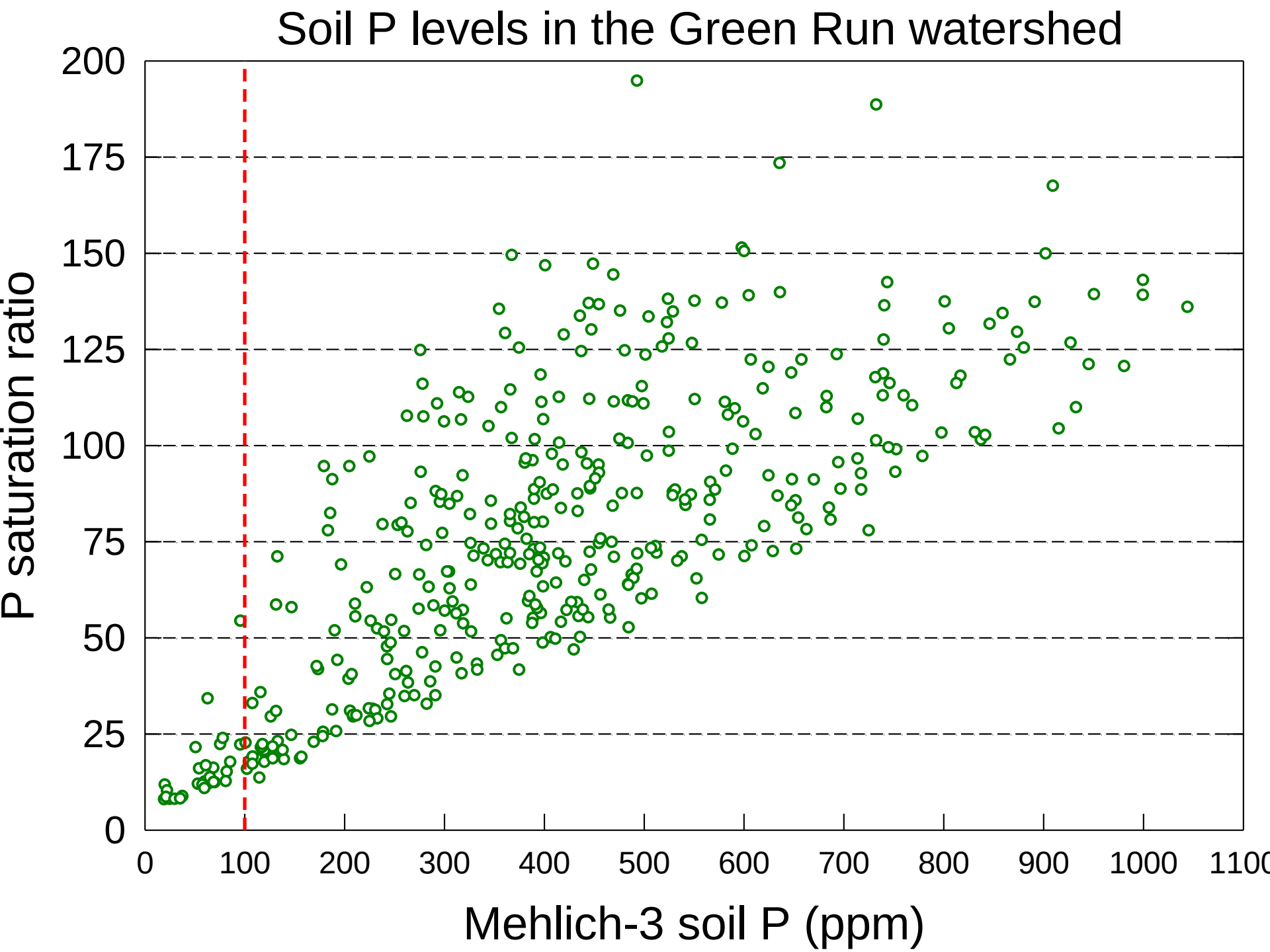
Ammonia losses:
small-moderate 5-20%

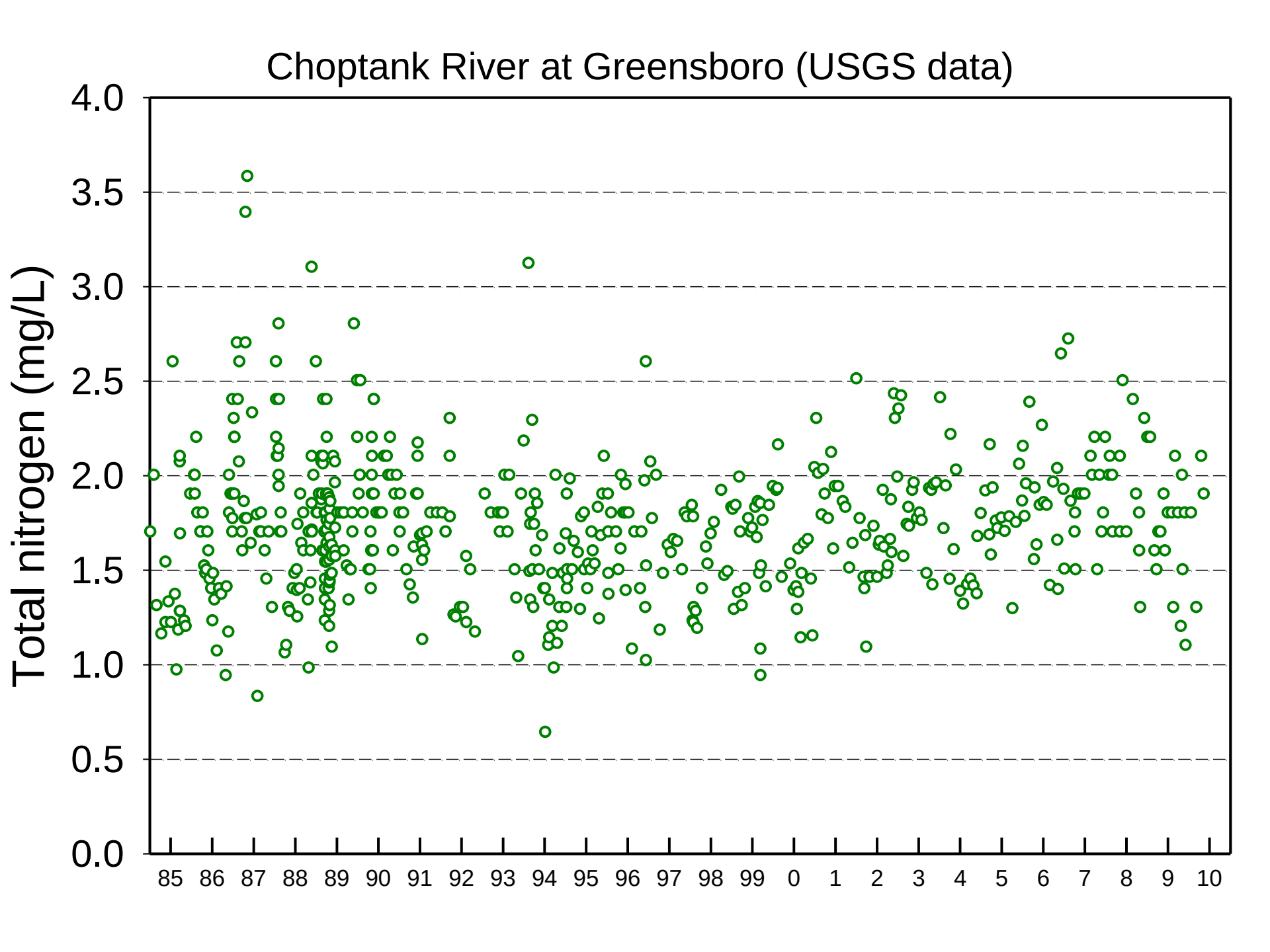
Eroded organic & mineral N:
small losses 1-5%

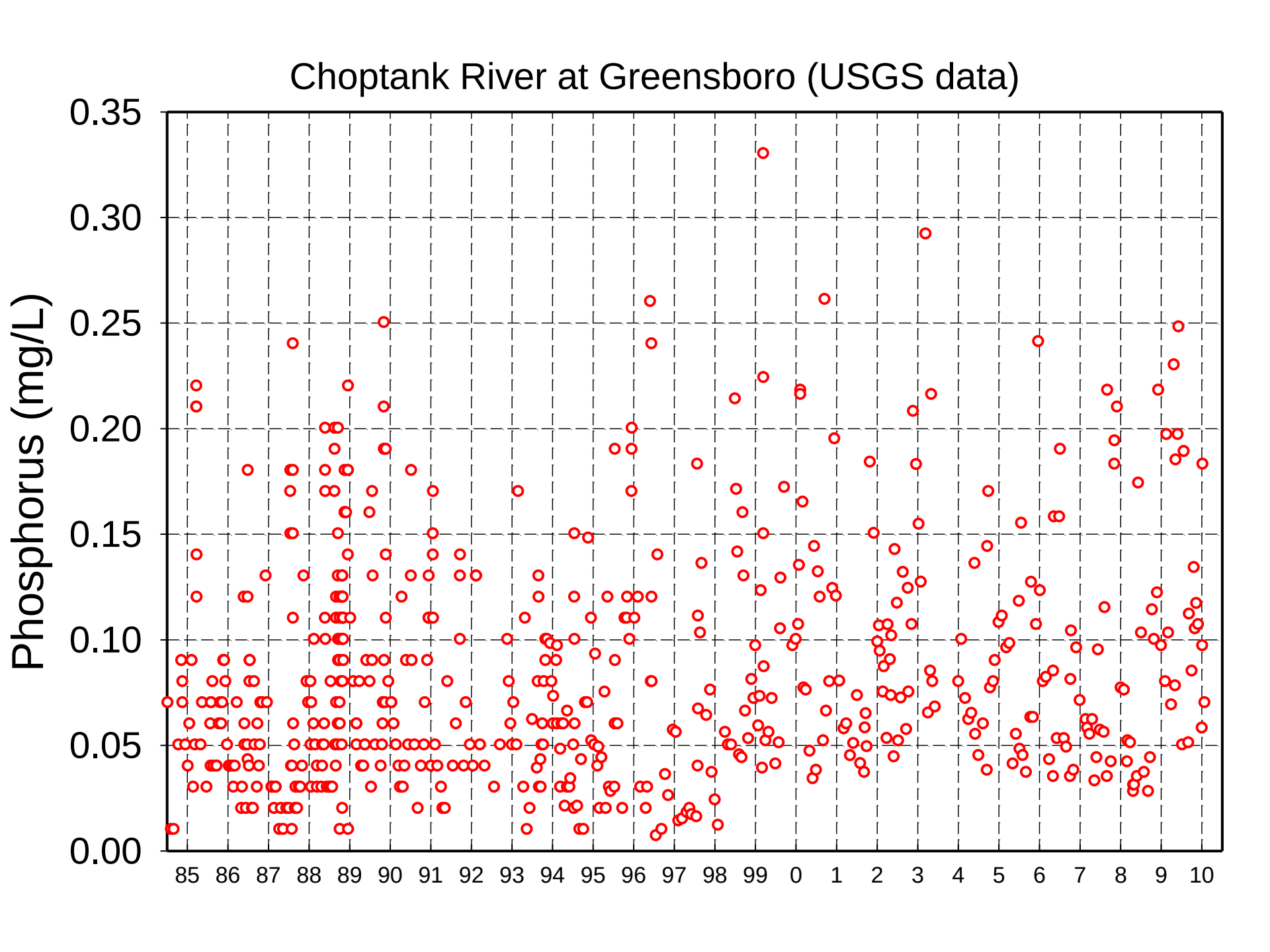
Leaching losses:
Large 10-40%

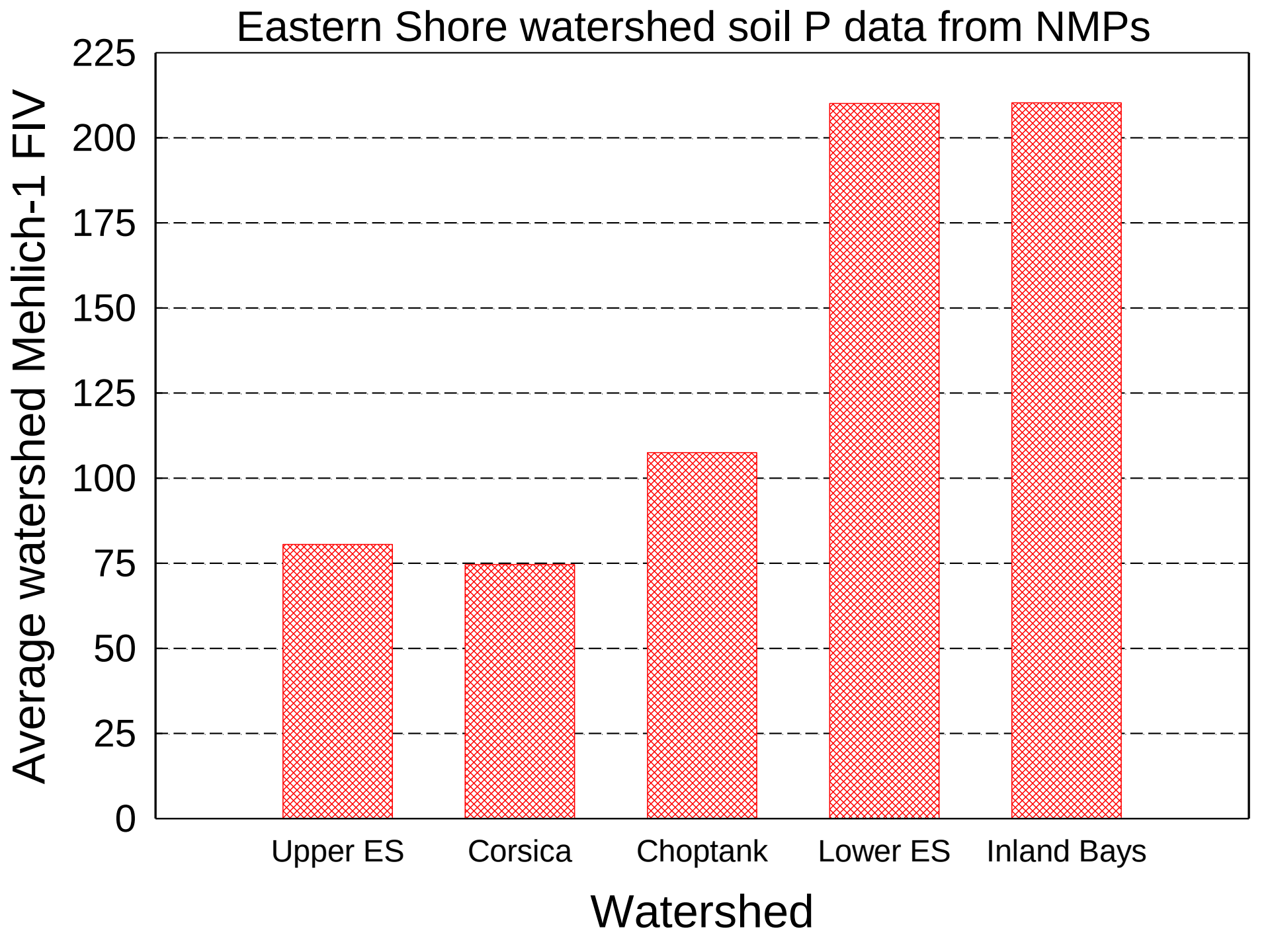
Note: N Cycle Losses are Driven by Hydrology


Eastern Shore soil P data from NMPs
Acres
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
<2
2-3
3-4
4-5
5-6
6-7
7-8
8-9
9-10
10-11
11-12
12-13
13-14
14-15
15-20
20-30
30-40
>40
Mehlich-1 Phosphorus Fertility Index Value (FIV)/10


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


Choptank River at Greensboro (USGS data)
Total nitrogen (mg/L)
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 0 1 2 3 4 5 6 7 8 9 10

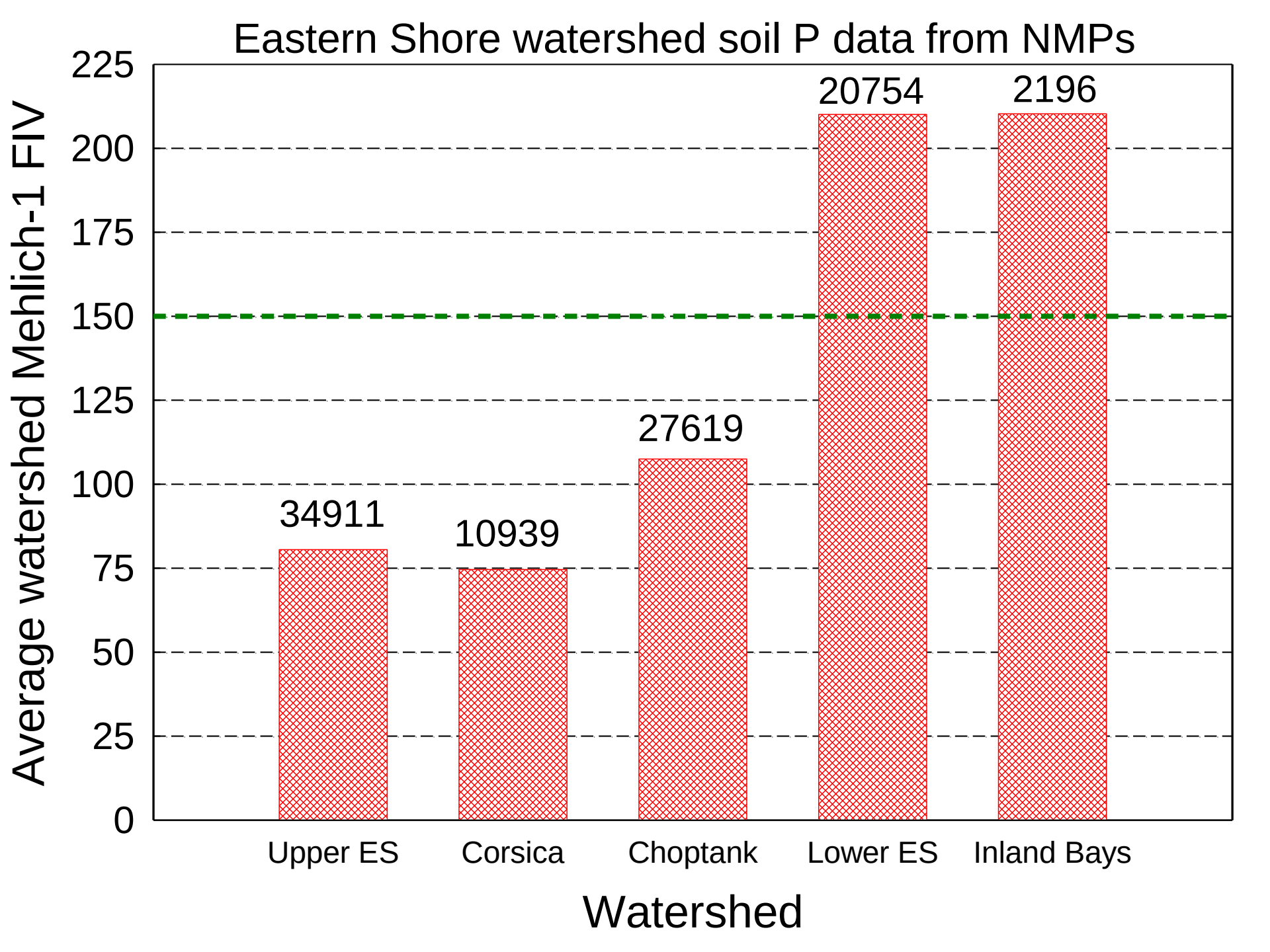

Choptank River at Greensboro (USGS data)
Phosphorus (mg/L)
0.35
0.30
0.25
0.20
0.15
0.10
0.05
0.00
85 86 87 88 89 90 91 92 93 94 95 96 97 98 99 0 1 2 3 4 5 6 7 8 9 10


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

Agriculture and Phosphorus Management

The Chesapeake Bay

Edited by Andrew N. Sharpley

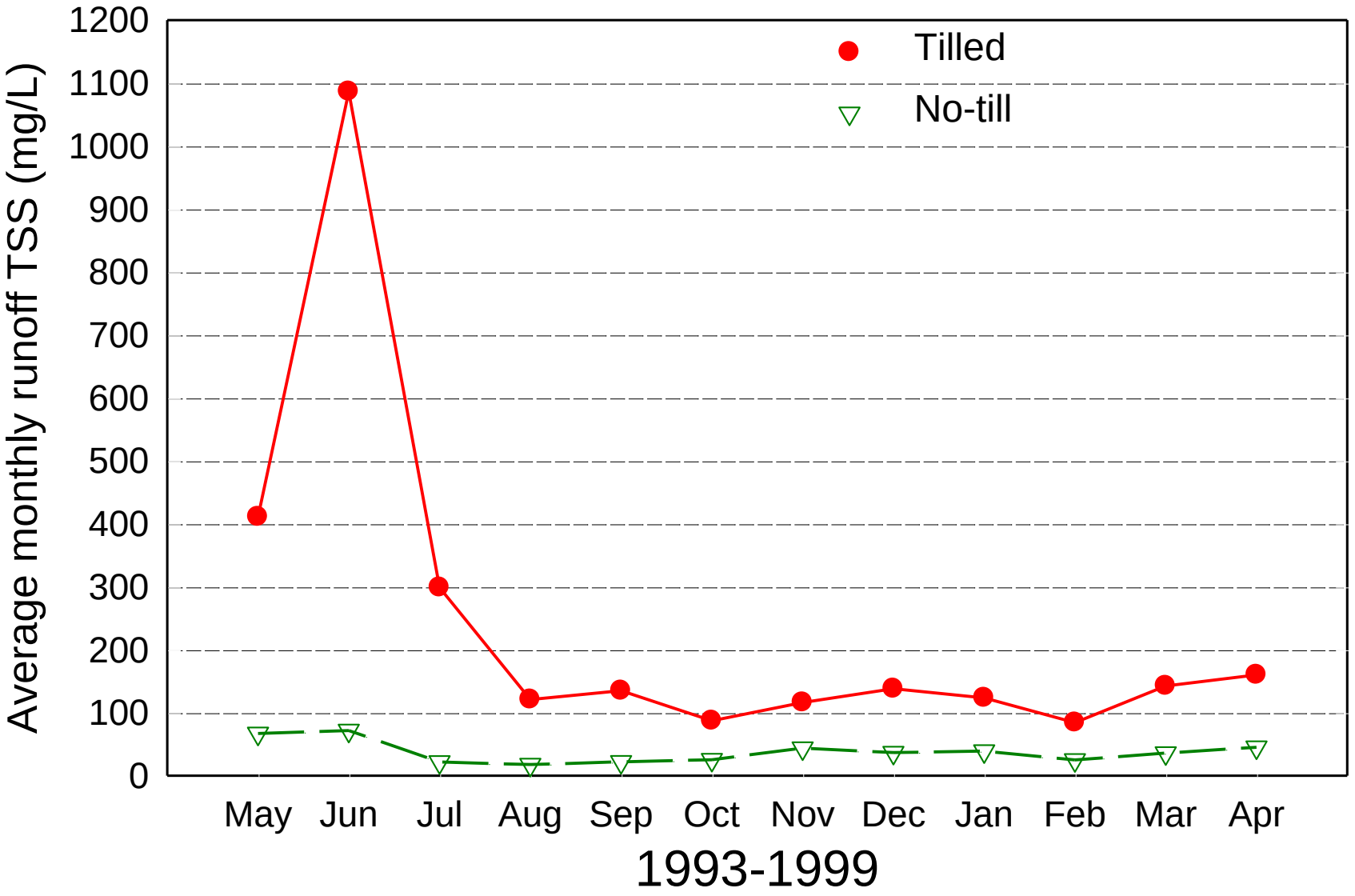

Eastern Shore watershed soil P data from NMPs
Average watershed Mehlich-1 FIV
225
200
175
150
125
100
75
50
25
0
34911
10939
27619
20754
2196
Upper ES
Corsica
Choptank
Lower ES
Inland Bays
Watershed

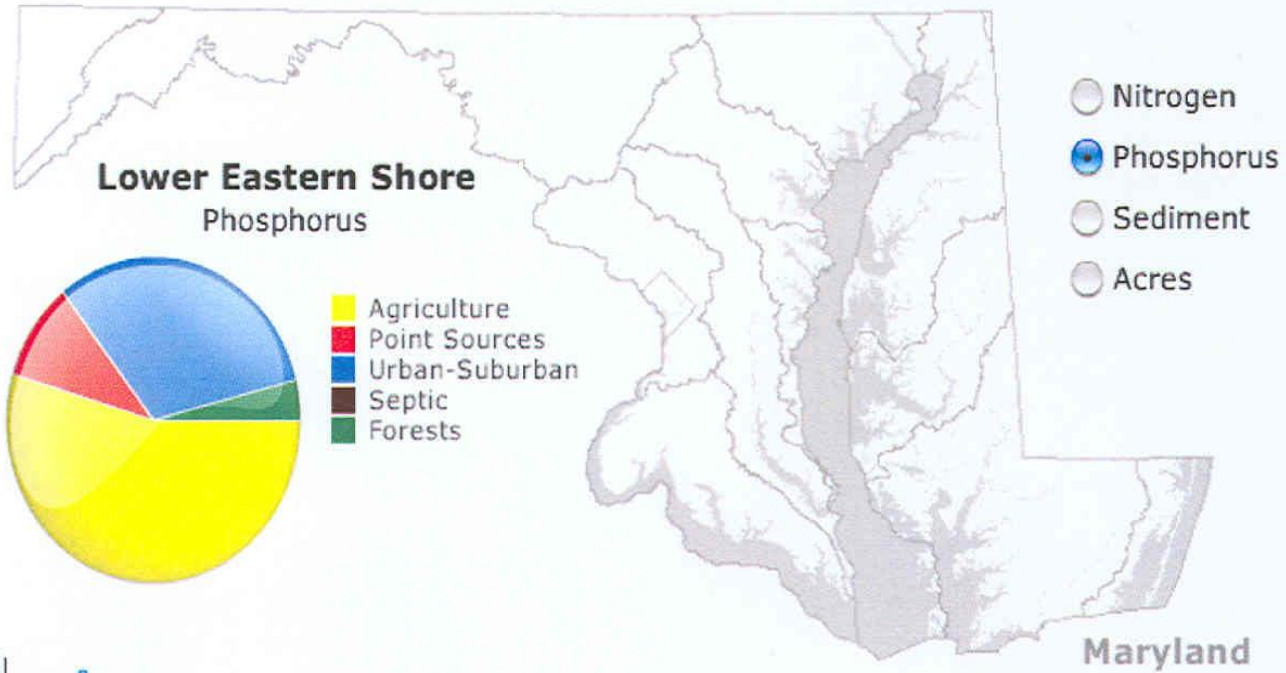
Concluding Remarks

"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."

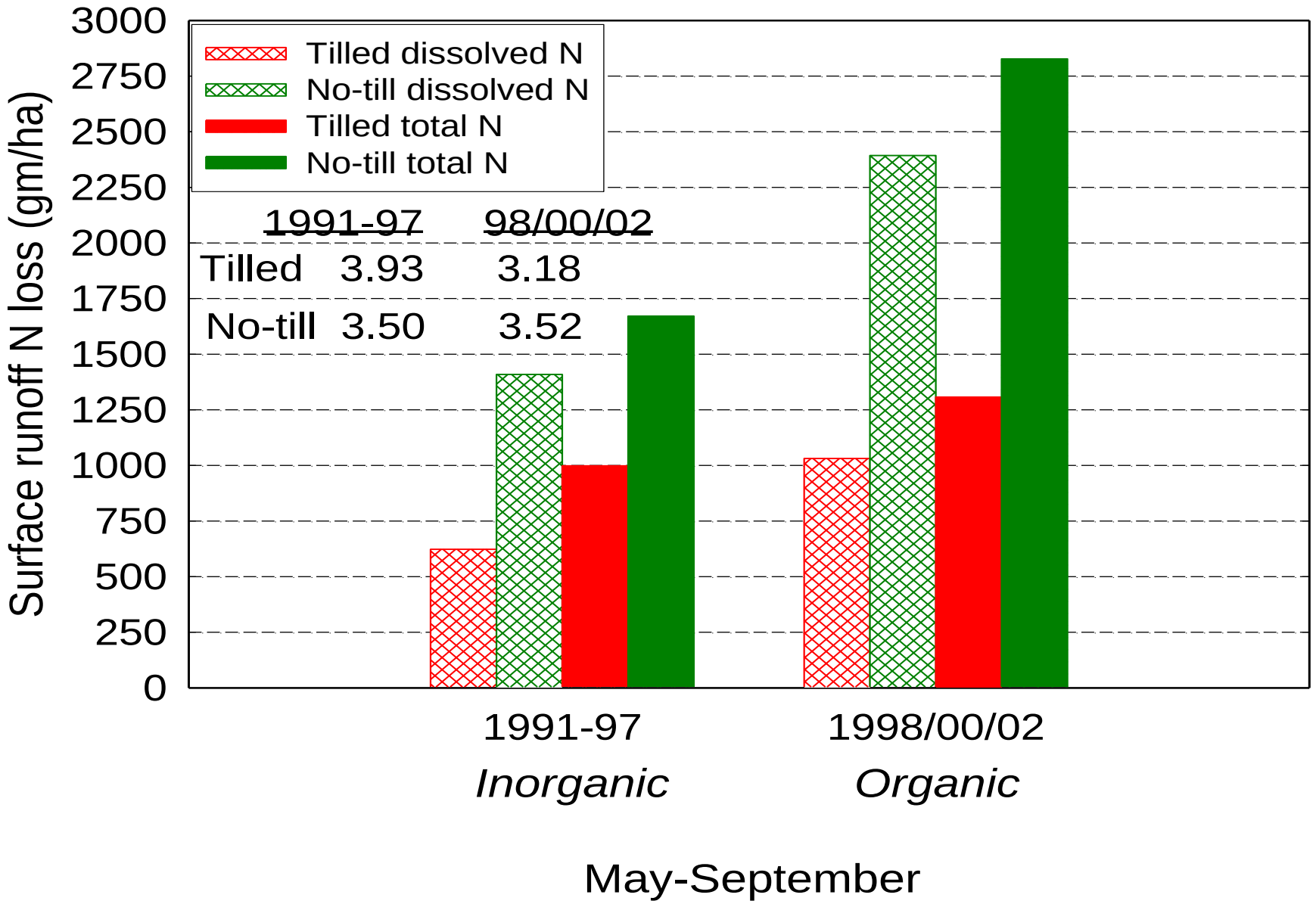
Sims et al. 2002 SSAJ

"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. "


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



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.


Surface runoff N loss (gm/ha)
3000
2750
2500
2250
2000
1750
1500
1250
1000
750
500
250
0
Tilled dissolved N
No-till dissolved N
Tilled total N
No-till total N
1991-97 98/00/02
Tilled 3.93 3.18
No-till 3.50 3.52
1991-97
1998/00/02
Inorganic
Organic
May-September


CASE IH