CBP/TRS-310-16

Cover Crops Practices For Use in Phase 6.0 of the Chesapeake Bay Program Watershed Model

Chesapeake Bay Program
Science. Restoration. Partnership.

January 2017

2020 – Keep moving!

The Problem on the Land

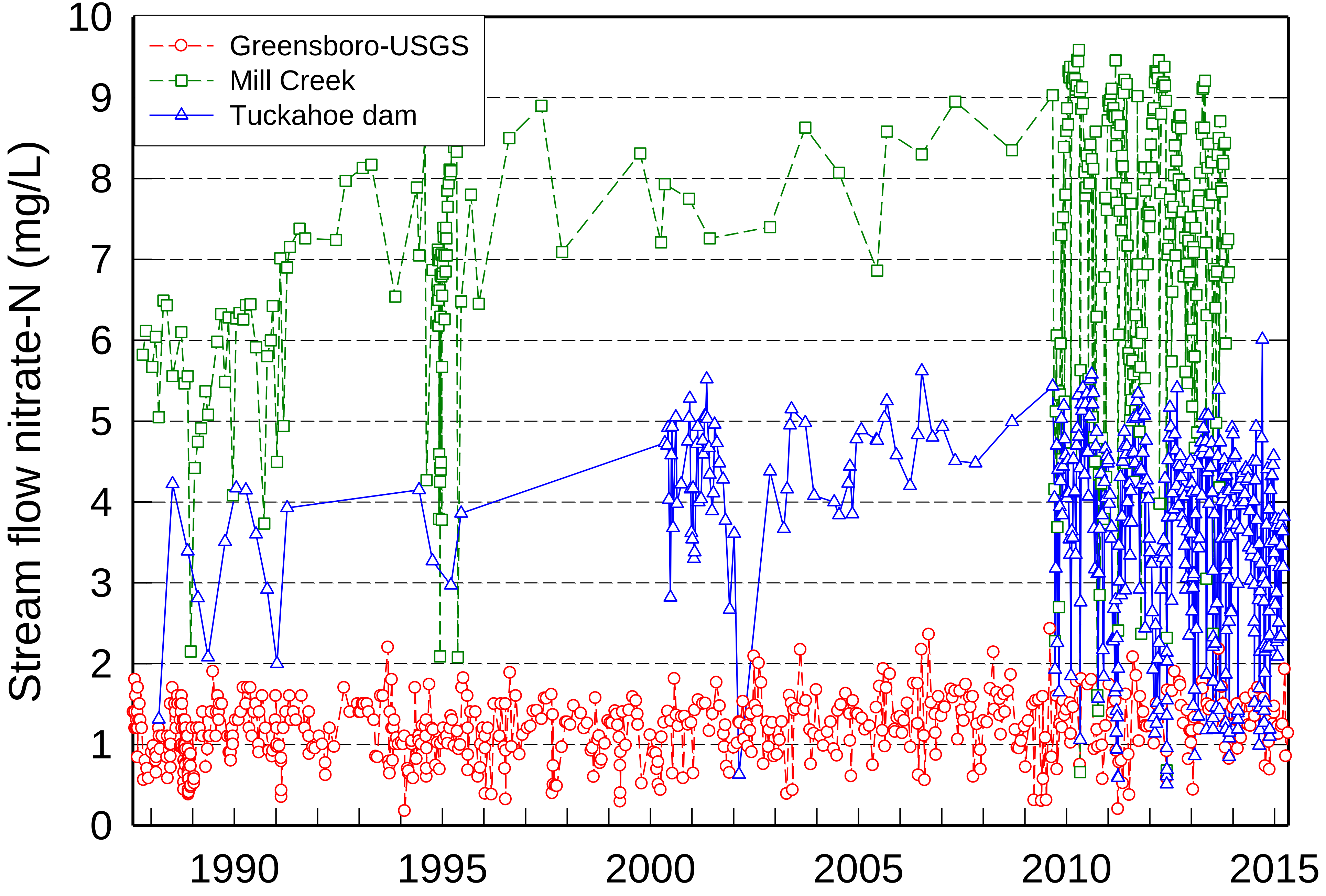
Groundwater under cropland is highly enriched in nitrate-N and results in high nitrate levels in stream flow and high loading rates of algal available N to tidal waters.

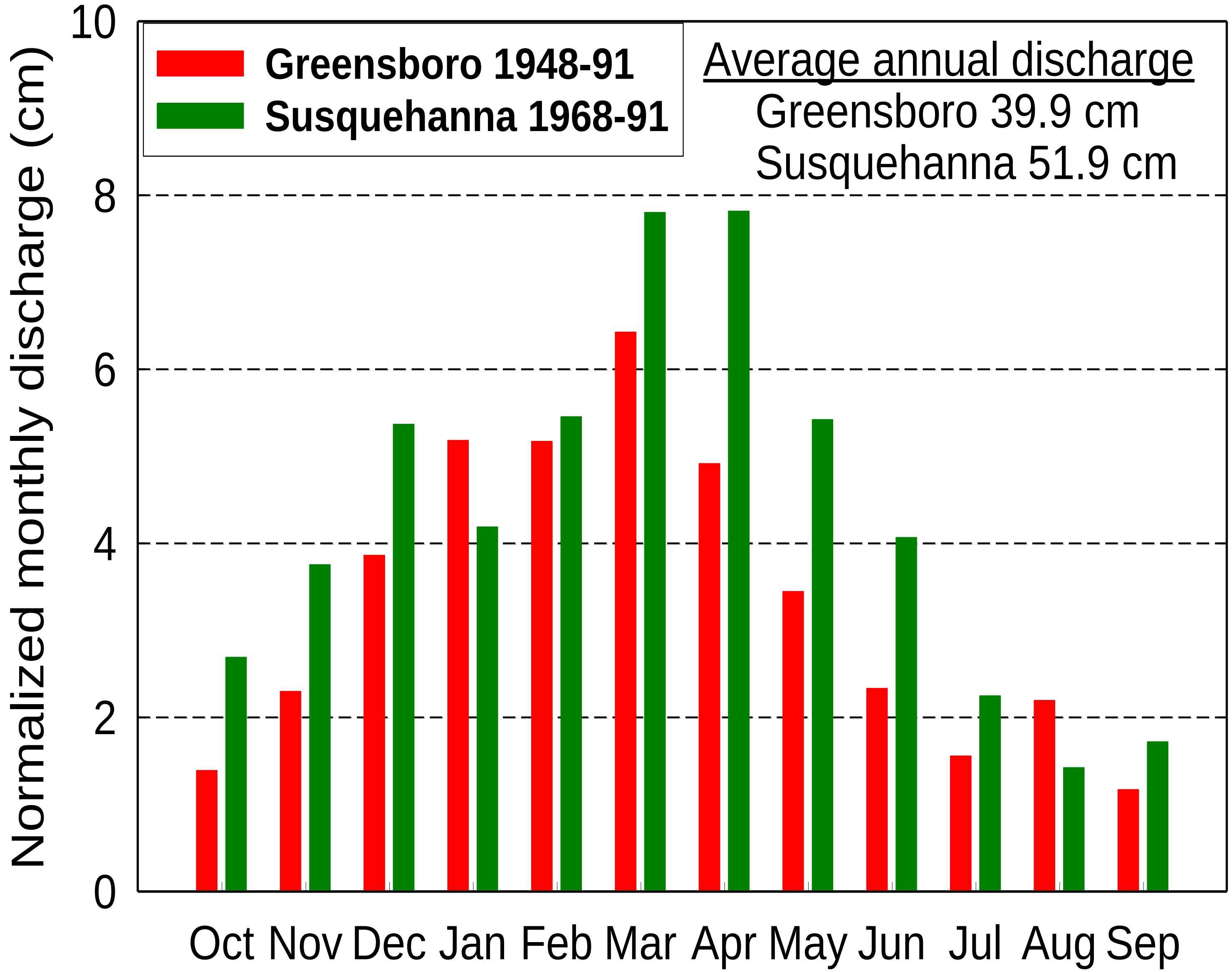
Some Rough Numbers

In the Coastal Plain, approximately 80 % of the N delivered to Chesapeake Bay from crop land moves through groundwater flow paths.

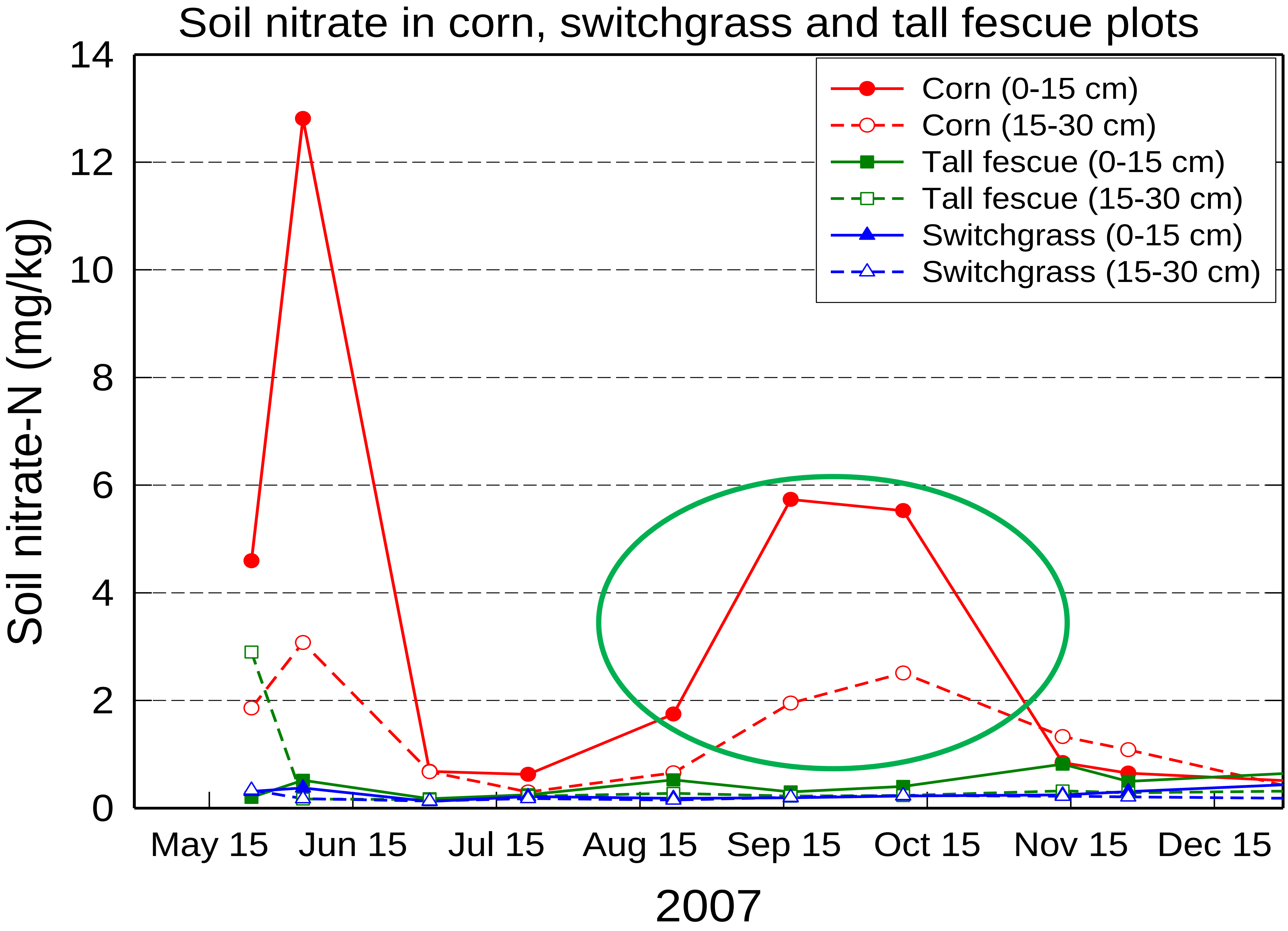
~20-30 kg/ha

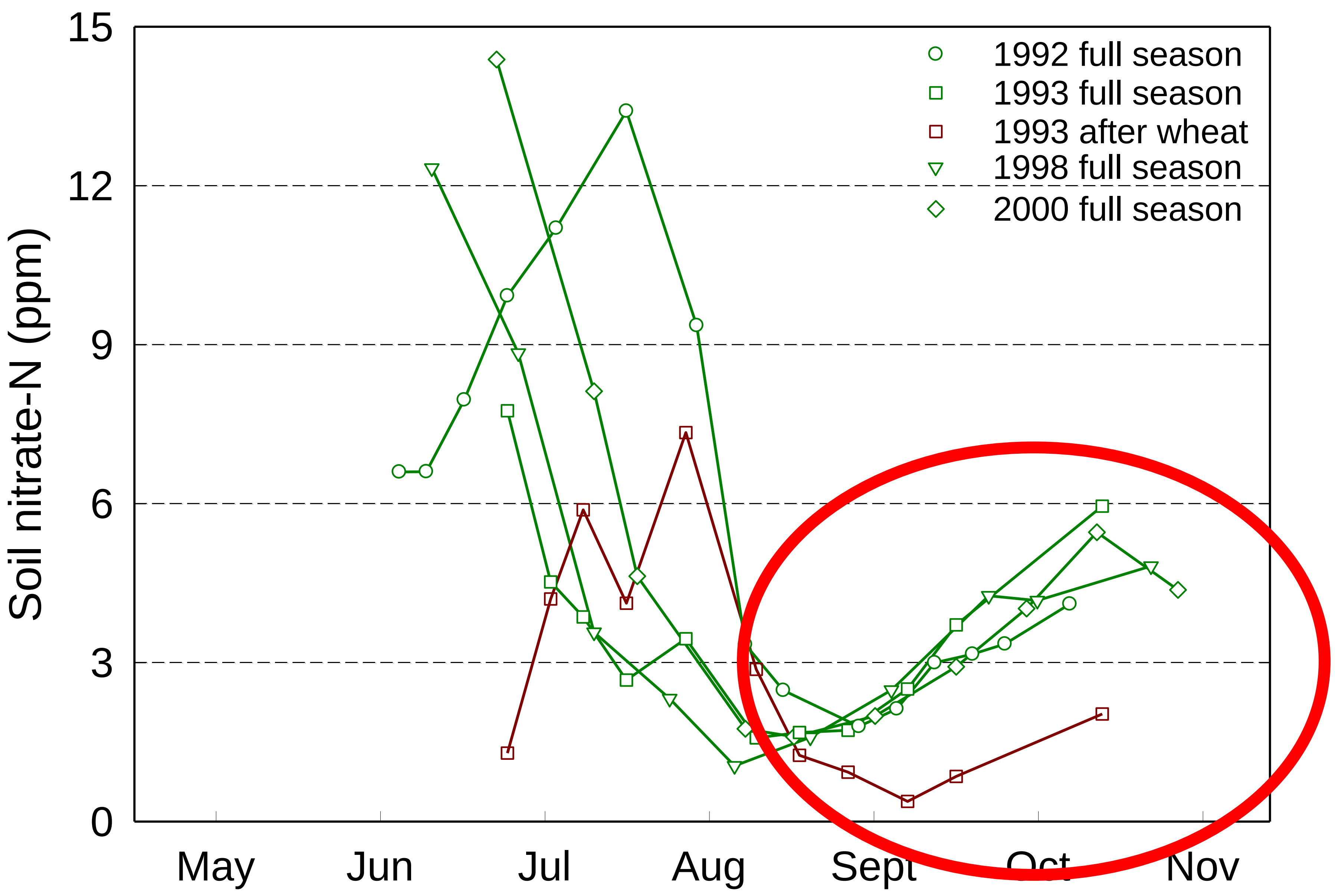
Long-term stream flow NO_3-N





Normalized monthly discharge (cm)
0
2
4
6
8
10
Greensboro 1948-91
Susquehanna 1968-91
Average annual discharge
Greensboro 39.9 cm
Susquehanna 51.9 cm
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep


Soil nitrate in corn, switchgrass and tall fescue plots
Soil nitrate-N (mg/kg)
0
2
4
6
8
10
12
14
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)
May 15
Jun 15
Jul 15
Aug 15
Sep 15
Oct 15
Nov 15
Dec 15
2007



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

Membership-Phase 6 Cover Crop Panel

Name	Affiliation	Role
Ken Staver	University of Maryland	Panel Chair
Charlie White	Penn State University	Panel Member
Jack Meisinger	USDA – Agriculture Research Service	Panel Member
Paul Salon	USDA-Natural Resources Conservation Service	Panel Member
Wade Thomason	Virginia Tech	Panel Member
Jason Keppler	*Maryland Department of Agriculture*	*Watershed Technical Workgroup representative*
David Wood	*Chesapeake Bay Program Office*	*Modeling Team representative*
Mark Dubin	*University of Maryland*	*AgWG Coordinator*
Lindsey Gordon	*Chesapeake Research Consortium*	*Staff*

The essential cover crop effect on N losses

- Reduce soil nitrate pool outside of summer growing season to minimize potential for nitrate leaching, which is the major route of N loss from cropland in many parts of the Bay watershed.
- Pretty simple in traditional case of pure stands planted in otherwise winter fallow settings with no fall nutrients (basically the 5.3.2 approach).
- P6, considering real world situations where nitrate pool is adjusted (up for fall manure, down for commodity cover crops), and cover crop uptake potential is reduced by reducing grass content in mixtures with legumes.

P6 CC panel three main tasks (May 19-2016)

- Use 5.3.2 panel table efficiencies for traditional cover crops as base and …

1. Modify efficiencies for mixtures based on new data from PSU and VT, probably a little higher.
2. Modify table to apply to cropland where manure is applied in fall, mostly corn silage.
3. Modify table to apply to winter cereal production fields (commodity) with no fall nutrients applied.

A couple of key changes from 5.3.2

- Traditional and commodity cover crops can be applied to all row crop land uses except for some minor specialty crops (e.g., spinach)
- Cover crop efficiencies will be applied to specific land uses, rather than the average crop acre
- Commodity cover crop effect will only consider impact of no fall nutrient applications. After Jan. 1 dealt with in the winter cereals land use with NM

P6 Cover crop panel recommendations

- All coefficients developed so far for traditional single species cover crops left unchanged, but P6 land use changes will lead to some changes in load reductions.
- Fall manure and mixture cover crop BMPs working off of traditional cover crop table values
- Commodity cover crop a limited data best-professional-judgement recommendation.

Many studies but many gaps. Consistent findings:

- Winter cereals respond to higher soil N, producing more biomass and moving more soil nitrate-N into above-ground biomass as soil N availability increases.
- The reference cover crop used in past panel reports (cereal rye planted at 2 bu/acre) when planted in early or standard planting periods is capable of taking more N out of the soil than is generally available post-harvest in summer annual row crop settings.
- Reducing cover crop uptake potential by reducing planting rates, or delaying planting, increases the likelihood that nitrate will be leached out of reach of cover crop roots before uptake can occur.
- Increasing the fall soil nitrate pool by applying manure or inorganic N will increase winter cereal N uptake but also increase the potential for nitrate leaching.

P6 Cover crop panel recommendations

- 5.3.2 grass/legume mixture values should apply to mixtures that are 25-50% of the monoculture grass planting rate (from 50-100%)
- Grass/legume mixture category added to include mixtures that are 50-100% of the monoculture grass planting rate. N reduction credit 0.7 of monoculture grass planting rate (only new "flavor").
- 50-100% monoculture grass planting eligible for this credit in early and standard planting period.

P6 Cover crop panel recommendations–II

- Crop land where fall manure application is unavoidable are a high priority for cover crop use and should be eligible for the cover crop BMP.
- The N reductions from cover crops planted where fall manure is applied are estimated as 0.7 of existing values for traditional full rate monoculture winter hardy grass and brassica cover crops (did not create new BMPs !).

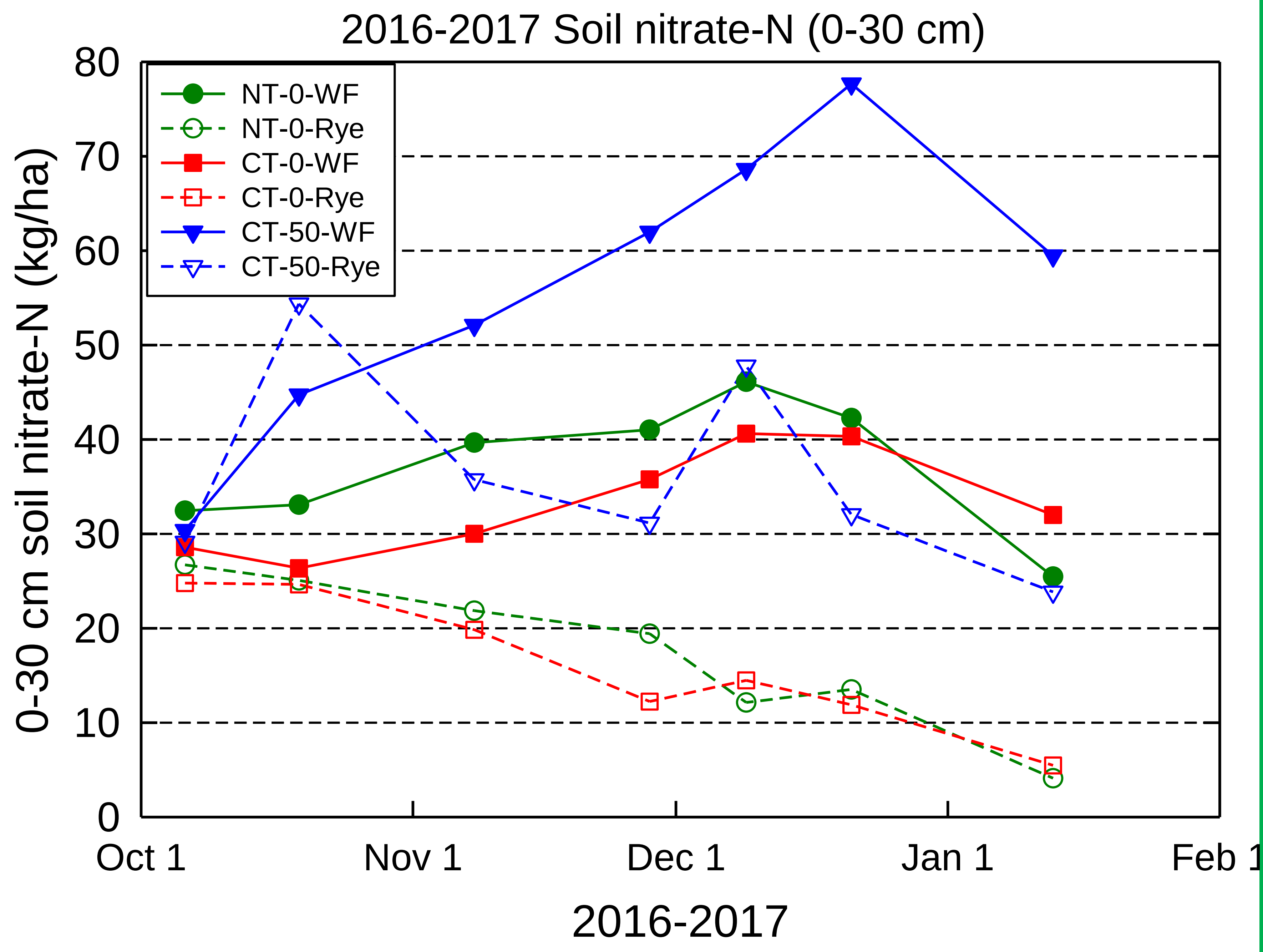
P6 Cover crop panel recommendations–III

- Baseline condition is summer crop followed by a winter cereal for production that receives a 30 lb/acre N application.
- Commodity cover crop BMP is elimination of fall N application.
- N reduction credit increases moving later as N uptake capacity of crop decreases and fraction of applied N leached increases.

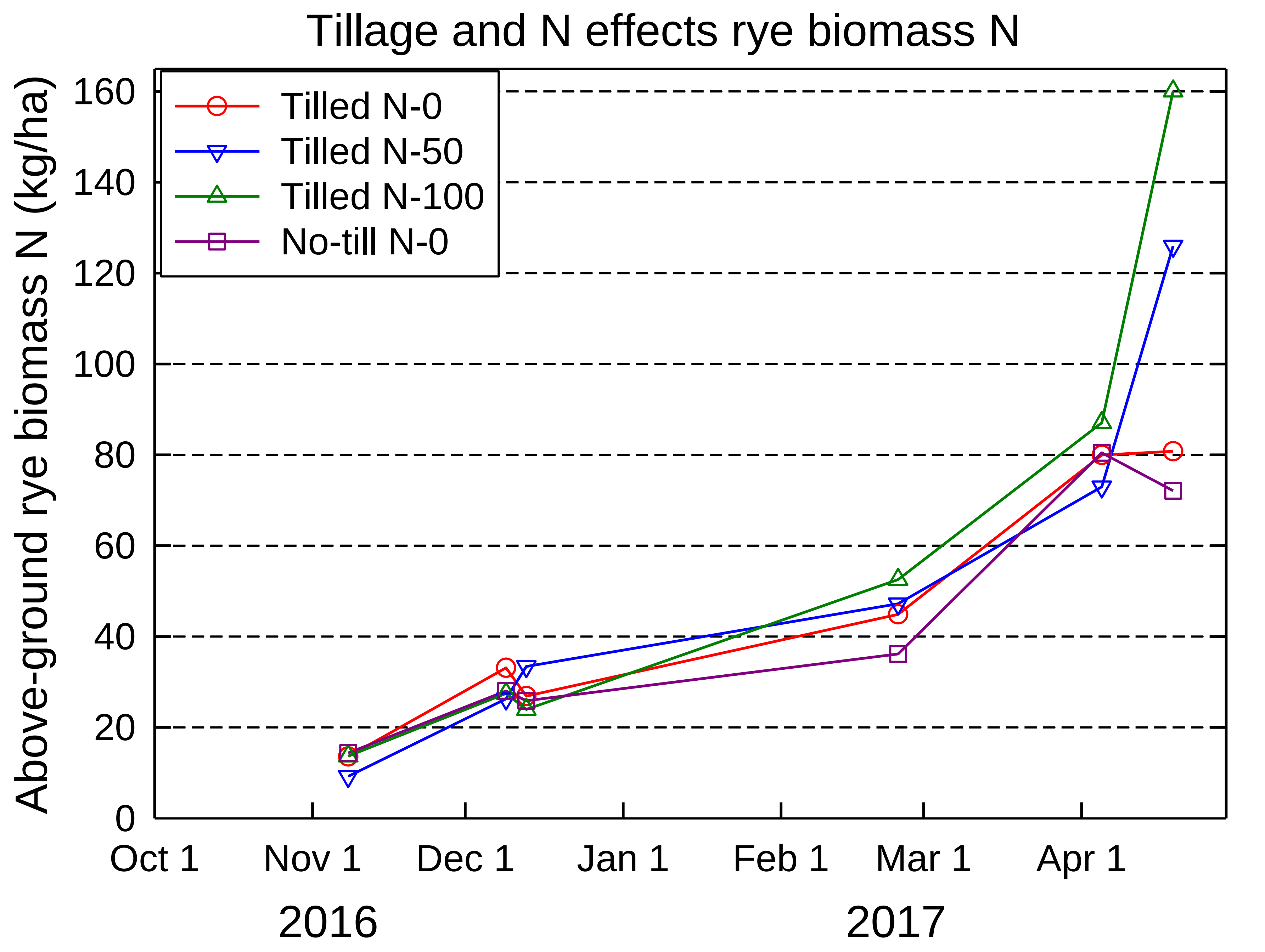
P6 Cover crop panel recommendations–IV

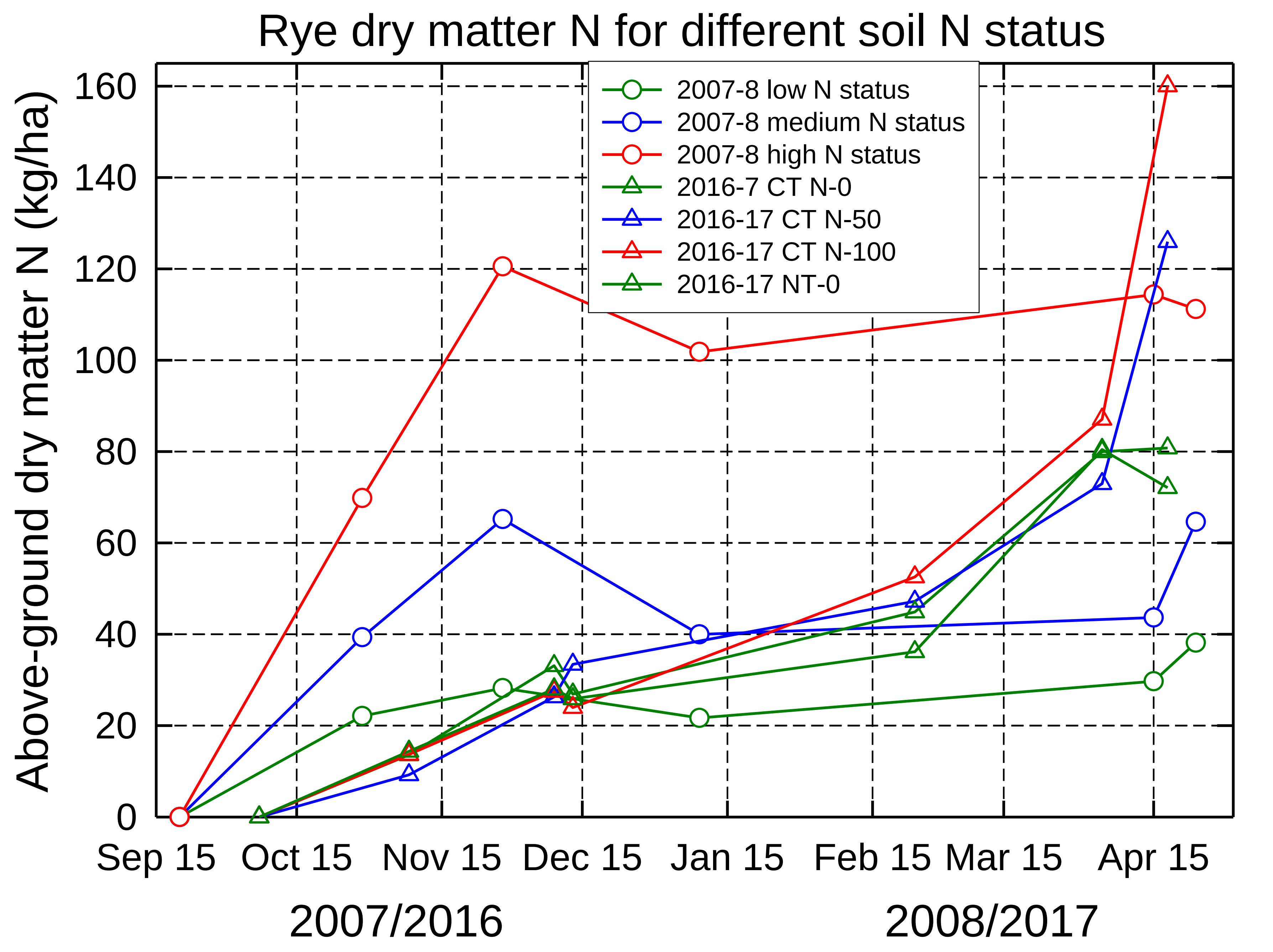
- Limited data on this specific case
- Withholding fall N application from a winter cereal crop planted for harvest credited to reduce annual N losses from from land use where planted by 5, 10, and 15% for early, standard and late planting dates in Coastal Plain/Piedmont Crystalline/Karst regions and 4, 8, and 12 % in Mesozoic Lowlands/Valley and Ridge Siliciclastic regions.

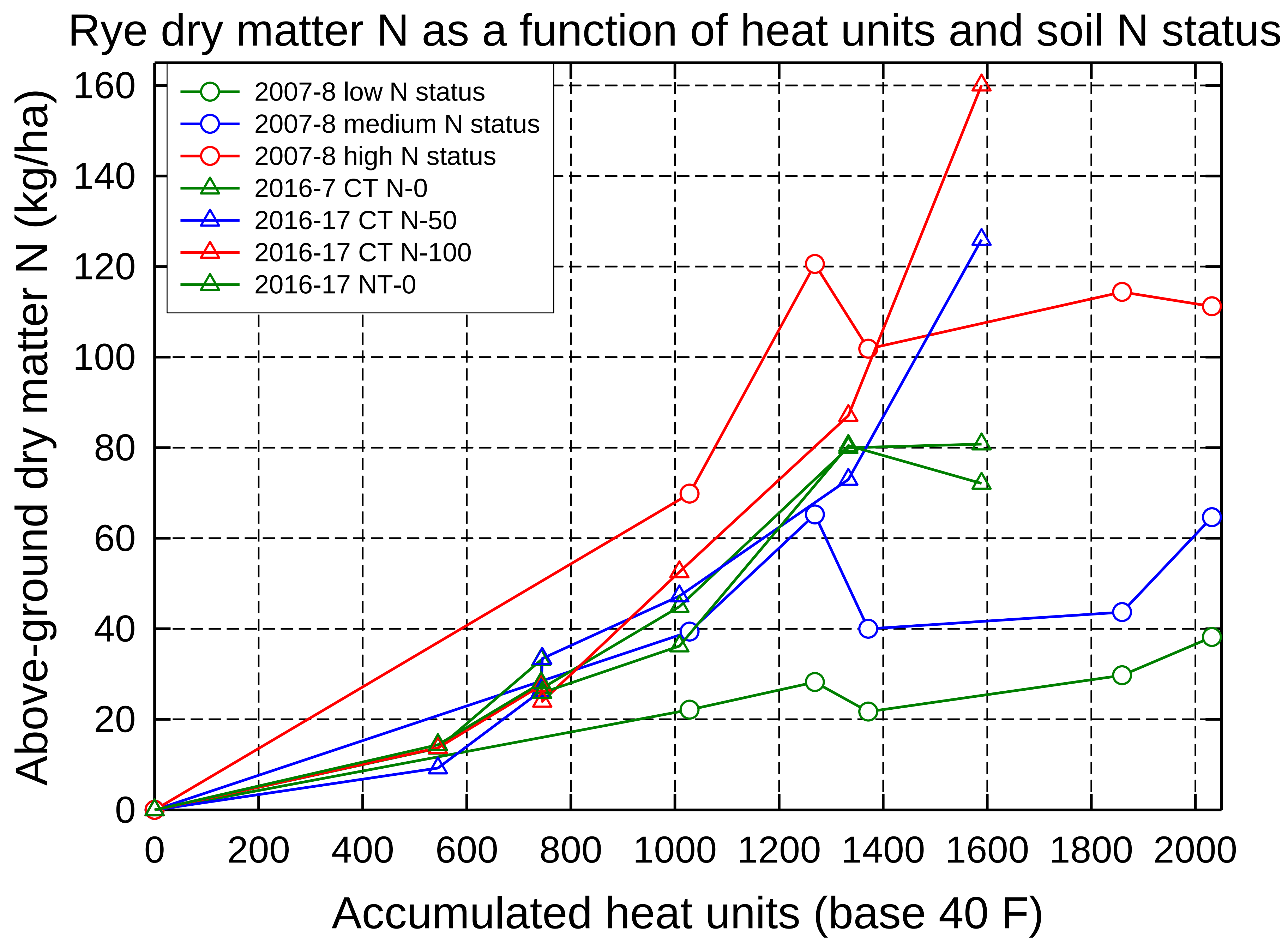

Great Plains

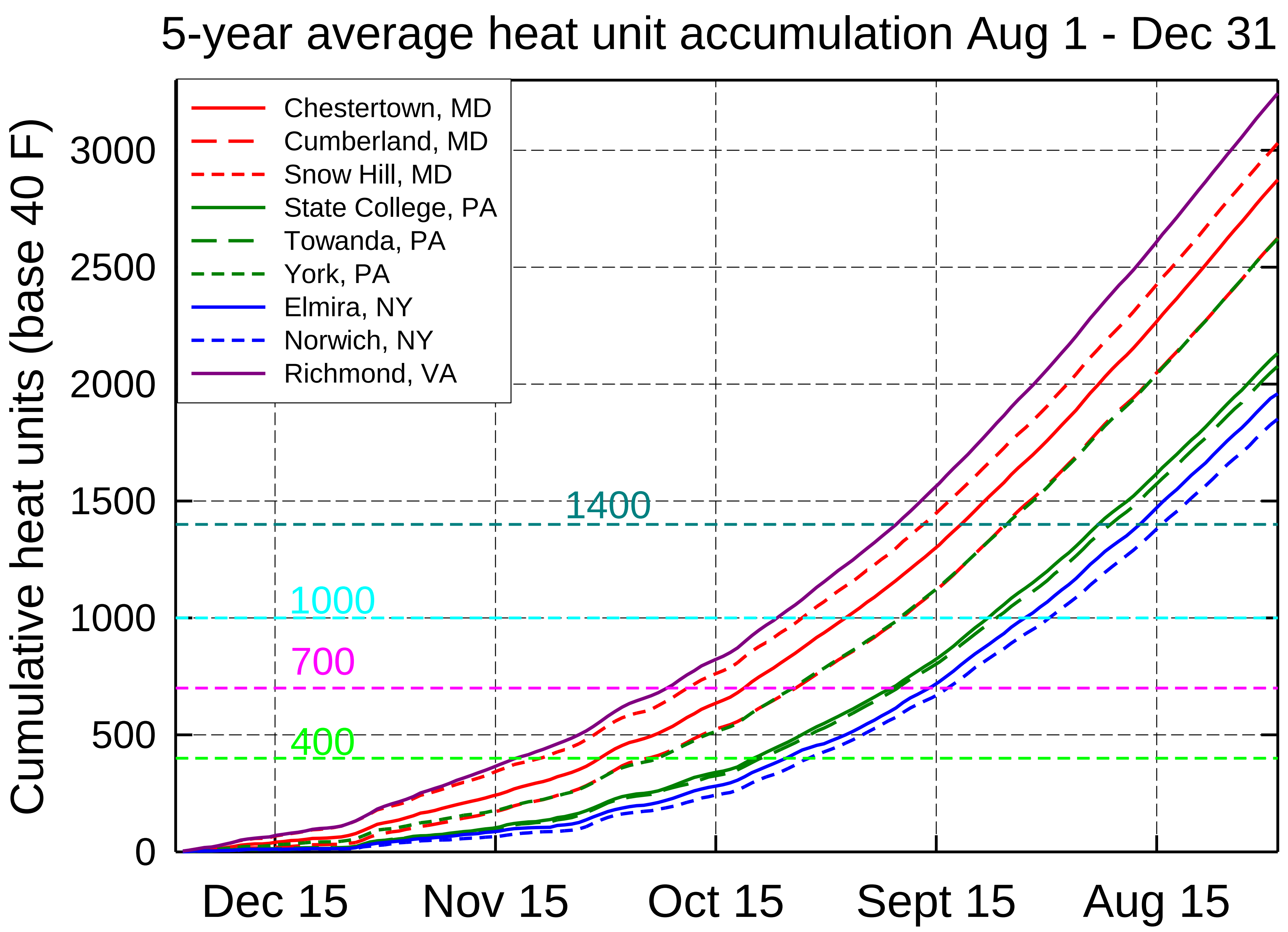


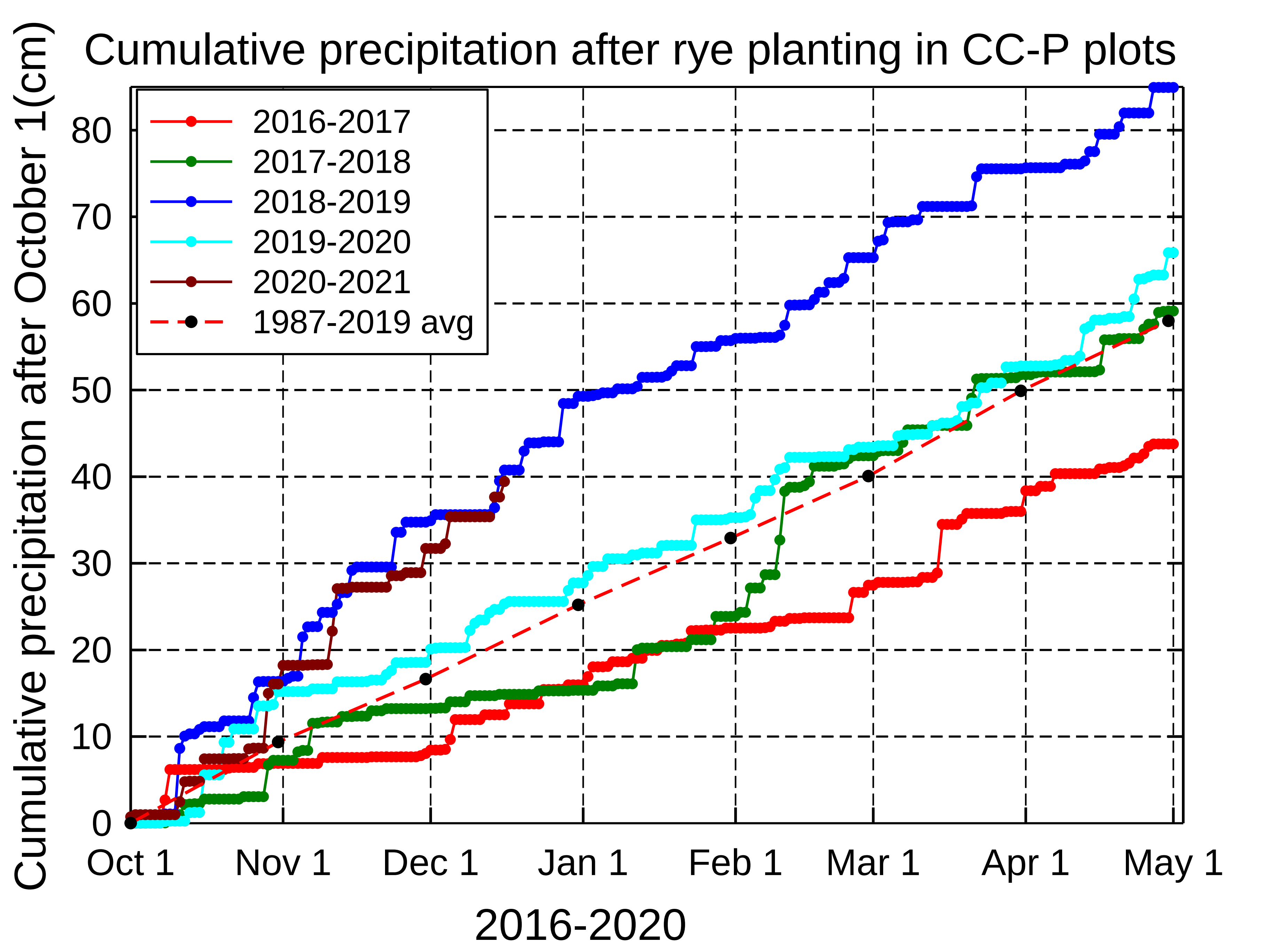
2016-2017 Soil nitrate-N (0-30 cm)
NT-0-WF
NT-0-Rye
CT-0-WF
CT-0-Rye
CT-50-WF
CT-50-Rye
0-30 cm soil nitrate-N (kg/ha)
0
10
20
30
40
50
60
70
80
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
2016-2017

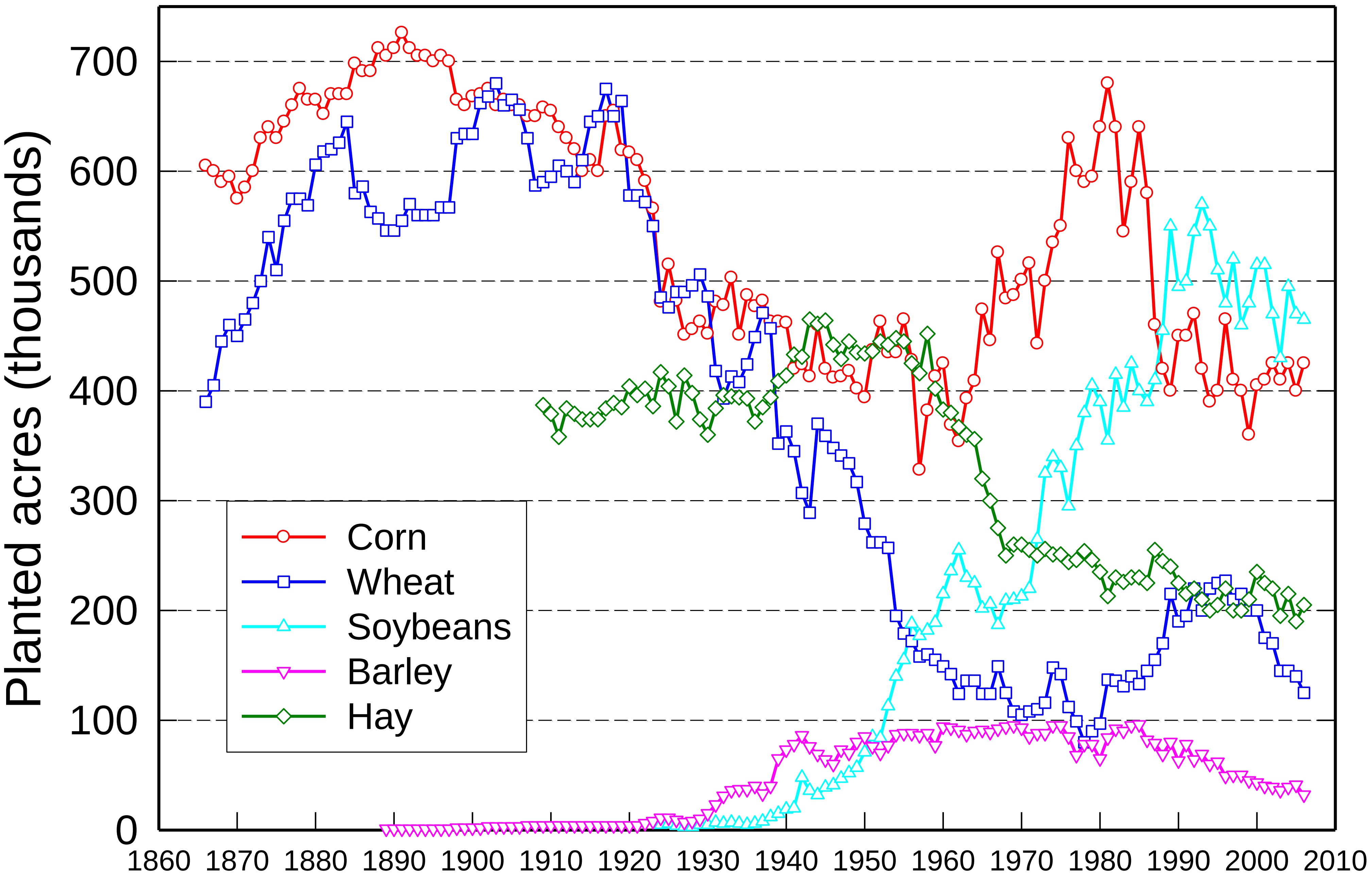

Tillage and N effects rye biomass N
Tilled N-0
Tilled N-50
Tilled N-100
No-till N-0
Above-ground rye biomass N (kg/ha)
0
20
40
60
80
100
120
140
160
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
2016
2017


Rye dry matter N for different soil N status
Above-ground dry matter N (kg/ha)
0
20
40
60
80
100
120
140
160
Sep 15
Oct 15
Nov 15
Dec 15
Jan 15
Feb 15
Mar 15
Apr 15
2007/2016
2008/2017
2007-8 low N status
2007-8 medium N status
2007-8 high N status
2016-7 CT N-0
2016-17 CT N-50
2016-17 CT N-100
2016-17 NT-0

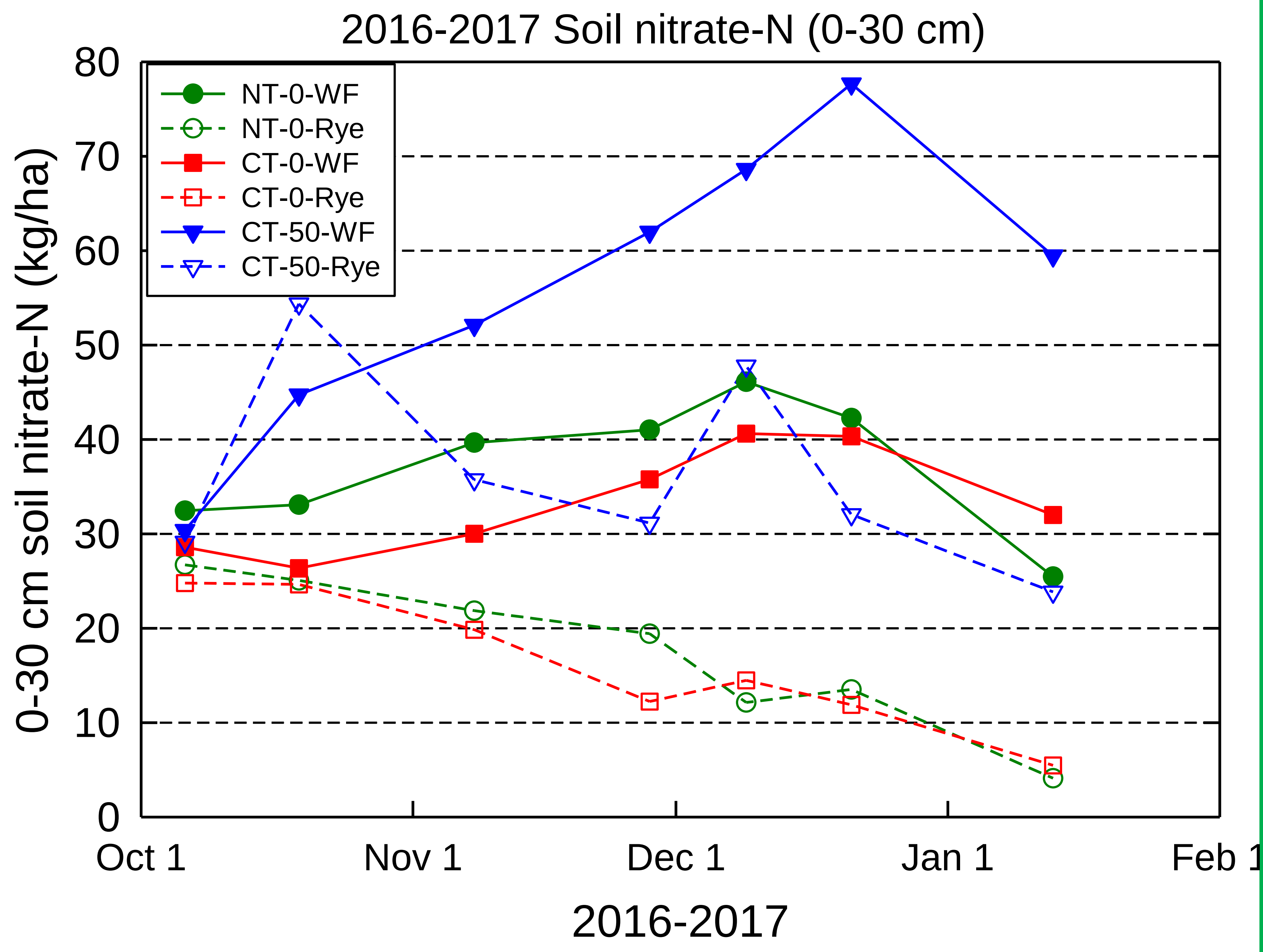

Rye dry matter N as a function of heat units and soil N status
Above-ground dry matter N (kg/ha)
Accumulated heat units (base 40 F)
2007-8 low N status
2007-8 medium N status
2007-8 high N status
2016-7 CT N-0
2016-17 CT N-50
2016-17 CT N-100
2016-17 NT-0
0
20
40
60
80
100
120
140
160
0
200
400
600
800
1000
1200
1400
1600
1800
2000

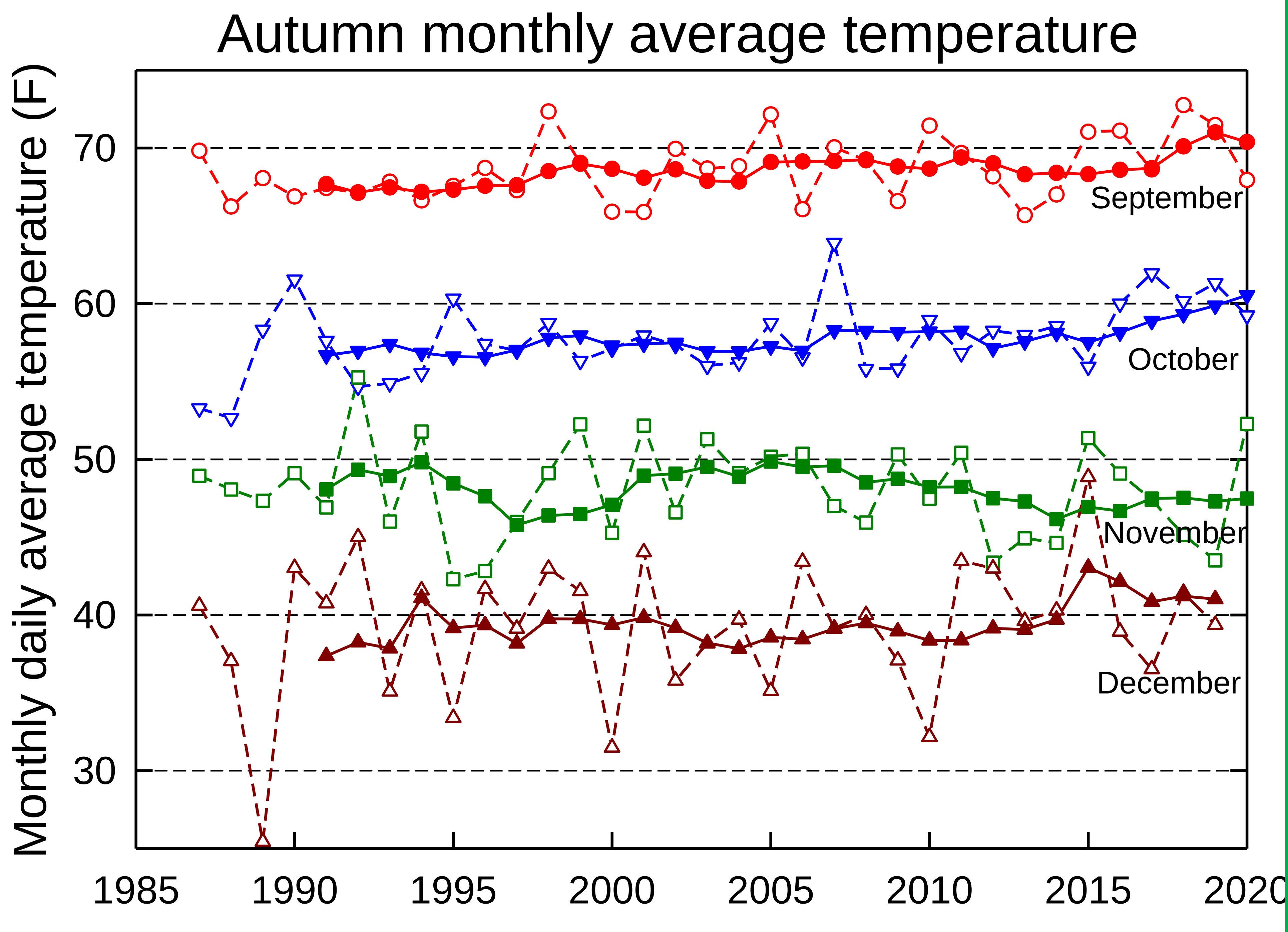

5-year average heat unit accumulation Aug 1 - Dec 31
Cumulative heat units (base 40 F)
Chestertown, MD
Cumberland, MD
Snow Hill, MD
State College, PA
Towanda, PA
York, PA
Elmira, NY
Norwich, NY
Richmond, VA
1400
1000
700
400
0
500
1000
1500
2000
2500
3000
Dec 15
Nov 15
Oct 15
Sept 15
Aug 15


Cumulative precipitation after rye planting in CC-P plots
Cumulative precipitation after October 1(cm)
0
10
20
30
40
50
60
70
80
2016-2017
2017-2018
2018-2019
2019-2020
2020-2021
1987-2019 avg
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
May 1
2016-2020

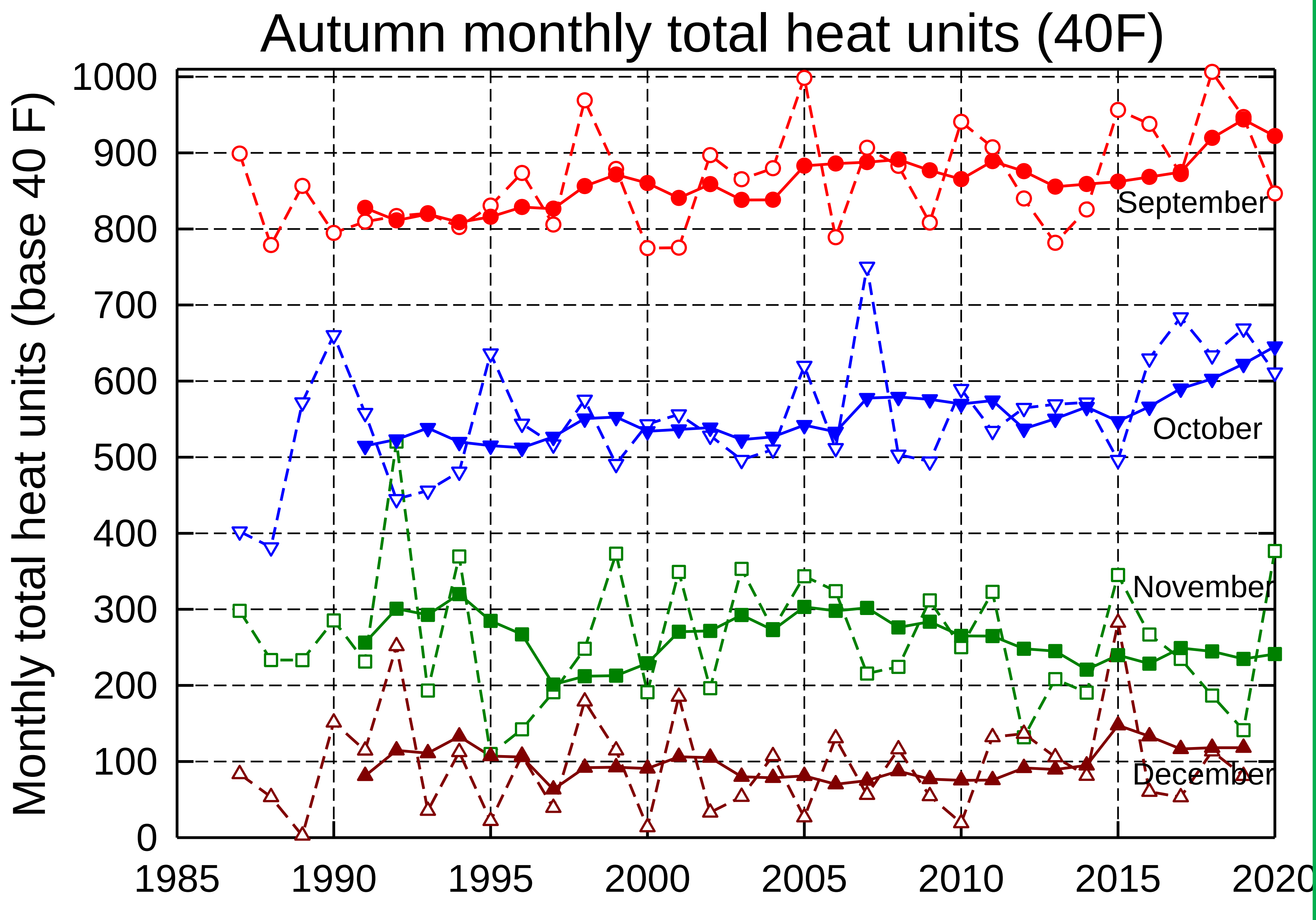


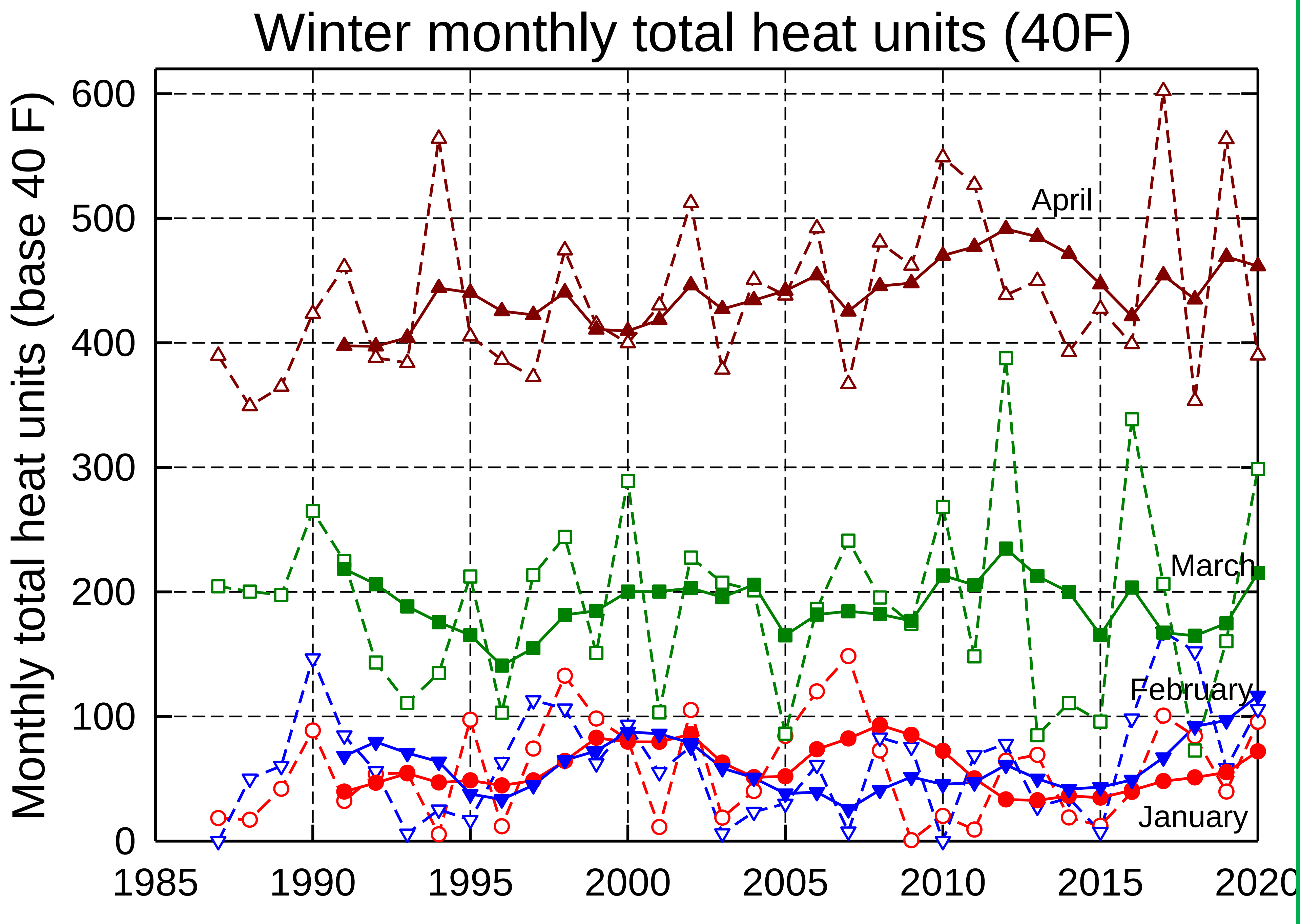
Planted acres (thousands)
0
100
200
300
400
500
600
700
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Corn
Wheat
Soybeans
Barley
Hay


2016-2017 Soil nitrate-N (0-30 cm)
NT-0-WF
NT-0-Rye
CT-0-WF
CT-0-Rye
CT-50-WF
CT-50-Rye
0-30 cm soil nitrate-N (kg/ha)
80
70
60
50
40
30
20
10
0
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
2016-2017

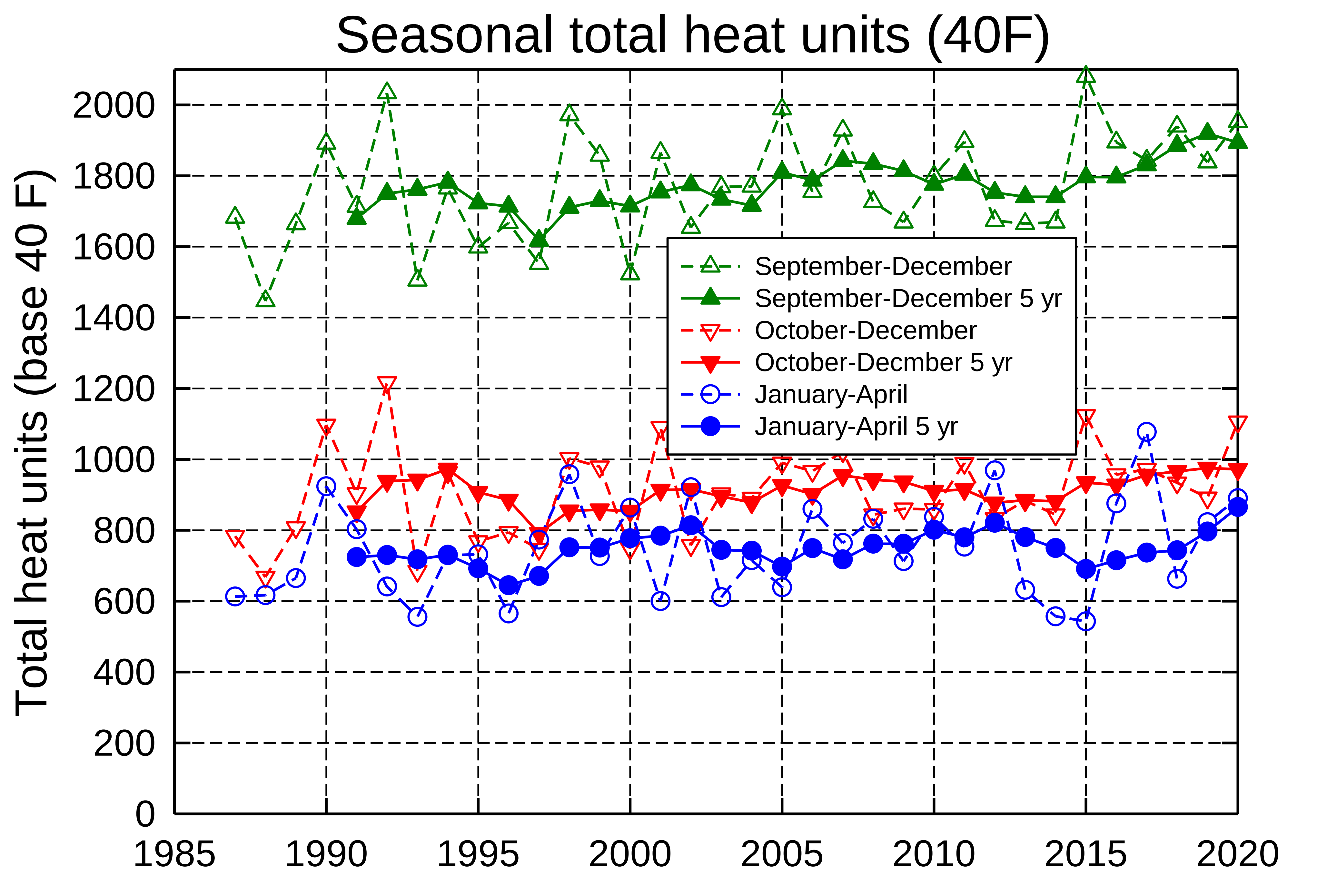


Autumn monthly average temperature
Monthly daily average temperature (F)
70
60
50
40
30
September
October
November
December
1985
1990
1995
2000
2005
2010
2015
2020

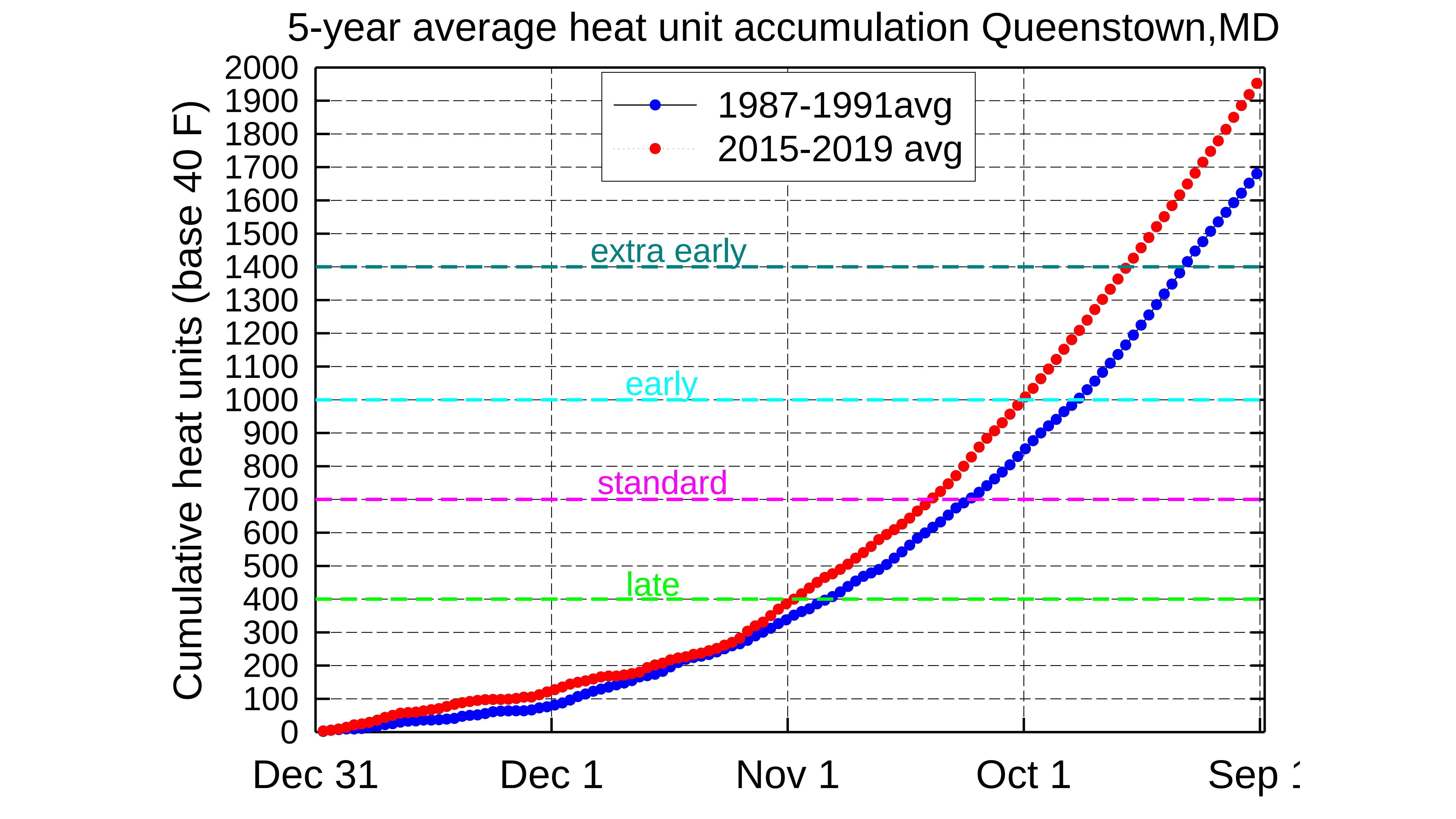

Autumn monthly total heat units (40F)
Monthly total heat units (base 40 F)
1000
900
800
700
600
500
400
300
200
100
0
1985
1990
1995
2000
2005
2010
2015
2020
September
October
November
December



Winter monthly total heat units (40F)
Monthly total heat units (base 40 F)
600
500
400
300
200
100
0
1985
1990
1995
2000
2005
2010
2015
2020
April
March
February
January

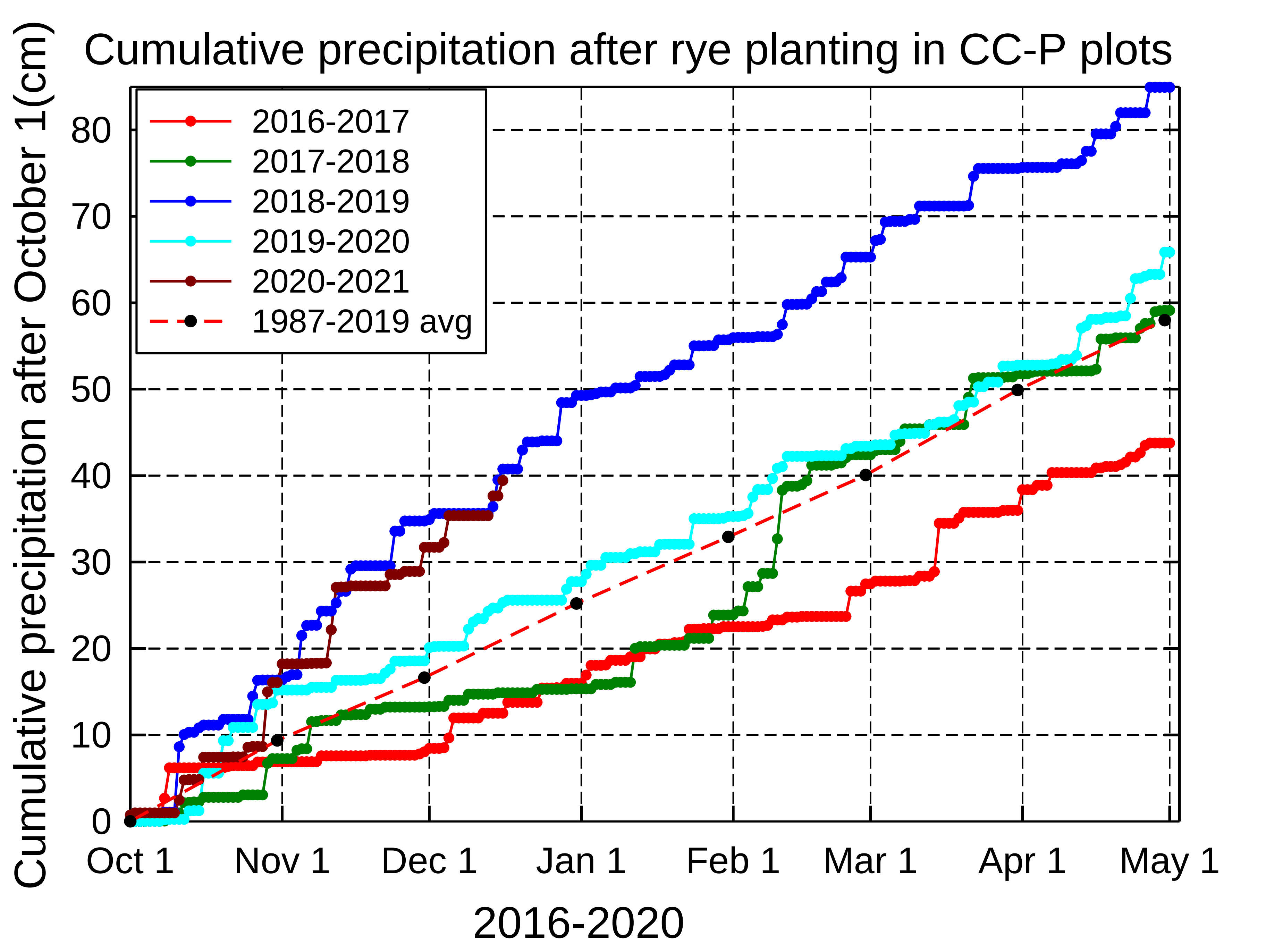


Seasonal total heat units (40F)
Total heat units (base 40 F)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
1985
1990
1995
2000
2005
2010
2015
2020
September-December
September-December 5 yr
October-December
October-Decmber 5 yr
January-April
January-April 5 yr

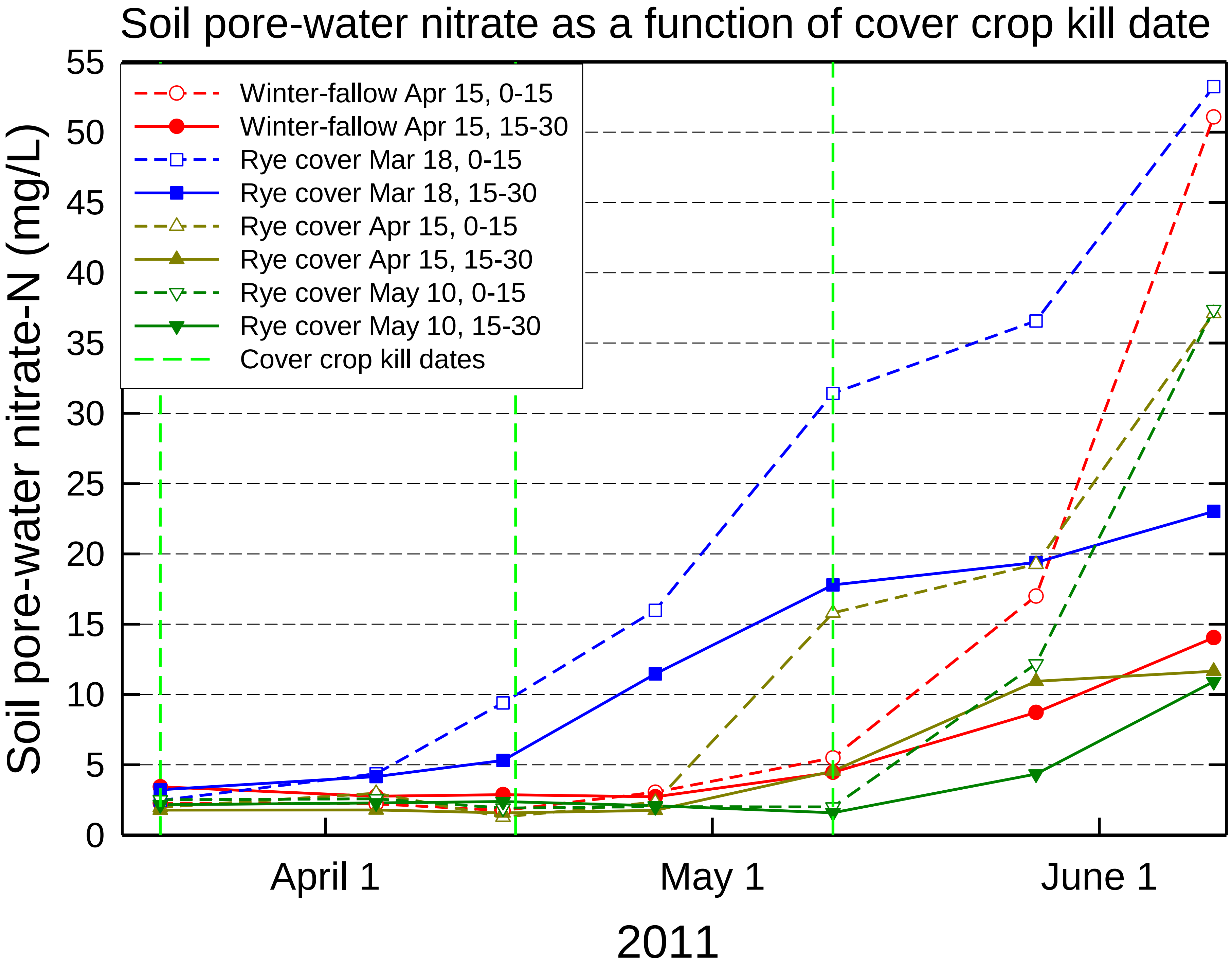

5-year average heat unit accumulation Queenstown,MD
Cumulative heat units (base 40 F)
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
1987-1991avg
2015-2019 avg
extra early
early
standard
late
Dec 31
Dec 1
Nov 1
Oct 1

		chestertown	cumberland	snow hill	state college	towanda	york	elmira	norwich	richmond
		MD	MD	MD	PA	PA	PA	NY	NY	VA
	cumulative 40 F Growing DD	Lastest planting date to achieve by December 31	Lastest planting date to achieve by December 31	Lastest planting date to achieve by December 31	Lastest planting date to achieve by December 31	Lastest planting date to achieve by December 31	Lastest planting date to achieve by December 31	Lastest planting date to achieve by December 31	Lastest planting date to achieve by December 31	Lastest planting date to achieve by December 31
late	400	3-Nov	27-Oct	11-Nov	13-Oct	12-Oct	26-Oct	8-Oct	5-Oct	15-Nov
standard	700	14-Oct	7-Oct	22-Oct	24-Sep	23-Sep	7-Oct	18-Sep	16-Sep	25-Oct
early	1000	30-Sep	22-Sep	6-Oct	10-Sep	9-Sep	22-Sep	5-Sep	2-Sep	10-Oct
extra early	1400	14-Sep	8-Sep	19-Sep	26-Aug	24-Aug	8-Sep	20-Aug	17-Aug	23-Sep

		Queenstown,MD	Queenstown,MD
		1987-1991 avg	2015-2019 avg
	cumulative 40 F Growing DD	Lastest planting date to achieve by December 31	Lastest planting date to achieve by December 31
late	400	26-Oct	31-Oct
standard	700	8-Oct	13-Oct
early	1000	24-Sep	1-Oct
extra early	1400	10-Sep	17-Oct

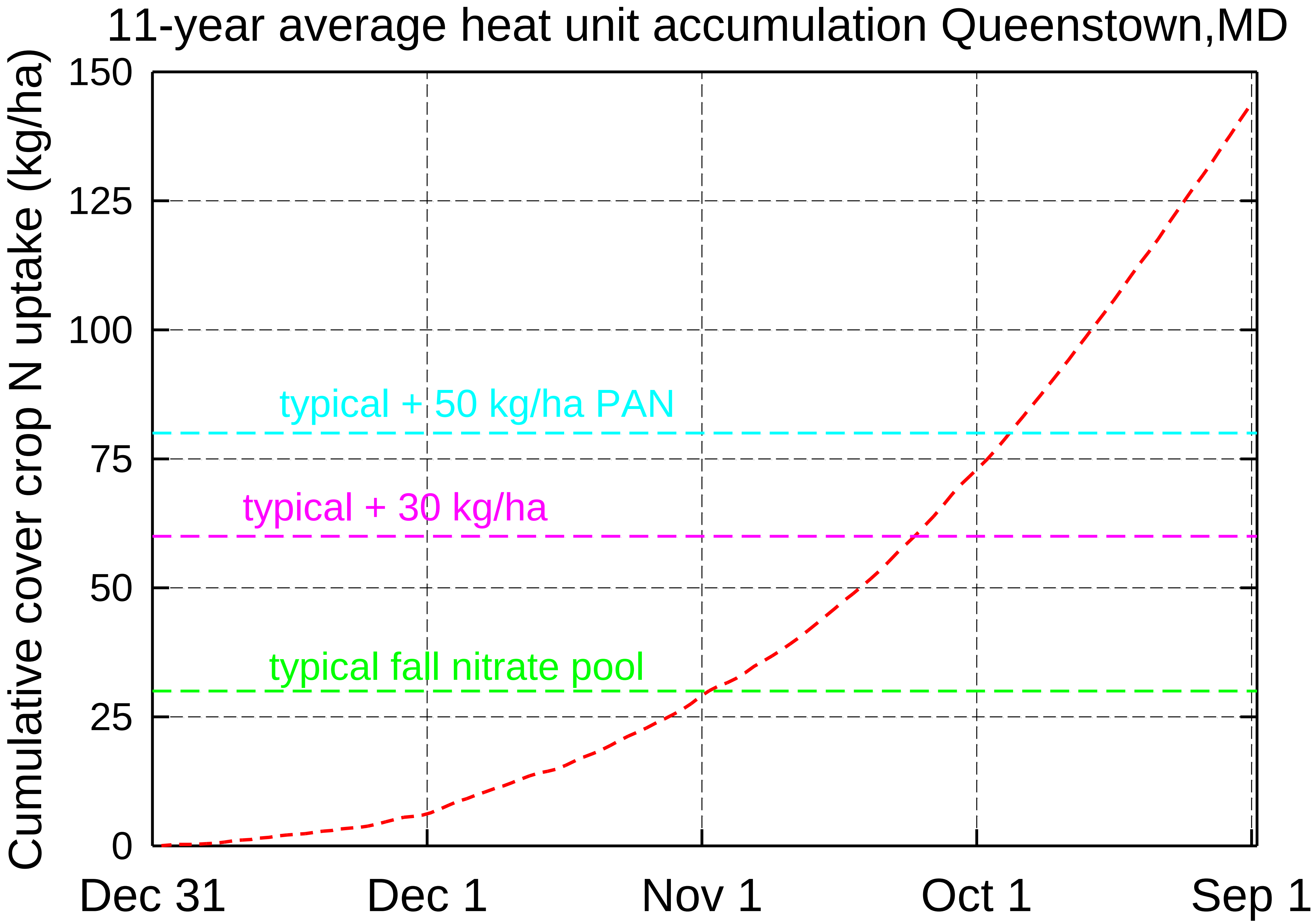


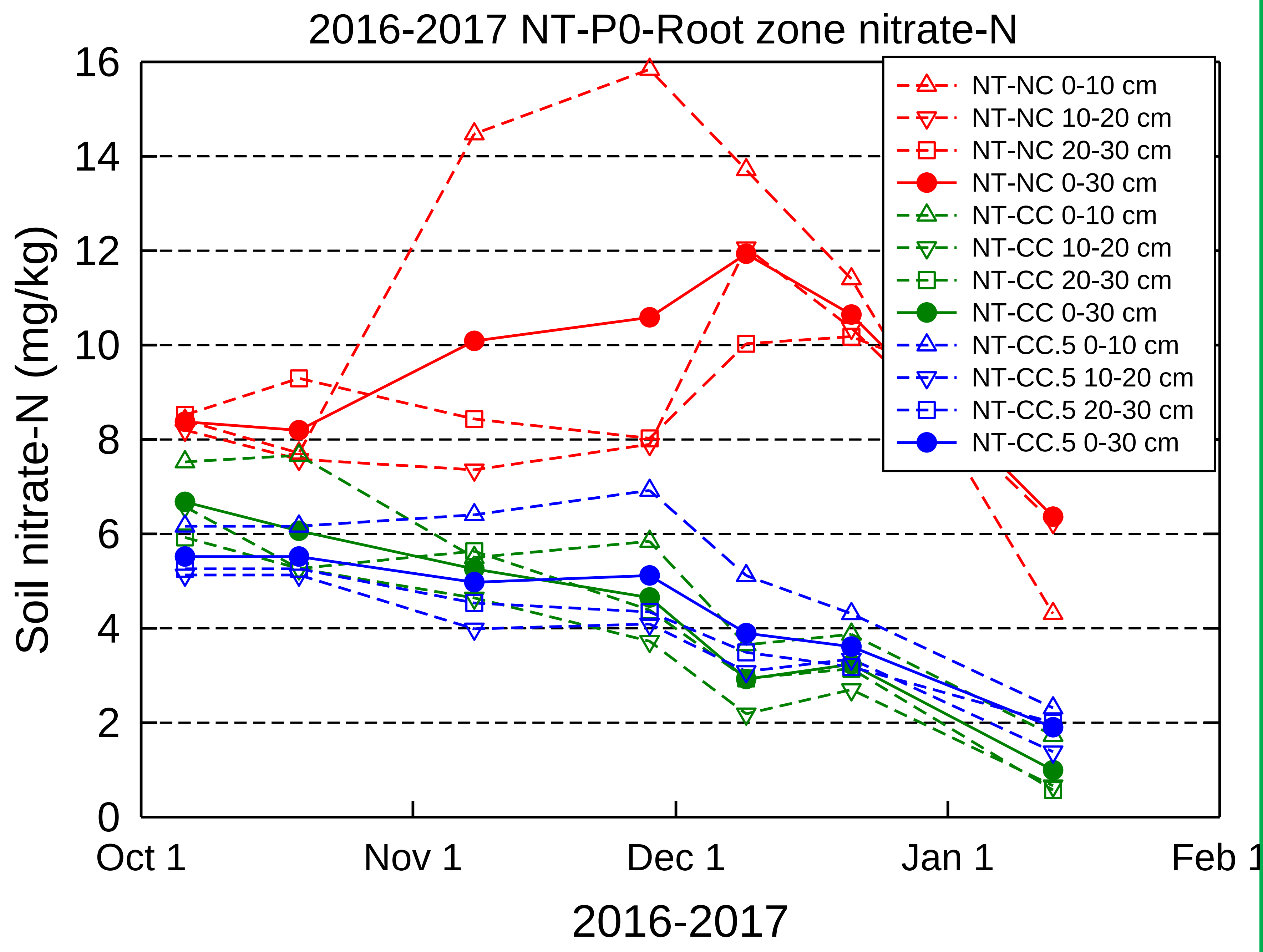
Cumulative precipitation after rye planting in CC-P plots
Cumulative precipitation after October 1(cm)
0
10
20
30
40
50
60
70
80
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
Mar 1
Apr 1
May 1
2016-2020
2016-2017
2017-2018
2018-2019
2019-2020
2020-2021
1987-2019 avg


Soil pore-water nitrate as a function of cover crop kill date
Soil pore-water nitrate-N (mg/L)
0
5
10
15
20
25
30
35
40
45
50
55
Winter-fallow Apr 15, 0-15
Winter-fallow Apr 15, 15-30
Rye cover Mar 18, 0-15
Rye cover Mar 18, 15-30
Rye cover Apr 15, 0-15
Rye cover Apr 15, 15-30
Rye cover May 10, 0-15
Rye cover May 10, 15-30
Cover crop kill dates
April 1
May 1
June 1
2011

Conclusions

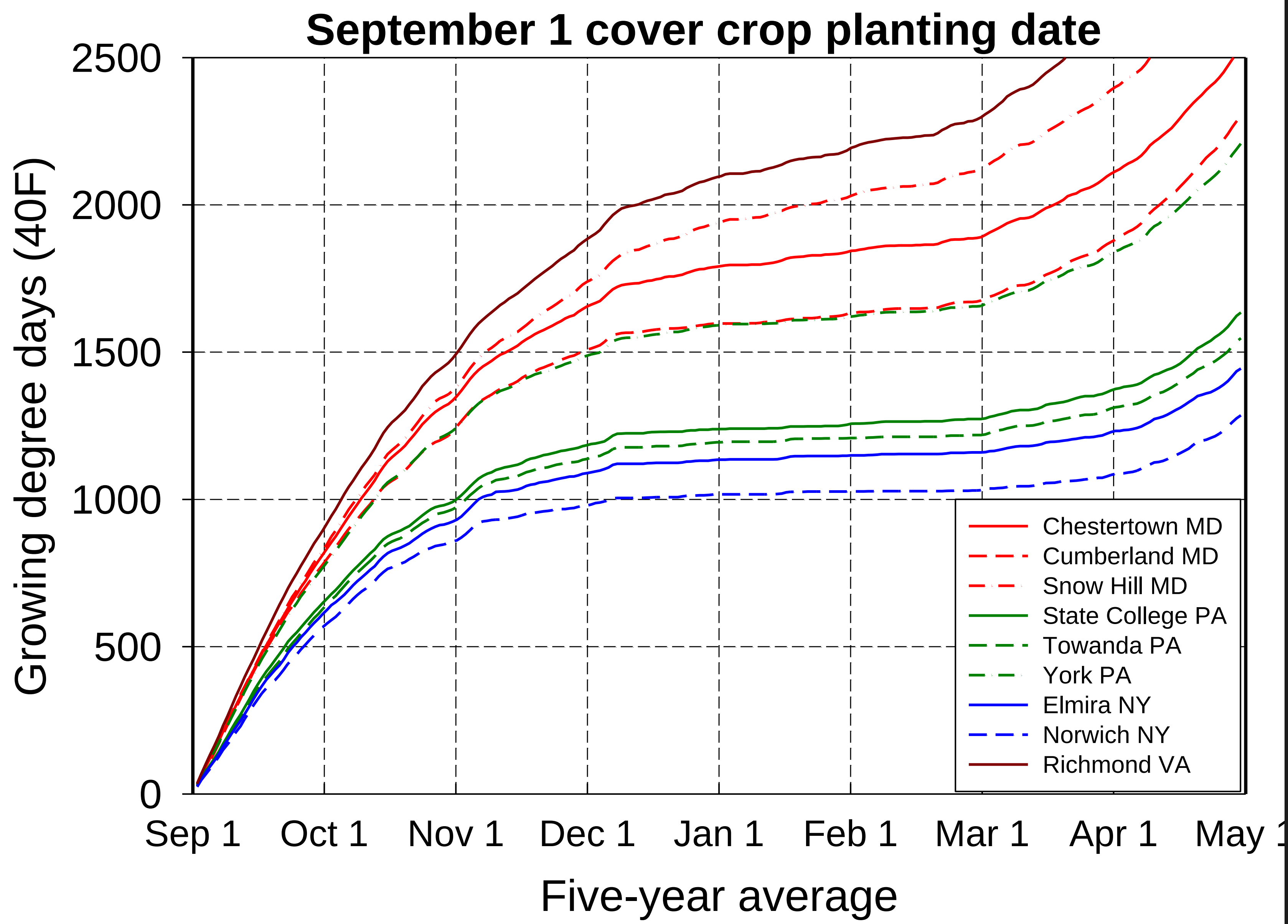
- First principles-Earlier planting, lower fall soil nitrate pool, higher grass seeding rate increase efficiency
- Highest soil nitrate settings offer greatest potential for total pounds reduction of nitrate leaching
- Critical to define baseline in determining reduction efficiency
- Increasing fall temperatures possibly allow 5-7 day later planting date for same heat unit accumulation
- But risk of leaching and other factors may counteract
- Delayed spring termination reduces leaching risk


11-year average heat unit accumulation Queenstown,MD
Cumulative cover crop N uptake (kg/ha)
150
125
100
75
50
25
0
typical + 50 kg/ha PAN
typical + 30 kg/ha
typical fall nitrate pool
Dec 31
Dec 1
Nov 1
Oct 1
Sep 1


2016-2017 NT-P0-Root zone nitrate-N
Soil nitrate-N (mg/kg)
0
2
4
6
8
10
12
14
16
Oct 1
Nov 1
Dec 1
Jan 1
Feb 1
2016-2017
NT-NC 0-10 cm
NT-NC 10-20 cm
NT-NC 20-30 cm
NT-NC 0-30 cm
NT-CC 0-10 cm
NT-CC 10-20 cm
NT-CC 20-30 cm
NT-CC 0-30 cm
NT-CC.5 0-10 cm
NT-CC.5 10-20 cm
NT-CC.5 20-30 cm
NT-CC.5 0-30 cm

The Bay watershed has large north-south differences in growing season, how do fall heat units vary within the watershed?

(Staver, Pers. Comm. 2008)



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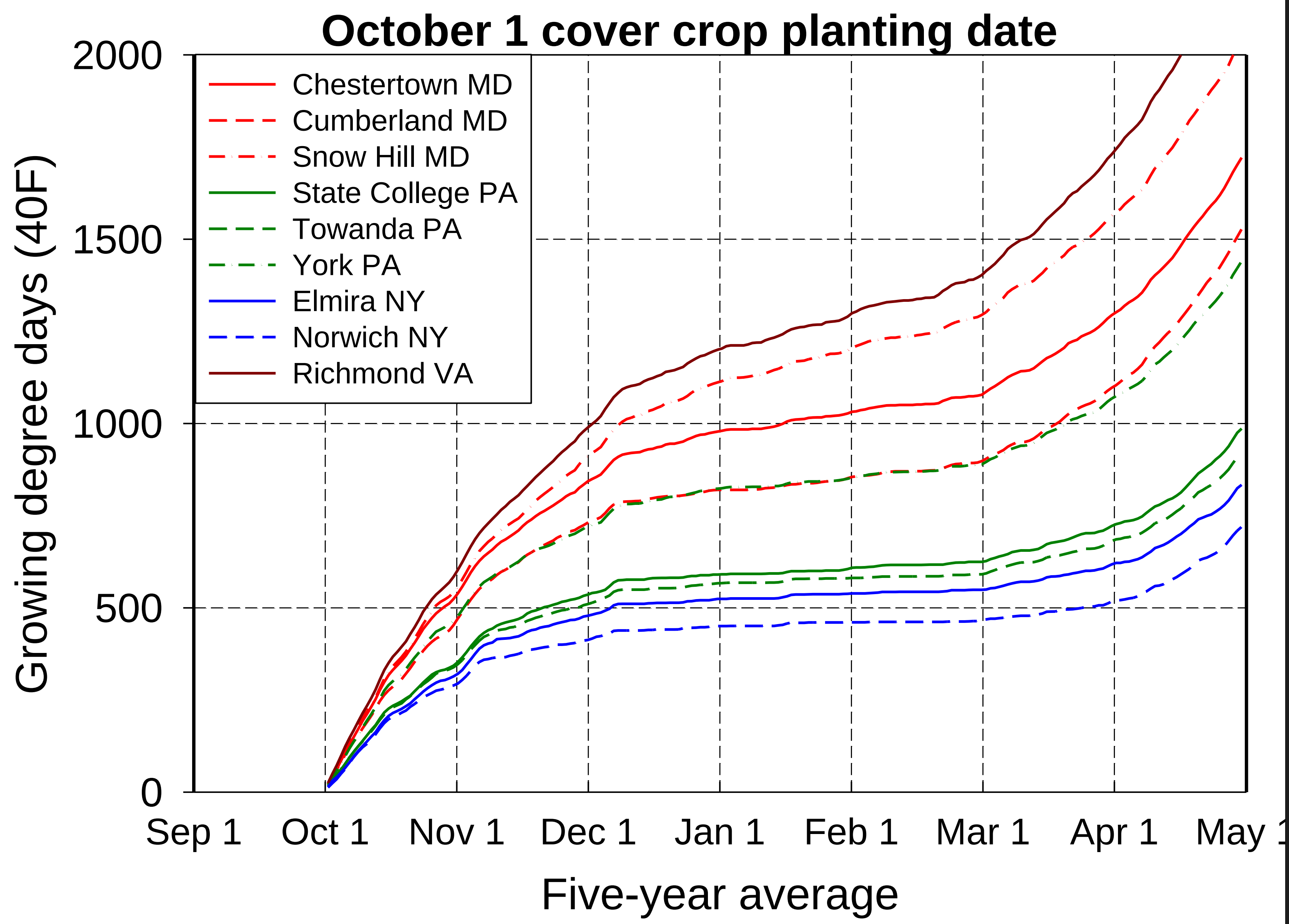

The Bay watershed has large north-south differences in growing season, how do fall heat units vary within the watershed?

(Staver, Pers. Comm. 2008)