Interseeded Cover Crops in Corn-Based Cropping Systems

M. SCOTT WELLS

UNIVERSITY OF MINNESOTA

AGRONOMY AND PLANT GENETICS

FORAGE AND CROPPING SPECIALIST

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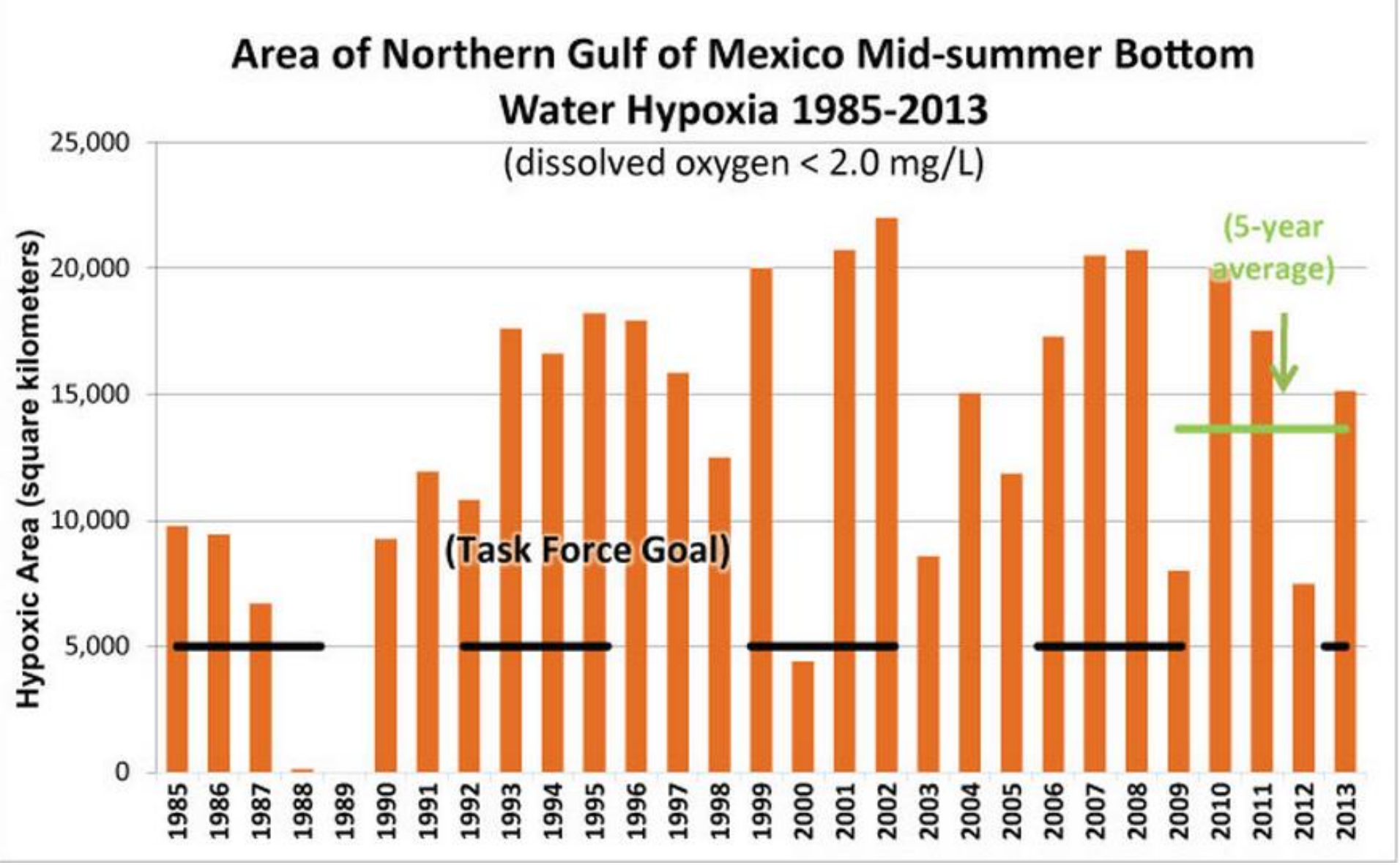

~5000 miles^2

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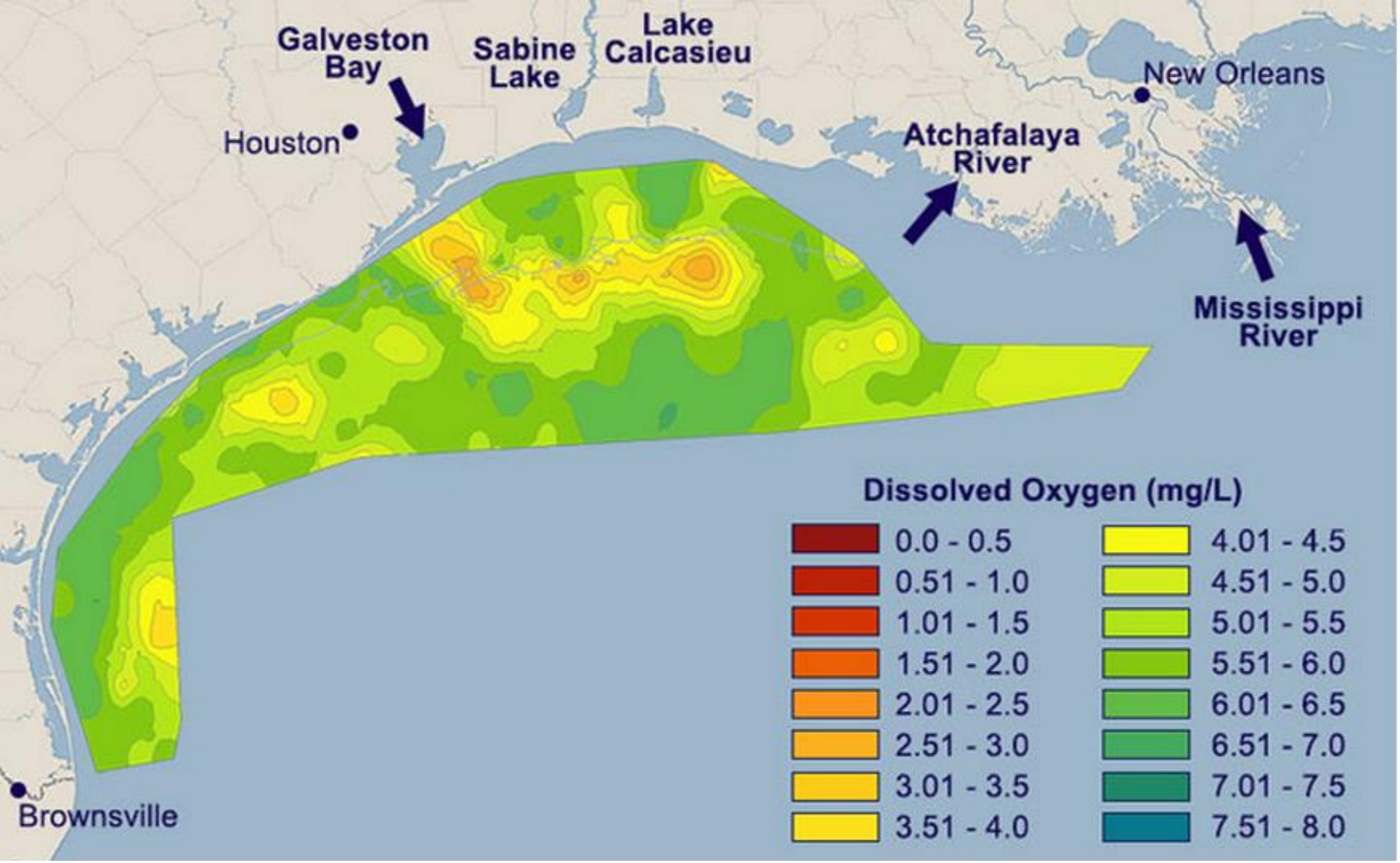

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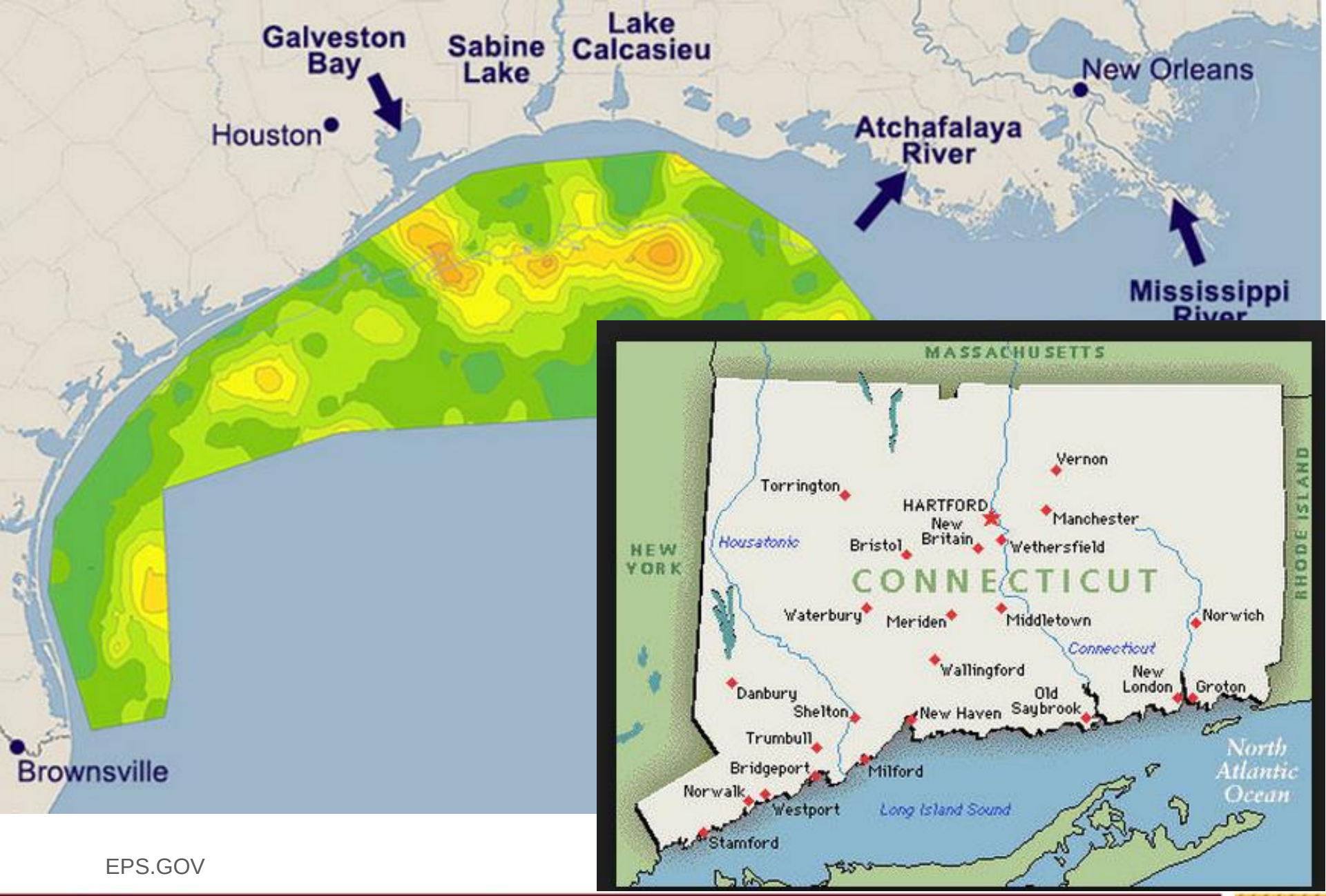

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Nitrate Losses through Subsurface Tile Drainage in Conservation Reserve Program, Alfalfa, and Row Crop Systems

G. W. Randall,* D. R. Huggins, M. P. Russelle, D. J. Fuchs, W. W. Nelson, and J. L. Anderson

Published in J. Environ. Qual. 26:1240–1247 (1997).

Table 3. Effect of the crop system on flow-weighted annual nitrate–nitrogen concentrations and 4-year total nitrate–nitrogen loss (Randall et al. 1997).

Crop system	Annual nitrate–nitrogen concentration (mg N per L)				Estimated 4-yr nitrate loss (kg N per ha)
	1990	1991	1992	1993	
Continuous corn	30	39	40	20	217
Corn–soybean	22	29	26	14	204
Soybean–corn	26	38	27	13	202
Alfalfa	–	4	4	1	7[2]
CRP [1]	–	4	10.3	4[2]	–

[1] CRP, Conservation Reserve Program (mixture of grass and alfalfa).

[2] Based on 3 years of data.

Continuous Corn 4-yr N loss = 217 kg N ha

Alfalfa Est. 4-yr N loss = 7 kg N ha

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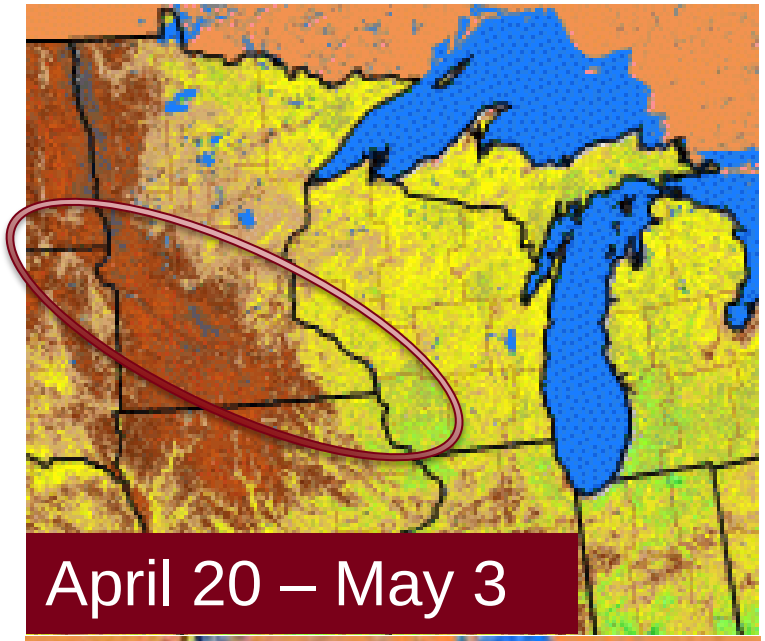
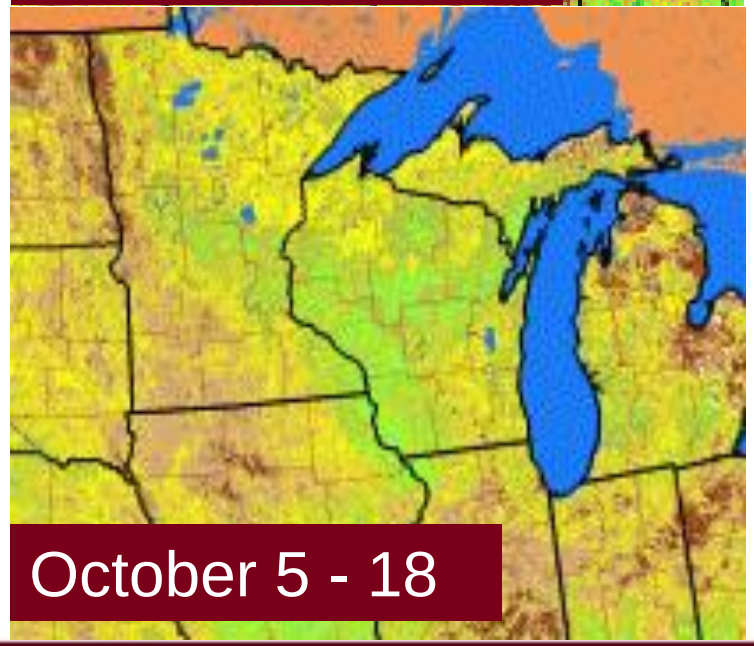
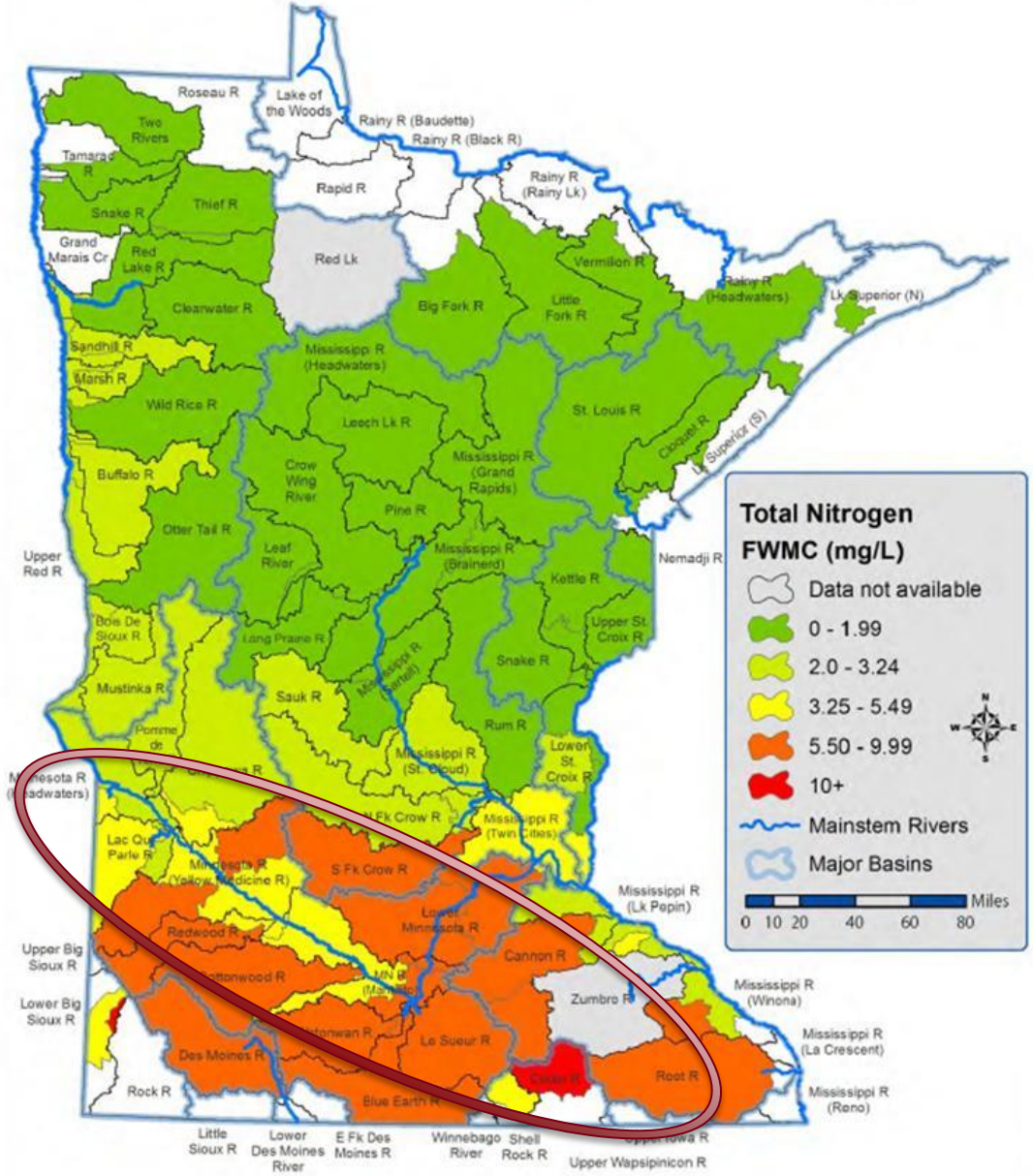

April 20 – May 3


October 5 - 18


Roseau R
Lake of the Woods
Rainy R (Baudette)
Rainy R (Black R)
Two Rivers
Tamarac R
Rapid R
Rainy R (Rainy Lk)
Snake R
Thief R
Grand Marais Cr
Red Lake R
Red Lk
Vermilion R
Rainy R (Headwaters)
Lk Superior (N)
Clearwater R
Big Fork R
Little Fork R
Sandhill R
Mississippi R (Headwaters)
Marsh R
Wild Rice R
Leech Lk R
St. Louis R
Cloquet R
Lk Superior (S)
Buffalo R
Crow Wing River
Mississippi R (Grand Rapids)
Pine R
Otter Tail R
Leaf River
Mississippi R (Brainerd)
Kettle R
Nemadji R
Upper Red R
Bois De Sioux R
Long Prairie R
Upper St. Croix R
Snake R
Mustinka R
Sauk R
Rum R
Pomme de
Mississippi R (St. Cloud)
Lower St. Croix R
Minnesota R (Headwaters)
N Fk Crow R
Mississippi R (Twin Cities)
Lac Qui Parle R
Minnesota R (Yellow Medicine R)
S Fk Crow R
Mississippi R (Lk Pepin)
Lower Minnesota R
Redwood R
Upper Big Sioux R
Cottonwood R
Cannon R
Zumbro R
Mississippi R (Winona)
Lower Big Sioux R
Watonwan R
Le Sueur R
Mississippi R (La Crescent)
Des Moines R
Root R
Rock R
Blue Earth R
Mississippi R (Reno)
Little Sioux R
Lower Des Moines River
E Fk Des Moines R
Winnebago River
Shell Rock R
Upper Iowa R
Upper Wapsipinicon R
Total Nitrogen
FWMC (mg/L)
Data not available
0 - 1.99
2.0 - 3.24
3.25 - 5.49
5.50 - 9.99
10+
Mainstem Rivers
Major Basins
Miles
0 10 20 40 60 80

Nitrogen Management Strategies to Reduce Nitrate Leaching in Tile-Drained Midwestern Soils

Dana L. Dinnes,* Douglas L. Karlen, Dan B. Jaynes, Thomas C. Kaspar, Jerry L. Hatfield, Thomas S. Colvin, and Cynthia A. Cambardella

- Vulnerable NO_3-N leaching periods in conventional corn systems

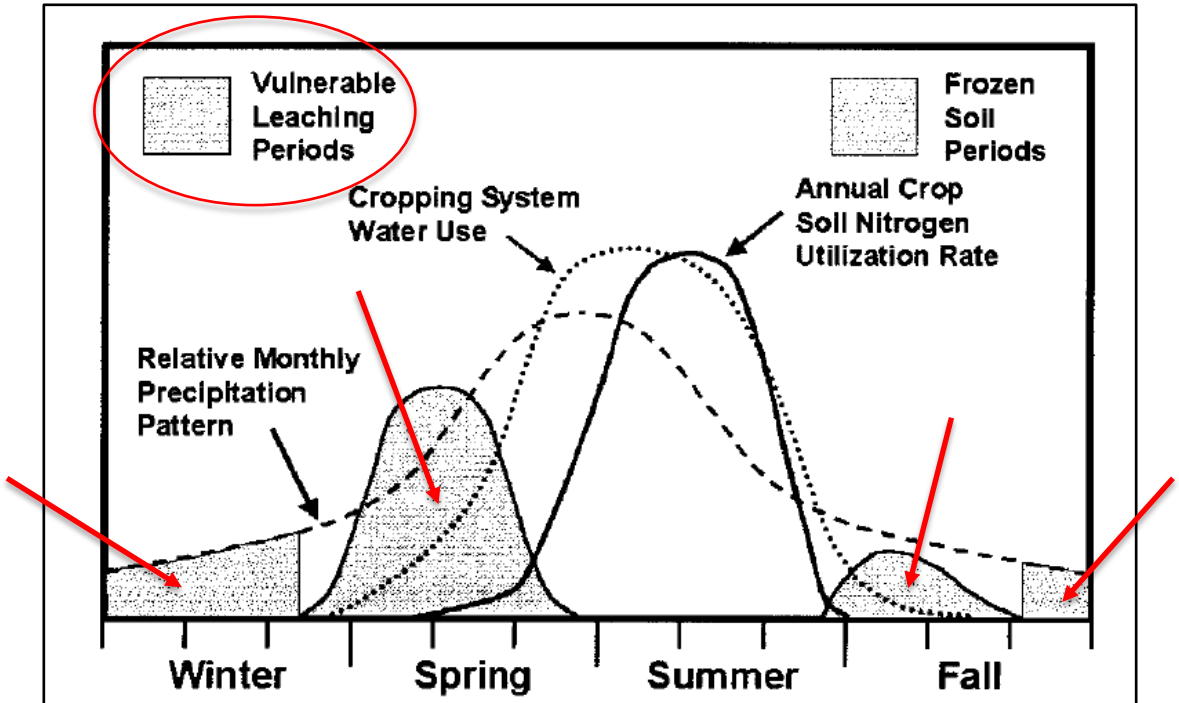


Fig. 3. General seasonal patterns for precipitation, N uptake rate by a corn crop, cropping system water use, and periods potentially favorable for NO_3 leaching from midwestern corn production (adapted from Fig. 4 of Power et al., 1998).

- Dinnes et al. (2002)
- Power et al. (1998)

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	Range in N reductions from literature review	N removal default in MN NBMP spreadsheet for treated areas	Notes for numbers with *
Tile depth and spacing	15-59%	NA	
Controlled drainage	14-96%	40%	
Bioreactors	10-99%	*13%	*Assumes 44% removal when fully treated, but only 30% of annual flow is treated
Reduced rates of application	11-70%	Varies by watershed and climate	
N application timing and inhibitors	10-58%	Varies by watershed and climate	
Wetlands	19-90%	50%	
Alternative cropping systems	5-98%	*95%	*Perennials replacing marginal land row crops
Riparian buffers	17-99%	*95%	*Perennials replacing row crops near waters
Cover crops	11-60%	*10%	*50% N leaching reduction when successfully established and 10% runoff N reduction. 20% establishment success rate assumed for MN average.

Nitrogen in Minnesota Surface Waters • June 2013 Minnesota Pollution Control Agency

F1-3

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	Range in N reductions from literature review	N removal default in MN NBMP spreadsheet for treated areas	Notes for numbers with *
Cover crops	11-60%	*10%	*50% N leaching reduction when successfully established and 10% runoff N reduction. 20% establishment success rate assumed for MN average.

- Cover crops 20% successful establishment rate ~ 10% N removal.
- 50% cover crop establishment success, the N reduction would increase from 7.3% to 18.3%.
- 75%, then the N reduction to waters statewide would increase to 27.4%.

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	Range in N reductions from literature review	N removal default in MN NBMP spreadsheet for treated areas	Notes for numbers with *
Cover crops	11-60%	*10%	*50% N leaching reduction when successfully established and 10% runoff N reduction. 20% establishment success rate assumed for MN average.

- 75%, then the N reduction to waters statewide would increase to 27.4%.
- ~ 8 Million ac corn
- Annual N losses 20 – 100 lb N ac^{-1}
- Suppose annual losses of 50 lb N ac^{-1}
- 15 lb N ac^{-1} removed with cover crops
- ≈ 60,000 Tons-N yr^{-1} reduction

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COVER CROP ECOSYSTEM SERVICES

- Protect surface and ground water quality by decreasing soil erosion, nitrogen (N) leaching, and phosphorus (P) runoff
- Increased N retention and reduce N fertilizer and manure application requirements via BNF
- Increased Soil Organic Matter
- Improved water infiltration, holding capacity
- Provide habitat for pollinators, weed seed predators and game animals

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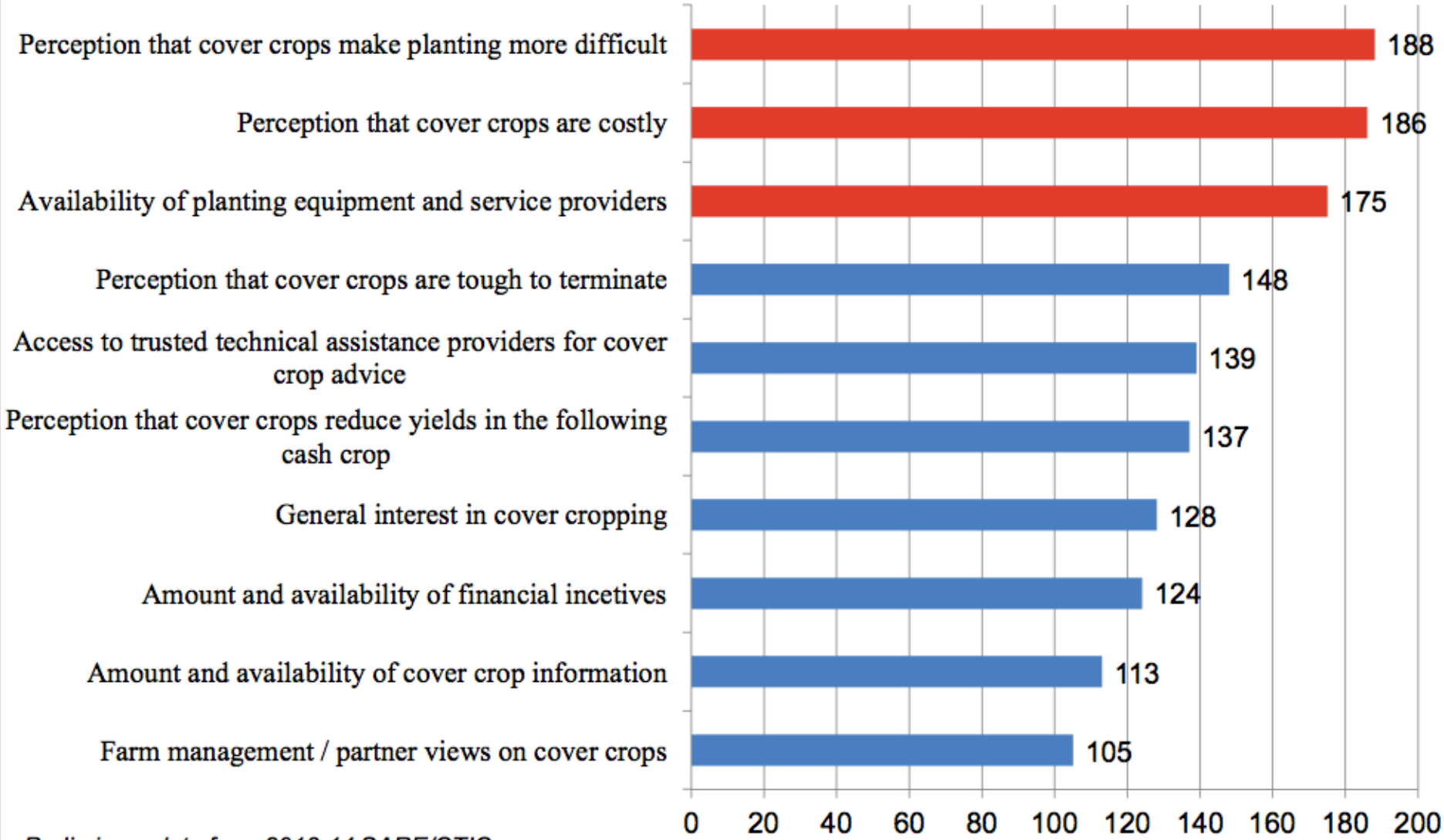
Farmers Not Yet Using Cover Crops

Rating the Factors that May Limit Cover Crop Adoption

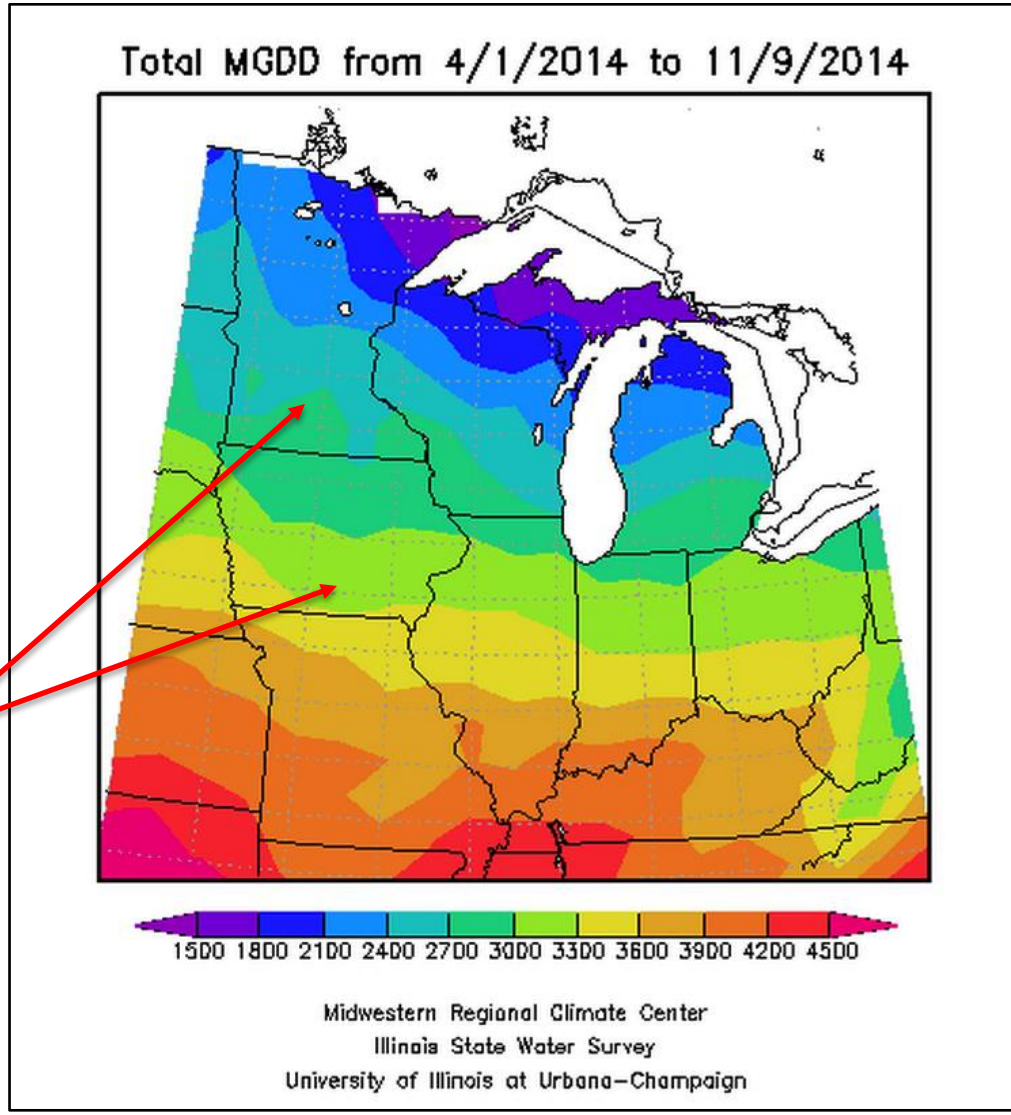


Preliminary data from 2013-14 SARE/CTIC cover crop survey

CHALLENGES

- Iowa Agricultural Extension service recommends drilling winter-hardy cereal cover crops as late as early November in southern Iowa.

- Southern Minnesota has ~600 fewer GDD units than southern Iowa.



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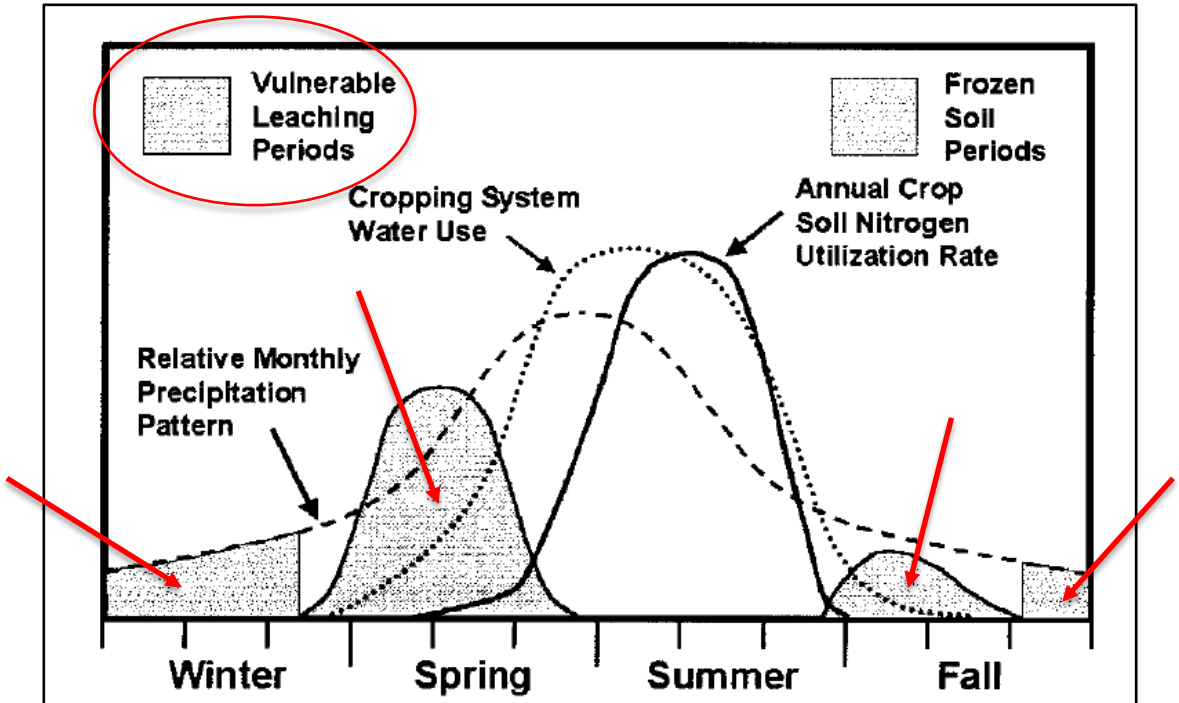

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- Dinnes et al. (2002)
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Factors Affecting Successful Establishment of Aerially Seeded Winter Rye

Melissa L. Wilson,* John M. Baker, and Deborah L. Allan

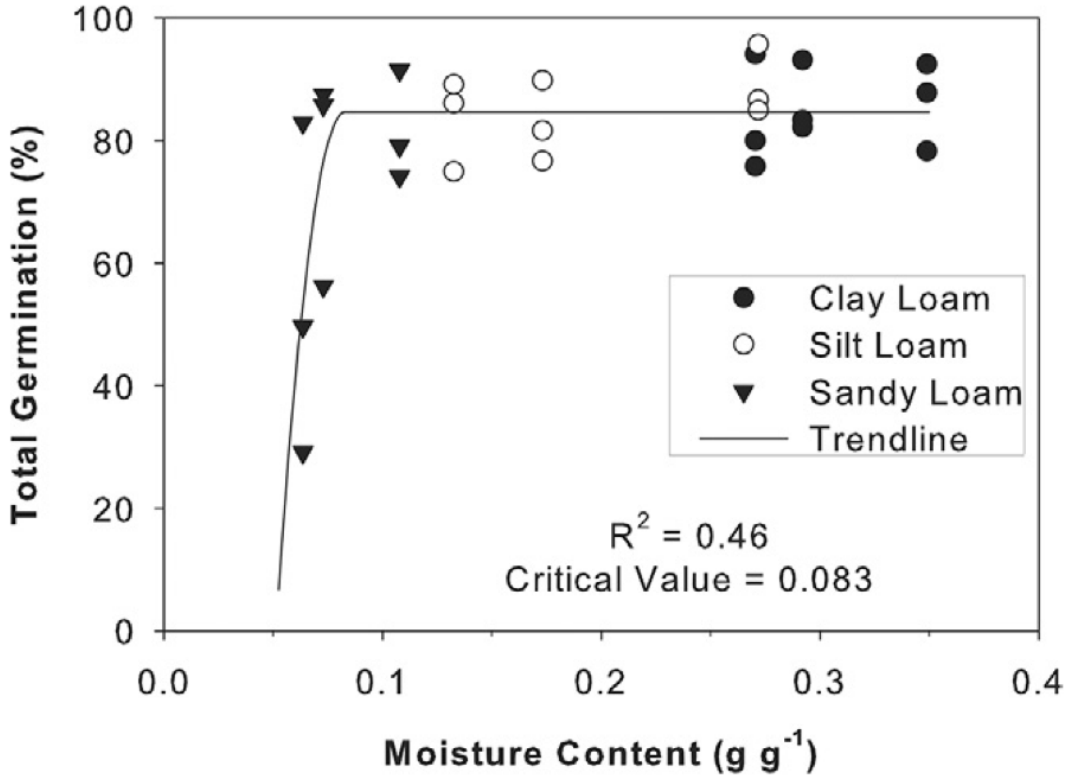

Fig. 7. Total winter rye germination on the surface of three different soils as a function of moisture content. The trend line is a quadratic plateau model (*P* < 0.001). The critical value is the moisture level below which germination is affected.

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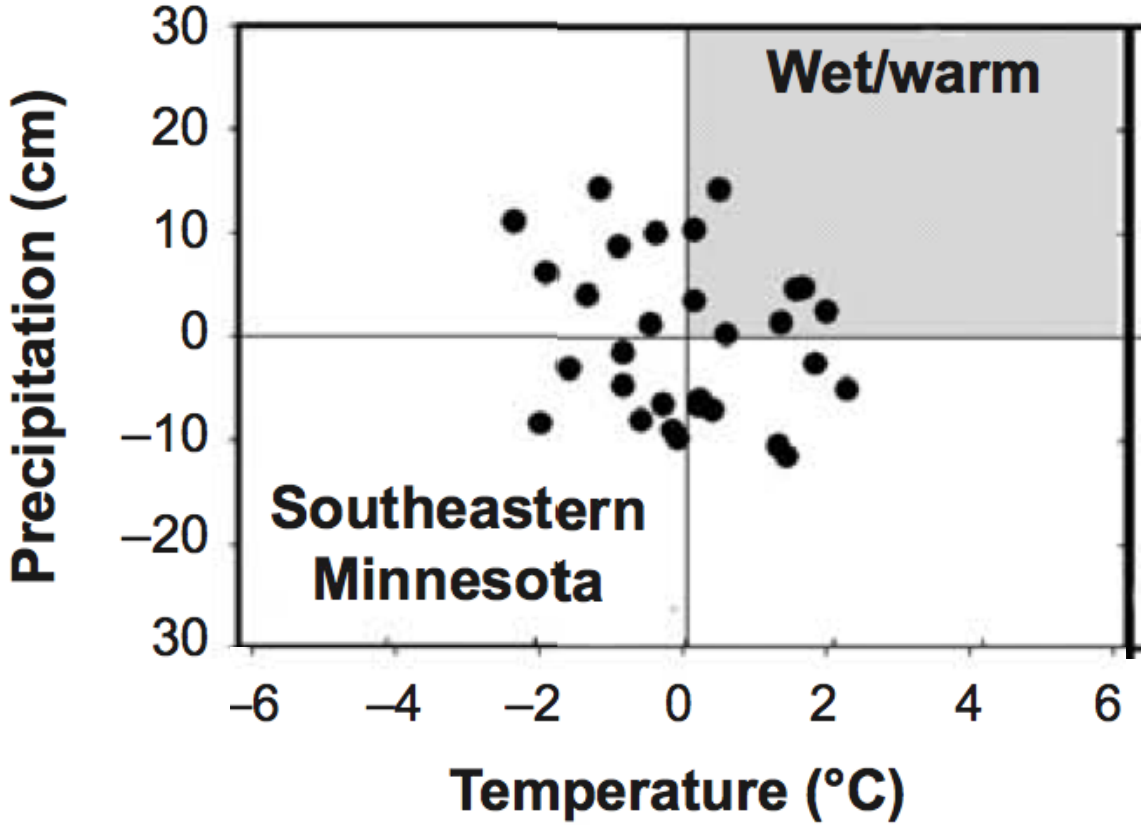
UMN SROC &SWROC Weather Data

doi:10.2489/jswc.69.3.67A

Aerially seeding cover crops in the northern US Corn Belt: Limitations, future research needs, and alternative practices

Melissa L. Wilson, Deborah L. Allan, and John M. Baker



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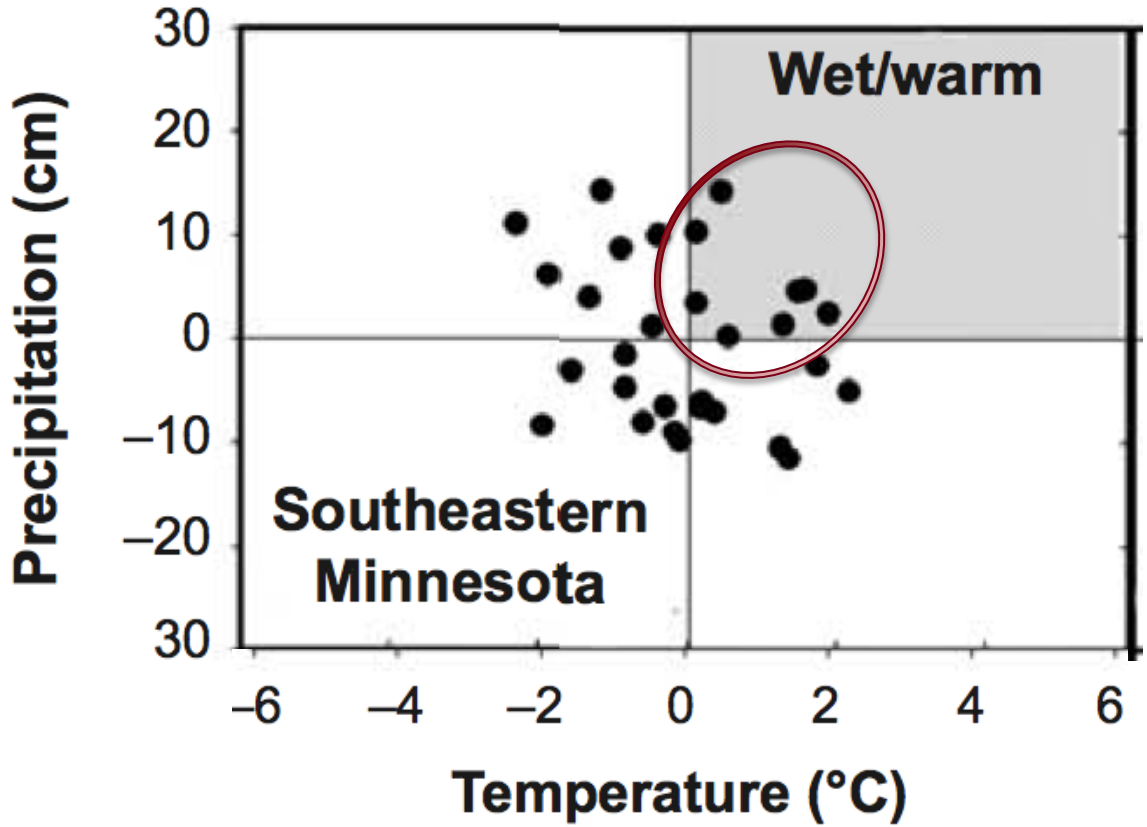

"based on average weather patterns in southwestern MN, winter rye (*Secale cereal* L.) would successful cover crop in one out of four years."

Strock, J.S., P.M. Porter, and M.P. Russelle. 2004. Cover cropping to reduce nitrate loss through subsurface drainage in the Northern US Corn Belt. Journal of Environmental Quality 33:1010-1016.

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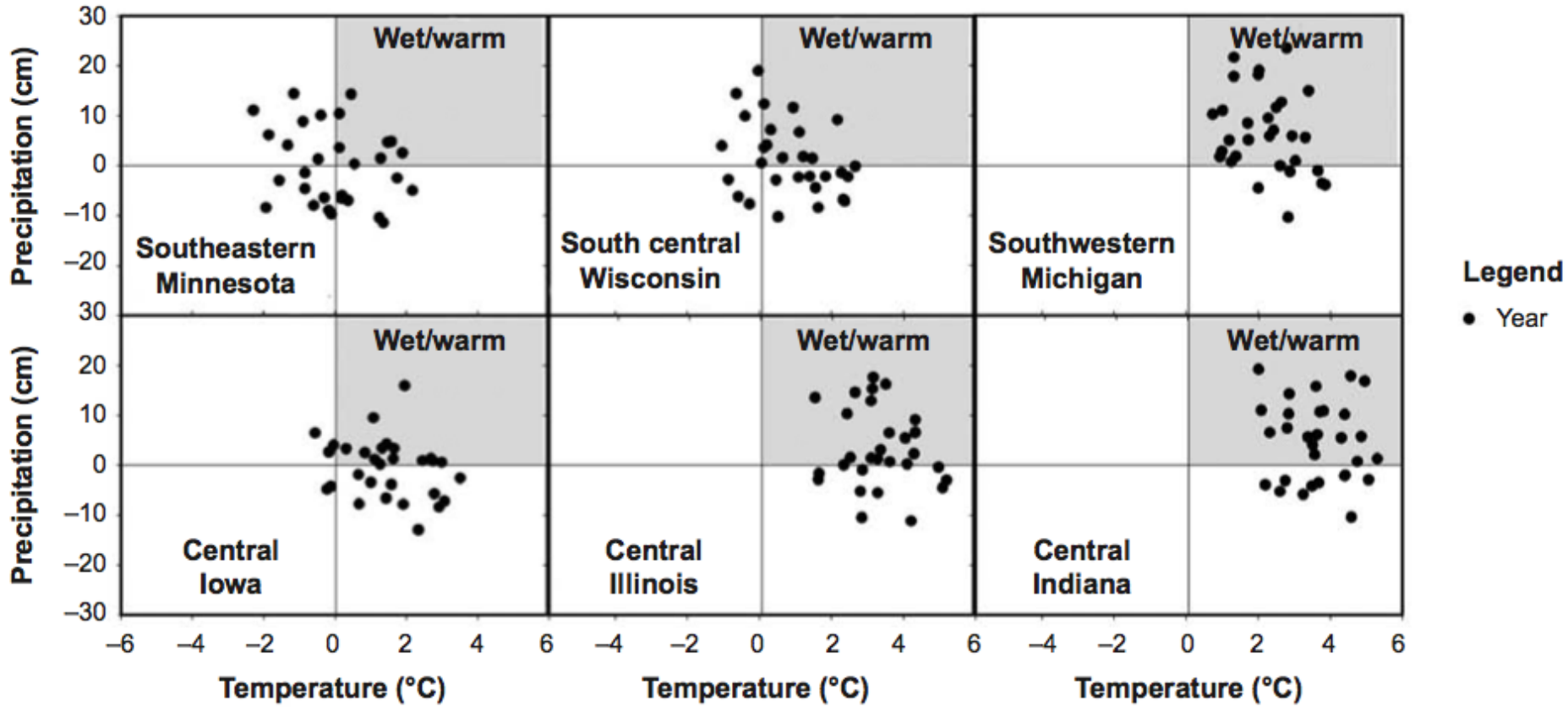
Figure 1

Yearly departure from the southeastern Minnesota 30-year average temperature (1981 to 2010) versus departure from the southeastern Minnesota 30-year average precipitation during September to November. Shaded areas highlight the years with favorable weather conditions (wetter and warmer than the Minnesota average) for establishment of aerially seeded cover crops.



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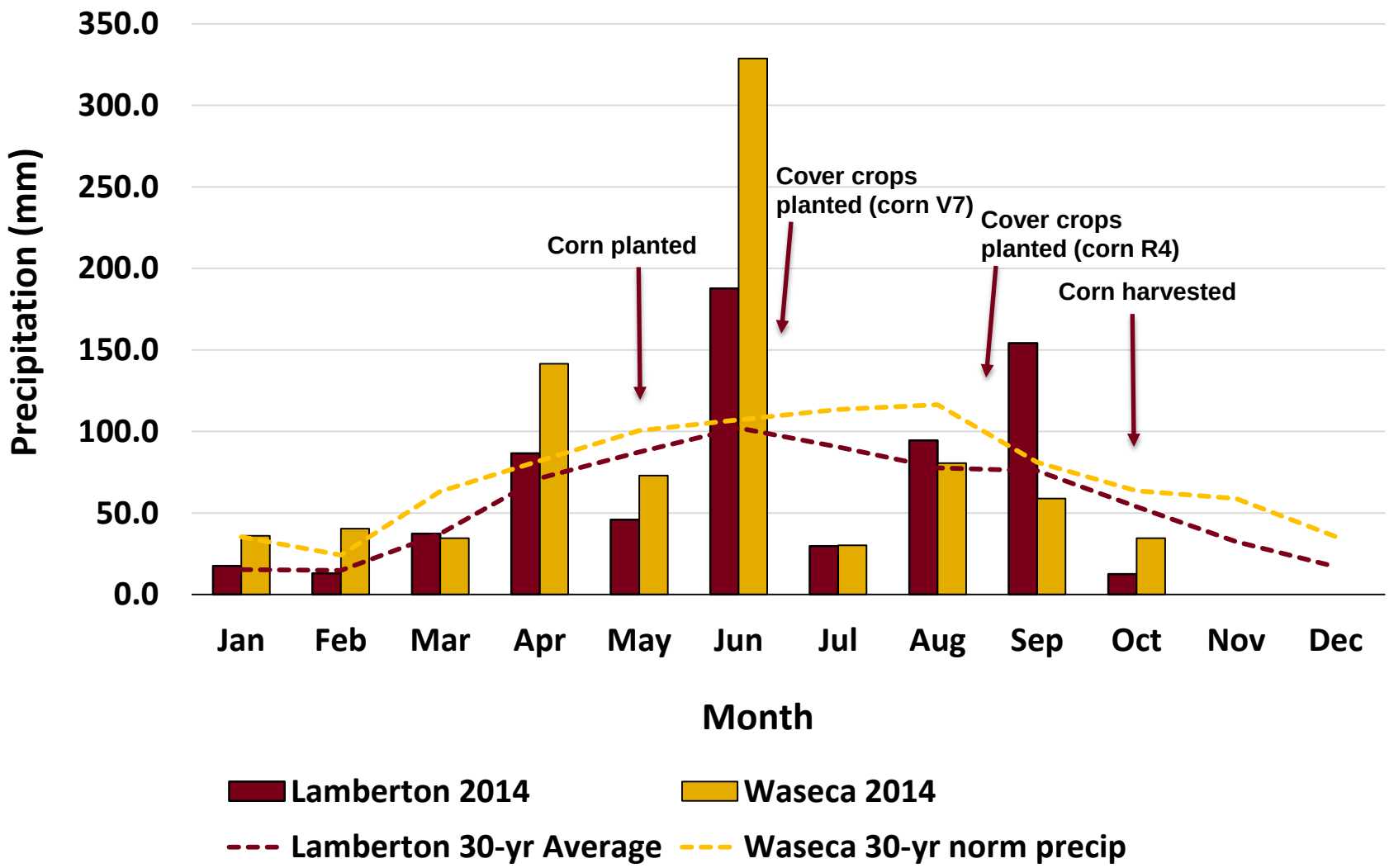
Monthly Precipitation Totals



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UMN SROC &SWROC Weather Data

COVER CROP SPECIE(S)

- Diverse set of functional groups with common characteristics
  - Shade tolerant, seedling vigor, drought tolerant, winter hardy, high biomass production
- Winter cereal grain
  - Notable nitrogen use efficiency and biomass accumulation
  - Rymin Rye
- Legumes
  - Nitrogen fixation
  - Lower growth habit may allow for better shade tolerance beneath the canopy
  - Rose Clover (Perennial)
  - Hairy Vetch (Annual)

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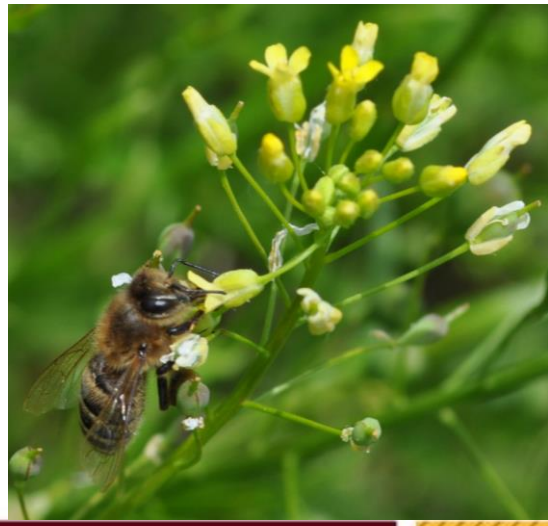
COVER CROP SPECIE(S)

- Pennycress:
  - Brassica: Notable N use efficiency
  - Extremely water efficient
  - Potential harvestable oilseed crop.
- Non Winter-Hardy Mix:
  - High fall biomass production
  - Intended to winterkill
  - Some potential for N fixation with pea



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COVER CROP SPECIE(S)

Cover crop	Fall Biomass	Winter Hardy	Spring Biomass	Legume N Fixing	High N Use Potential	Relative Seed Size
Cereal Rye	✓	✓	✓		✓	Large
Red Clover	✓	✓	✓	✓		Small
Hairy Vetch	✓	✓	✓	✓		Medium
Fall Mix	✓			✓		Large
Pennycress		✓	✓		✓	Small

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COVER CROPS AND NITROGEN

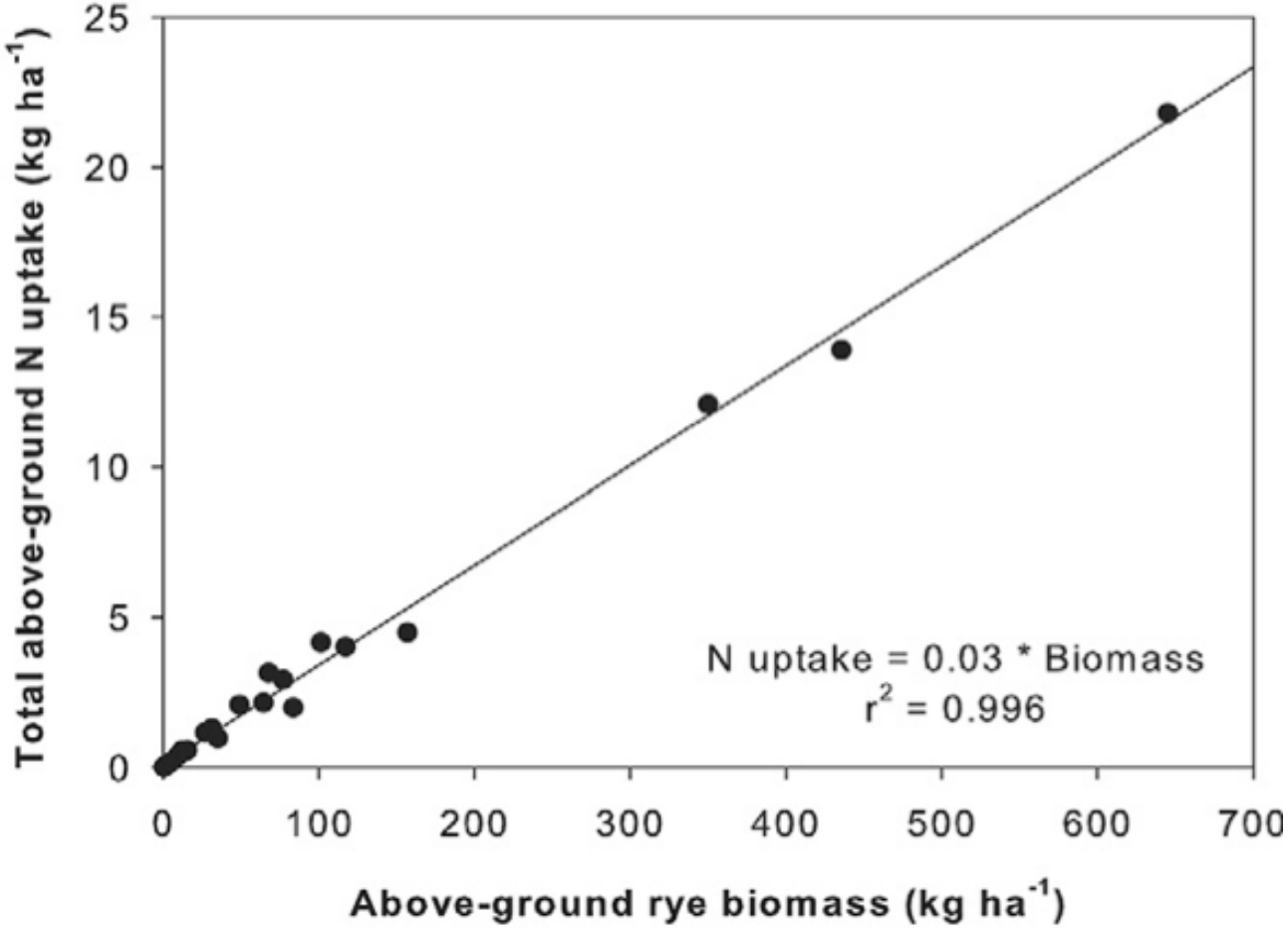

Fig. 4. Aboveground winter rye biomass as related to total N uptake. Rye biomass was collected in the fall.

Melissa L. Wilson, John M. Baker, and Deborah L. Allan. 2004. Factors Affecting Successful Establishment of Aerially Seeded Winter Rye. J. Environ. Qual. 33:1010-1016

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COVER CROP ESTABLISHMENT

- Arial Seed = Mixed Results (30% Est.)

- Drilling After Corn = Reduced Fall Biomass

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OBJECTIVES

- Identify suitable cover crops and effective planting methods for interseeding into full season corn systems.
- Assess cover crops effects on corn yield, soil moisture, and biomass accumulation.

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COVER CROPS

Cover Crop		Species	Variety	Seeding Rate (kg ha^{-1})
Cereal Rye		***Secale cereale***	**Rymin**	**168**
Pennycress		***Thlaspi arvense***	**PC 105, 106, 109, 111**	**9.9**
Red Clover		***Trifolium pratense***	unspecified	**13.4**
Hairy Vetch		***Vicia villosa***	unspecified	**35.1**
Fall Green Manure Mix			**Albert Lea NitroMax CC1**	**140**
	Oats	*Avena sativa*	unspecified	
	Field pea	*Pisum sativum ssp. Arvense*		
	Tillage radish	*Raphanus sativus L.*		

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COVER CROP ESTABLISHMENT

– "The Penn State Interseeder"

- High clearance drill designed to:
  - Plant three rows of cover crops (per interrow)
  - Spray post-emergent herbicide
  - Apply fertilizer… all at once

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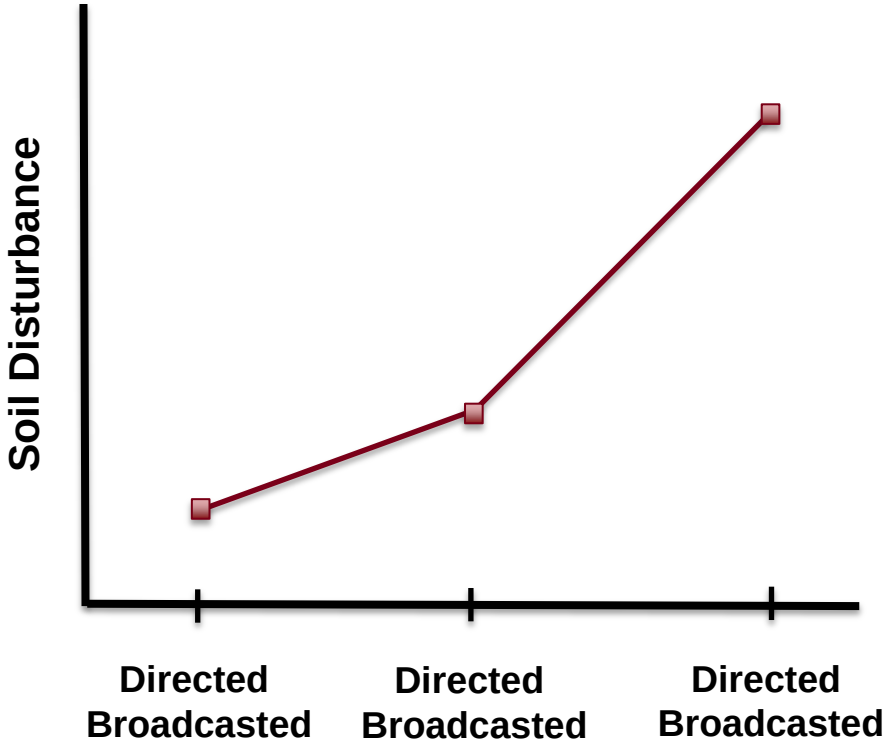
COVER CROP ESTABLISHMENT

- Cover crop planting treatments:
  - Directed Broadcasted
  - Directed Broadcasted + Light incorporation
  - Drilled



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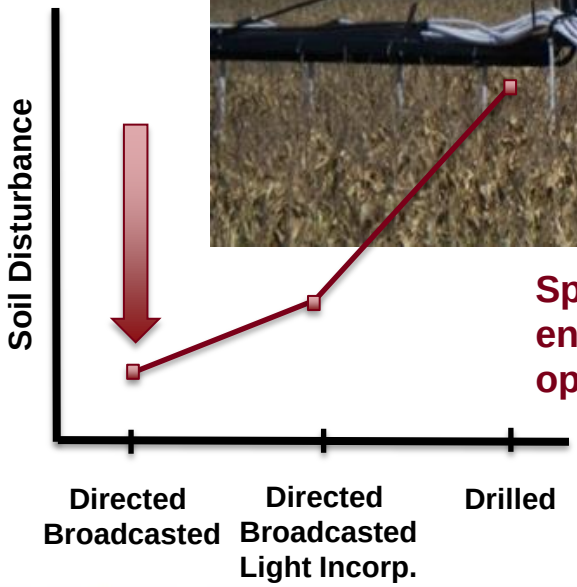
COVER CROP ESTABLISHMENT

- Directed Broadcasted



Spacers used to operate drill without engaging wavy coulters, double disc openers, and closing wheels

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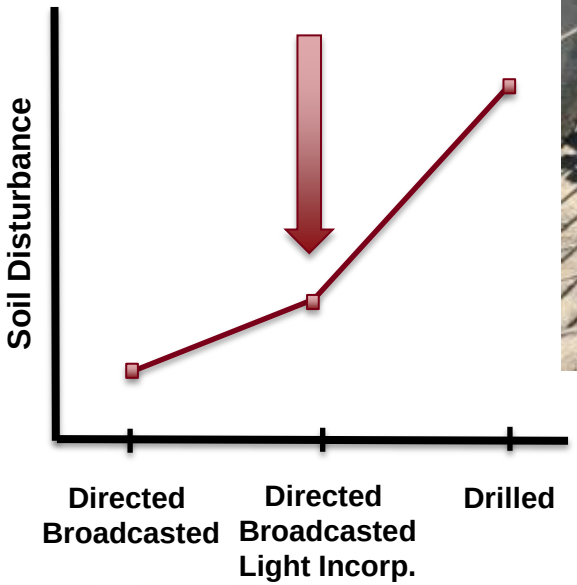
COVER CROP ESTABLISHMENT

- Directed Broadcast + Incorporation
  - Drill units lifted
  - Incorporation units installed



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COVER CROP ESTABLISHMENT

- Drilled

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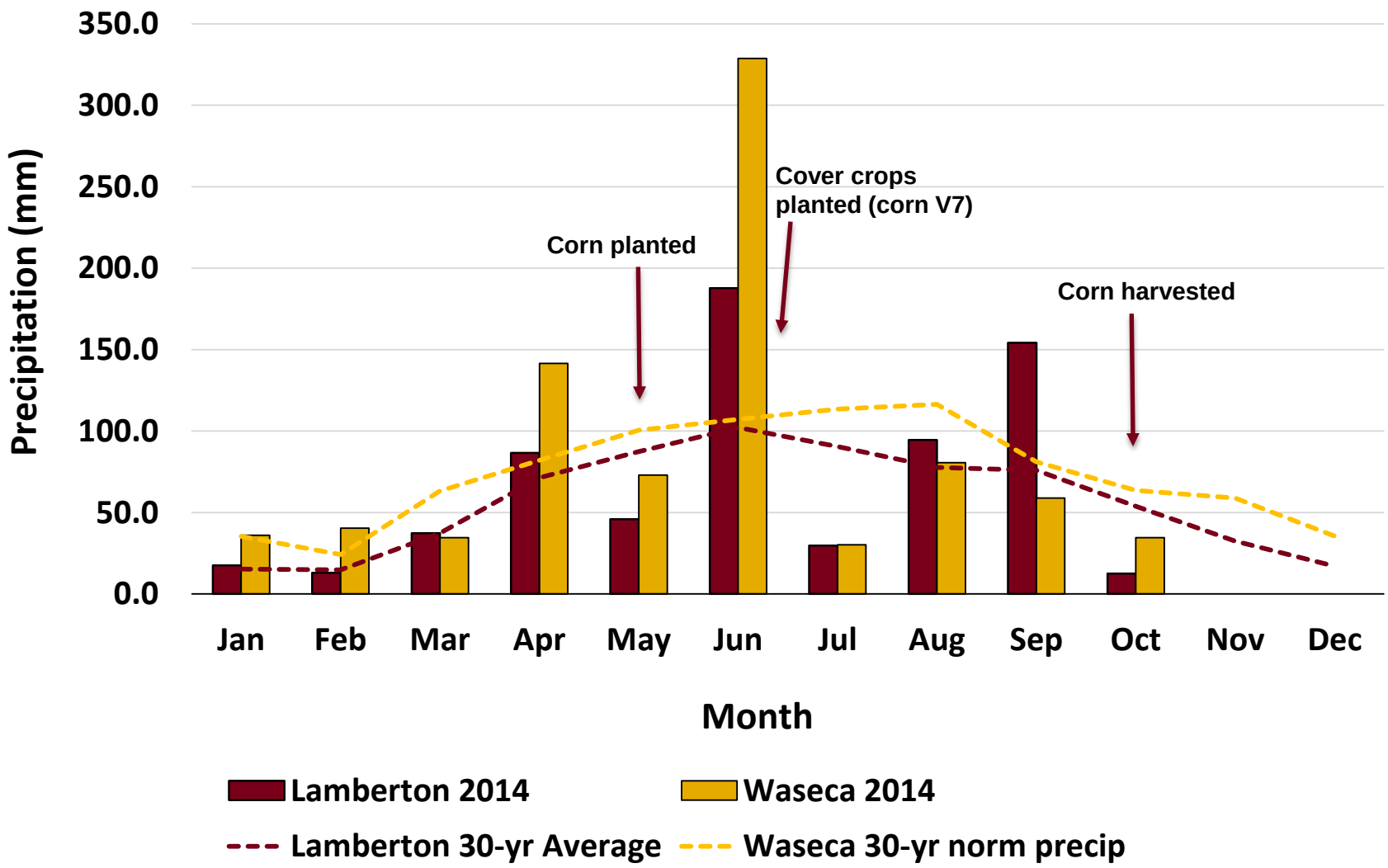
Monthly Precipitation Totals



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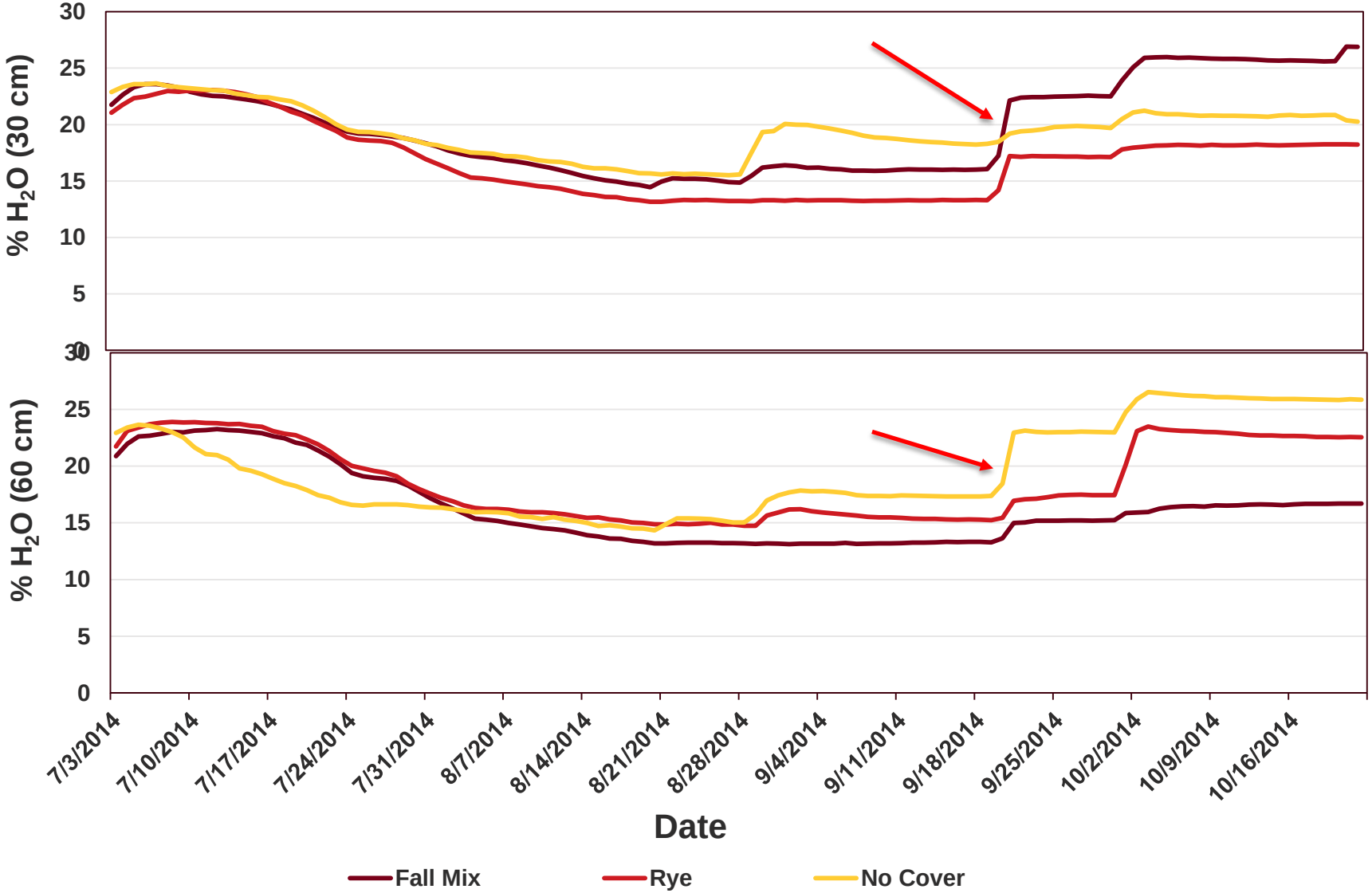
UMN SROC &SWROC Weather Data

SOIL MOISTURE (WASECA)



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COVER CROP ESTABLISHMENT

Cover Crops Planting Date: 6/25/2014

Red Clover

Winter Rye

7/1/2014

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COVER CROP ESTABLISHMENT

Cover Crops Planting Date: 6/25/2014

Rye: Early VT

Directed Broadcasted

Directed Broadcasted + Incorp.

Drilled

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COVER CROP – 8/1/2014

Cover Crops Planting Date: 6/25/2014

Directed Broadcasted + Incorp.

Drilled

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COVER CROPS - 9/16/2014

Broadcast

Broadcast + Incorp

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COVER CROP - 9/16/2014

Broadcast

Broadcast + Incorp

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COVER CROP – 9/16/2014

Hairy Vetch

NWH Fall Mix

Red Clover

Winter Rye

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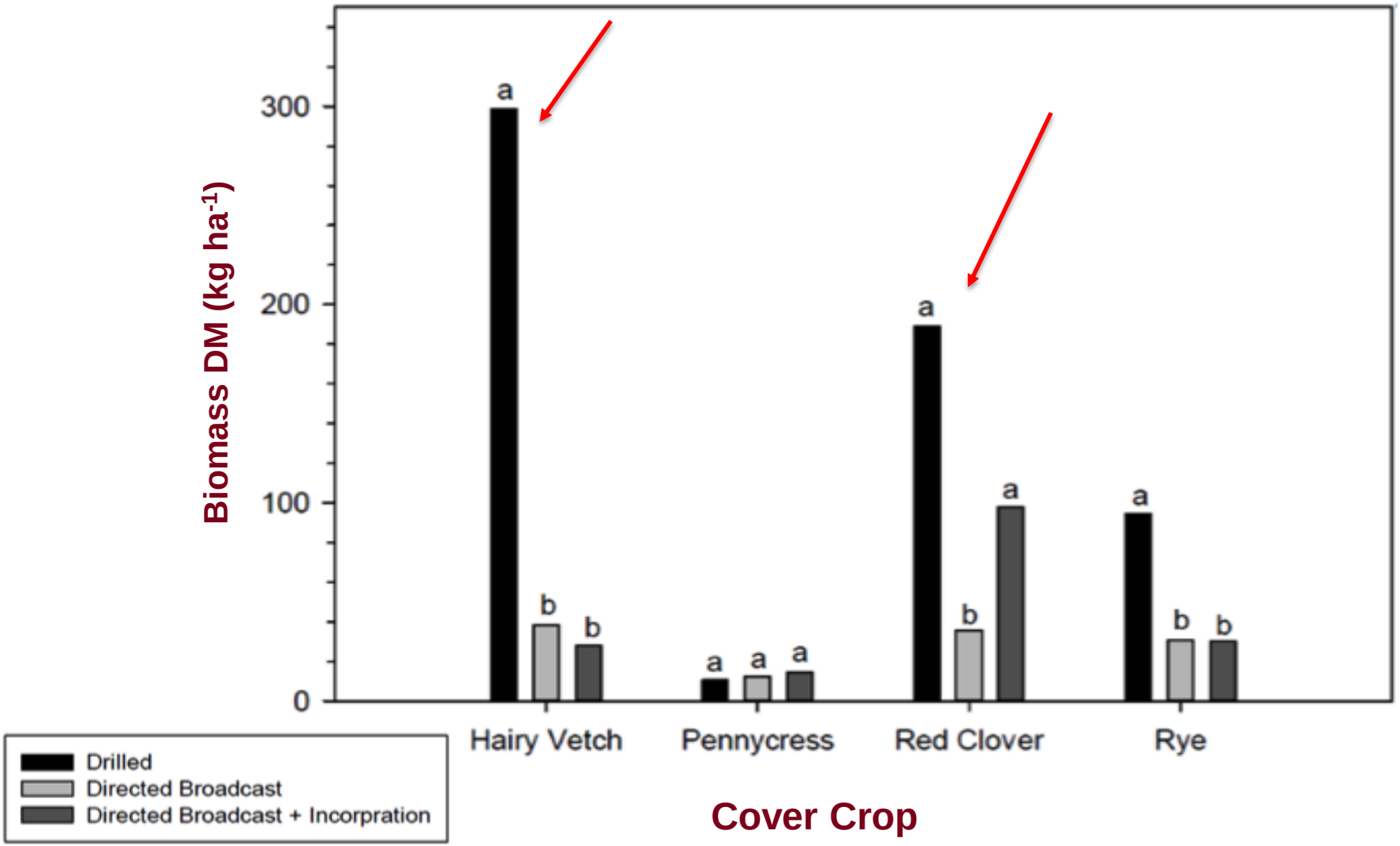
COVER CROP BIOMASS (WASECA)



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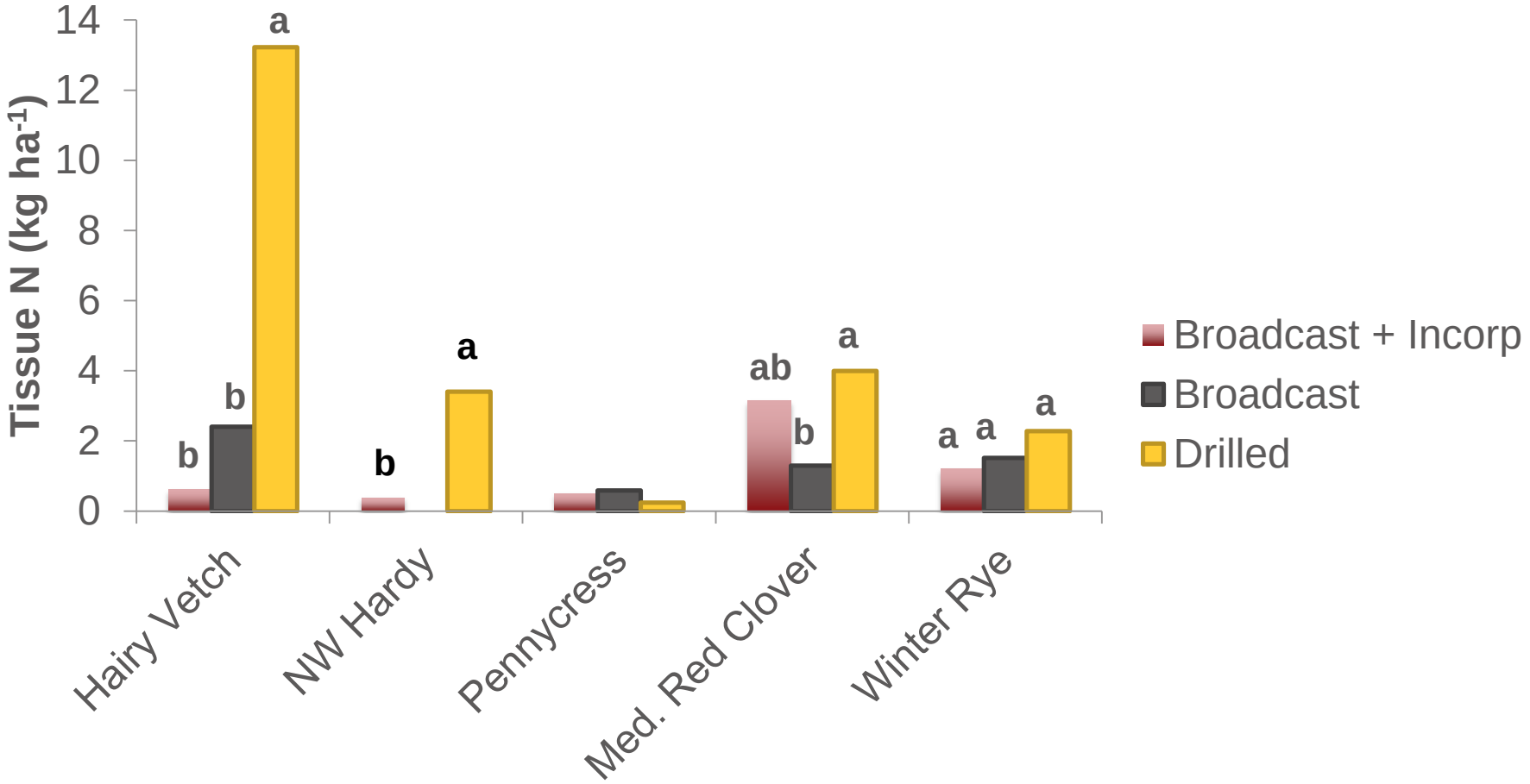
COVER CROP TISSUES N (WASECA)



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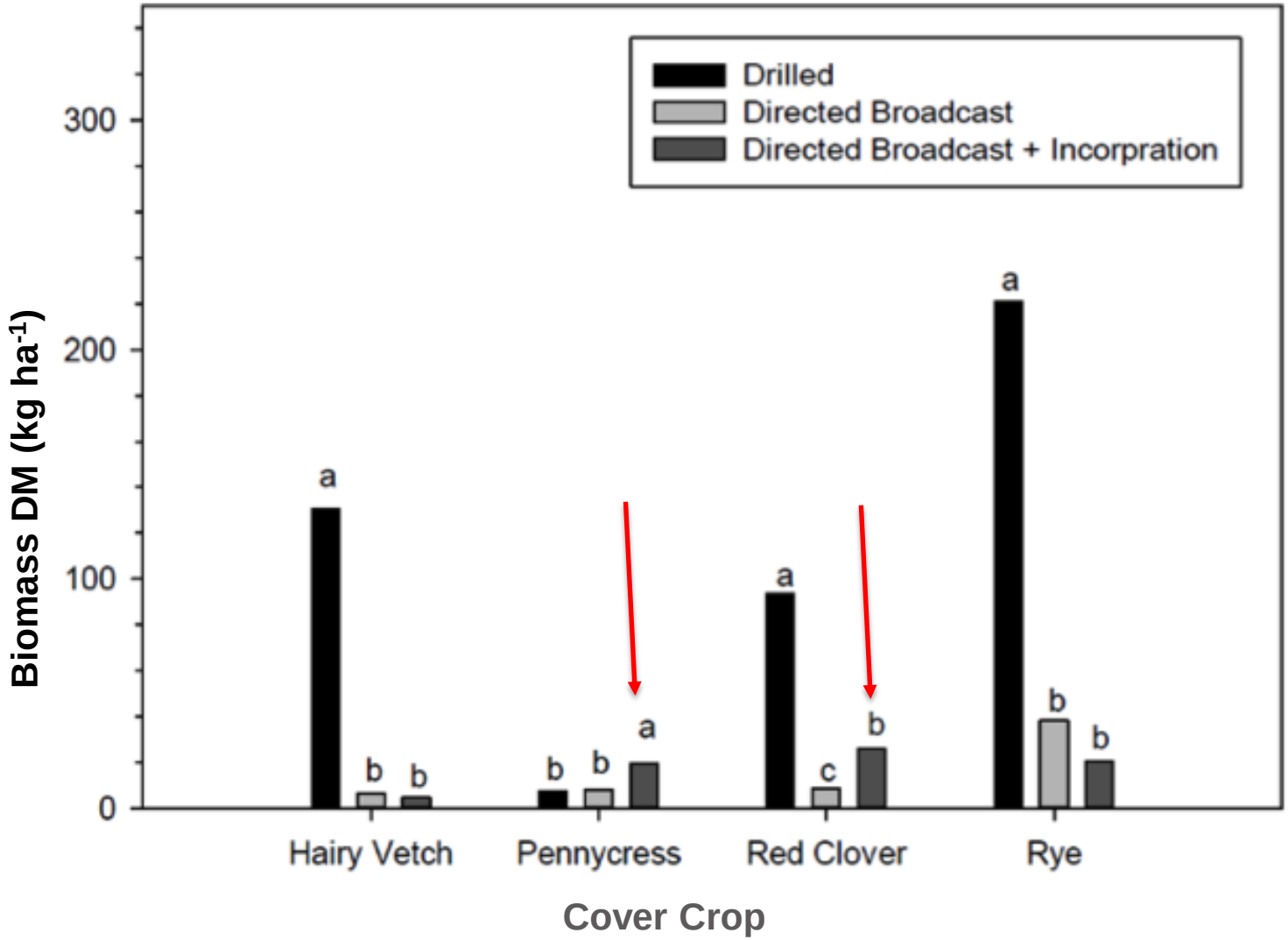
COVER CROP BIOMASS (LAMBERTON)



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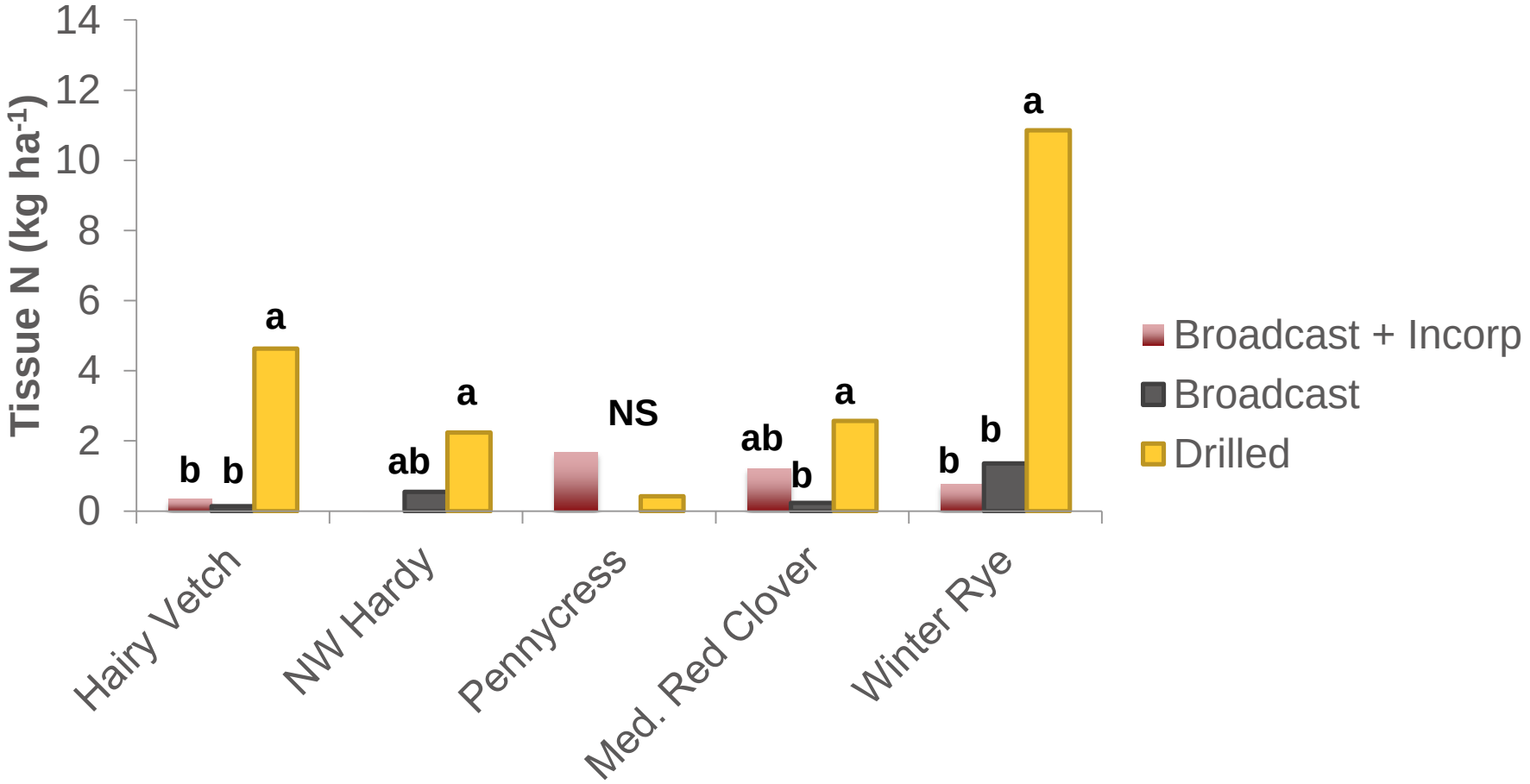
COVER CROP TISSUES N (LAMBERTON)



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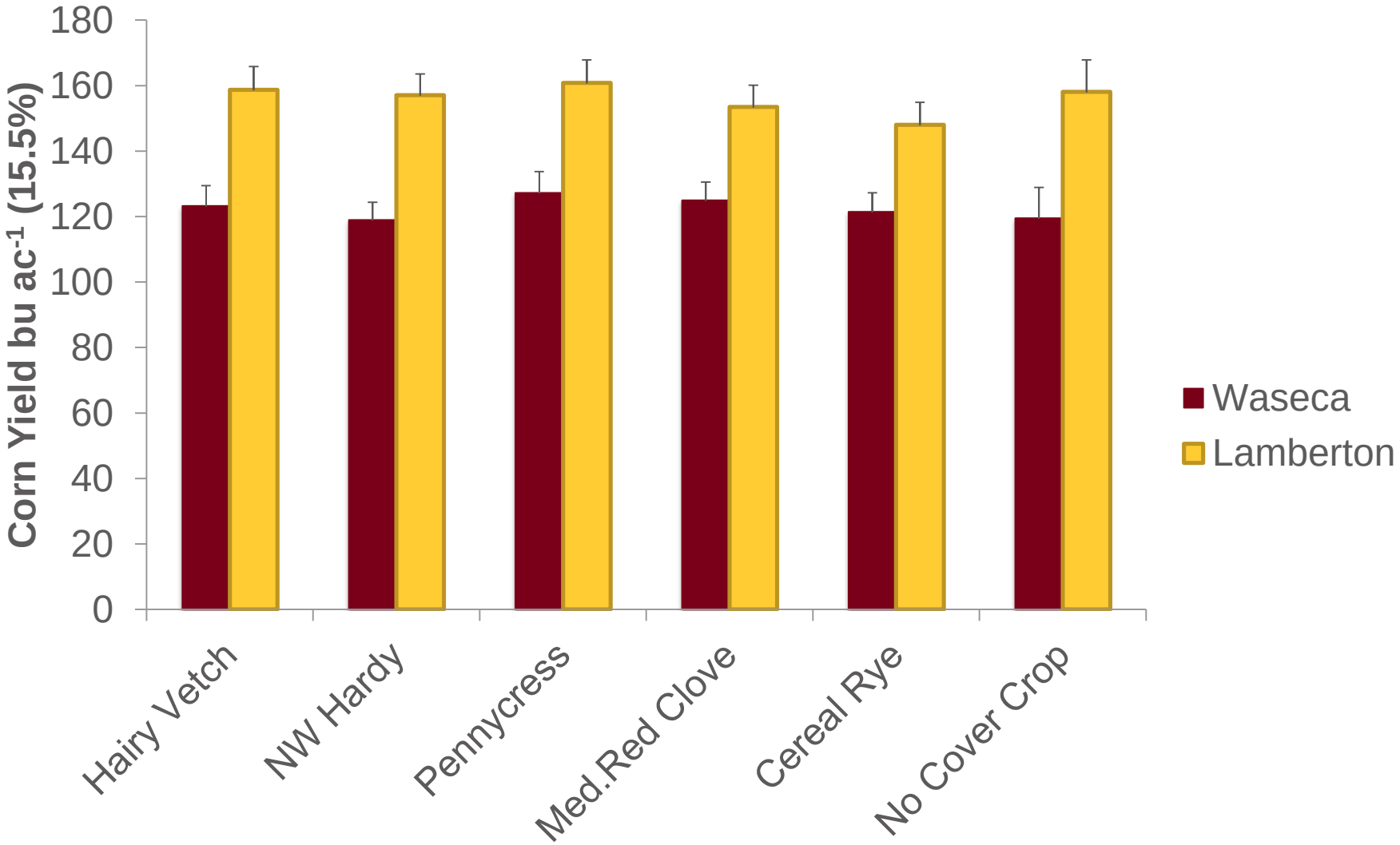
GRAIN YIELD



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FUTURE RESEARCH

- Planting date by cover crop species across Minnesota in both corn and soybean
- Determine N contribution to subsequent crop (i.e. N-credit)
- Agronomic management of new value added cover crops

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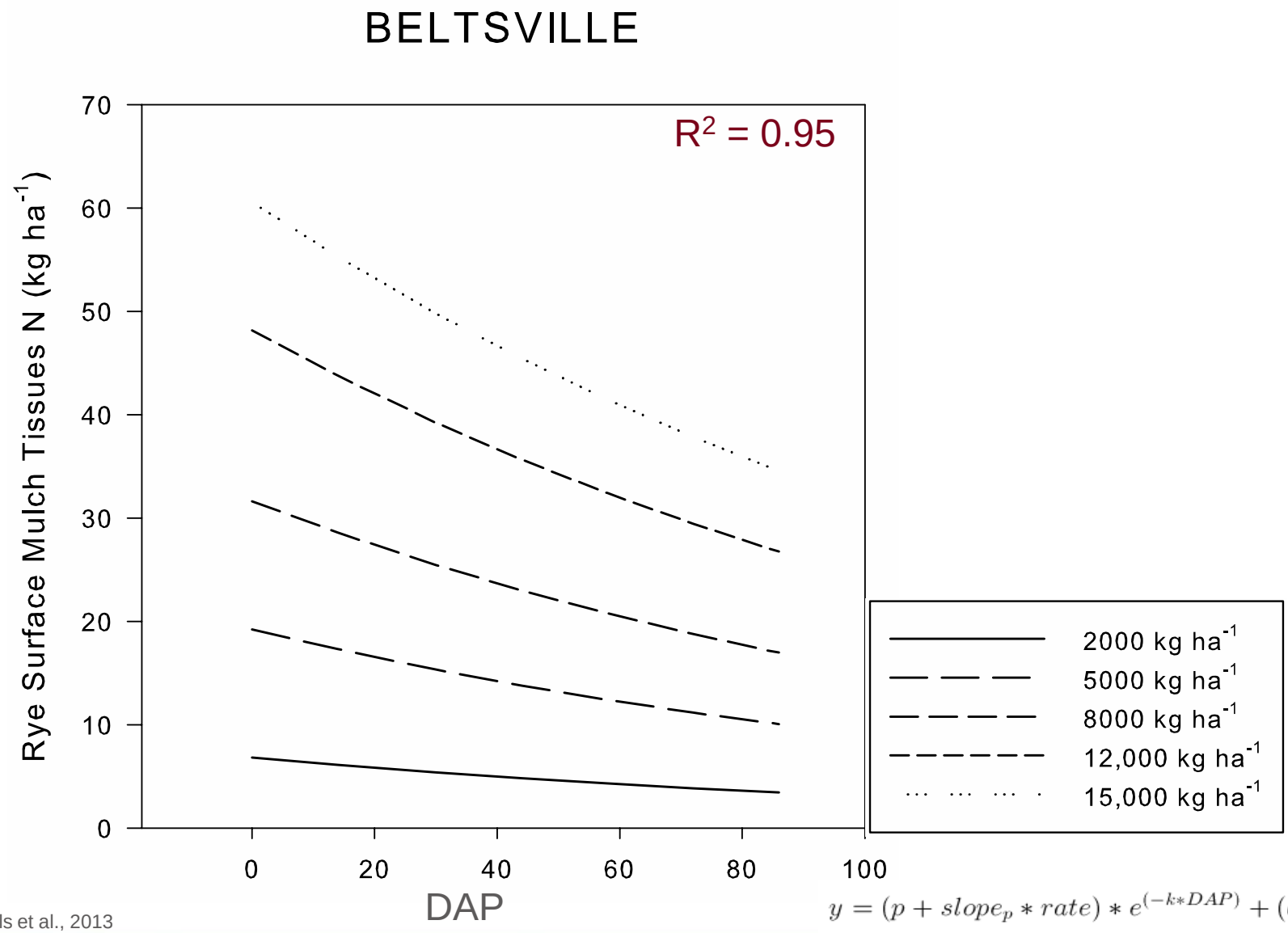
COVER CROPS AND NITROGEN



$$y = (p + slope_p * rate) * e^{(-k*DAP)} + (b + slope_b * rate)$$

Wells et al., 2013

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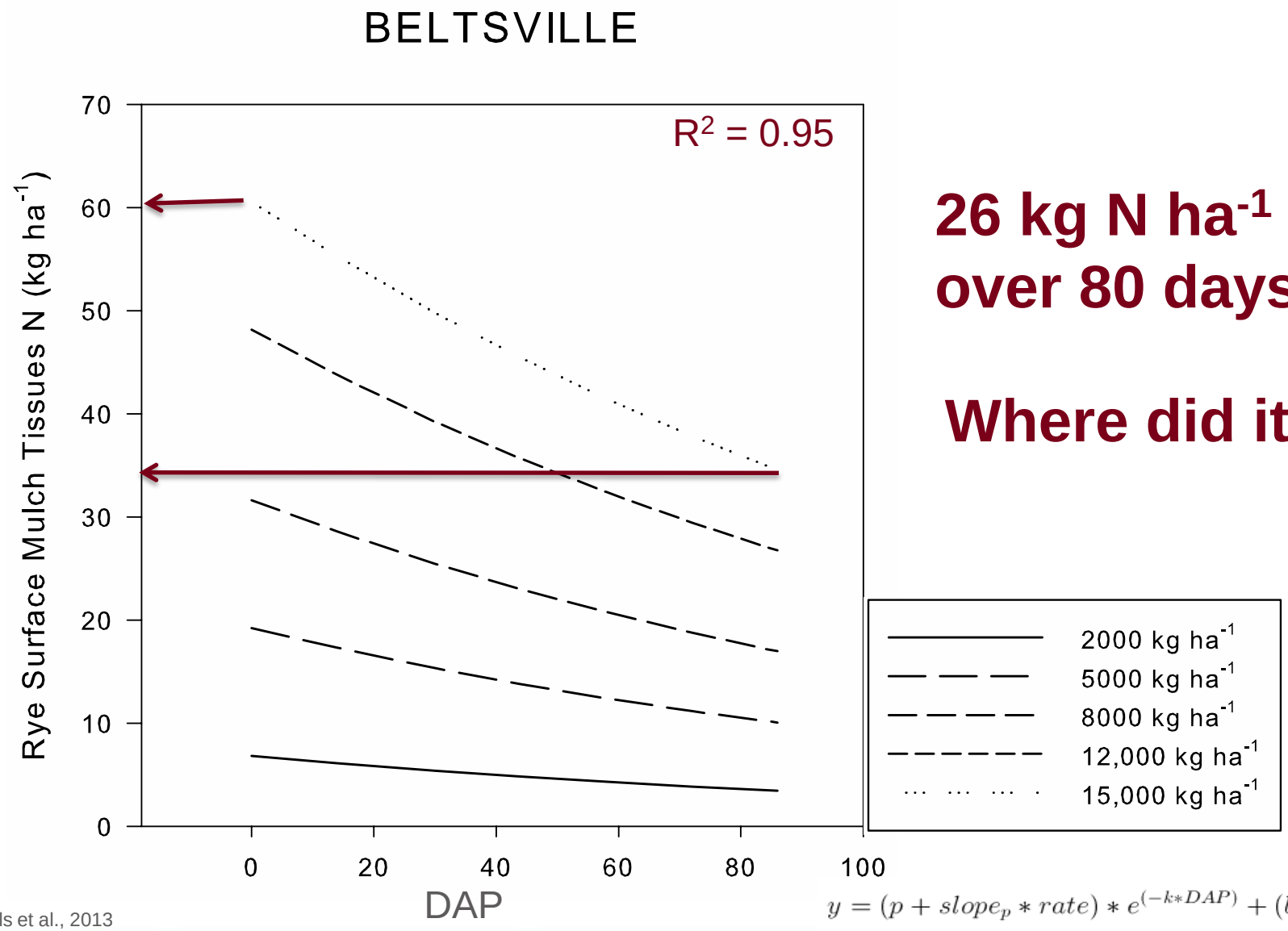
COVER CROPS AND NITROGEN



26 kg N ha^{-1} Loss over 80 days

Where did it go?

Wells et al., 2013

$$y = (p + slope_p * rate) * e^{(-k*DAP)} + (b + slope_b * rate)$$

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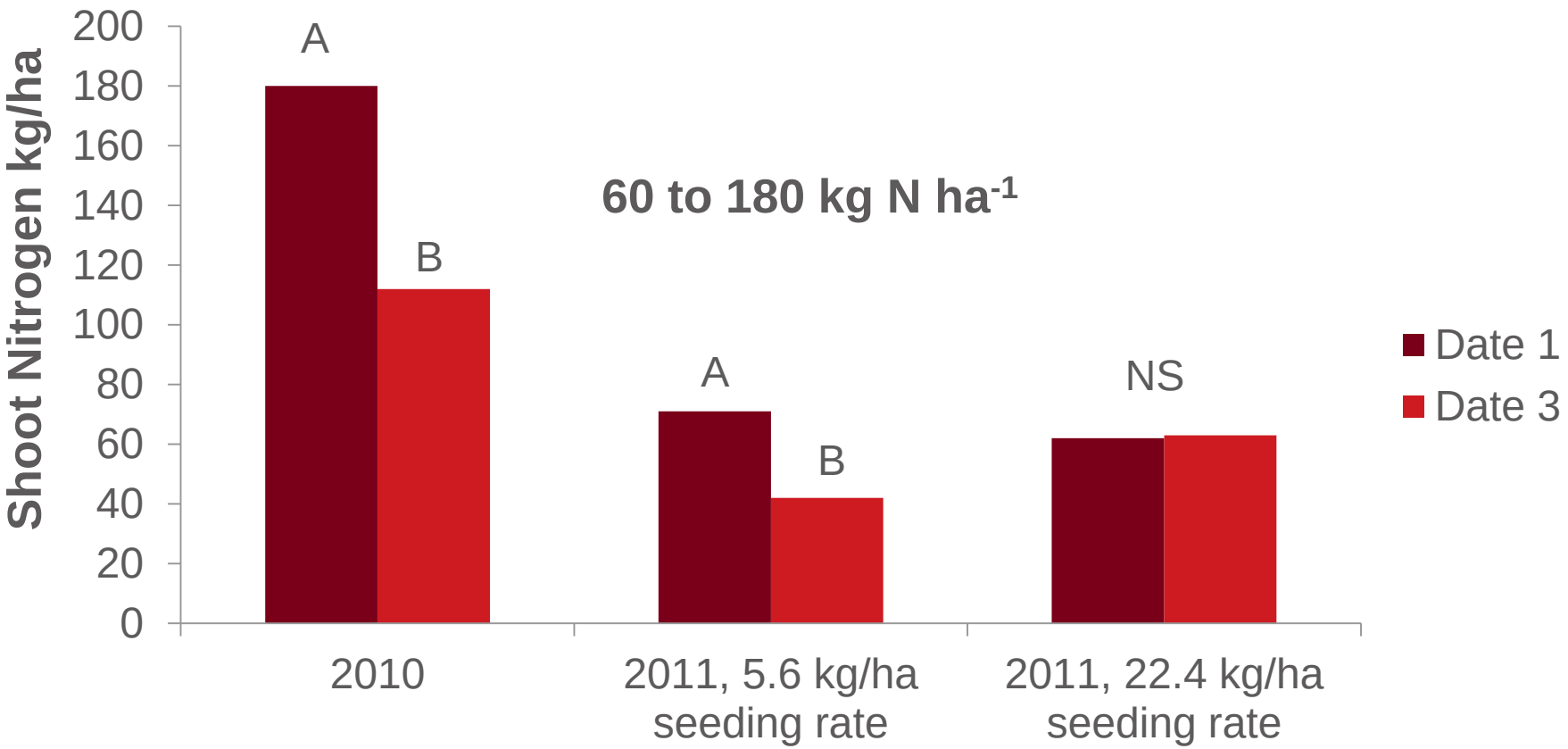
COVER CROPS AND NITROGEN

RADISH NITROGEN ACCUMULATION



Shoot nitrogen accumulation only. Biomass collected mid- to late October. 2010: means presented are averaged across accessions and seeding rates. 2011: means are averaged across accessions. Within year and seeding rate, means with the same letter are not different (ANOVA test, α = 0.05).

Gieske et al., 2014 Thesis.

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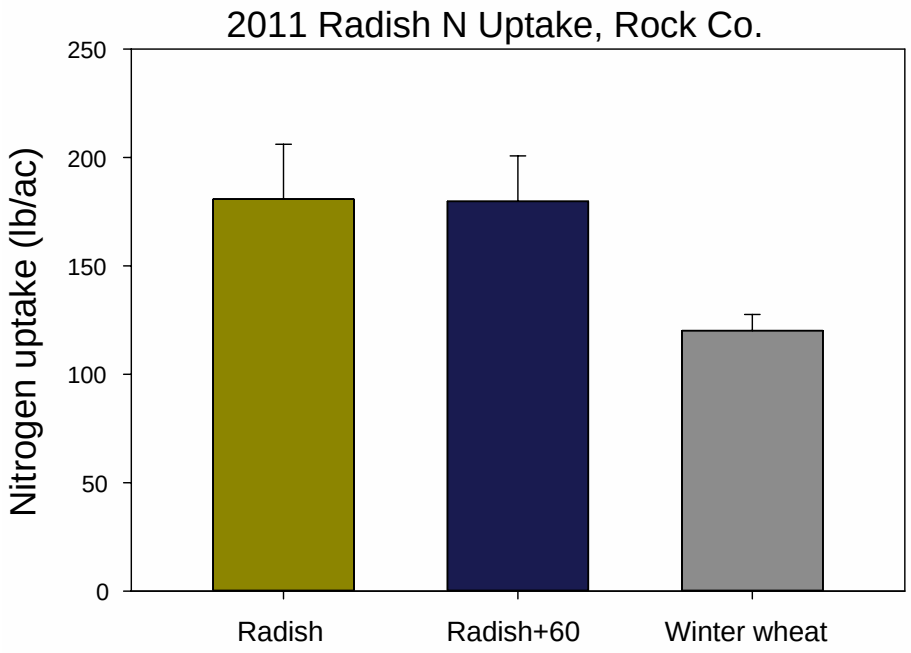
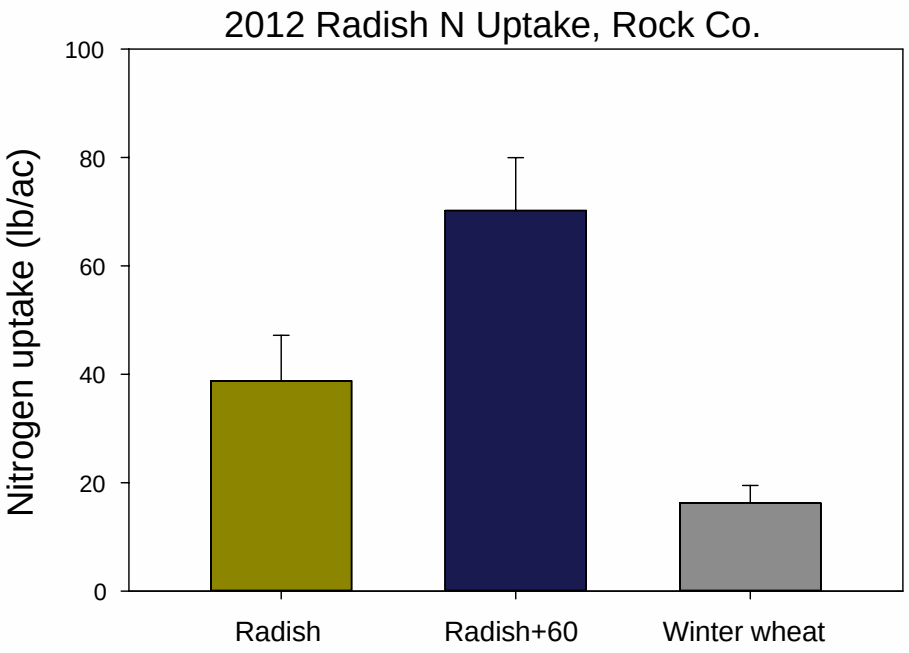
COVER CROPS AND NITROGEN

RADISH NITROGEN ACCUMULATION



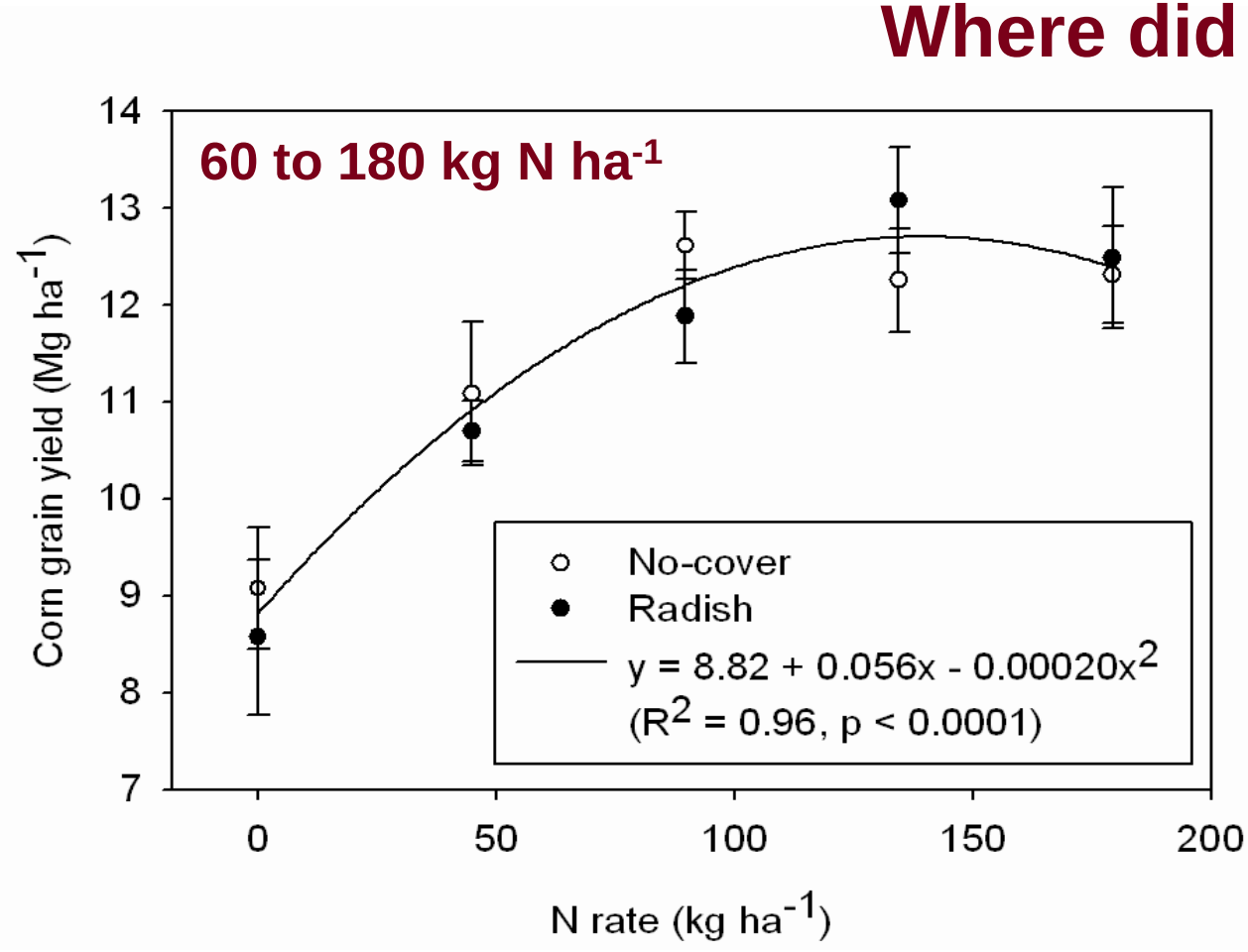


Dr. Matt Ruark UW-Madison

DEPARTMENT OF SOIL SCIENCE
University of Wisconsin-Madison

COVER CROPS AND NITROGEN

Where did it go?



Treatment means averaged over 3 site-years. Cover crop treatments did not differ (ANOVA test, α = 0.05).

Gieske et al., 2014 Thesis.

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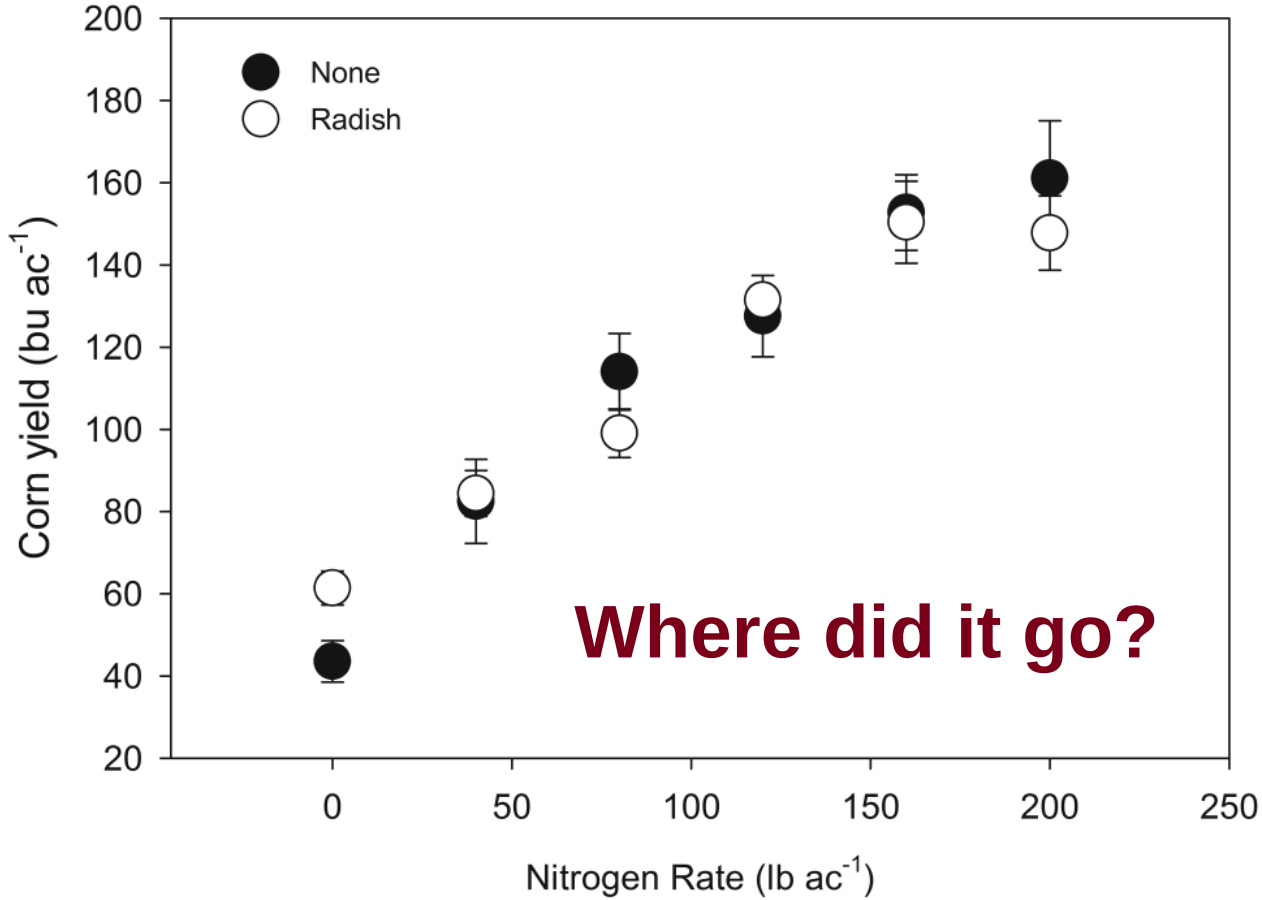
COVER CROPS AND NITROGEN

2013 Corn yields. Washington County, WI. No-till corn following winter wheat



No effect of radish on yield or response to N in 2012 as well.

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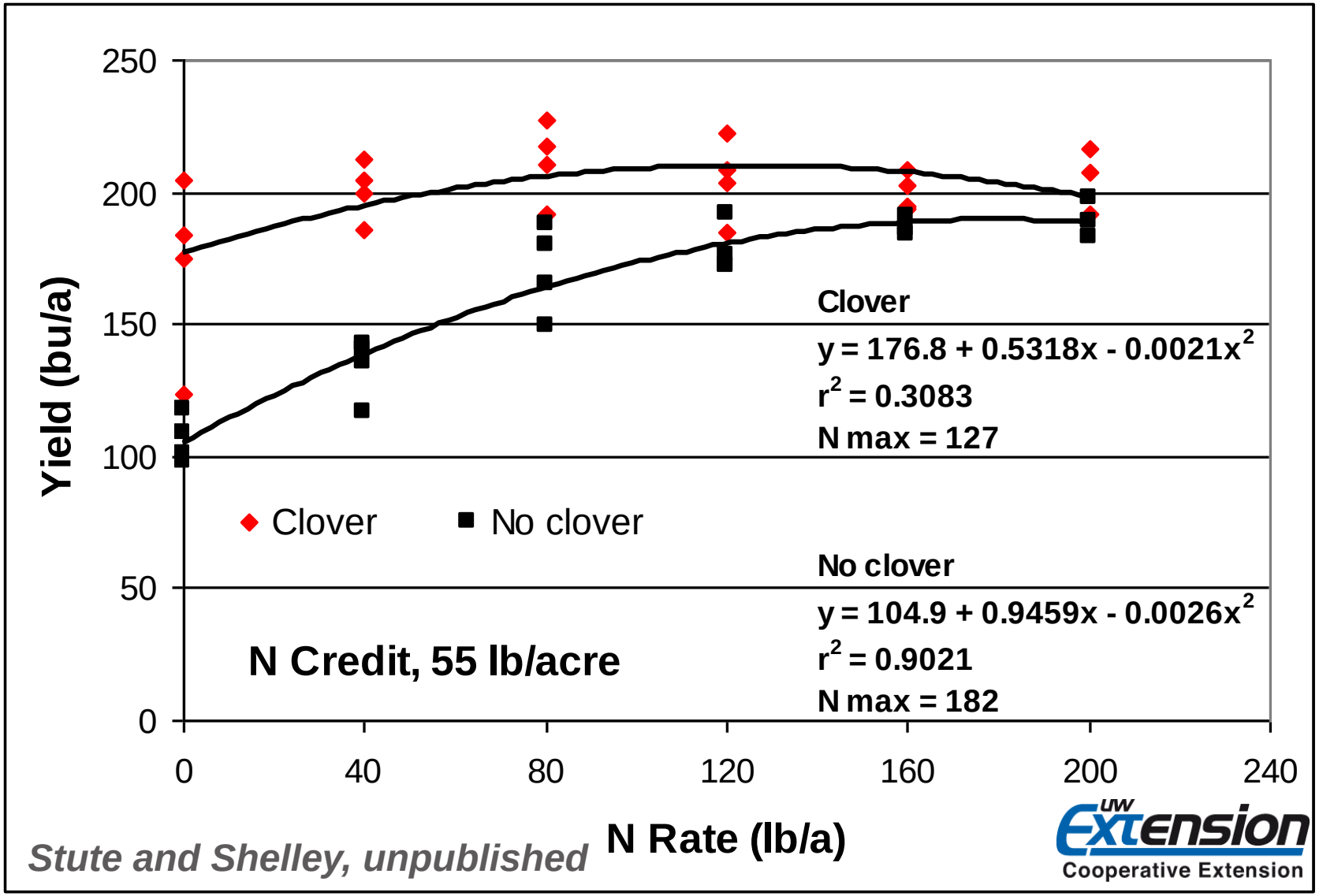
Corn response to nitrogen, Janesville 2010



Questions?

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