

# Minimizing Nutrient Loss by Diversifying Crop Rotation



**Lowell Gentry**

Principal Research Specialist in Agriculture,  
NRES

**Small Grains Conference**

March 5, 2020

**(by adding wheat and cover crops to  
your corn/soybean rotation)**

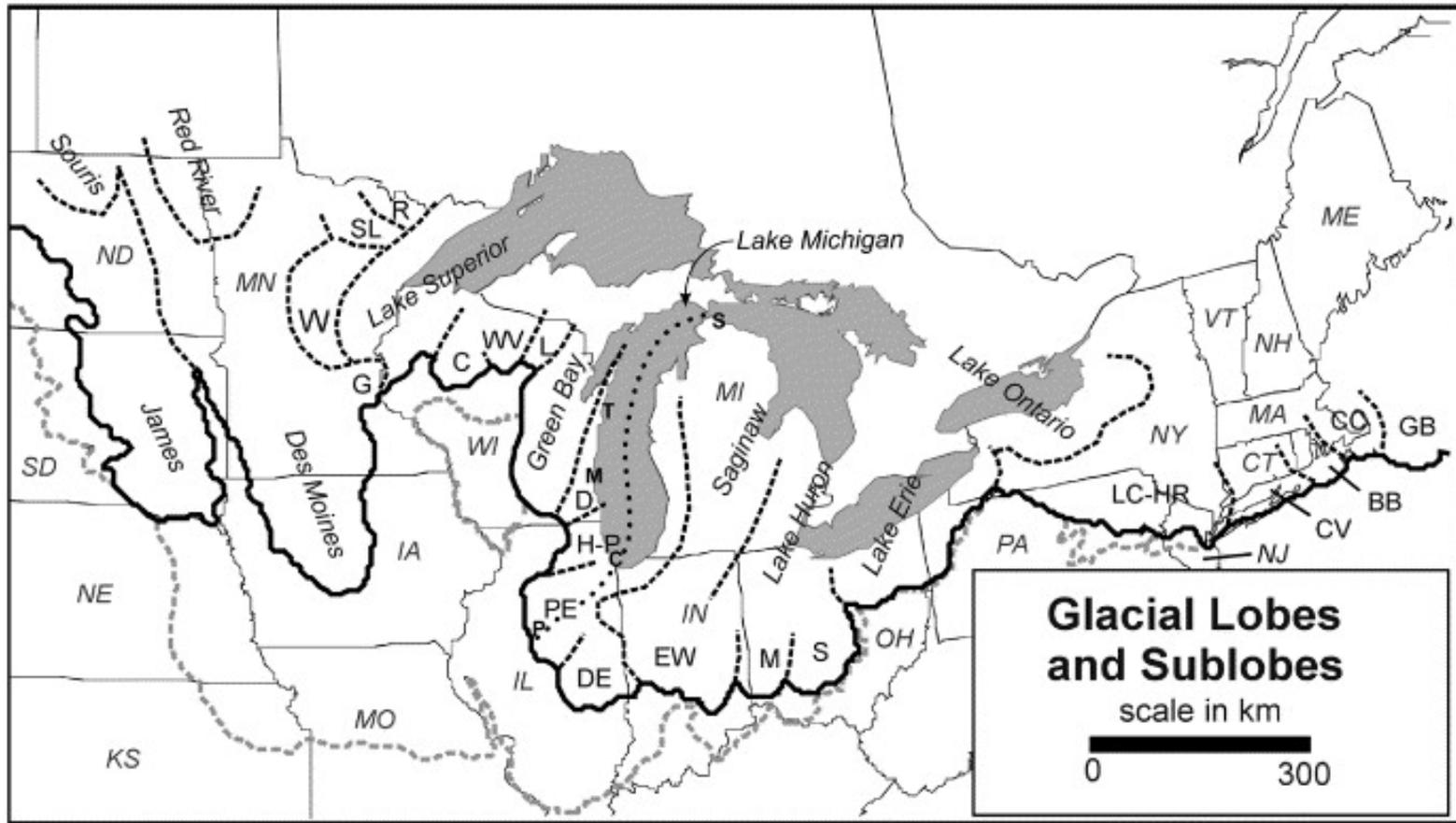


# Topographic Map of Illinois

Wisconsin glaciation scoured and flattened the eastern upper-half of the state.



# Glaciation/Tile Drainage/Nitrate Loss



Reference: Mickelson and Colgan (2003)



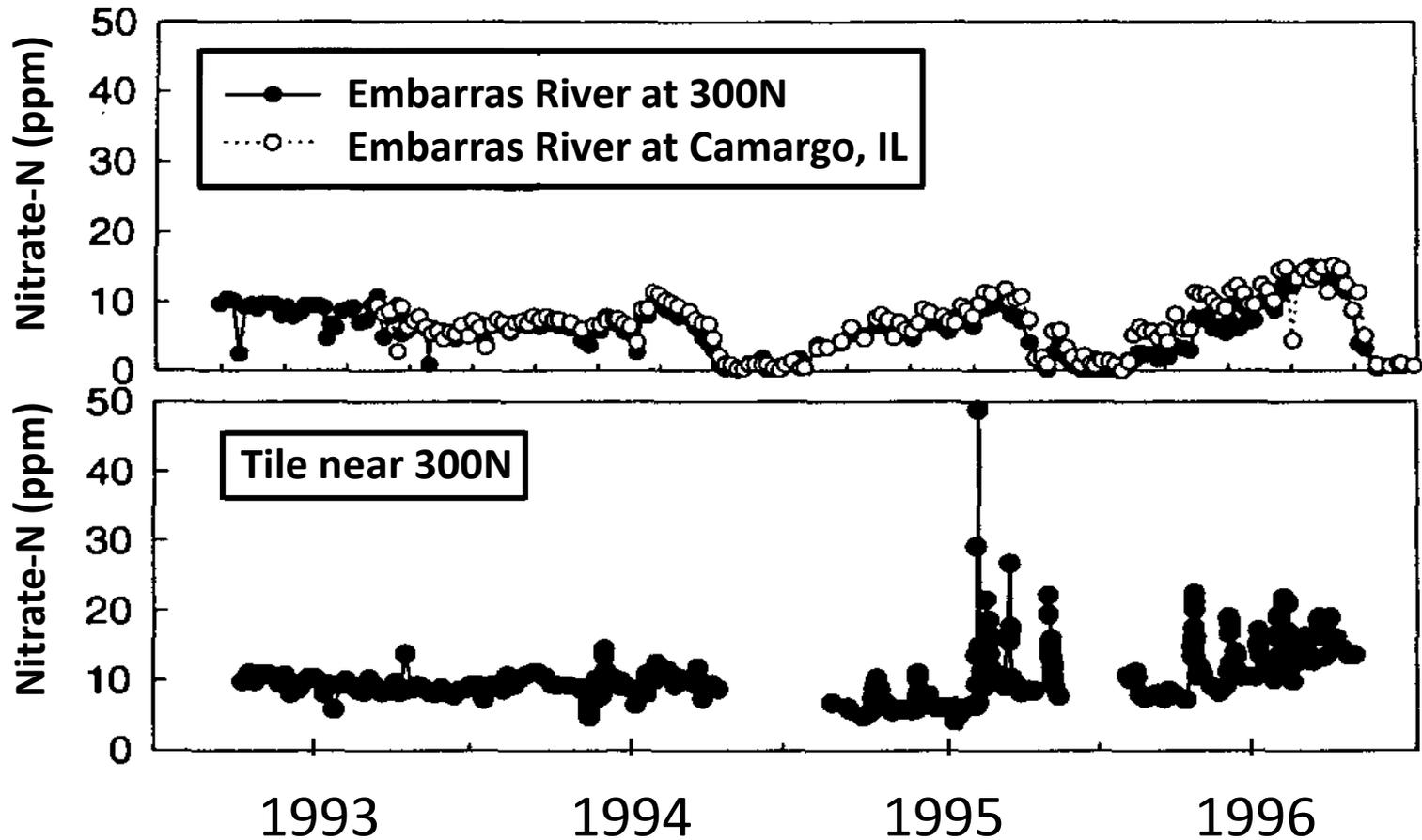
# Tile drainage created fertile crop land



Tile drainage is a prerequisite for high yields;  
however, tile water carries nitrate.

# Tile vs. River Nitrate

( $R^2 = 0.70$ )

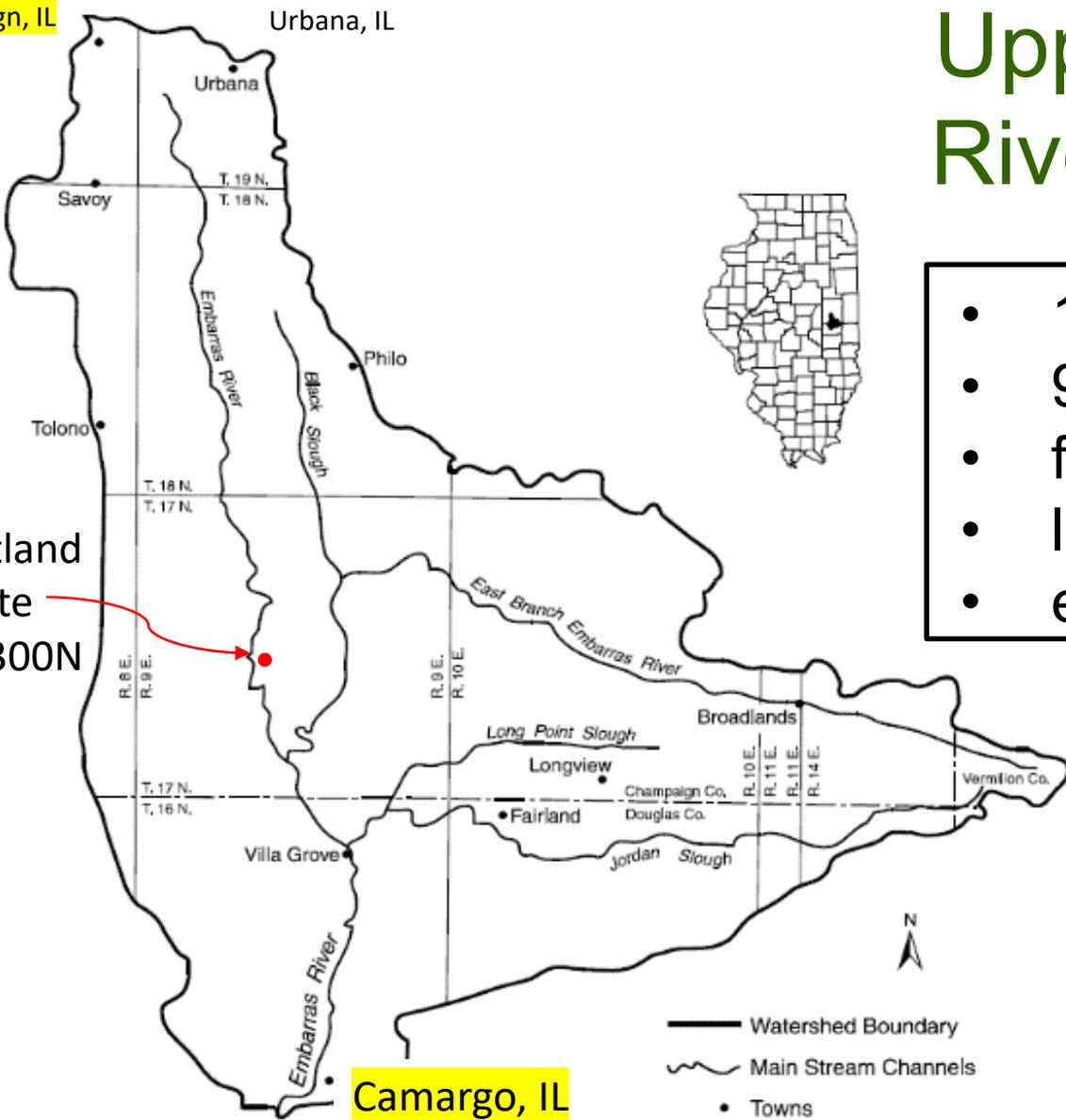


Champaign, IL

Urbana, IL

# Upper Embarras River Watershed

Wetland site on 300N



- 119,000 acres
- 90% row crop ag
- few animals
- little sewage effluent
- extensive tile drainage



# USGS River Gauge (Camargo, IL)

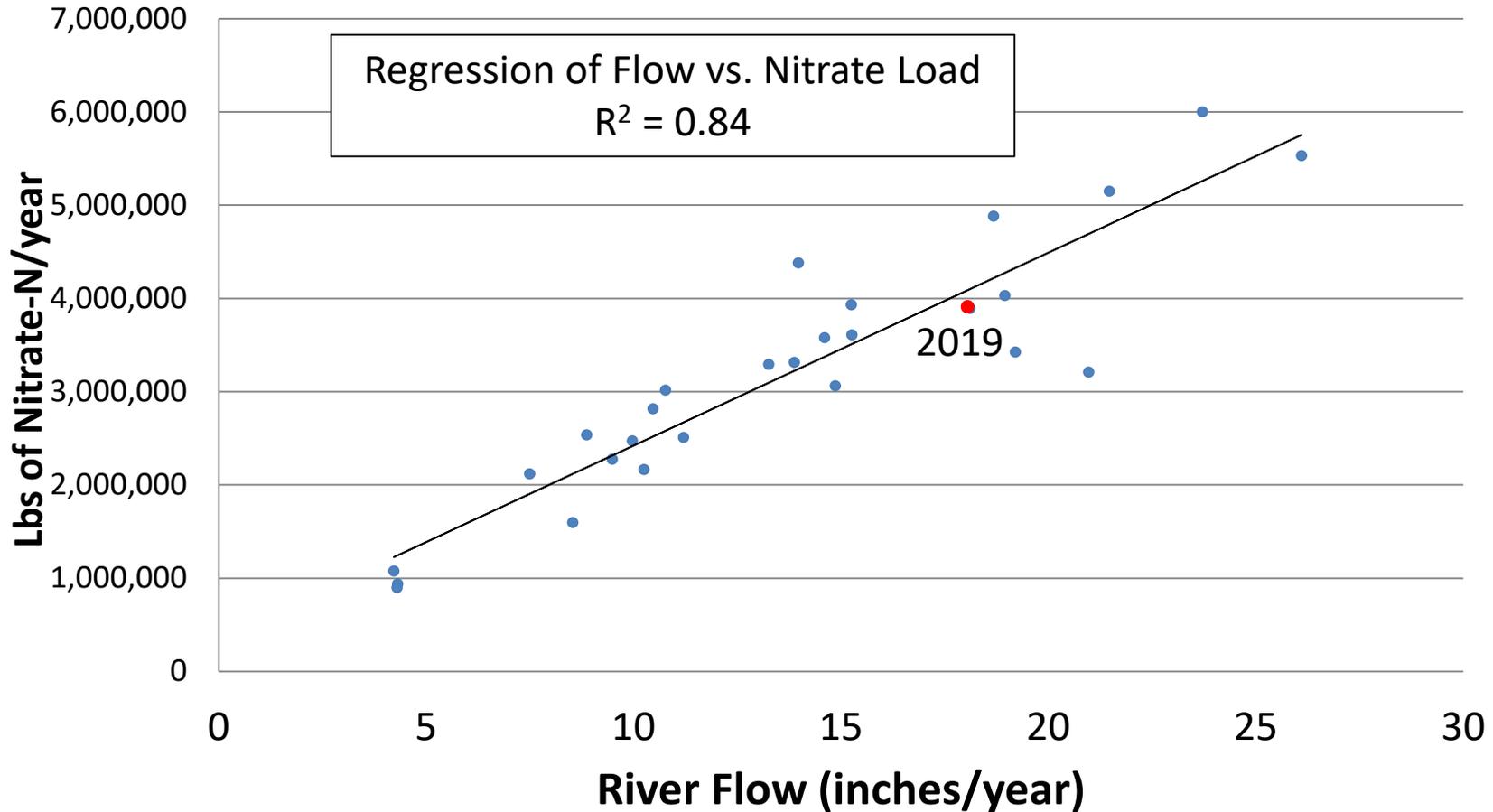
(Visited bridge 1,510 times since 1993)



Bridge serves as a large weir

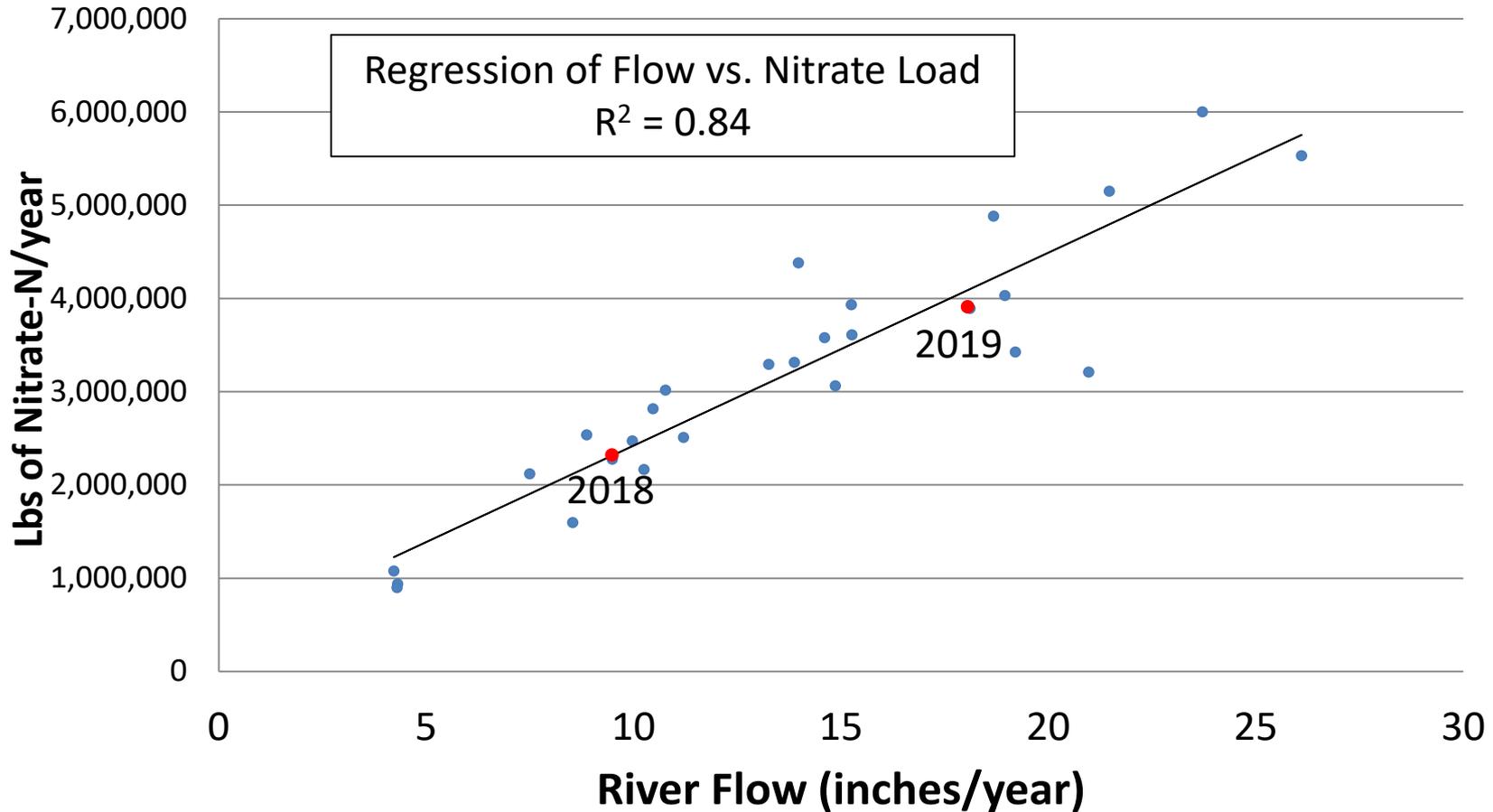
# Upper Embarras River Watershed (at Camargo IL)

Annual N load = 27 lbs/A/yr



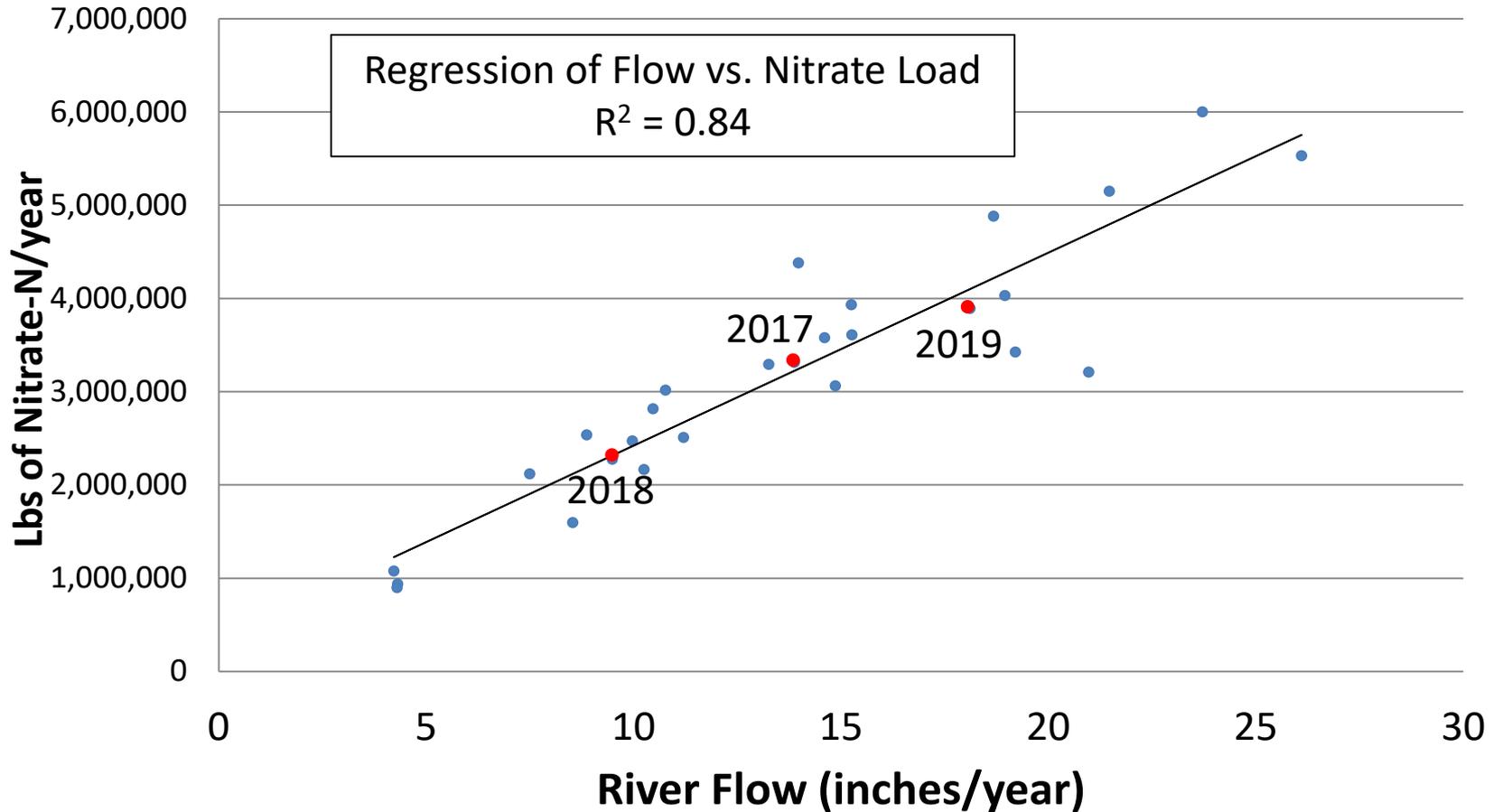
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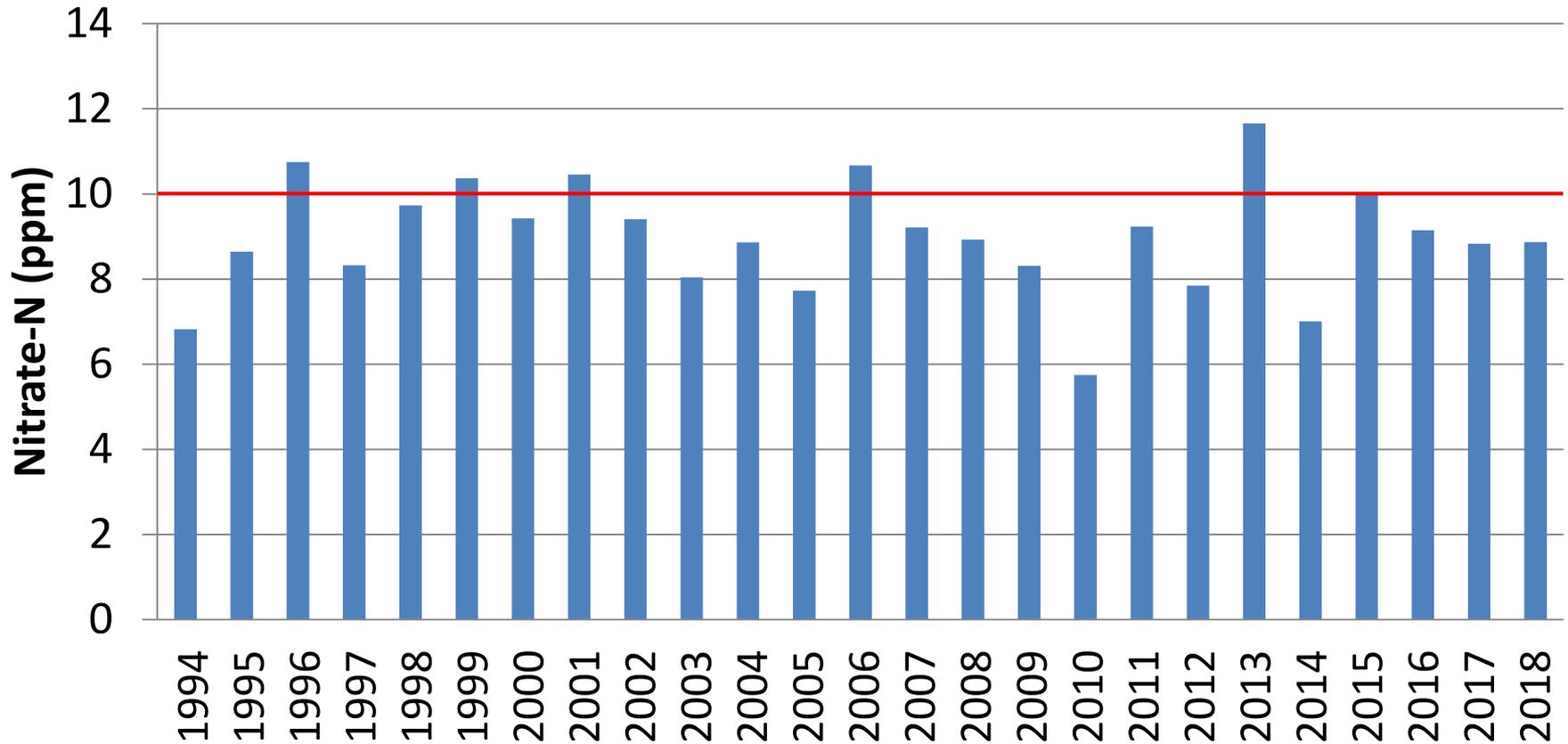
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# Flow-Weighted Mean of Nitrate Conc.

(Upper Embarras R. for past 25 years)

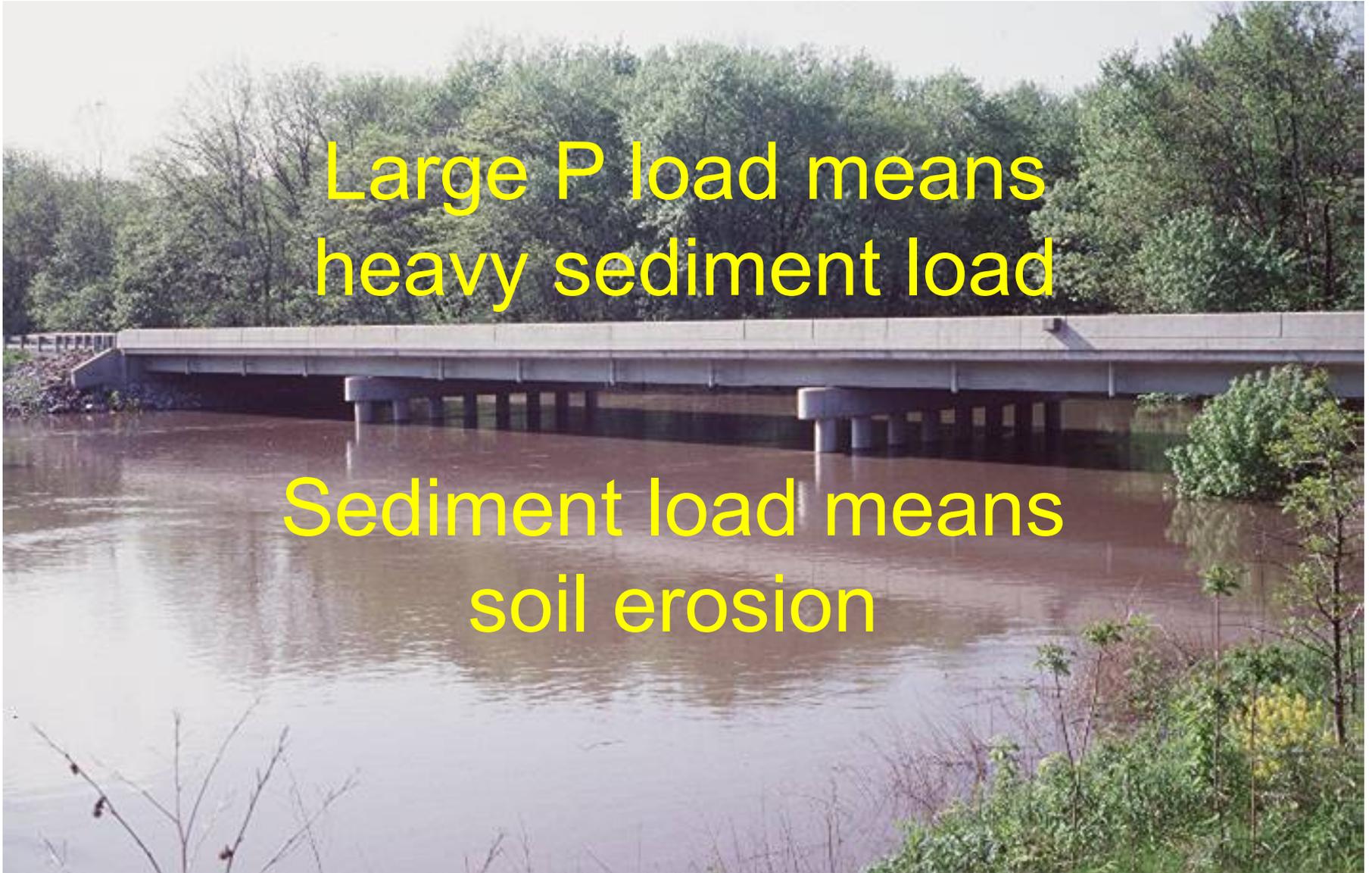
(Average FWM of nitrate = 9 ppm)



# Large River Flow (Camargo, IL)

Large P load means  
heavy sediment load

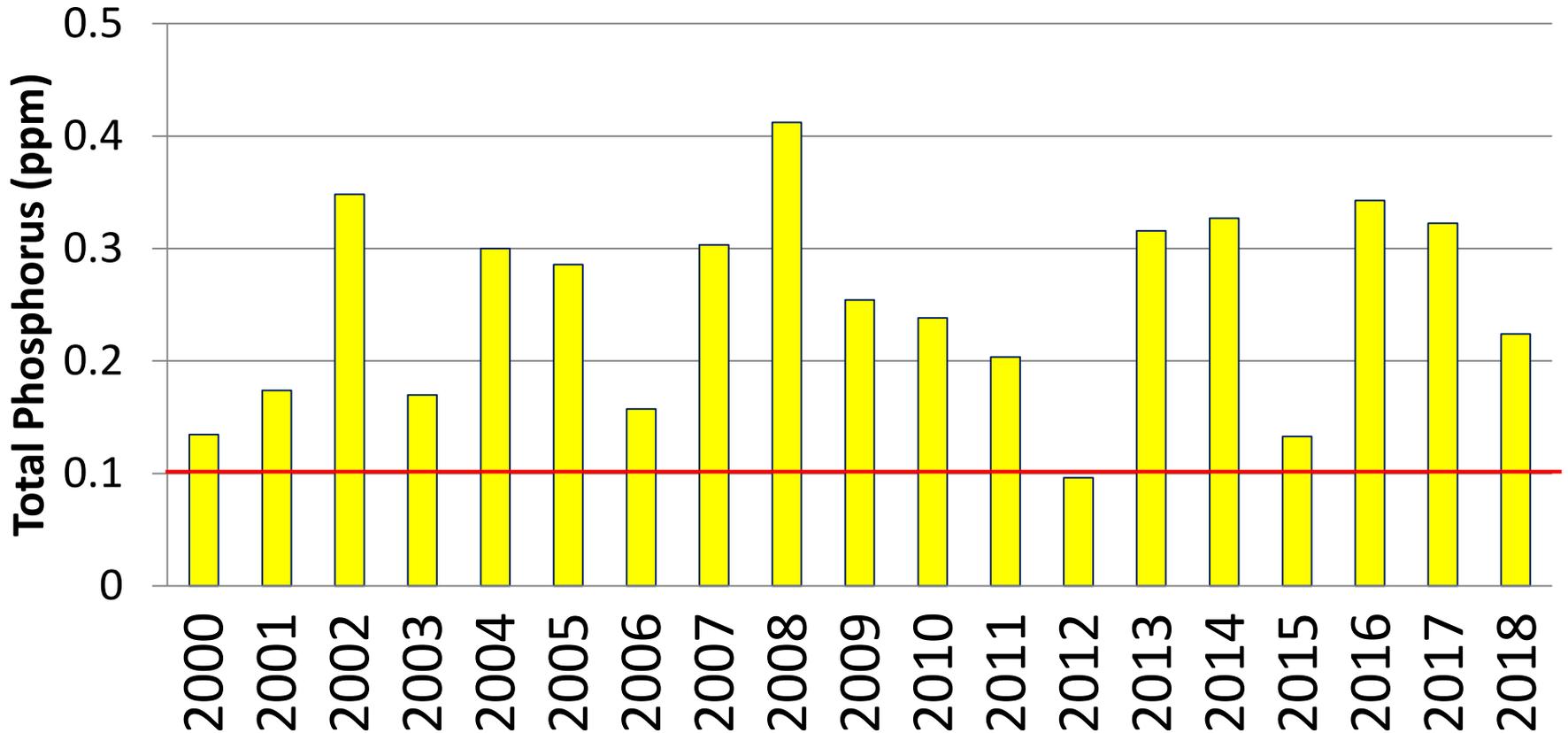
Sediment load means  
soil erosion



# Flow-Weighted Mean of TP Conc.

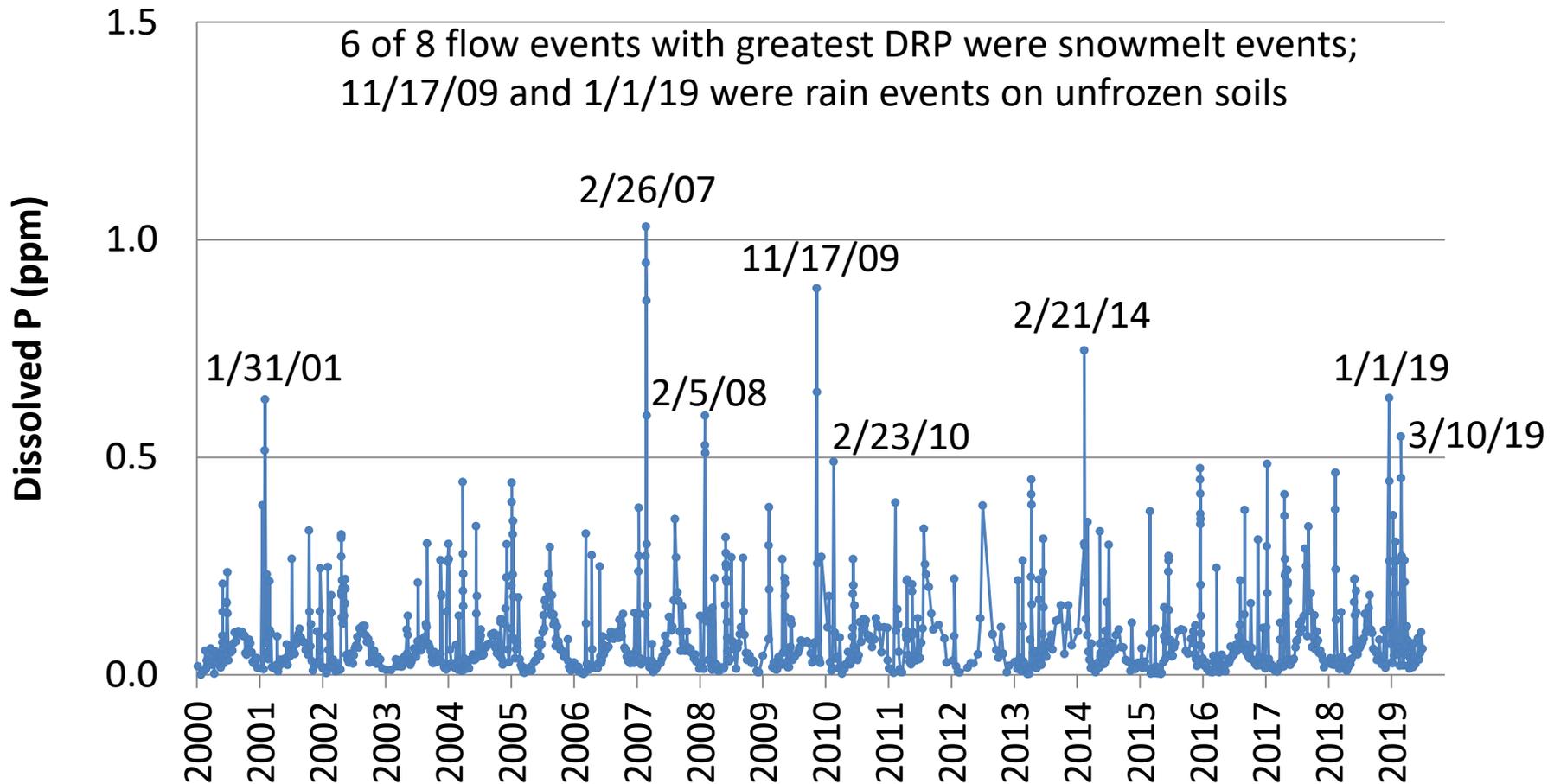
(Upper Embarras R. for past 19 years)

(Average FWM of Total Phosphorus = 0.25 ppm)

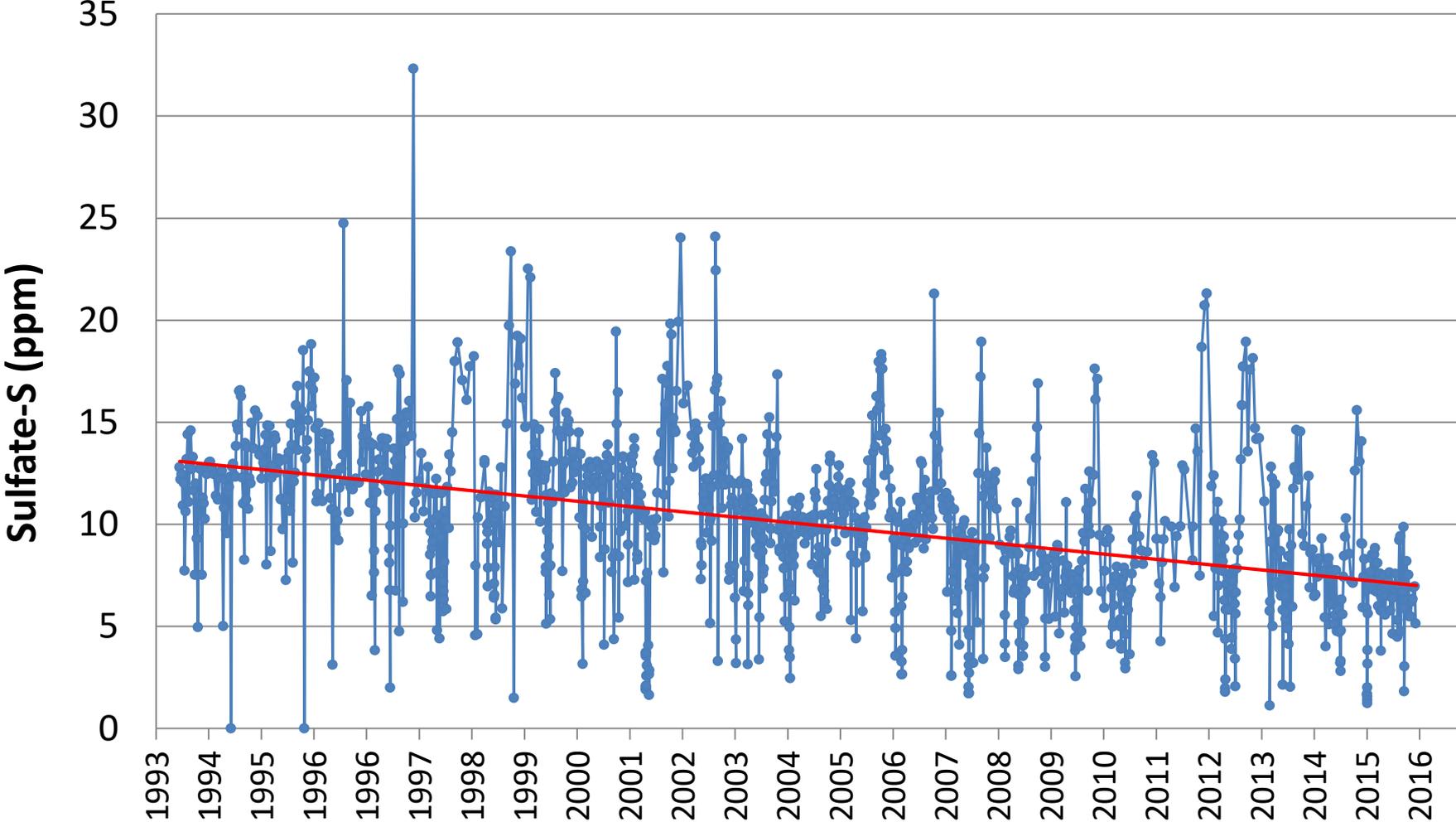


# Dissolved P Concentration (Camargo IL)

Average Total P Loss = 0.80 lb/A/yr



# River Sulfate Concentration (Camargo, IL)



# NREC Project

## Testing the IL NLRs

Longer Rotation with Cover Crops and Bioreactors



Corn



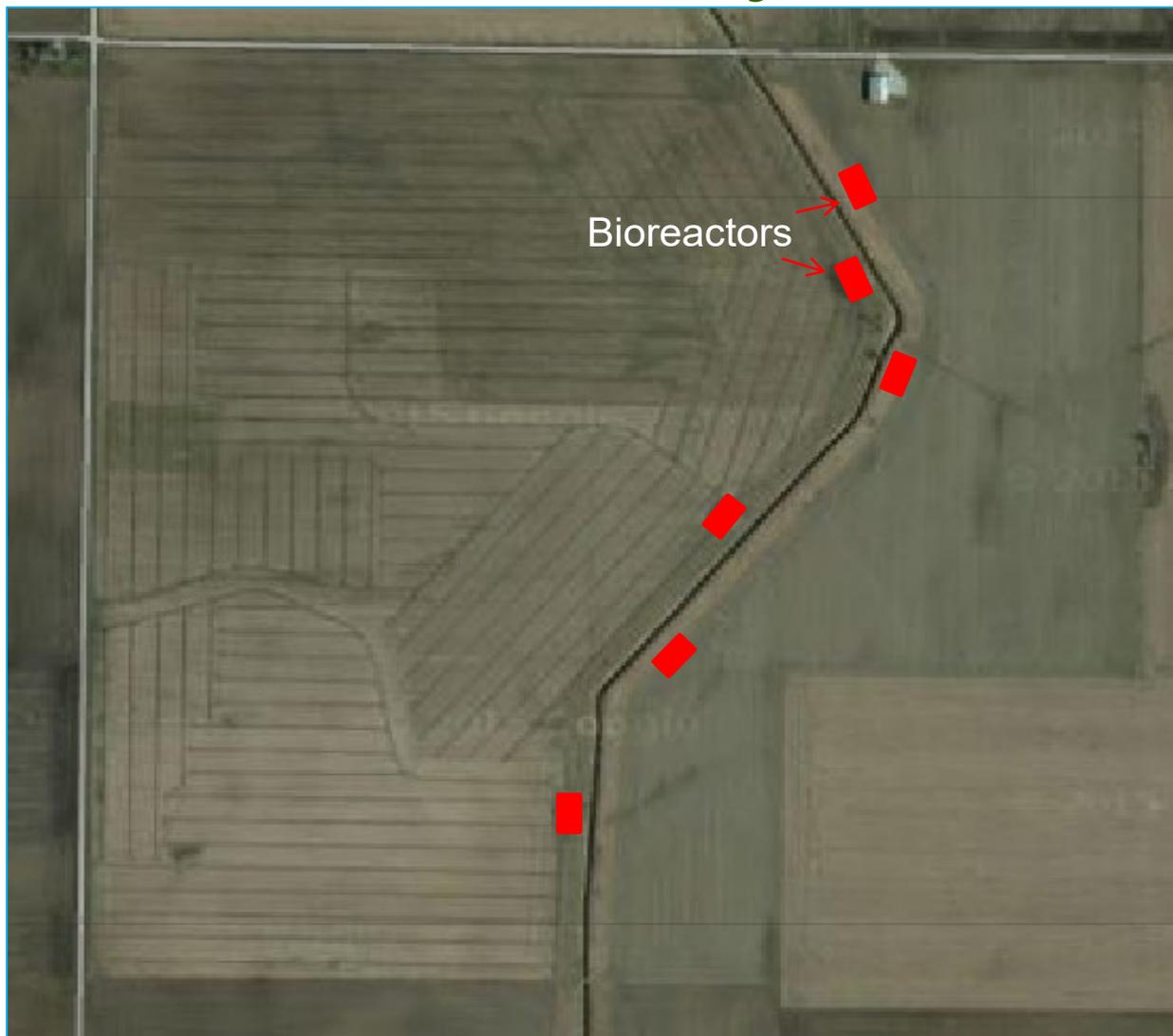
Soybean



Wheat

# Piatt County Farm

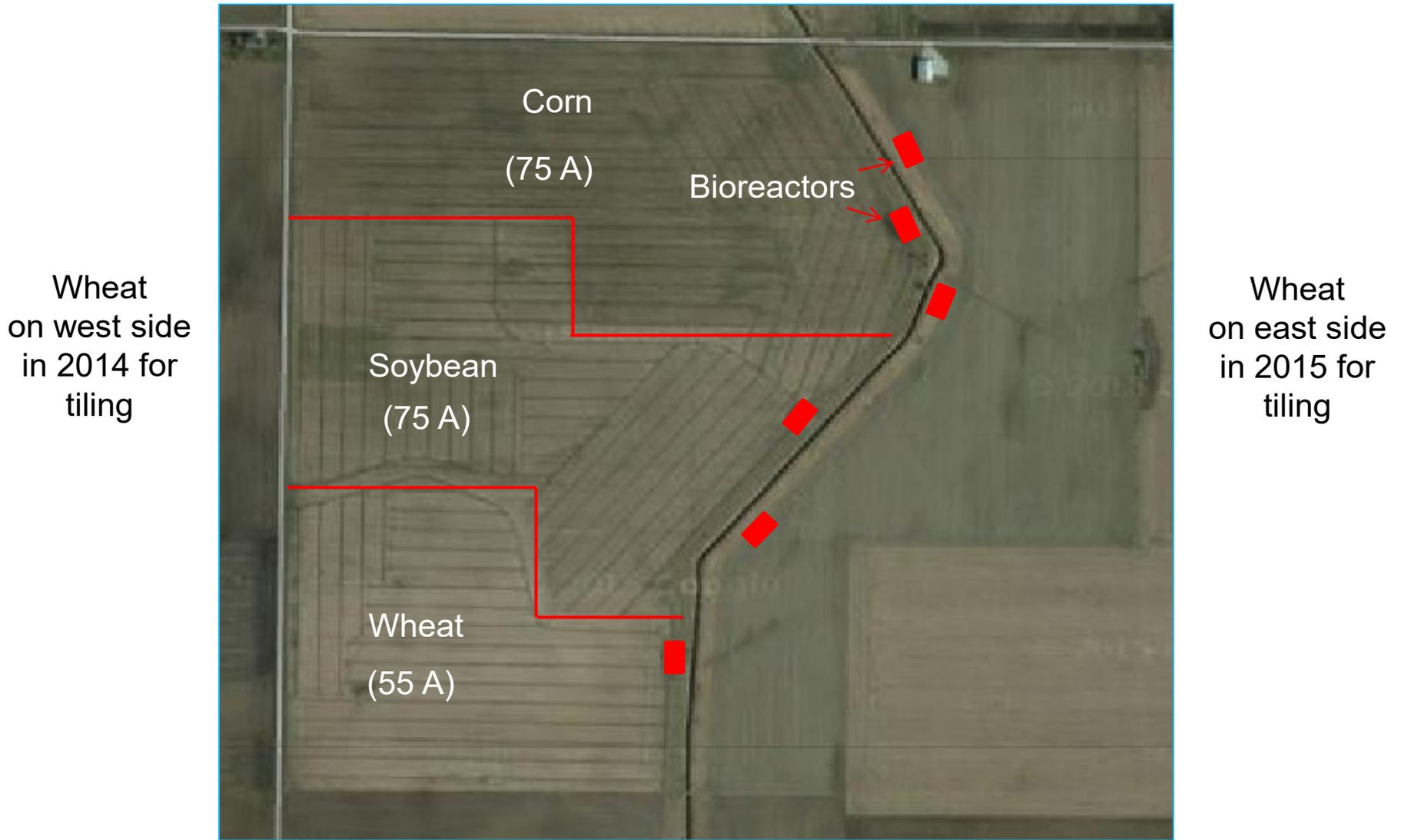
Wheat  
on west side  
in 2014 for  
tiling



Wheat  
on east side  
in 2015 for  
tiling



# C-S-W

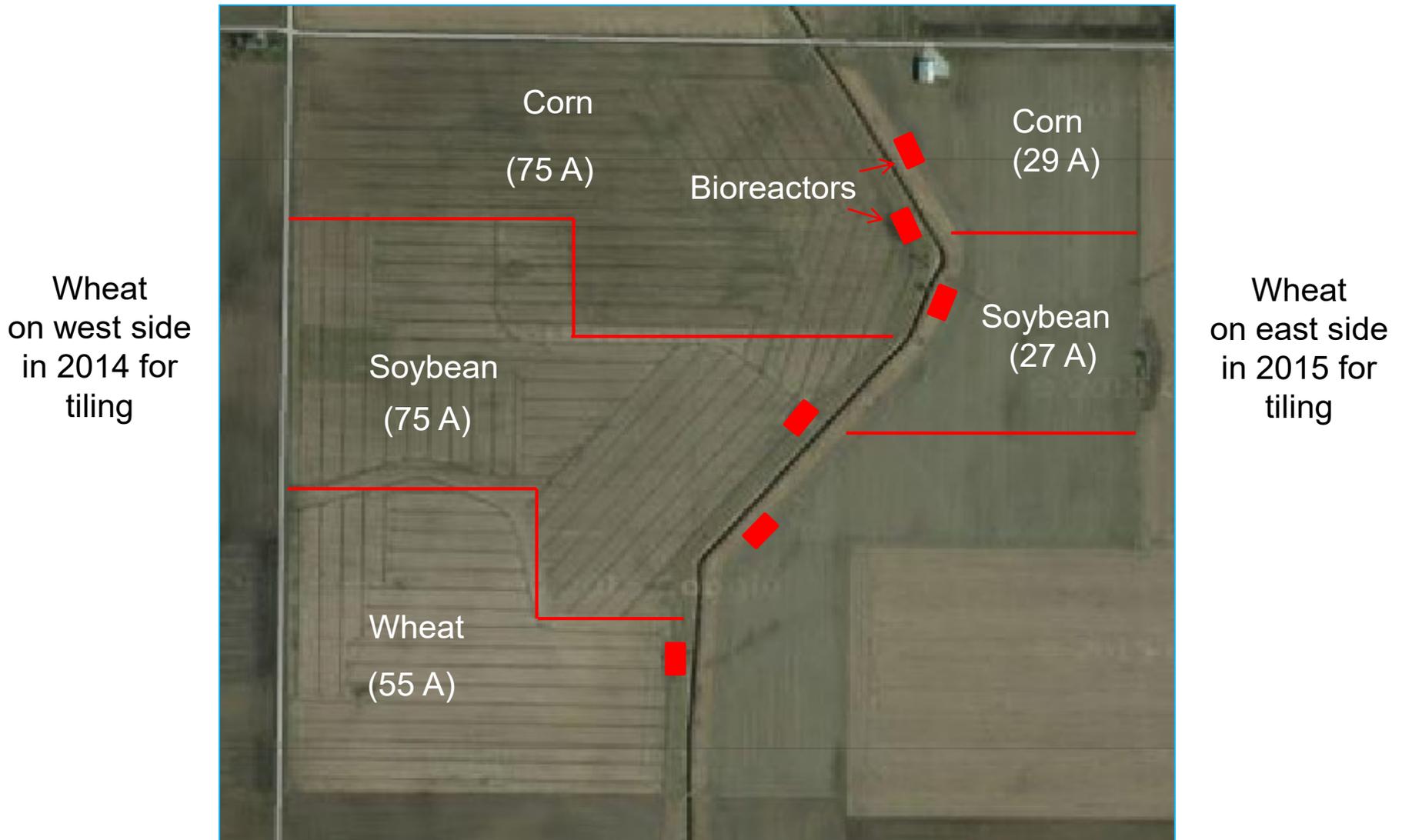


# Benefits of C-S-W Rotation

- Pest cycles broken
- More ground cover (decrease erosion)
- Wheat in rotation benefits corn and soybean yield
- Double-cropped soybean opportunity after wheat
- “Soybean N credit” to wheat



# C-S-W vs. C-S



# C-S-W Methods

- C-S-W with each phase of the rotation every year.
- Cereal rye after corn, winter wheat after soybean, and cover crop or double crop soybean after wheat.
- Strip-till corn, no-till soybean, and no-till wheat.
- Corn N = 20 lbs/A starter; 160 lbs/A as side-dress
- Wheat N = 24lbs/A as 1240D; 100 lbs/A as Super U with stabilizer.



# Eric Miller Strip-tilling

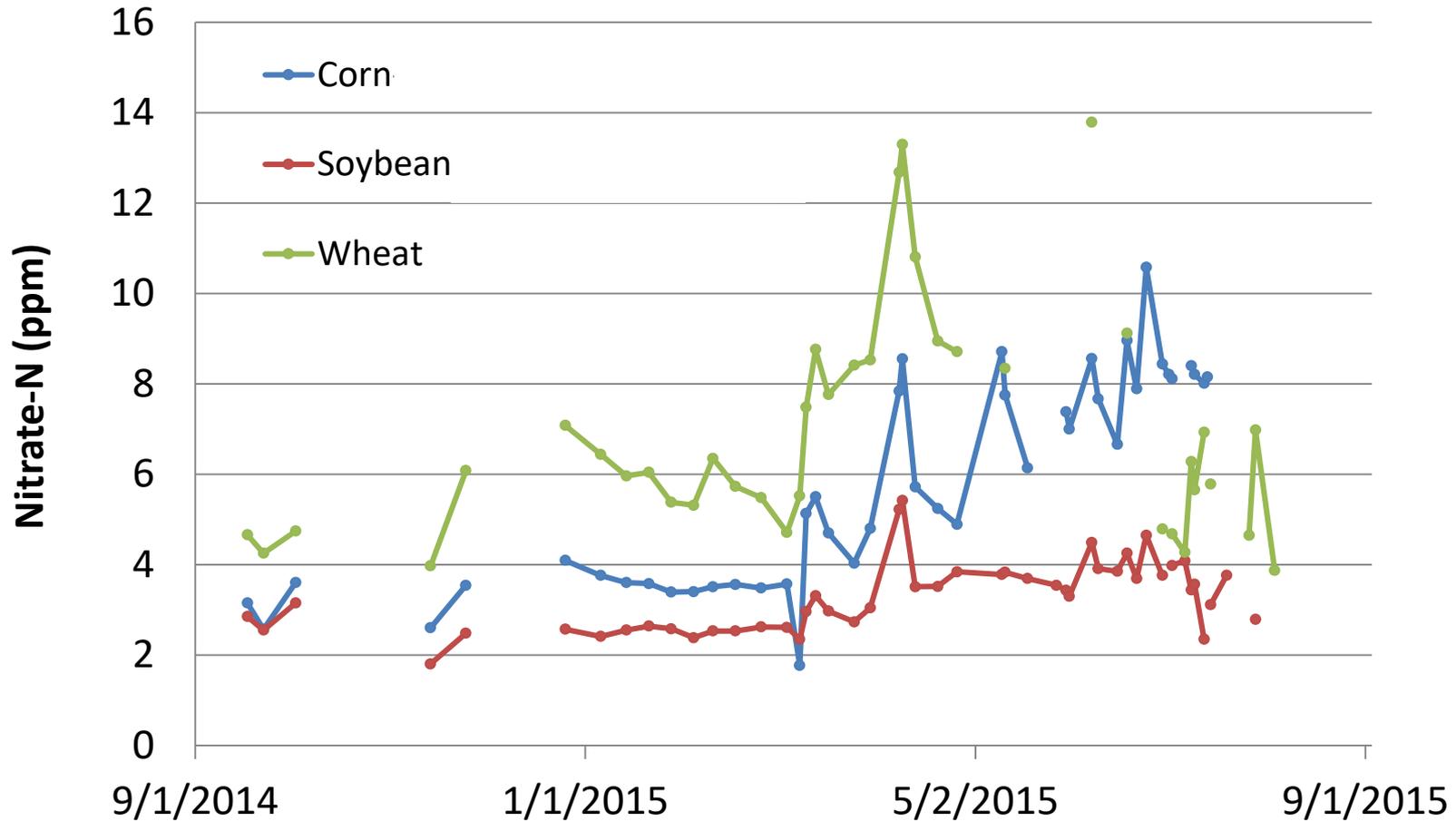


# C-S Methods

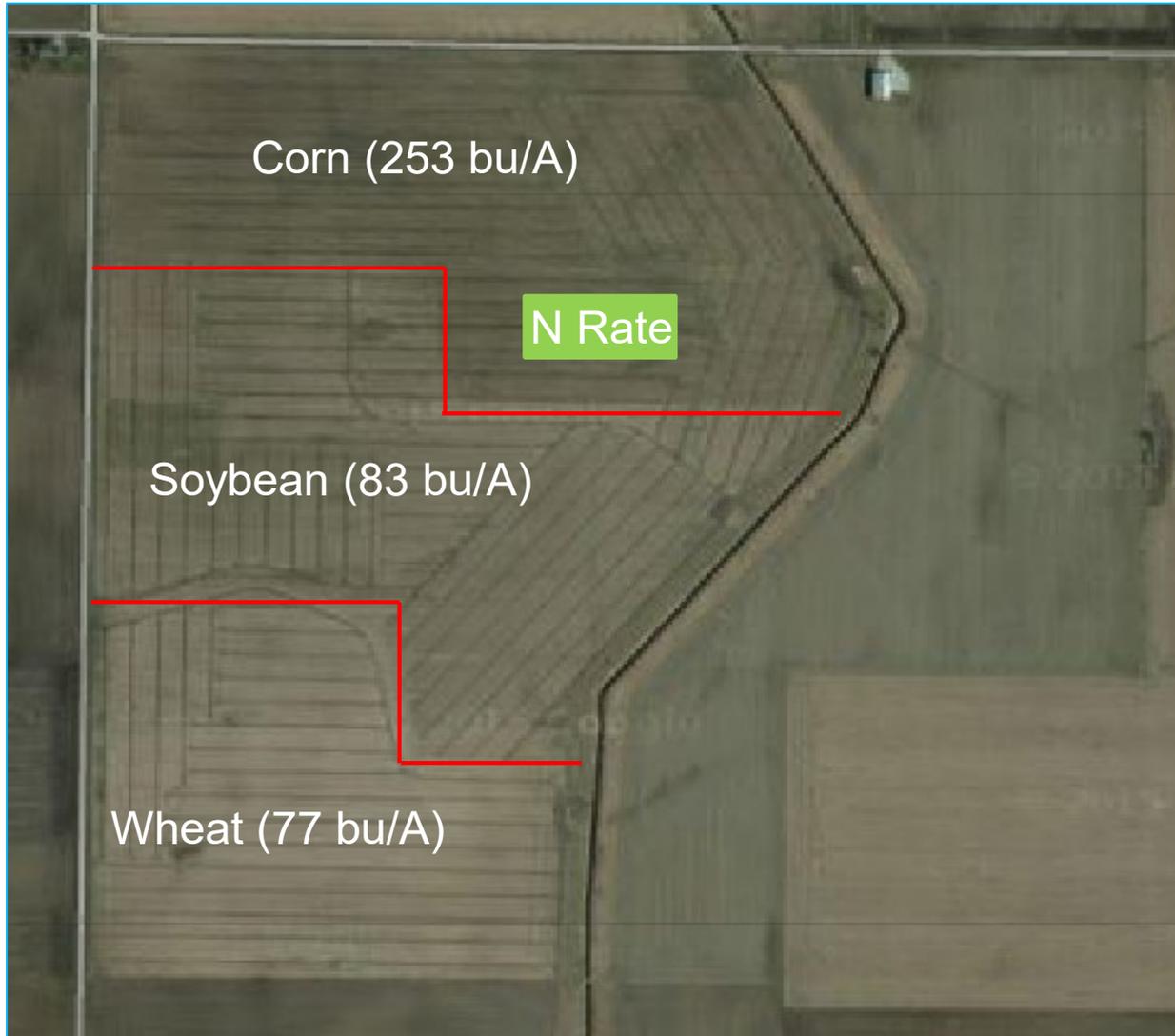
- C-S with both phase of the rotation every year.
- No cover crops
- Conventional tillage (fall and spring)
- Corn N = 180 lbs/A in the fall (if possible) or all spring preplant



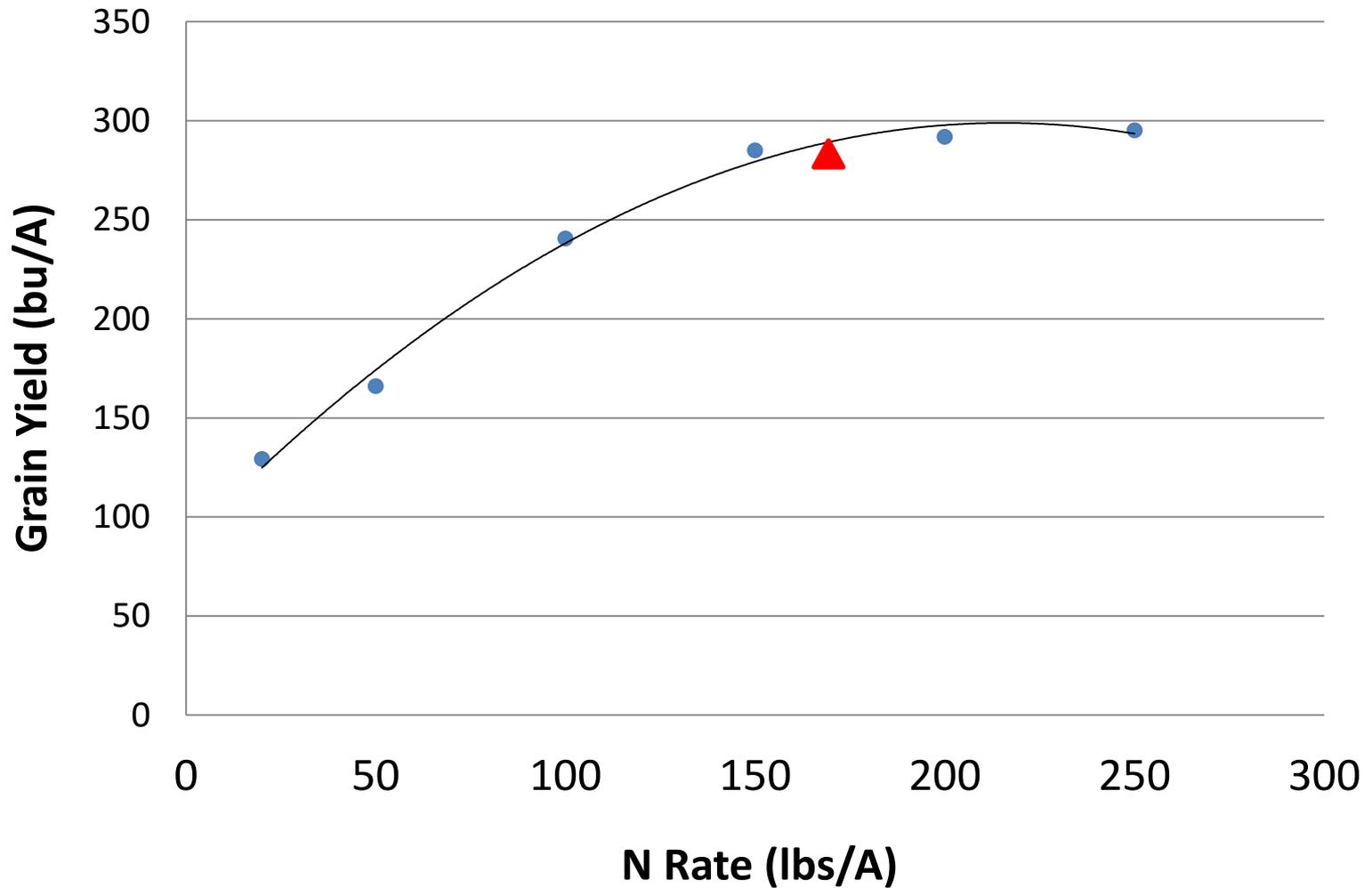
# Tile Nitrate in 2015



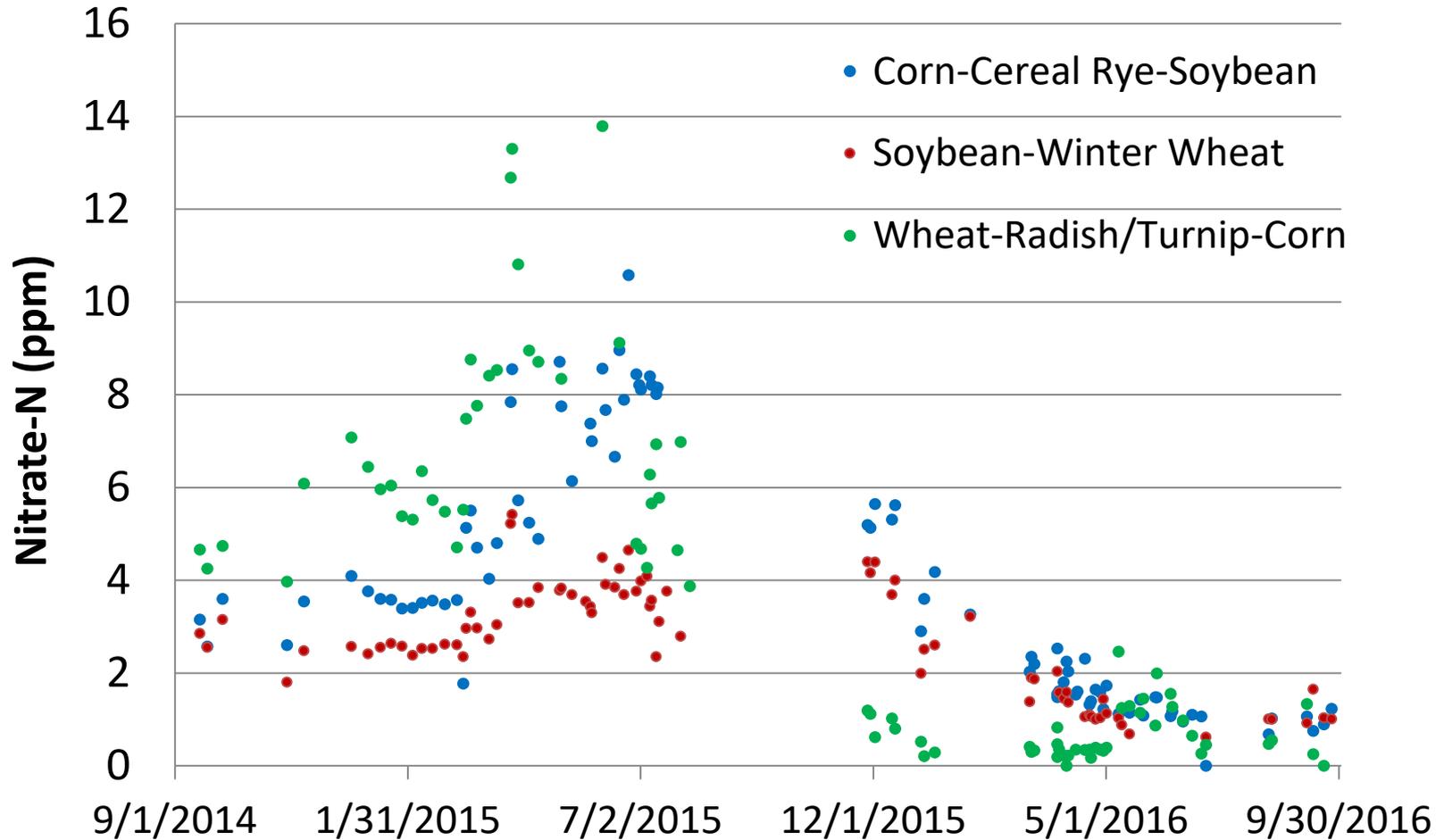
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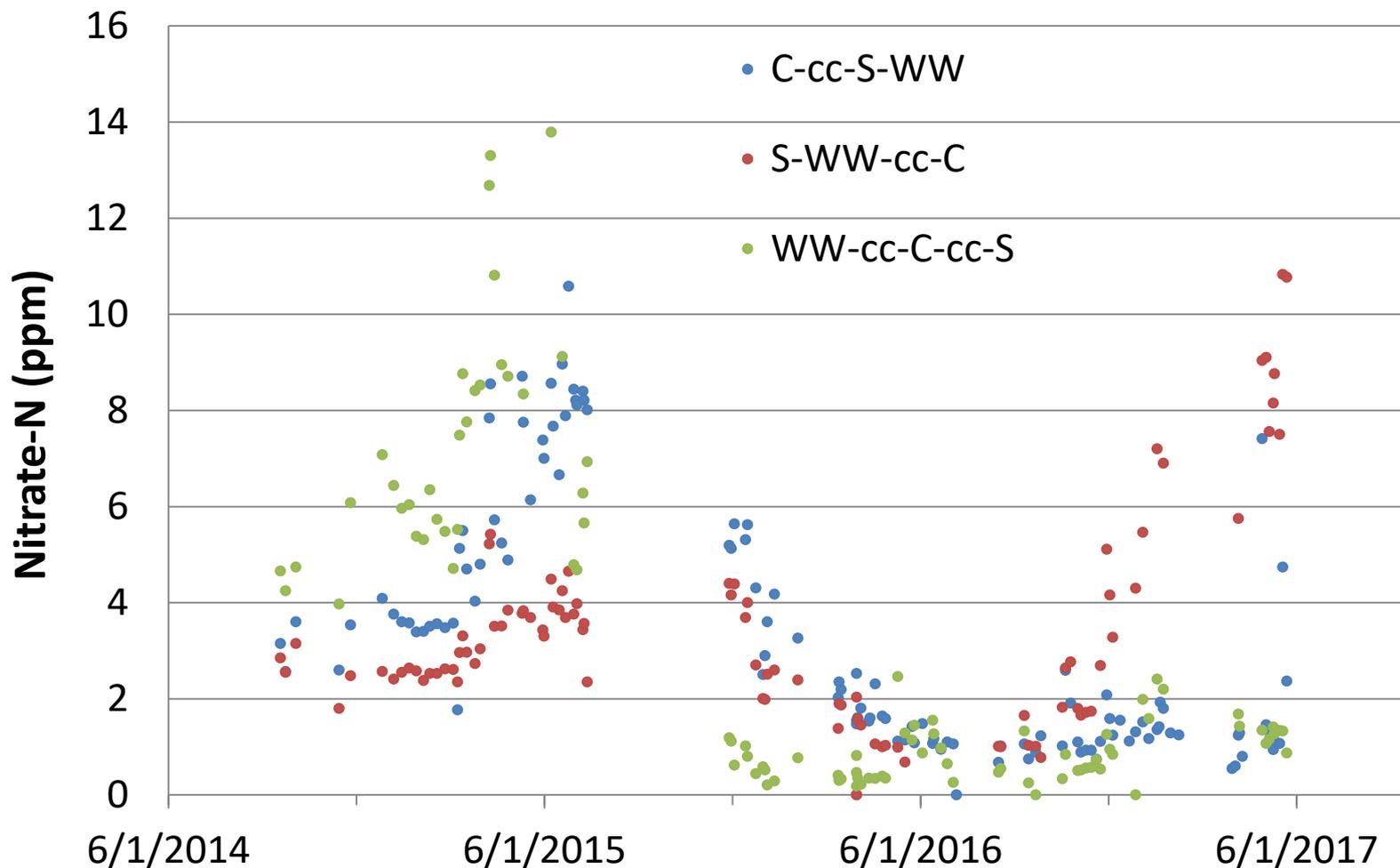
# 2015 Corn Grain Yield



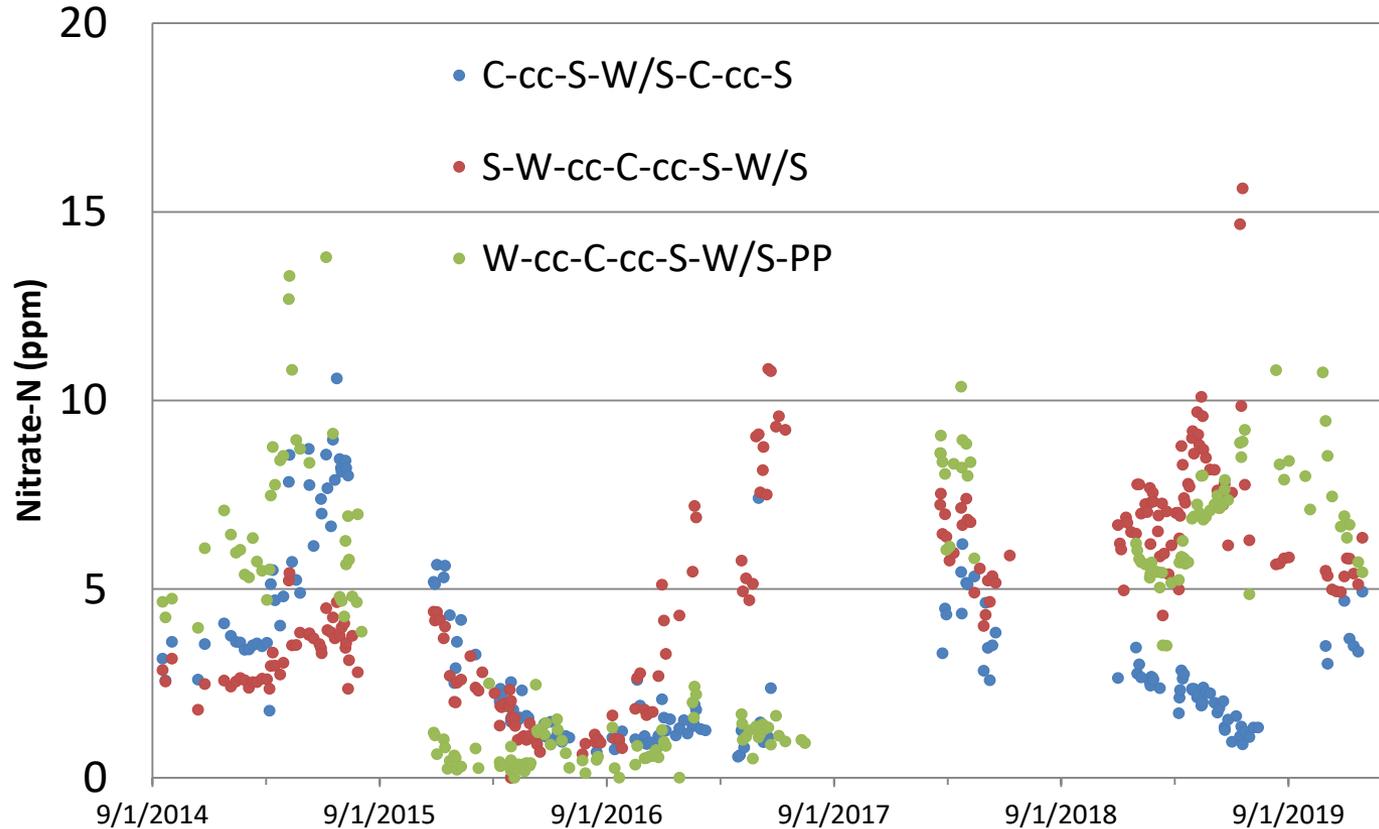
# Tile Nitrate 2015 and 2016



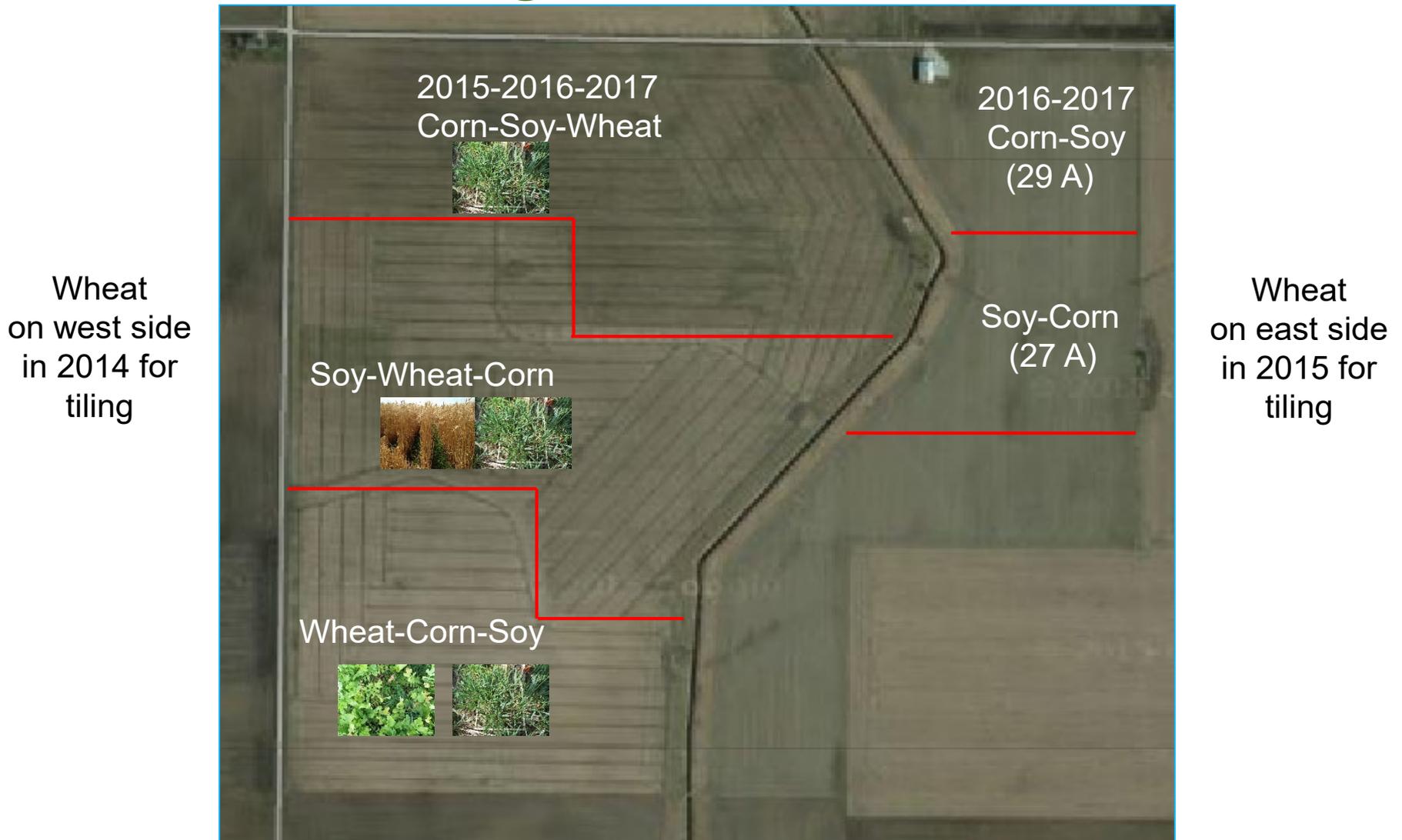
# Tile Nitrate 2015-2017



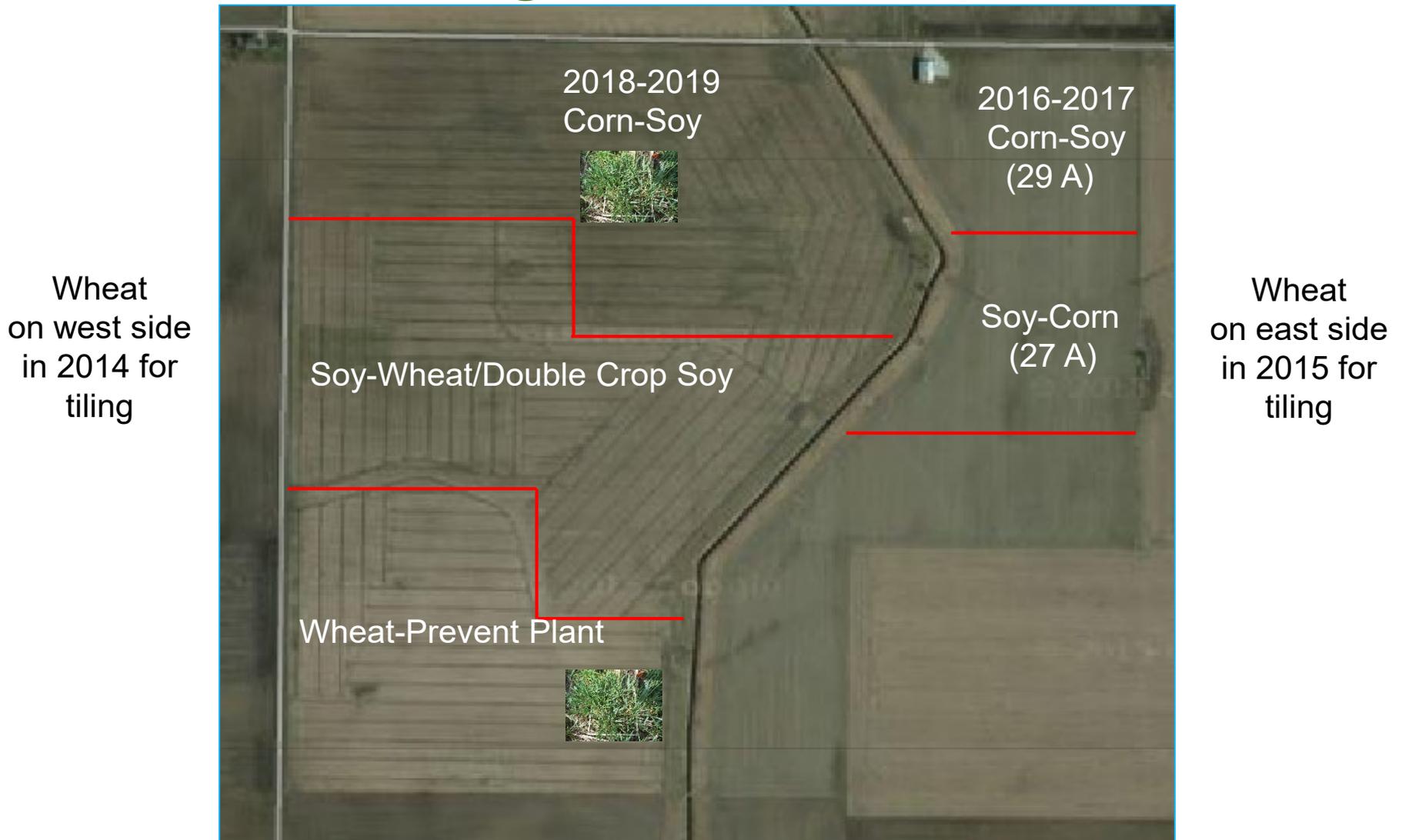
# Tile Nitrate 2015-2019



# Field Design and Crop Rotation



# Field Design and Crop Rotation



# Planting Soybean “Green”



Photo by Mary Auth



# Cereal Rye Residue



Photo by Greg McIsaac



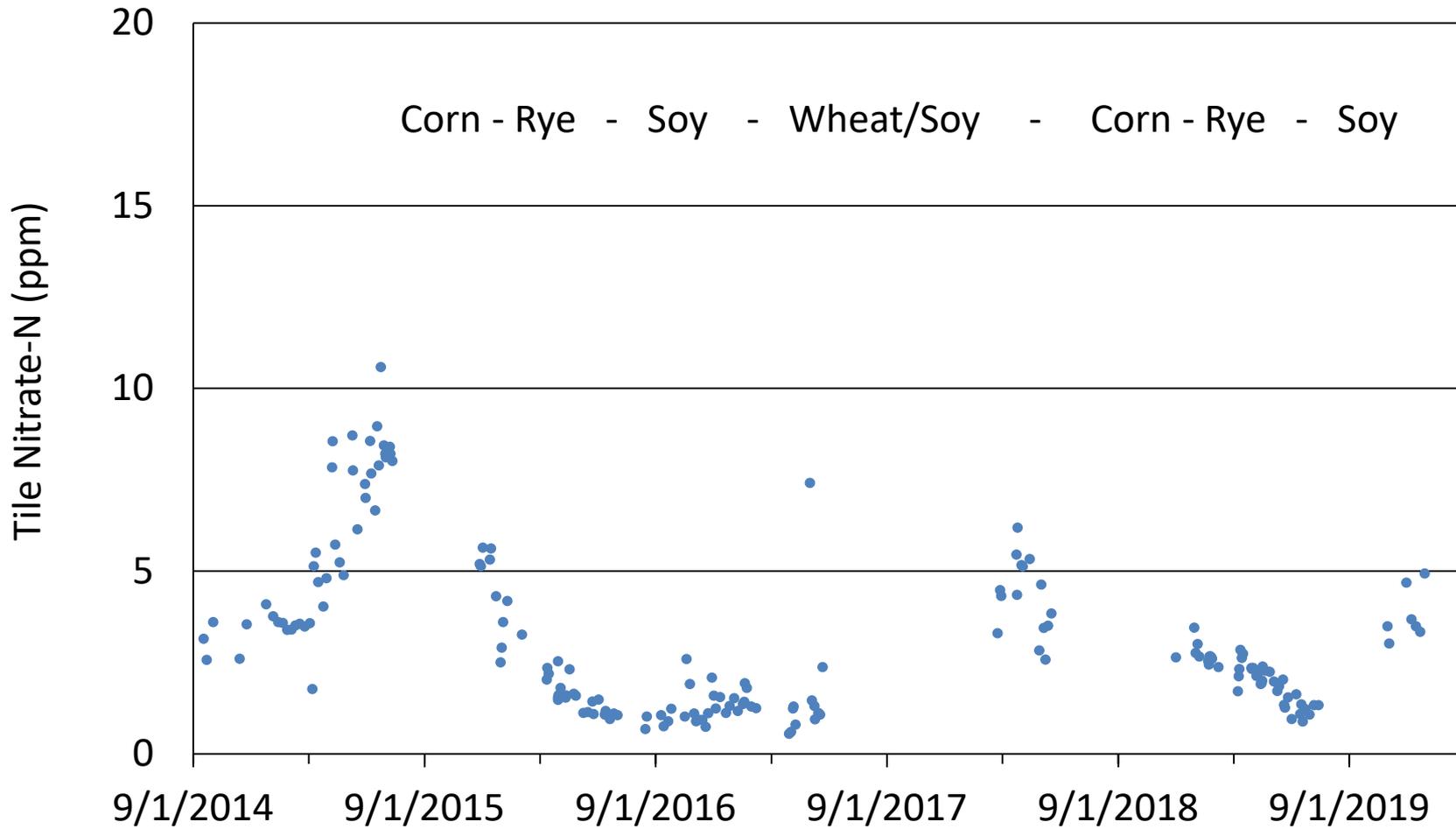
# Rolling cereal rye would be better!



Photo by Greg McIsaac



# Field W1 (C-S-W)

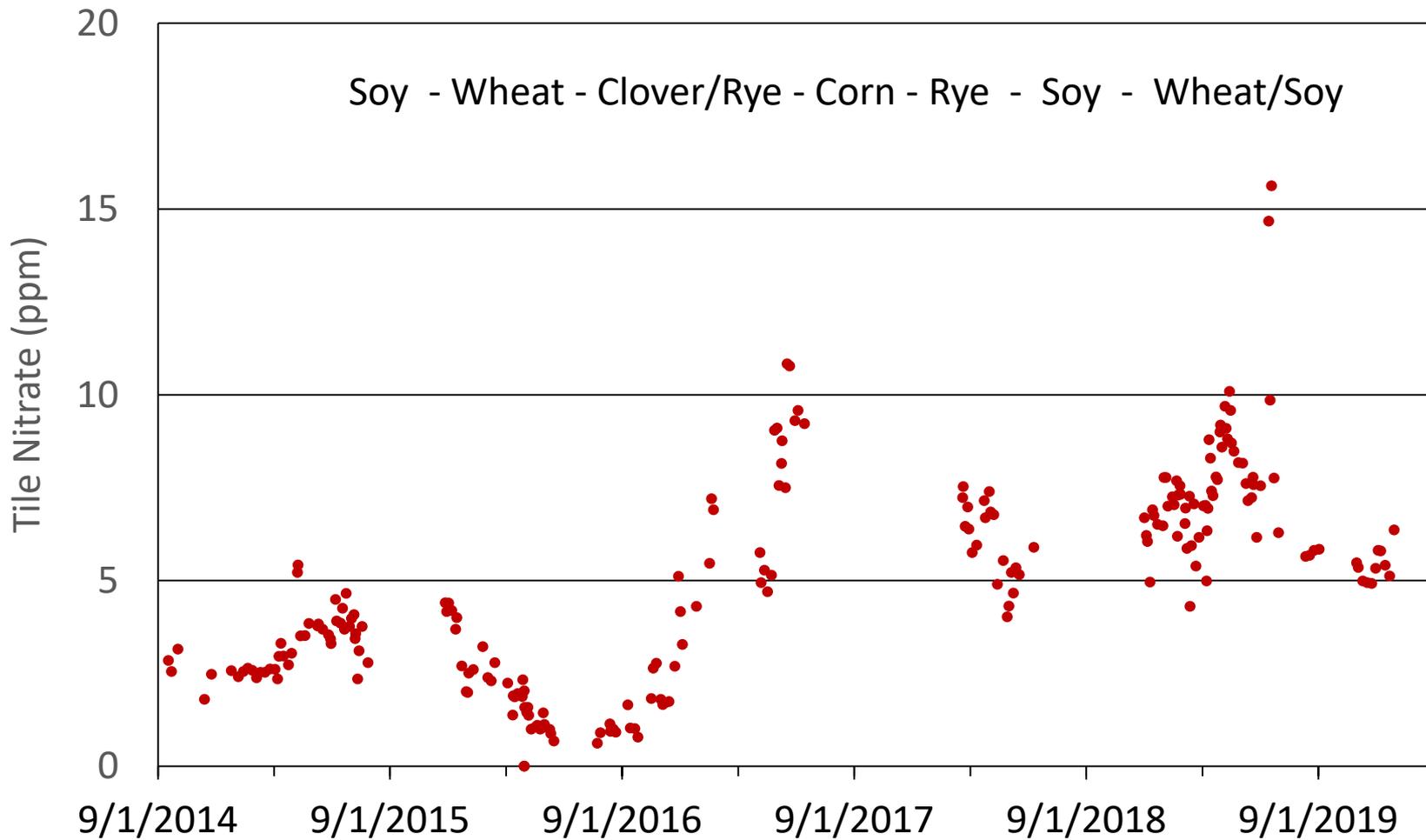


# Crop Yield and Tile Nitrate

	2015	2016	2017	2018	2019
Crop	Corn	Soy	Wheat/DC Soy	Corn	Soy
Yield (bu/A)	253	75	88/55	265	75
NO <sub>3</sub> -N FWM (PPM)	7.7	2.1	2.2	4.7	1.9



# Field W2 (C-S-W)



# Red clover seeded into wheat



Photo by Eric Miller



# Red clover biomass!



Photo by Eric Miller



Cover Crop (August)	Biomass	Biomass N
	Tons/A	lbs/A
Red Clover	2.10	135



# Cereal Rye after Red Clover



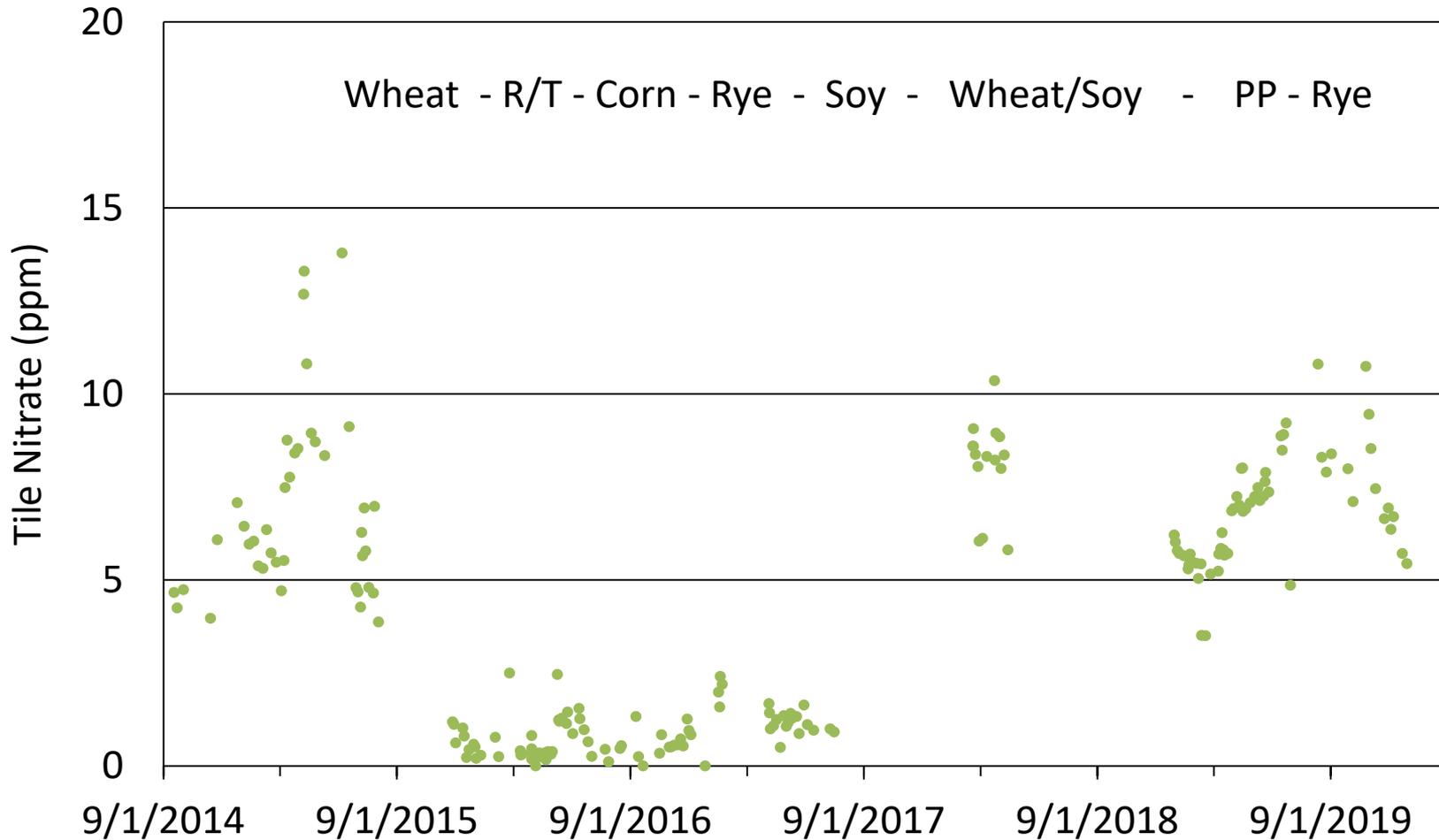
Cover Crop (Spring)	Biomass	Biomass N
	Tons/A	lbs/A
Cereal Rye	0.61	33



# Red clover (winter-killed!)



# Field W3 (C-S-W)



# Cover Crop Cocktail

Radish, turnip, and red clover (plus volunteer wheat)



Photo by John M. Green



# Radish and Turnip

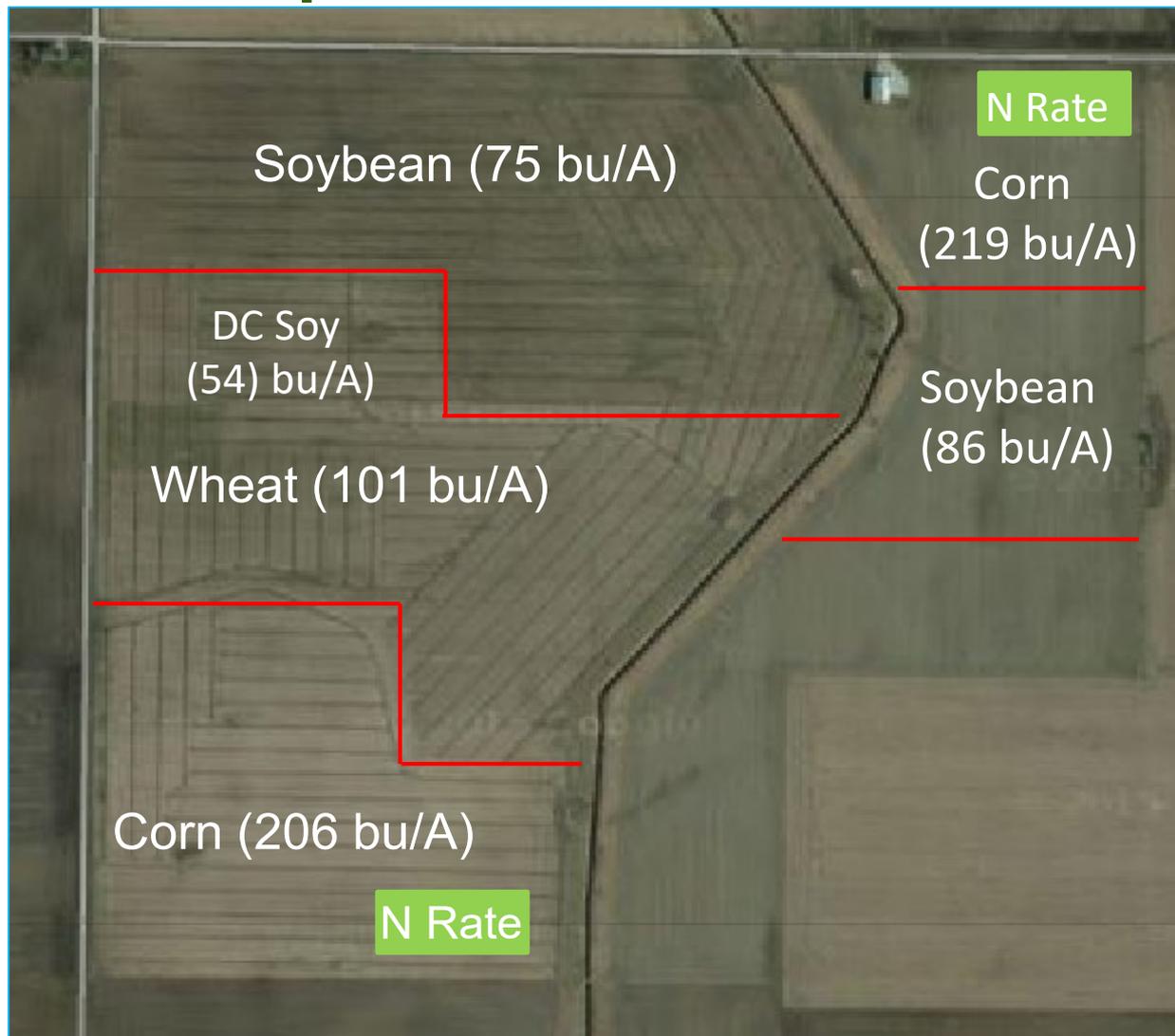
Sown in August and sampled in early November



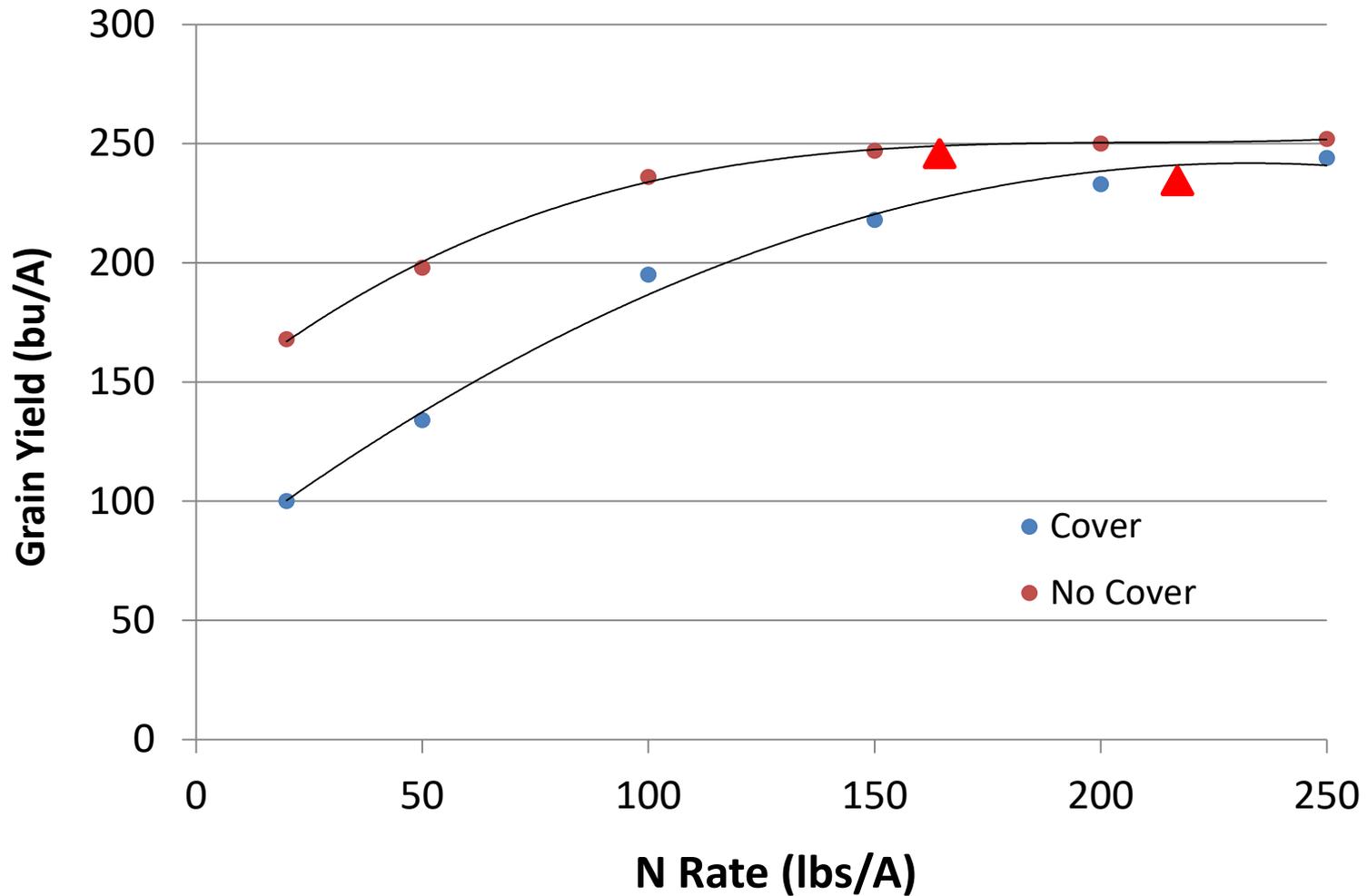
Photo by John M. Green

Cover Crop (Fall)	Biomass	Biomass N
	Tons/A	lbs/A
Radish	1.67	55
Turnip	0.73	20
Red Clover	0.26	15
Volunteer wheat	0.21	10
<b>Total</b>	<b>2.87</b>	<b>100</b>

# Crop Yields in 2016



# 2016 Corn Grain Yield



# What caused the problem?



- Huge cover crop biomass (↓ soil temps.)
- Poor quality biomass (↑ immobilization)
- Too much volunteer wheat (allelopathy)

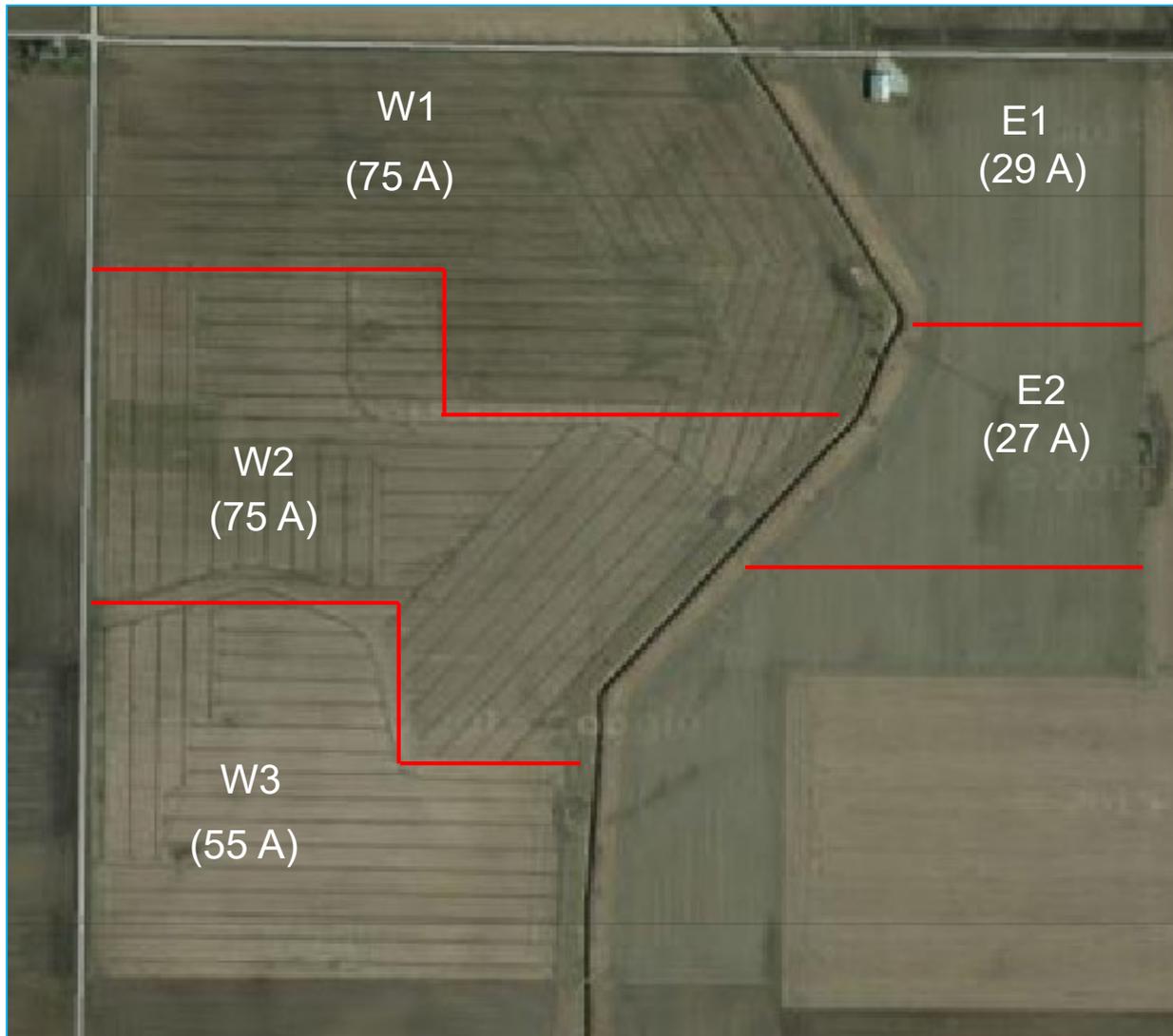
# Over-tightened the N cycle?



Apparently, it is possible to have too much of a good thing.

# Field Code

Wheat  
on west side  
in 2014 for  
tiling



Wheat  
on east side  
in 2015 for  
tiling



# Crop Yields and Tile Nitrate

<b>C-S-W</b>	<b>2015</b>	<b>Cover</b>	<b>2016</b>	<b>Cover</b>	<b>2017</b>	<b>Cover</b>	<b>2018</b>	<b>Cover</b>	<b>2019</b>
<b>W-1</b>	Corn	CR	Soy	-	Wheat/Soy	-	Corn	CR	Soy
<b>Yield</b>	253		75		98/55		265		75
<b>Tile N</b>	7.7		2.2		2.2		4.7		1.9
<b>W-2</b>	Soy	-	Wheat	RC/CR	Corn	CR	Soy	-	Wheat/Soy
<b>Yield</b>	83		101		259		97		102/??
<b>Tile N</b>	3.8		2.3		7.5		6.7		8.2
<b>W-3</b>	Wheat	R/T	Corn	CR	Soy	-	Wheat/Soy	-	Prevent
<b>Yield</b>	77		206		80		88/52		-
<b>Tile N</b>	7.3		0.8		1.2		8.7		7.0
<b>C-S</b>									
<b>E-1</b>			Corn	-	Soy	-	Corn	-	Soy
<b>Yield</b>			219		79		271		83
<b>Tile N</b>			7.2		5.0		9.4		7.8
<b>E-2</b>			Soy	-	Corn	-	Soy		Corn
<b>Yield</b>			86		242		86		221
<b>Tile N</b>			7.0		7.3		5.8		12.1



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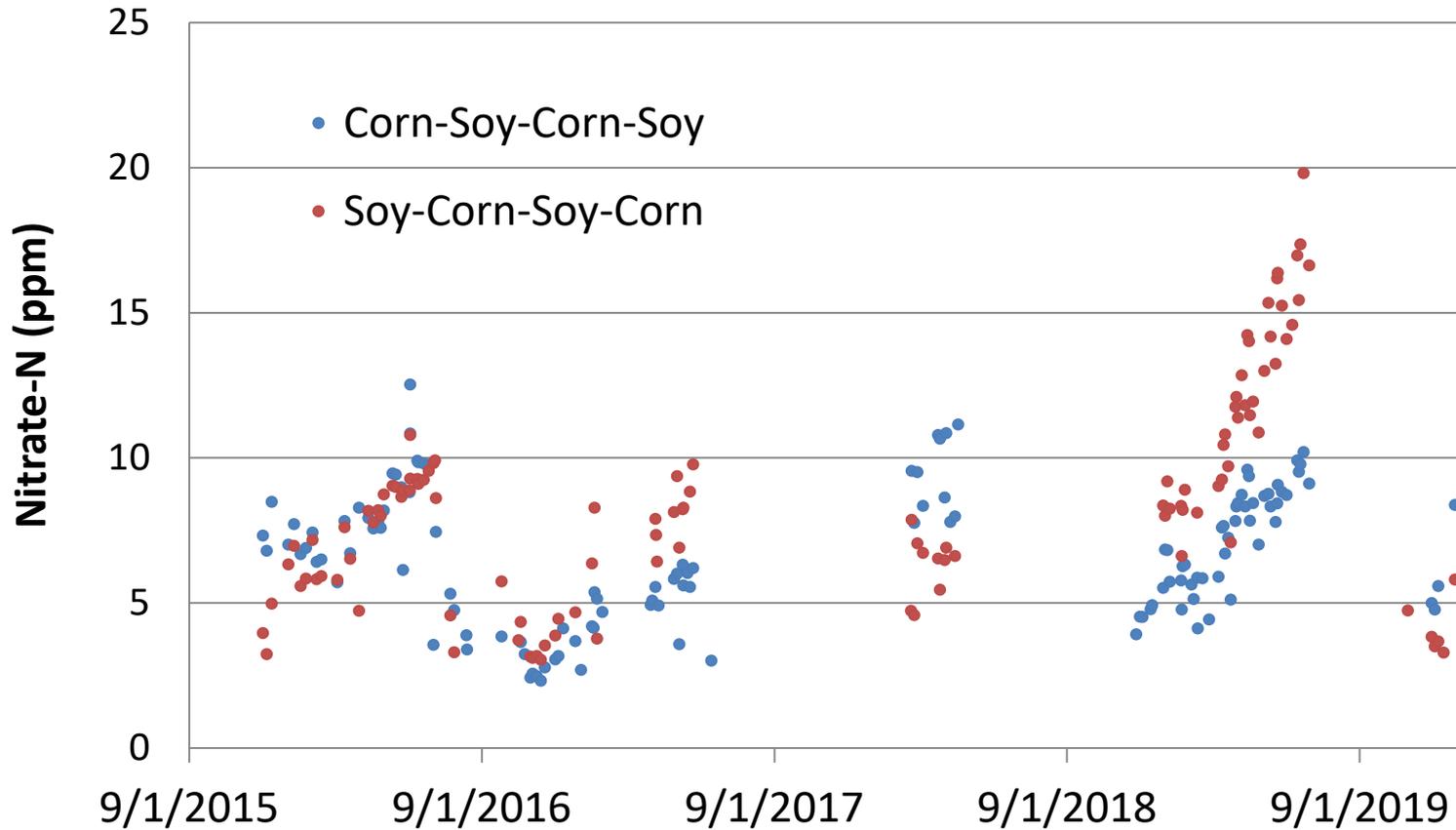


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# Tile Nitrate from C-S



# Longer rotation (C-S-W) tightens N cycle; greatly reducing tile nitrate



Wheat takes up mineralized N following soybean production.

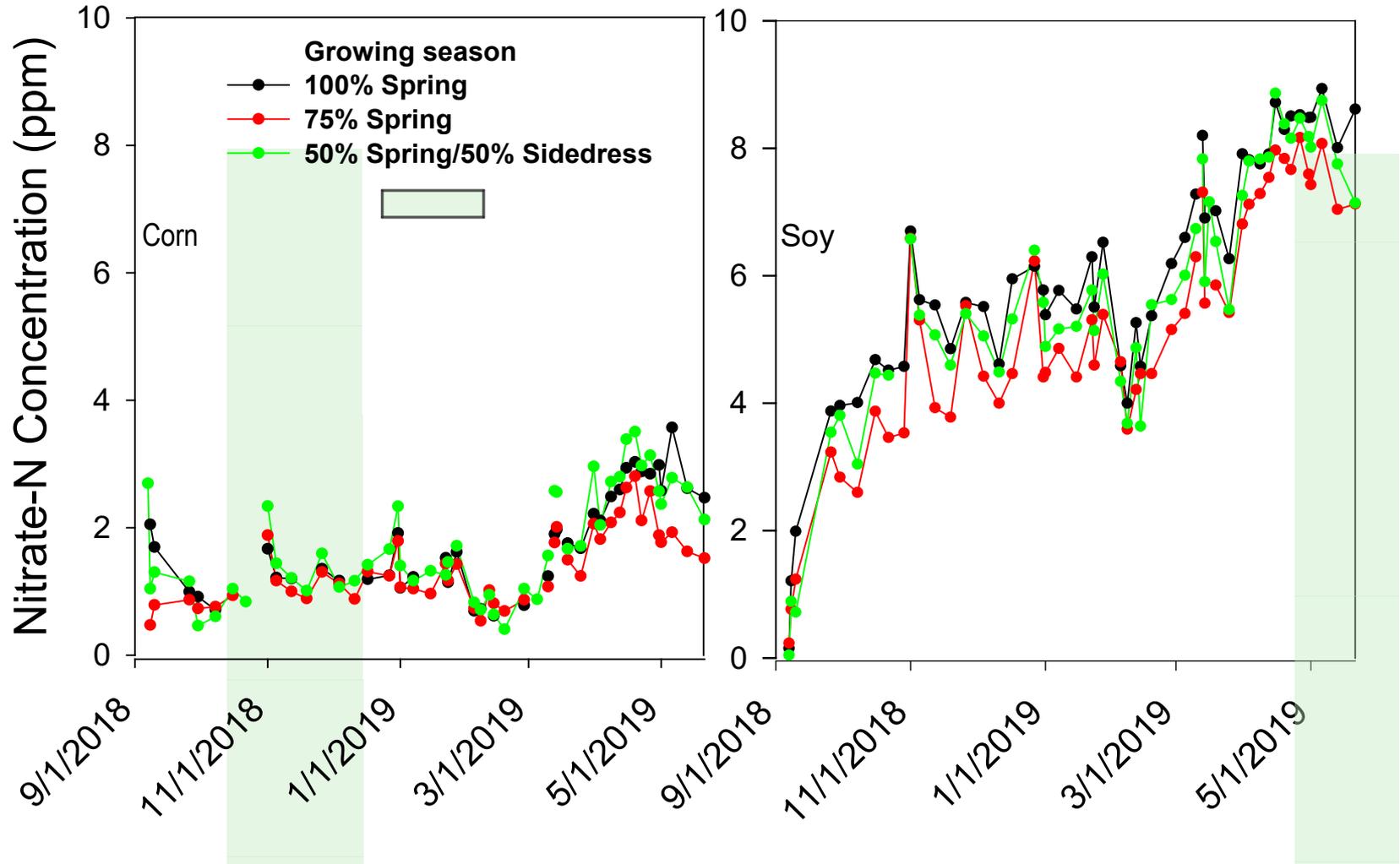
Soil system may be C-limited following soybean production.

Cover crops inserted into C-S-W

- Radish and turnip nearly eliminate tile nitrate (<1 ppm for 4 months)
- Cereal rye after corn reduces concentration below 2 ppm (again)

# Tile Nitrate Concentration

(Effect of previous crop)



# Immobilization Following Corn

(Lean corn crop of 2018 produced wide C:N ratio of  $70 > 1$ )



# Net Mineralization Following Soybean

( Formerly referred to as the “Soybean N Credit”)



# Summary

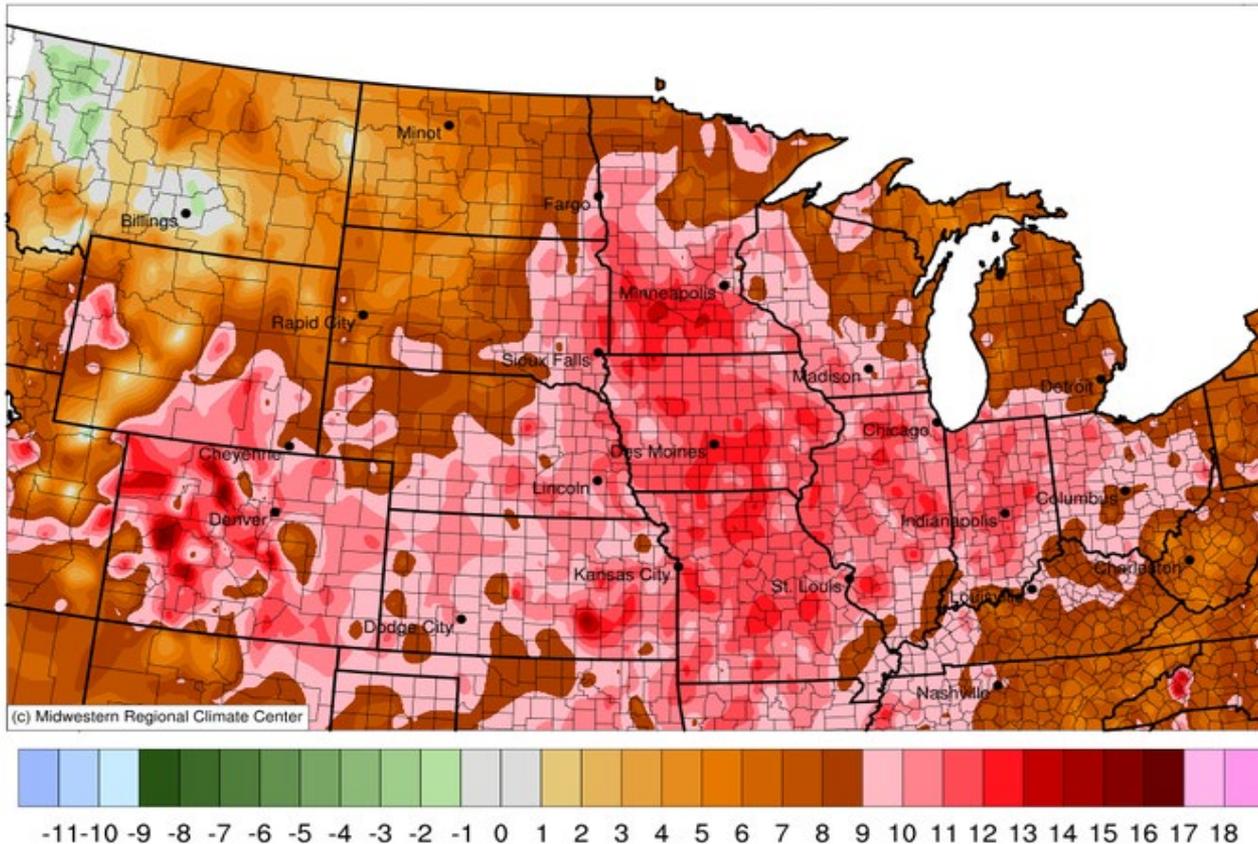
- High C:N ratio of corn residue promotes N immobilization
- Quantity and quality of residue influences net N mineralization
- Mineralization following soybean adds to tile nitrate load
- Need to tie up mineralized N during non-crop growing season
- Adding winter wheat may be best strategy
- Adding cover crops to C-S-W (even better!)



# Warm winters are draining our ecological capital from the prairie.

Average Temperature (°F): Departure from 1981-2010 Normals

February 01, 2017 to February 24, 2017



Warm winters enhanced mineralization before the row crop growing season.

Winter wheat will capture mineralized N after soybean taking advantage of the rotation effect.

In-field strategies best as we should treat the cause, not the symptom.

# Increasing frequency of extreme rainfall events and warm winters

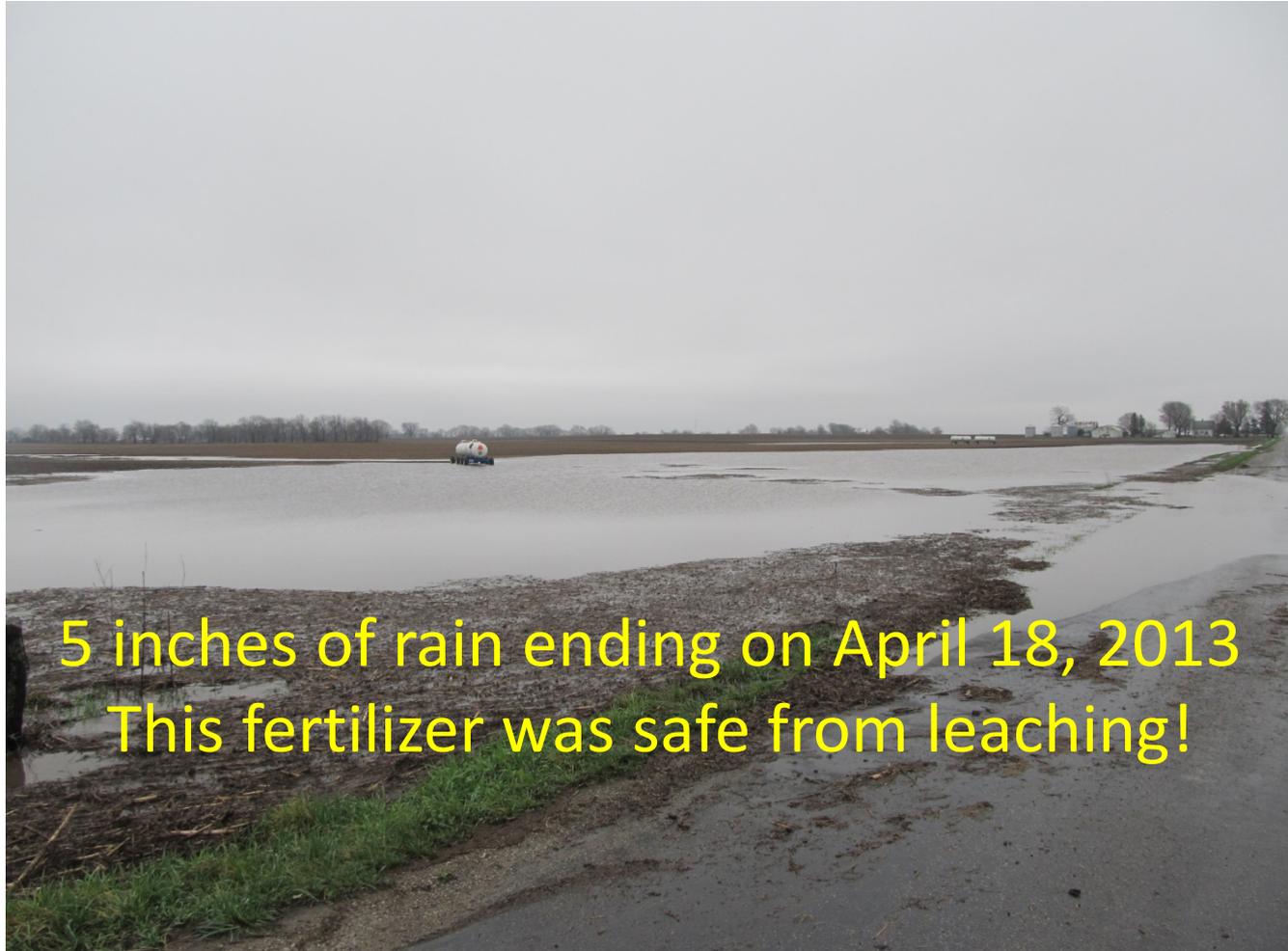


Photo by Mark B. David



# Thank you



Support:

Nutrient Research and Education Council

Foundation for Food and Agriculture Research

# Proposed Remedy for N in Drain Tiles

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Quote from an article in *Science* by H.P. Armsby in 1884.

