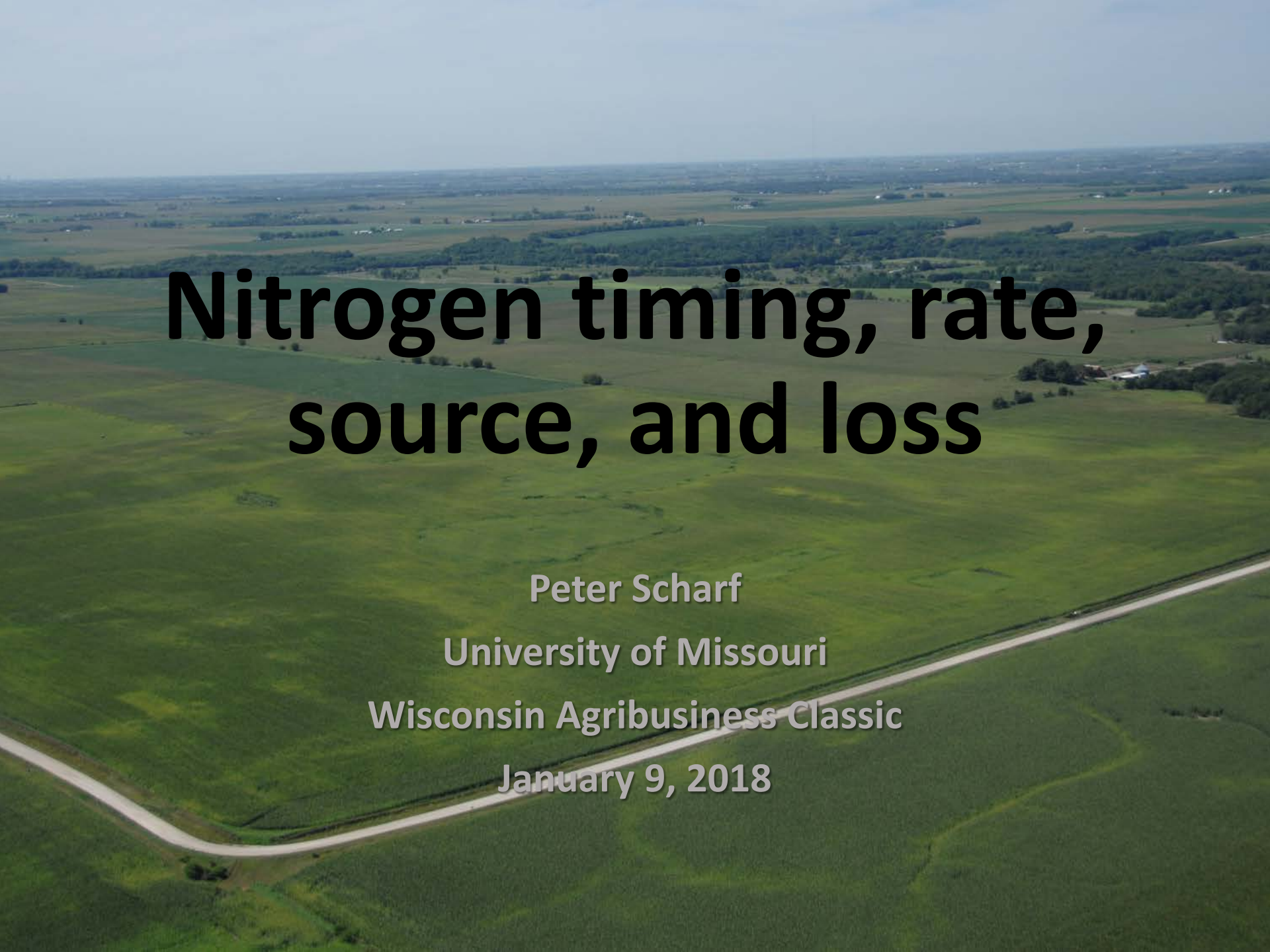


Nitrogen timing, rate, source, and loss

Peter Scharf

University of Missouri

Wisconsin Agribusiness Classic

January 9, 2018

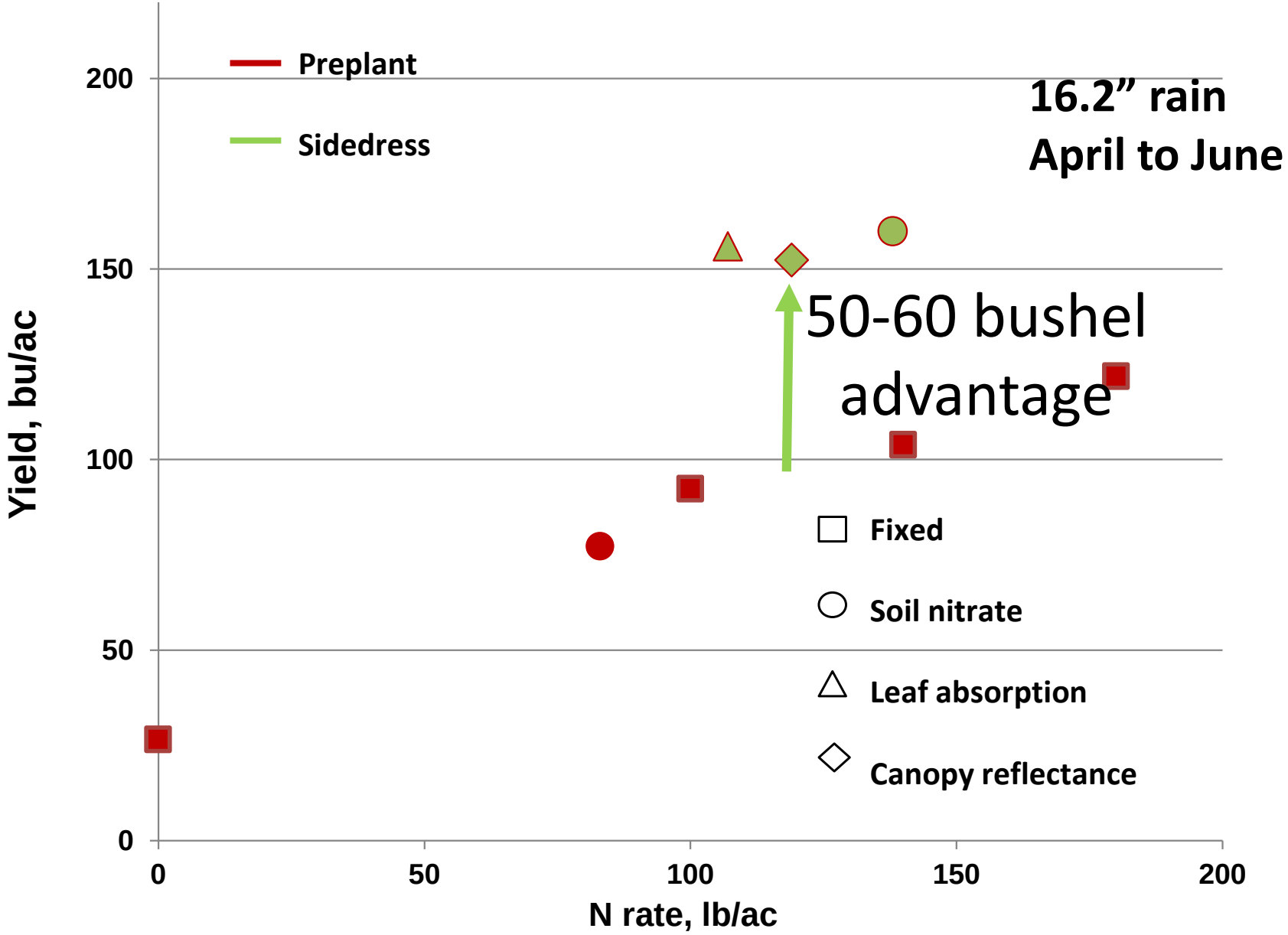
Why does N timing matter?

1. **Potential for N loss** in wet weather if applied too far before crop uptake (June & July for corn)
2. Potential for yield loss due to N stress before main N application
   - My data says this isn't much of a problem

replanted

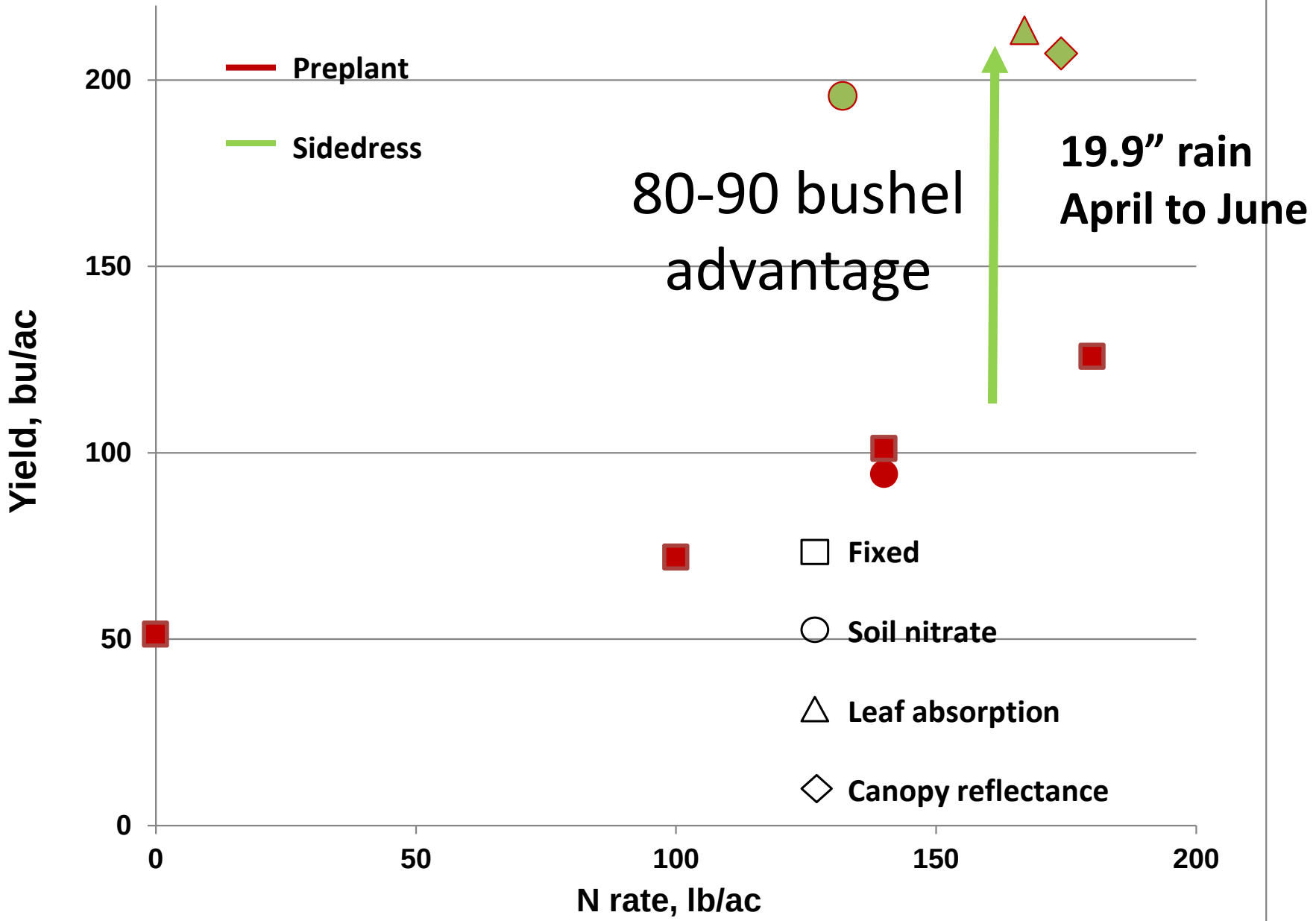
2017 corn yield:

Effect of N timing and rate system



2013 corn yield:

Effect of N timing and rate system

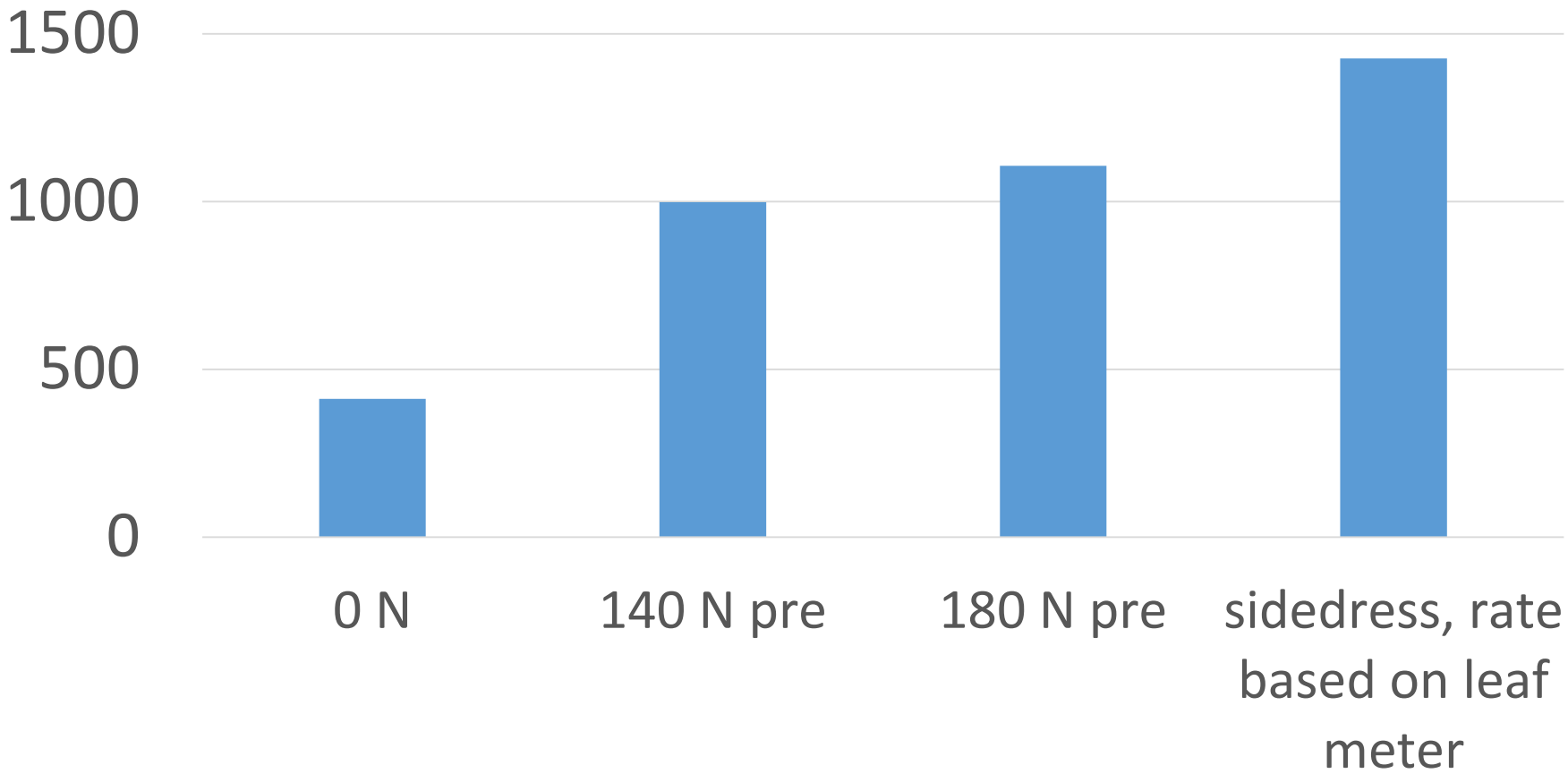


Long-term cumulative corn yield:

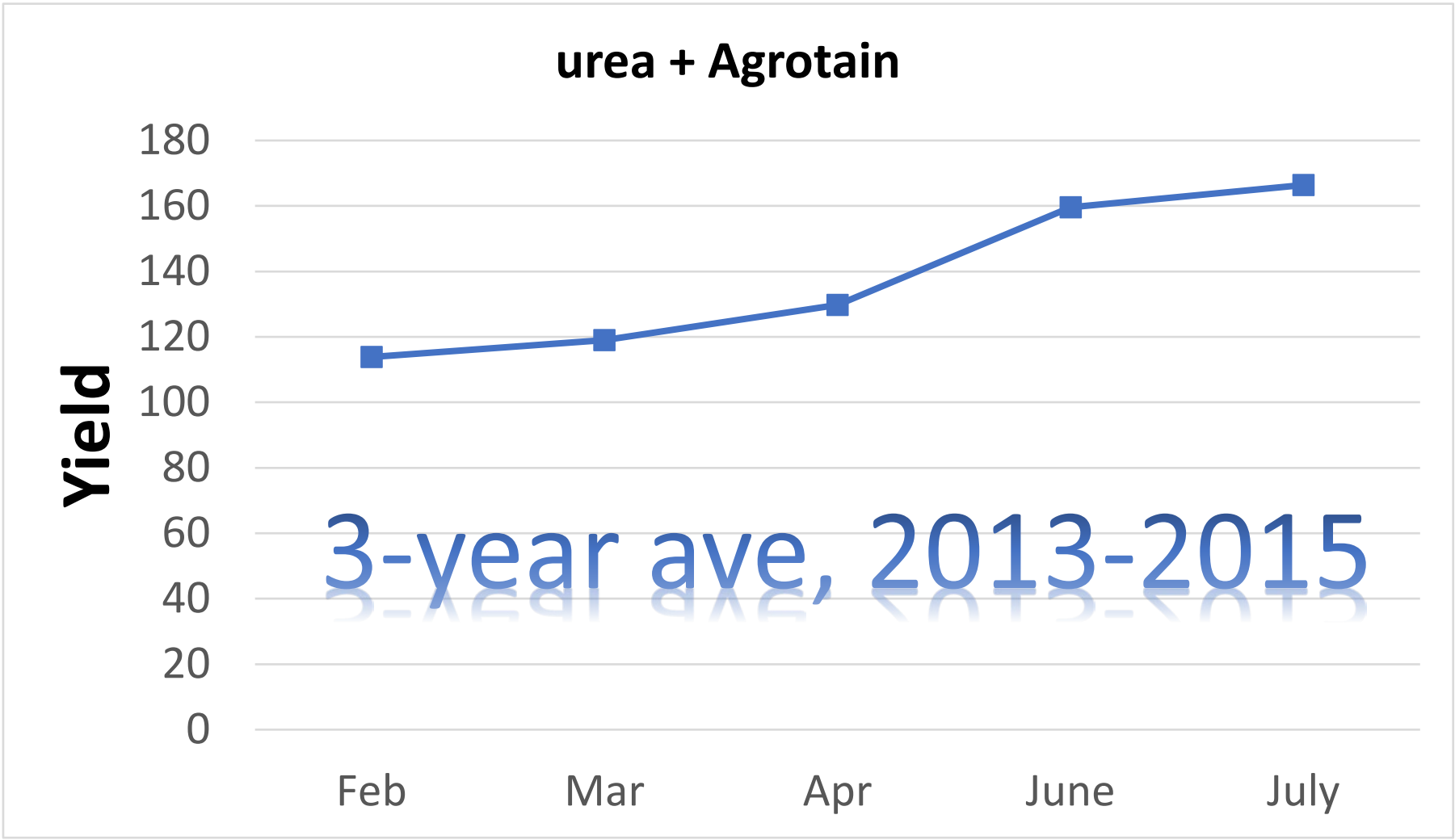
Effect of N timing and rate system

Sidedress 320 bu advantage

All in wet years: 2008, 2009, 2010, 2013, 2014, 2015, 2017



Earlier? Later?

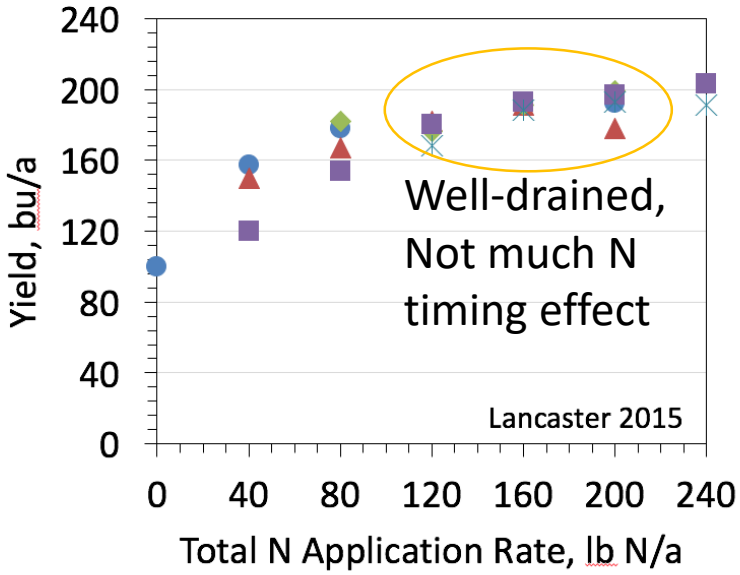


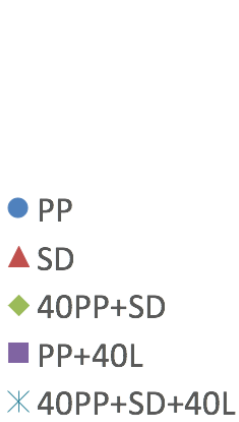
Drainage class & N loss

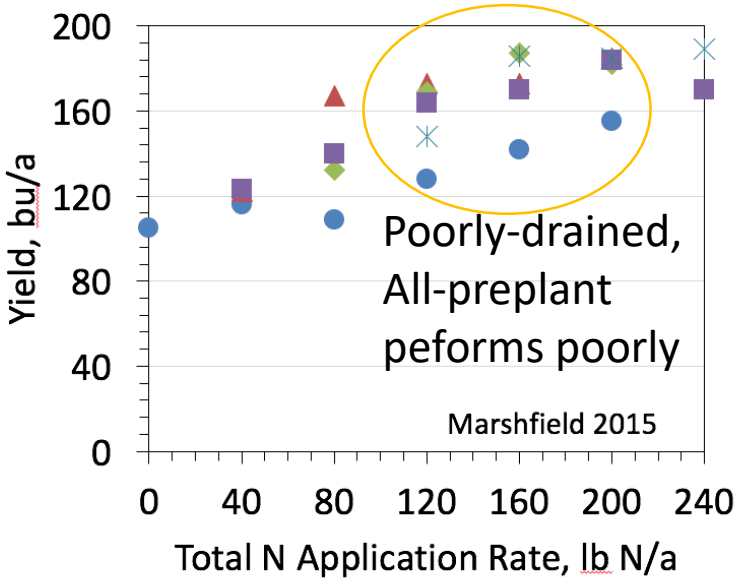
- The experiments I've shown are on poorly-drained soils
- Denitrification when soils are warm & wet
- I've seen more widespread deficiency on poorly-drained soils than on well-drained soils

Soil drainage class impact on N loss in Wisconsin (courtesy Carrie Laboski)

Effect of N timing on corn yield





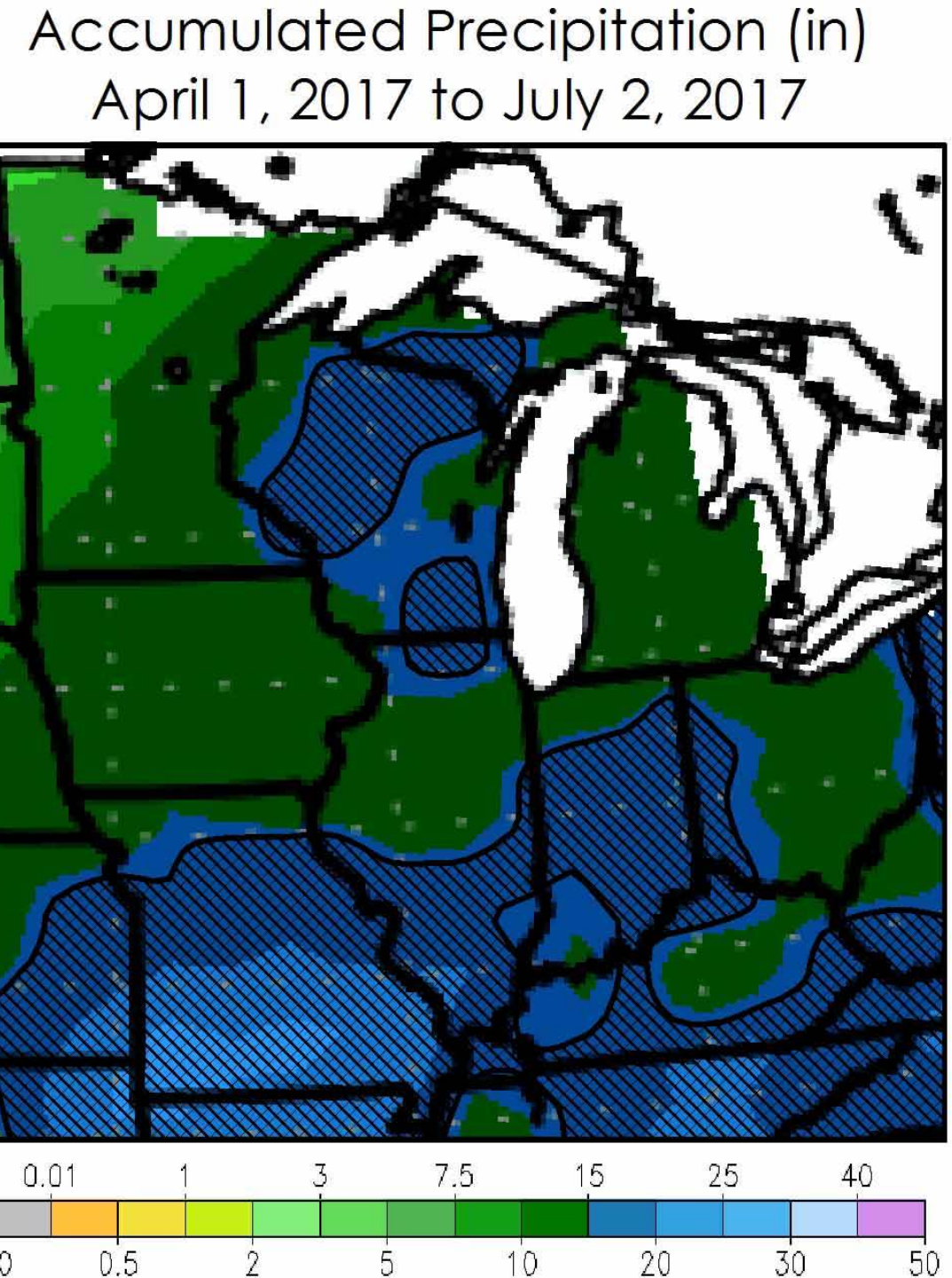


- Well drained silt loam soil
- No yield difference between timings at EONR
- Pre-tassel application doesn't provide yield bump

- Somewhat poorly drained silt loam soil
- Sidedress best timing – lowest EONR
- Pre-tassel application effective for rescue


Major N loss can occur
in well-drained soils too
$45,000 in yield lost in this field
Central Missouri, August 2009

2017

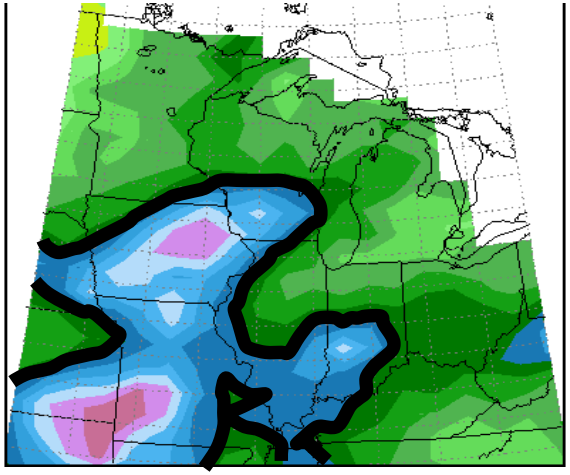


- Crosshatch area: Danger Zone for N loss (above 16” rain April-June)
- Nitrogen Watch (since 2009)
- Updated weekly April-June

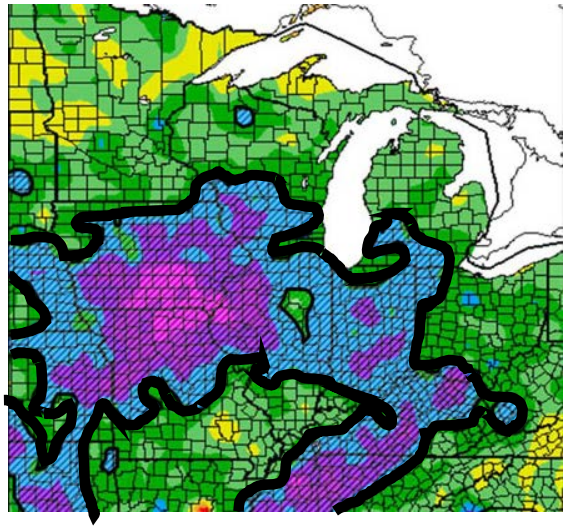
Four wet springs in WI

Outlined areas > 16 inches rain April-June

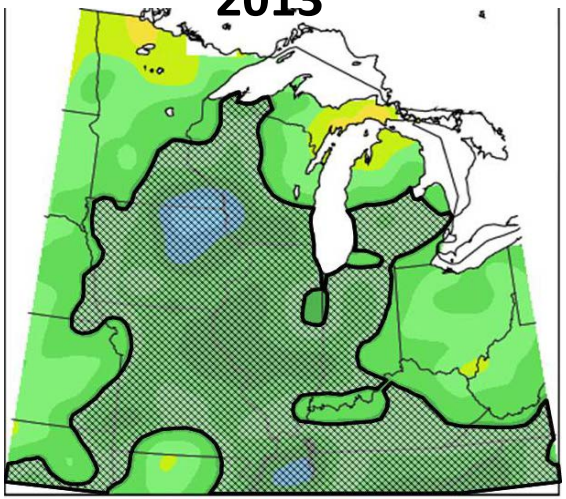
2008



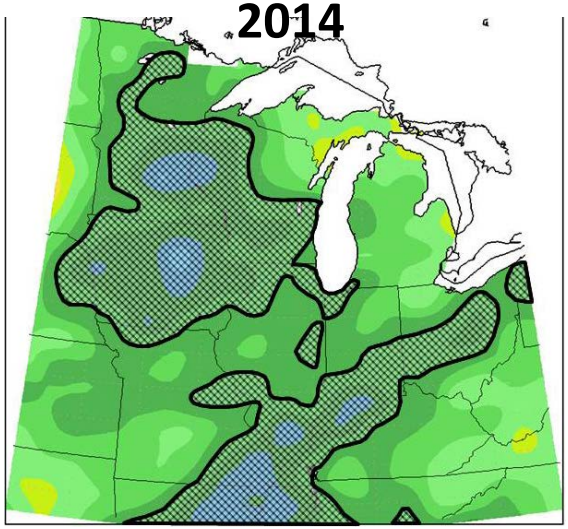
2010



2013

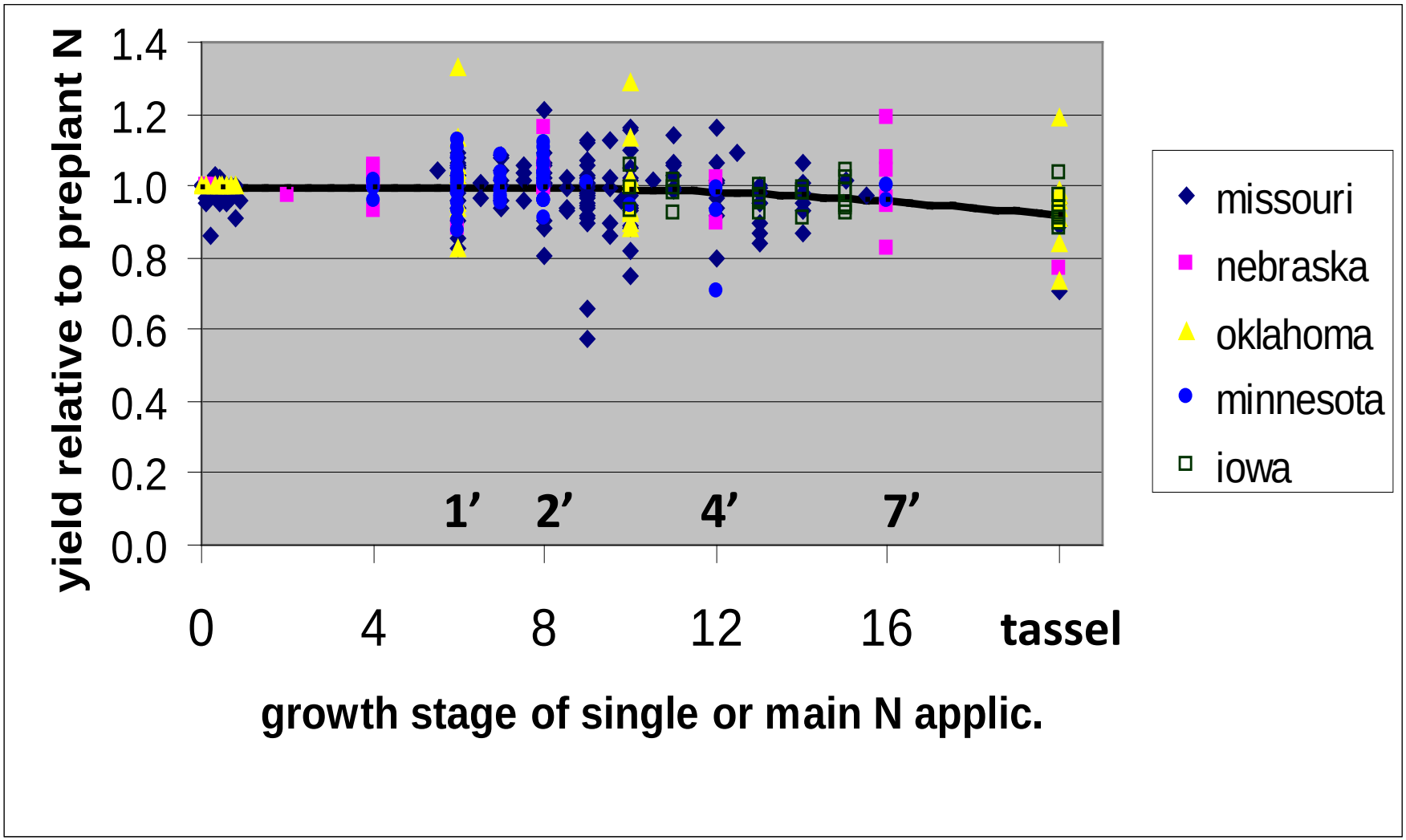


2014



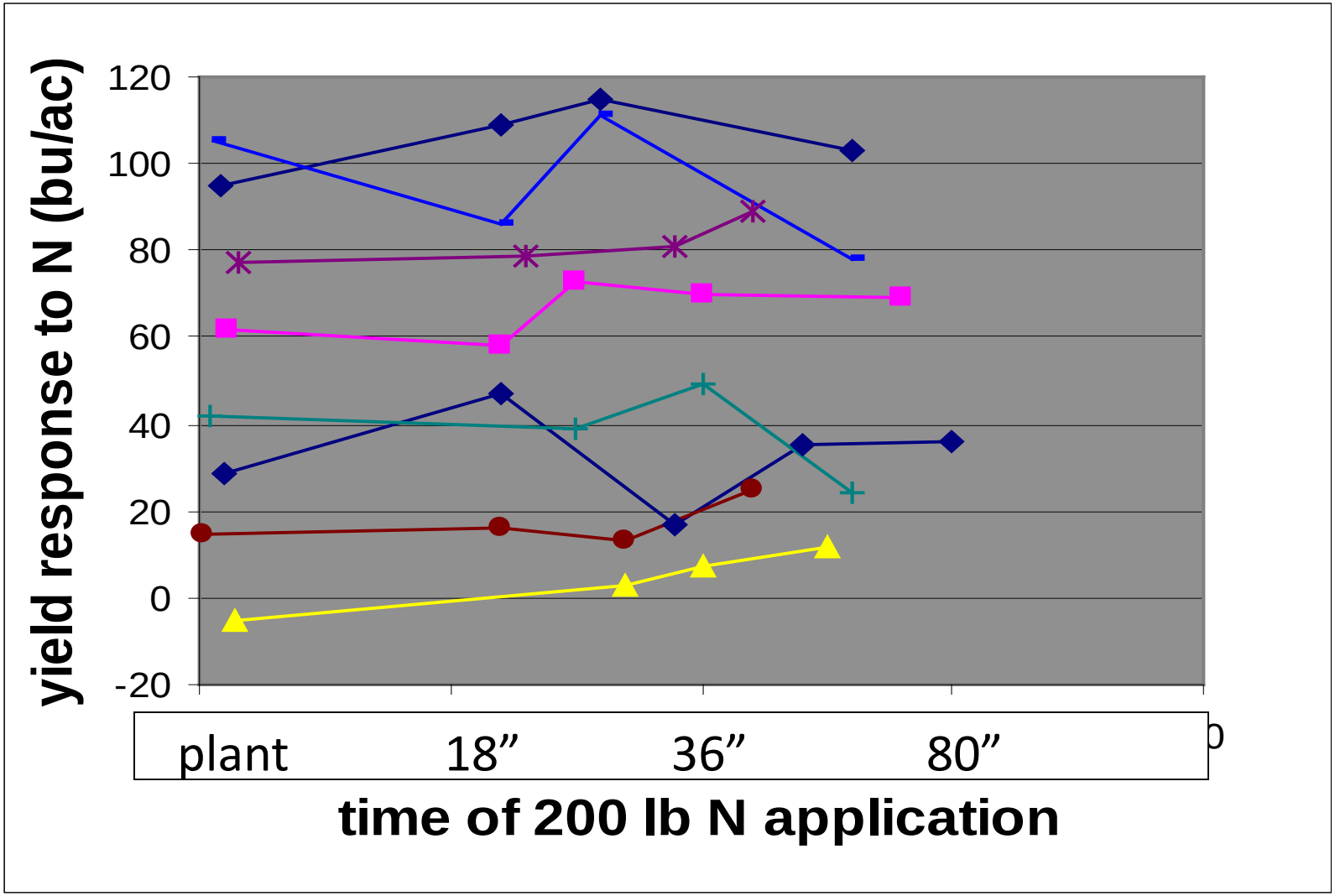
What if you get delayed? Will N stress kill your yield?

N timing: no net yield impact from planting until 4 feet tall (not wet)



Corn yield is not as sensitive to late N application timing as you might think

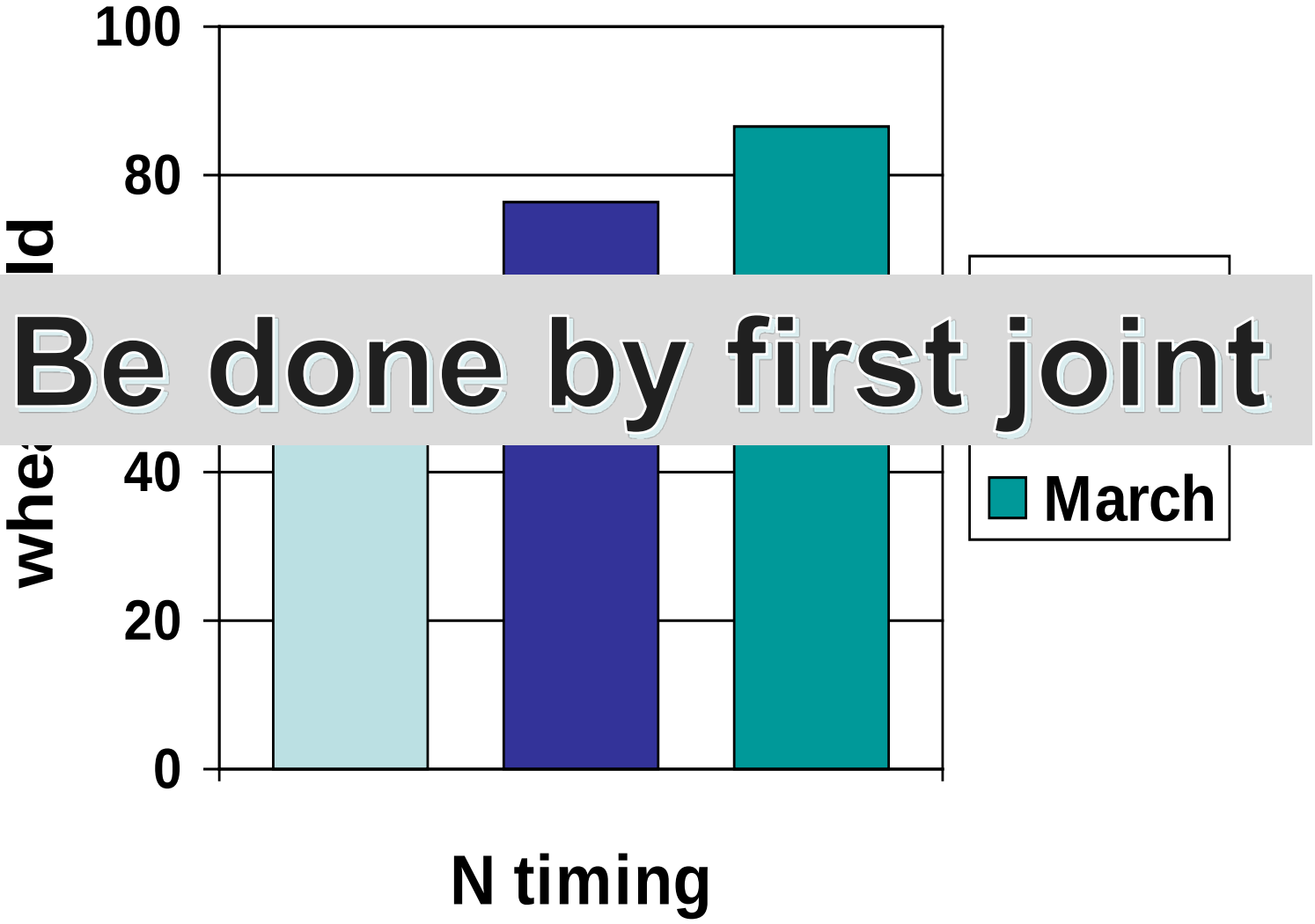
8 small-plot trials in producer fields, 1997



Does N stress cut back on ear row number?

- Long-term N systems experiment near Columbia, 2007-2017
- 11 years continuous corn with zero N
- Zero N treatment in 2017
  - 135 bushels behind best treatment
  - 0.3 rows behind best treatment
- It takes monster N stress to reduce row number

Wheat: topdress N timing



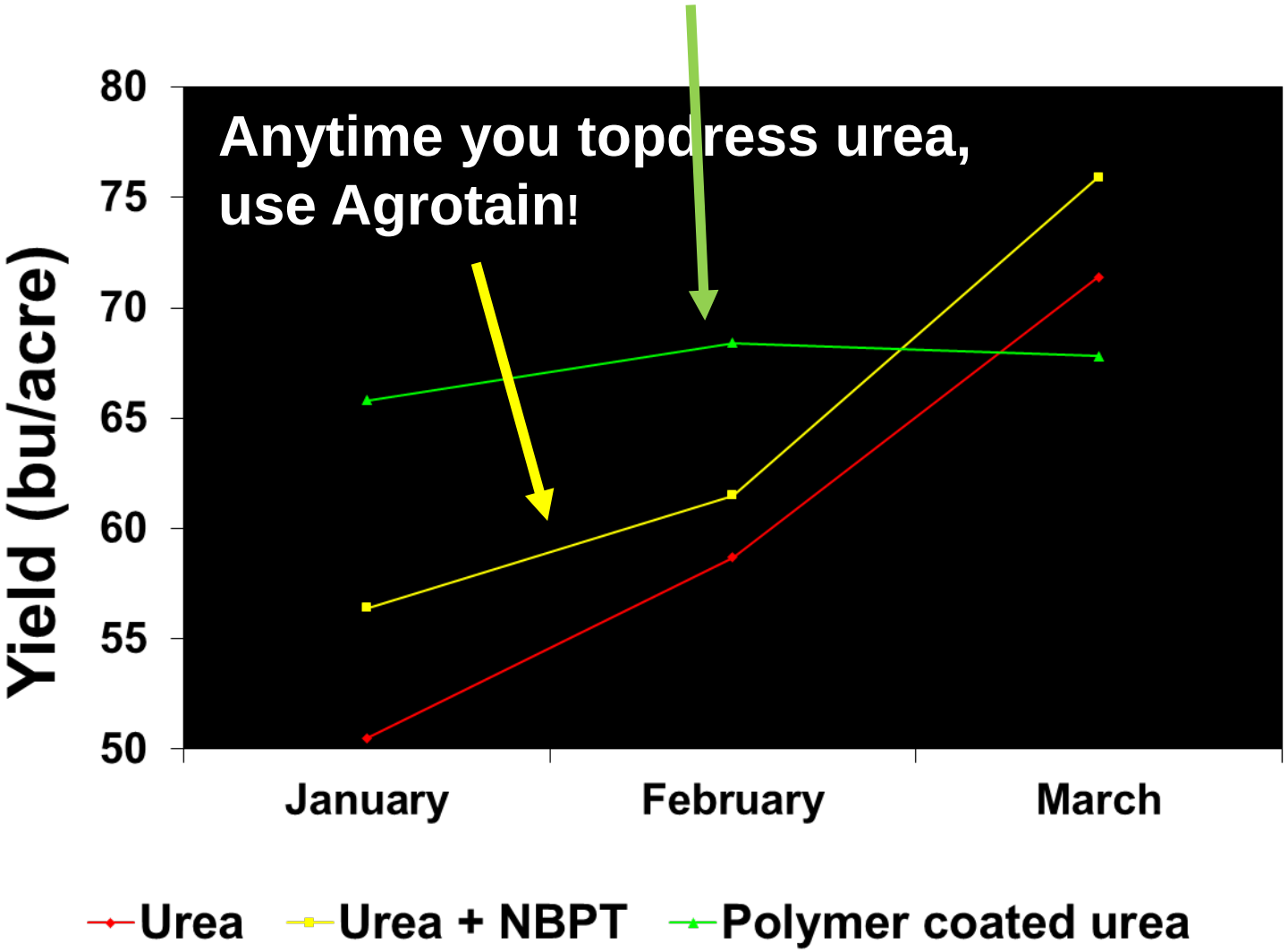
Be done by first joint

When should I apply my spring N?

- **Answer: March!**
  - 20 bushels more than January (2 tests)
  - 5 bushels more than February (10 tests)
  - 8 bushels more than February when yield is above 70 (4 tests)

- But I can't get it all done in March

If you must topdress early, use ESN!



Columbia 2005, 2006

The most profitable N fertilizer rate varies among fields

- 20 on-farm experiments in Missouri with corn after soybean, no manure
- Optimal N rates were 109, 114, 175, 0, 90, 190, 244, 63, 119, 300, 0, 146, 146, 180, 52, 175, 112, 149, 136, 114 lb N/acre
- Does anybody see a pattern?
- There is confusion about how much N to apply, and how to make the decision

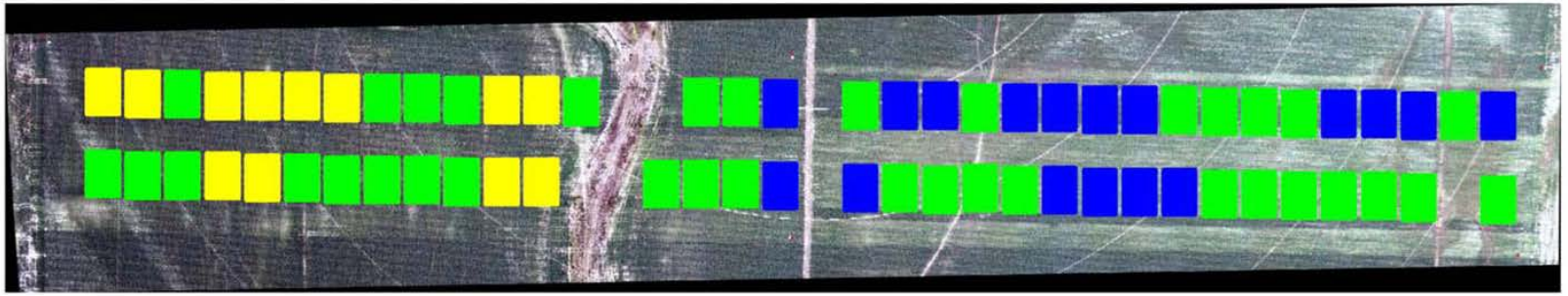
Spatial variability in N need of corn

We studied eight fields this way—seven were as variable as this one

In one field, average best rate was 65;
In another field it was 200

Yes: Minnesota, Kansas, Missouri, Pennsylvania
No: Wisconsin

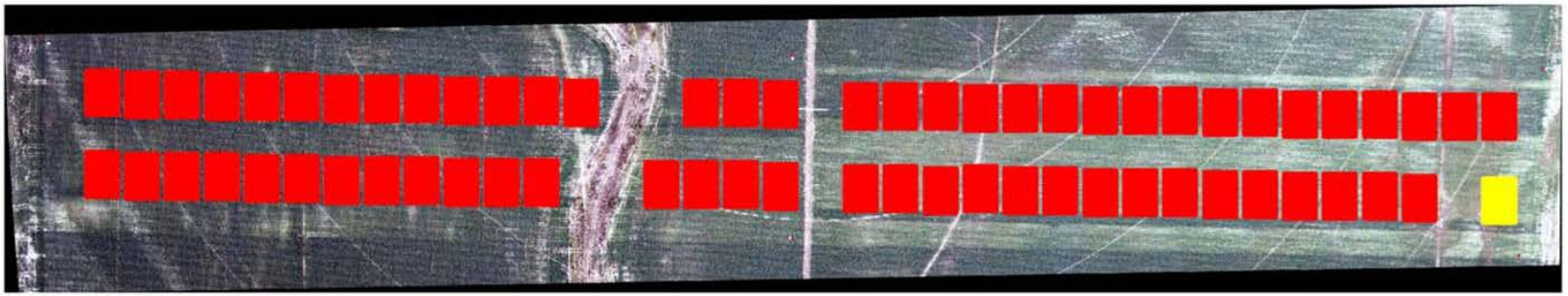
Why? Soil N supply is spatially variable



Yield with no N:
13 to 145 bu/acre

Yield
- 0-50
- 50-100
- 100-160
- 160-220

Wide yield variability



Yield with unlimited N:
160 to 220 bu/acre

Adding N reduces variability

Okay, N rate diagnosis (and variable-rate N) is needed

But how?

Crop color predicts N need a lot more accurately than:

--yield

--soil nitrate

--soil texture

Not sure how it compares to simulation models

Crop color detection—how?

Aerial photos

I've calibrated all 3 to predict optimal N rate—all give about the same quality of prediction

Reflectance sensors

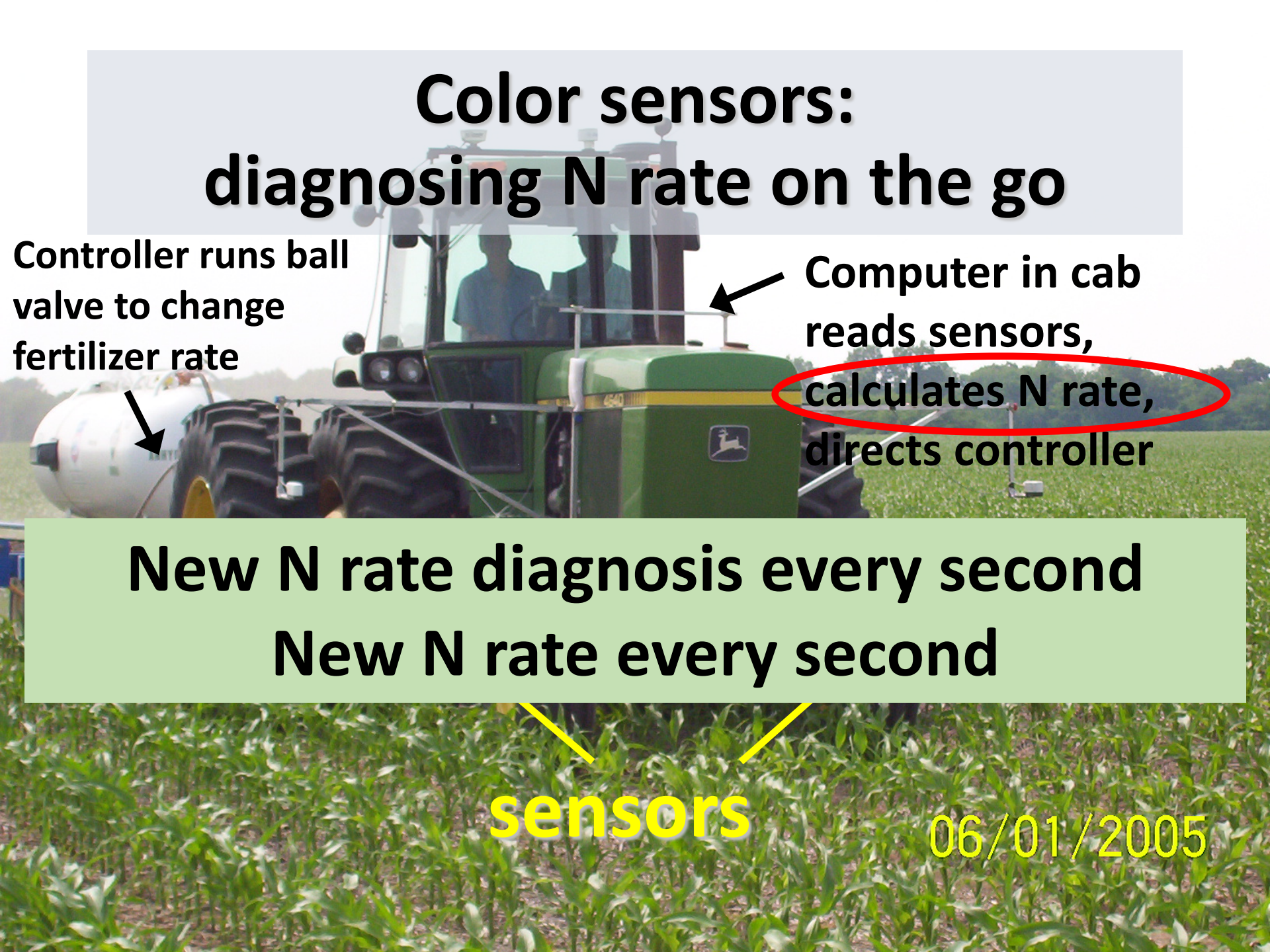
Crop color detection—how?

Aerial photos

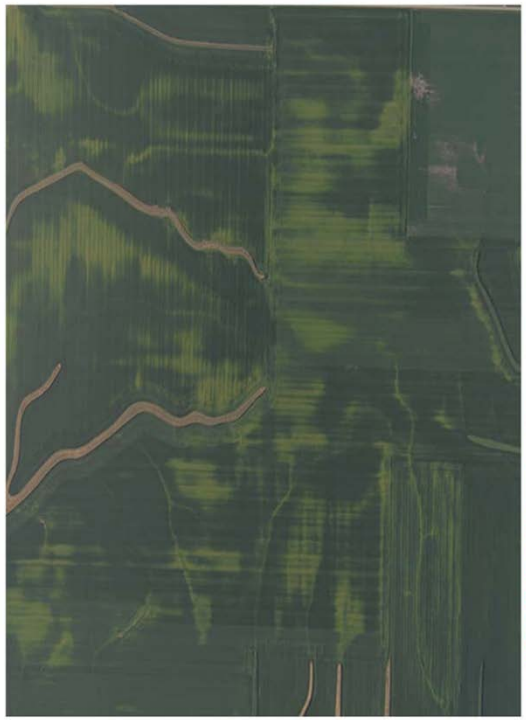
Too hard for variable-rate N

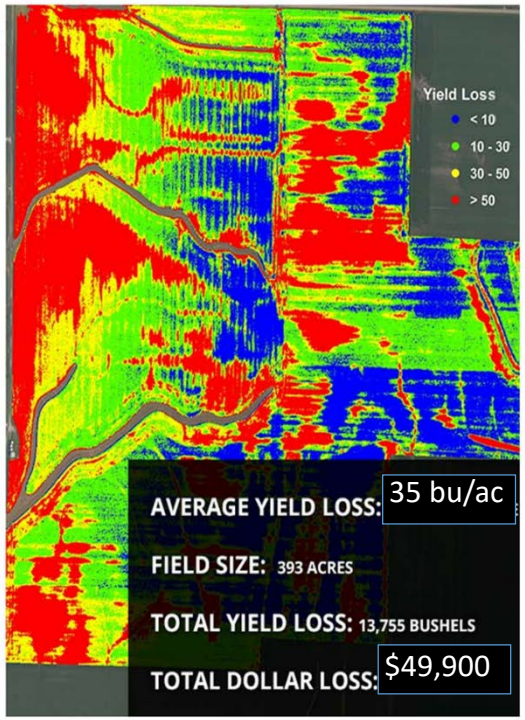
Reflectance sensors

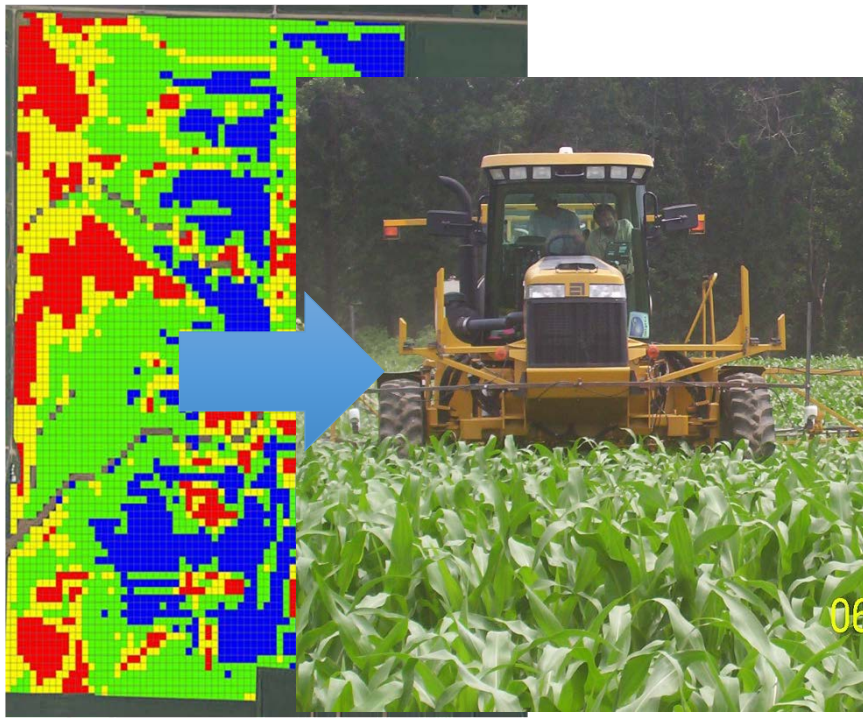
Color sensors: diagnosing N rate on the go



Translating images to bushels and pounds







Aerial photo:
Color = N status

Yield loss map:
Serious N loss??

N rate prediction--
Put it where it needs to go

Manure as an N source?

- Manure: plenty of N in WI but tricky to manage
- Analysis?
- Well-mixed?
- Evenly spread?
- Prone to denitrification
- N release rate depends on weather

Manure: fall vs spring

- Spring more compaction
- Fall more N loss
- Example: 55 fields receiving swine manure in Des Moines Lobe (IA) evaluated in 2007
  - 45% of fall-applied fields were N-deficient
  - 25% of spring-applied fields were N-deficient

N fertilizer sources

- If there is no N loss, all N fertilizer sources are equal

N source & loss

most resistant to wet-weather loss:

- Spring anhydrous ammonia
  - N-Serve helps a little, either fall or spring
- ESN (plastic-coated urea)
  - Has helped a lot in some tests, but mixed results

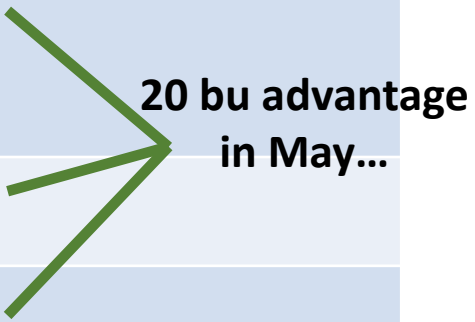
How good are they?

How good are they?

2013 N source & timing study

Single shot N management

N source	Timing	Yield
Anhydrous ammonia*	May	140
ESN	May	140
Urea + Agrotain	May	120
Urea + Agrotain	June	150
Urea + Agrotain	July	150



…but not as good as in-season N

*with or without N-Serve, no difference

Timing is better protection than source

N source & loss

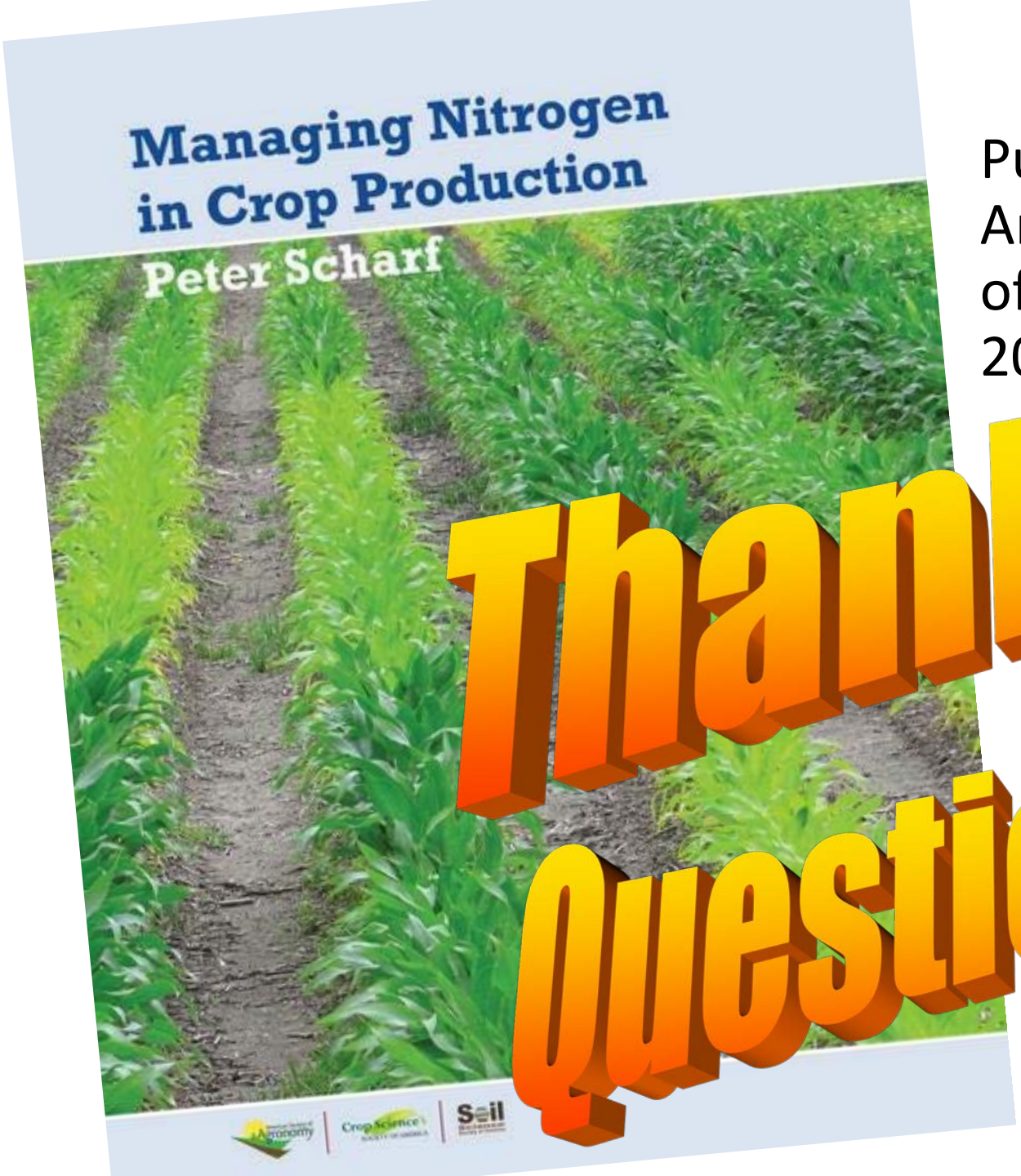
Urea is vulnerable to loss to air as ammonia gas

- When surface-applied (up to 50%)
- Incorporation with tillage, irrigation, or injection prevents loss
- NBPT (Agrotain) effective:
  - Corn: 7 bu (15 tests)
  - Wheat: 4 bu (9 tests)

N source & loss

UAN solution is vulnerable to tie-up on residue

- Mainly when broadcast
- Solved by injection
- Reduced by dribbling (bands)

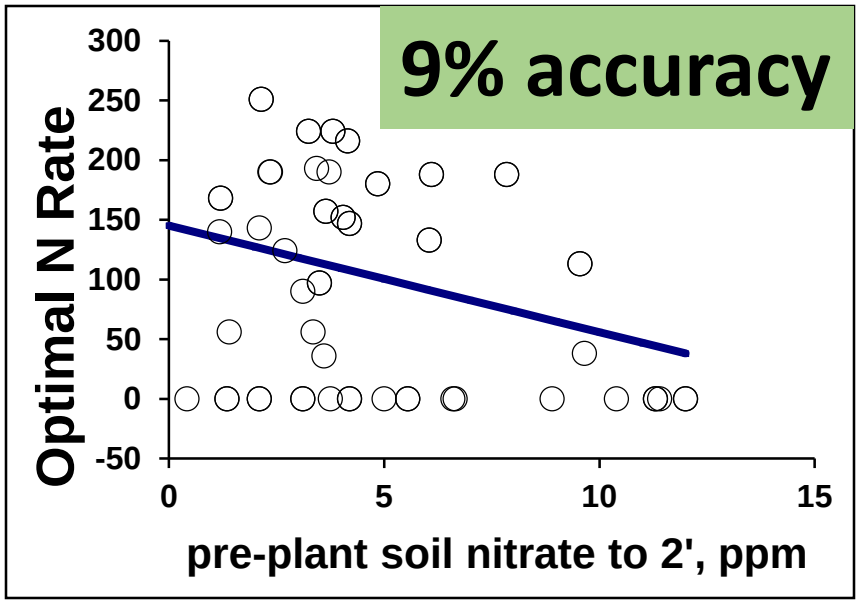


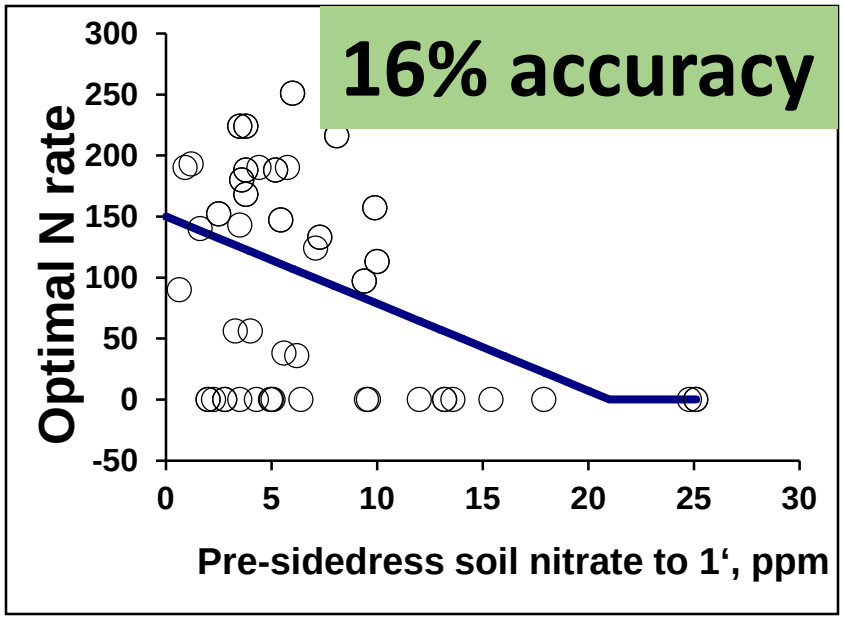
Published by the American Society of Agronomy in 2015

Thanks!

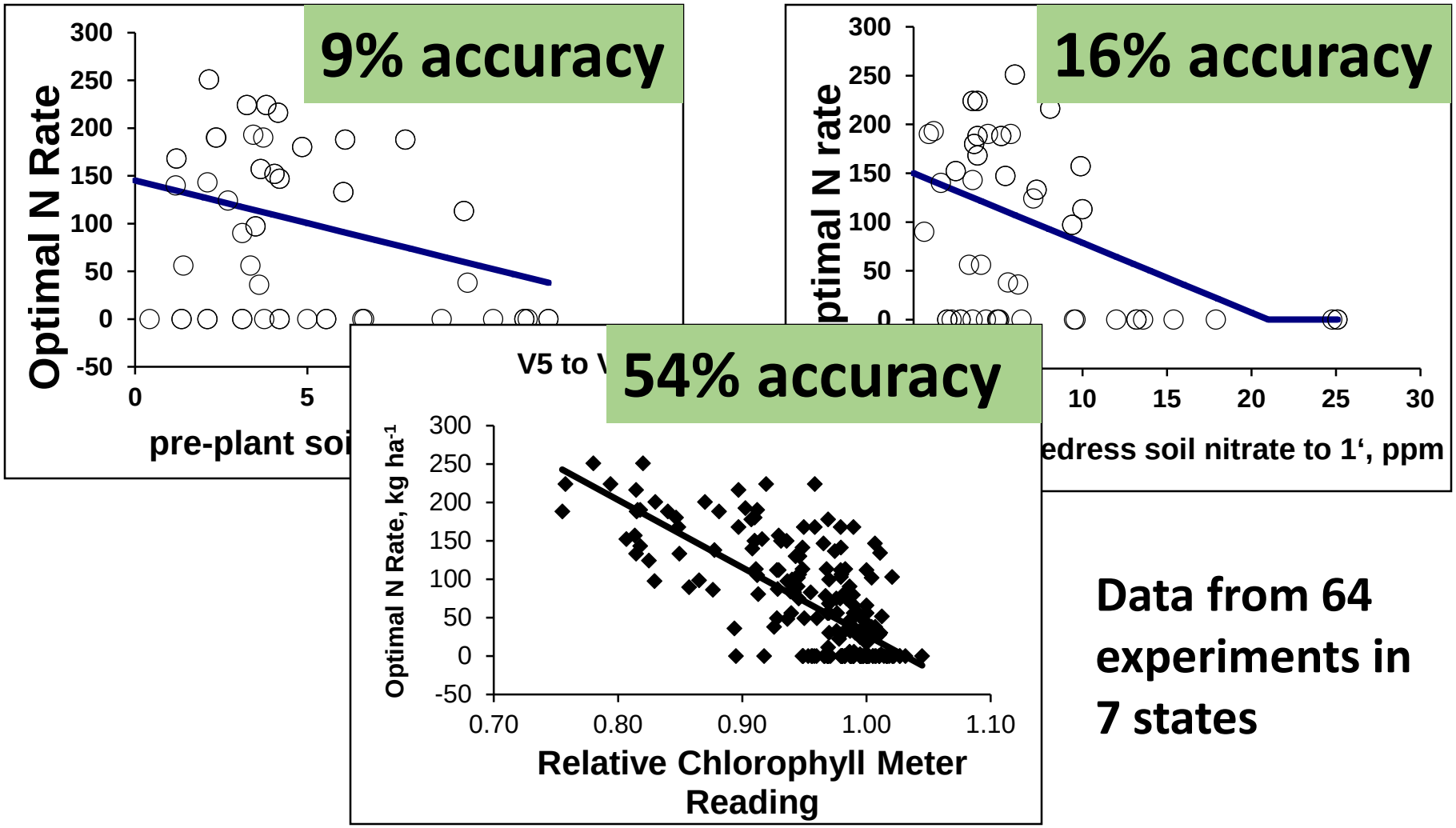
Questions?

Color-based diagnosis: more accurate than soil tests, yield, conductivity





Color-based diagnosis: more accurate than soil tests, yield, conductivity



Data from 64 experiments in 7 states

injecting solution (tractor)

injecting solution (high-clearance)

Dribbling solution

Dry N with a cart

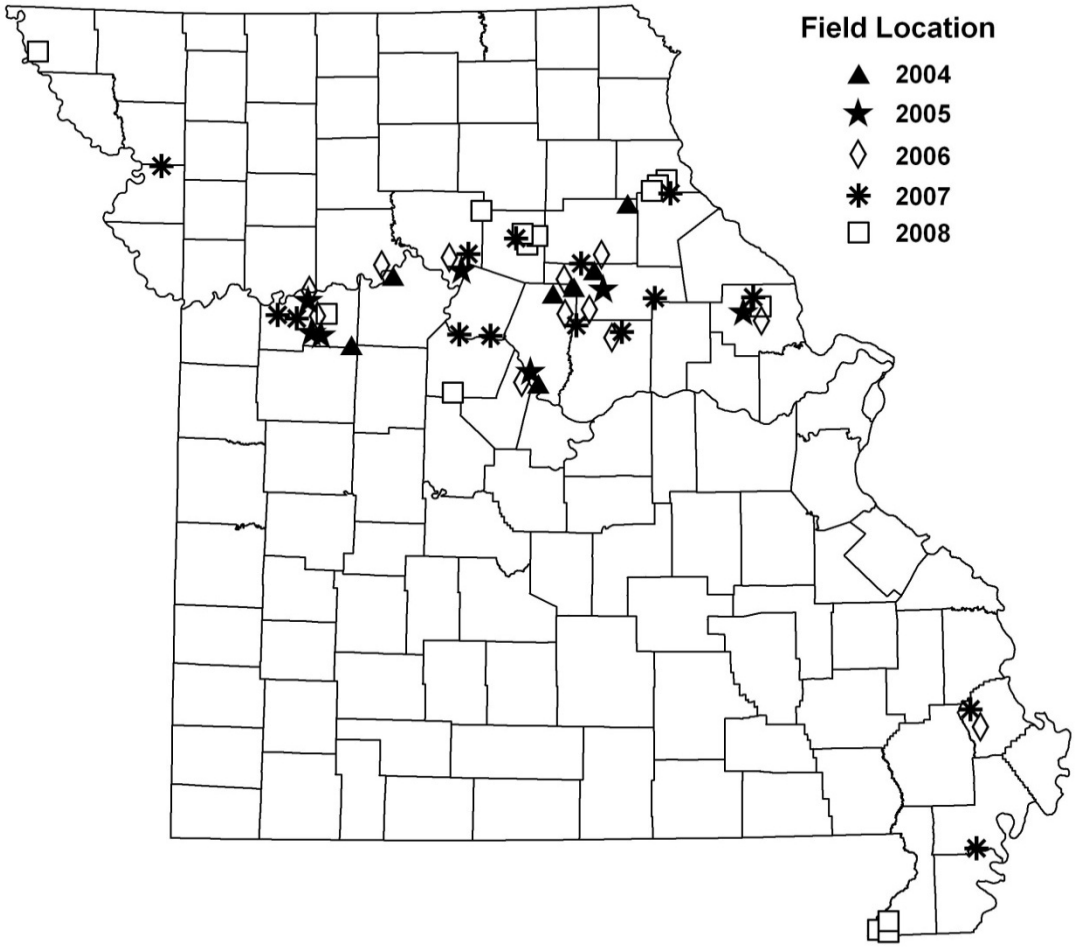
Dry N with high clearance

Dry N with higher clearance

Dry N with a boom spreader

On-Farm Demonstrations

to help producers try this technology



55 on-farm demos (corn) 2004-2008

- Sensor-guided N rate vs producer N rate (same day)
- Minimum 3 replications
- High-N reference applied 4 to 8 weeks before demo

Demo Outcomes: Corn

- Saved 14 lb N/acre
  - Worth $7/acre at $0.50/lb N
- Increased yield by almost 2 bushels/acre
  - Worth $10/acre at $5/bu
- Increased profit by $17/acre minus sensor costs
- Decreased ‘surplus N’ by 25%
  - ‘Surplus N’ is the difference between N applied and N carried away in grain

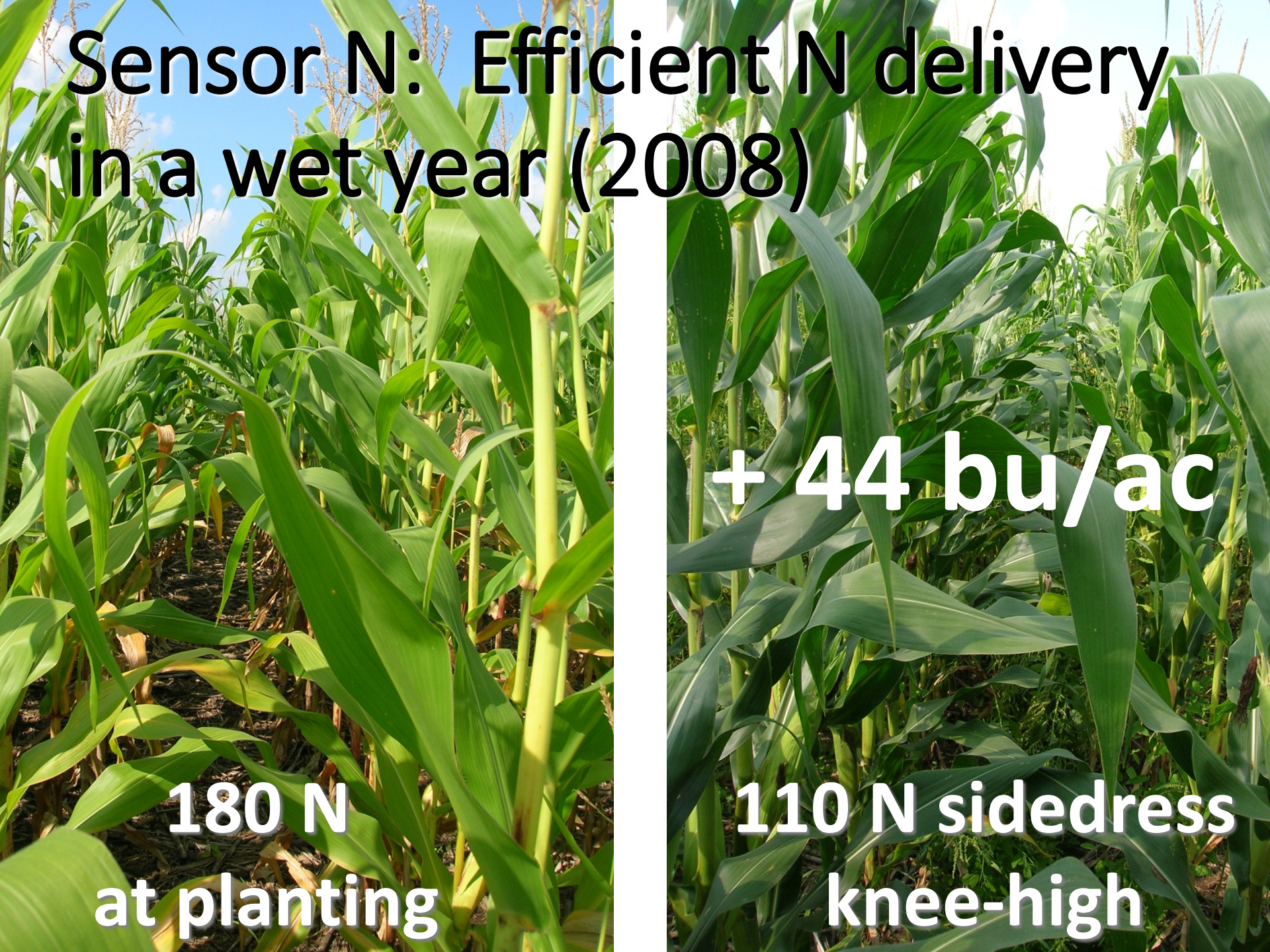
Sensor-based N management can be used with:

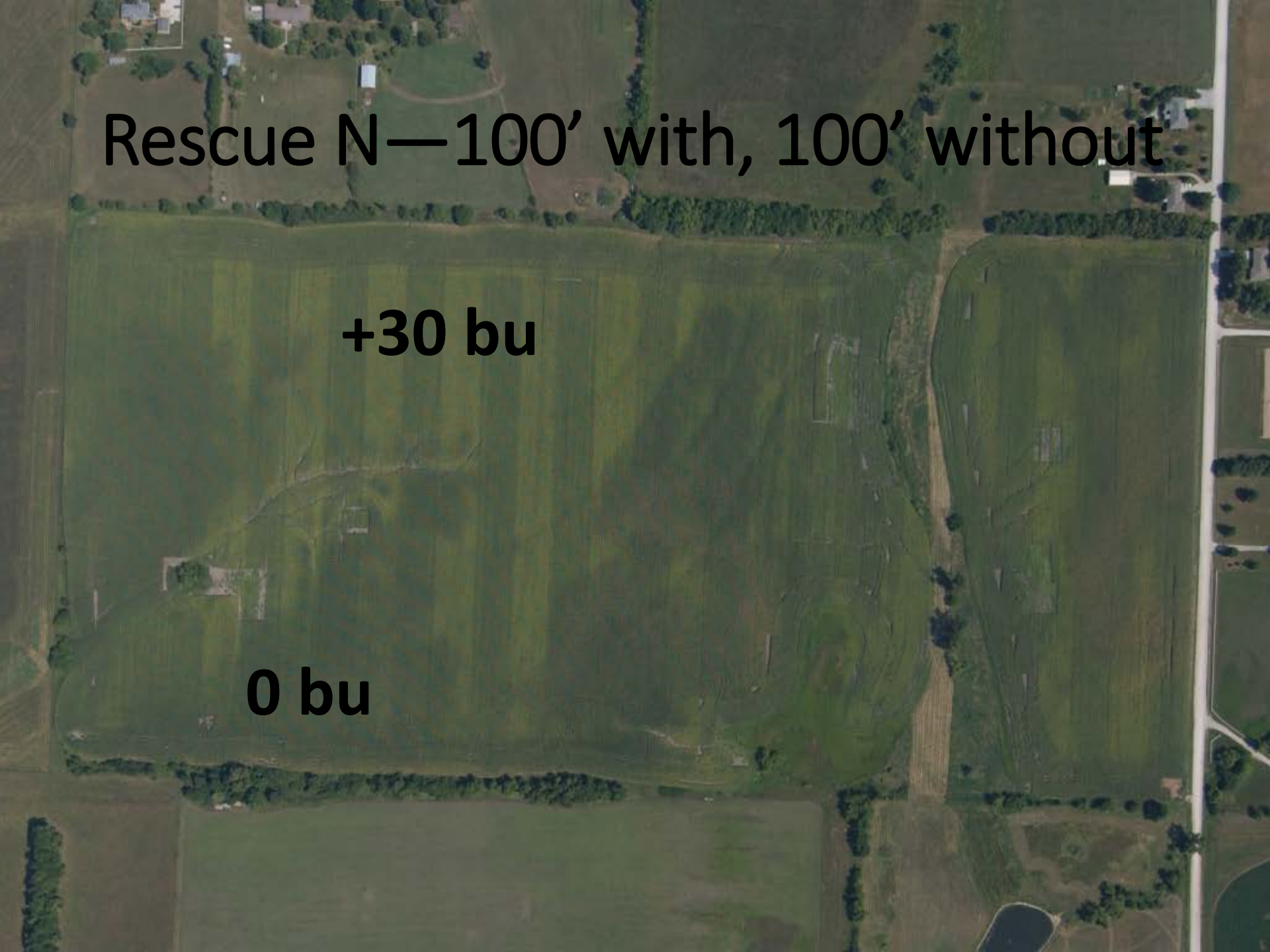
- Any N source
- Any type of applicator
- Corn 1 foot to 7 feet tall

Making money with sensors

- We’re making money:
  - At any growth stage from 1 foot to 7 feet
  - Whether we lower or raise N rate relative to the producer’s rate
  - At any yield level
  - At any preplant N rate
- We’re losing money when the reference area is bad

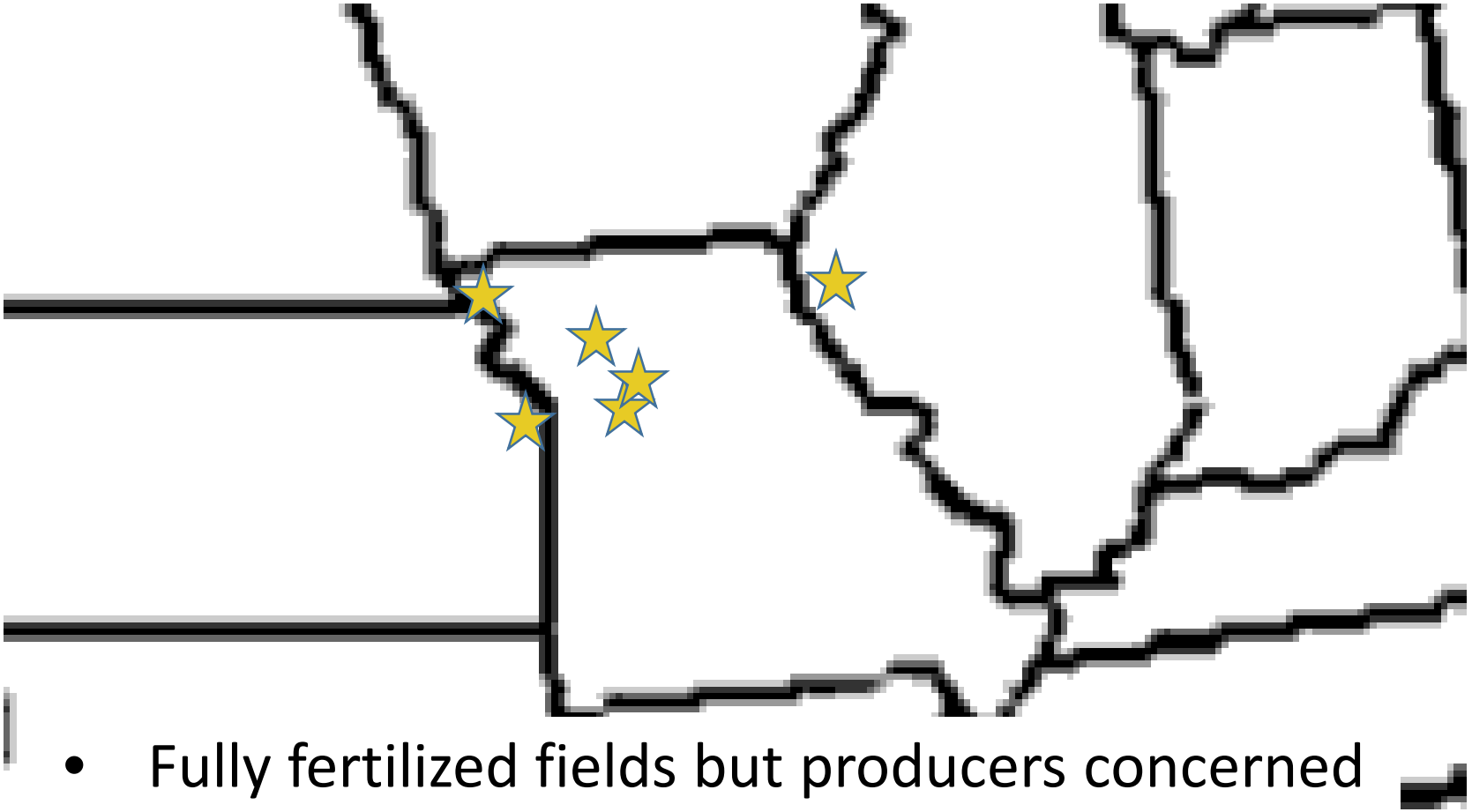
Sensor N: Efficient N delivery in a wet year (2008)




Rescue N—100’ with, 100’ without
+30 bu
0 bu


UREA Post Application at 40 lbs/Acre
90 bu
60 bu
126 bu
135 bu
125 bu
60 bu

Yellow corn can be rescued



- Fully fertilized fields but producers concerned
- N applied anywhere from thigh-high to tassel

Rescue N trial	Year	Stage	Yield response (bu/acre) to N when stress level was:		
			Low	Medium	High
1	1998	V8		23	57
4	2010	VT	17	42	
5	2010	VT	28	54	57
6	2010	VT	8		
Average			**13**	**40**	**57**

The worse it looks, the more it responds

Rescue N trial	Year	Stage	Yield response (bu/acre) to N when stress level was:		
			Low	Medium	High
		8		23	57
		8		50	
		14	-2	30	
4	2010	VT	17	42	
5	2010	VT	28	54	57
6	2010	VT	8		
Average			**13**	**40**	**57**

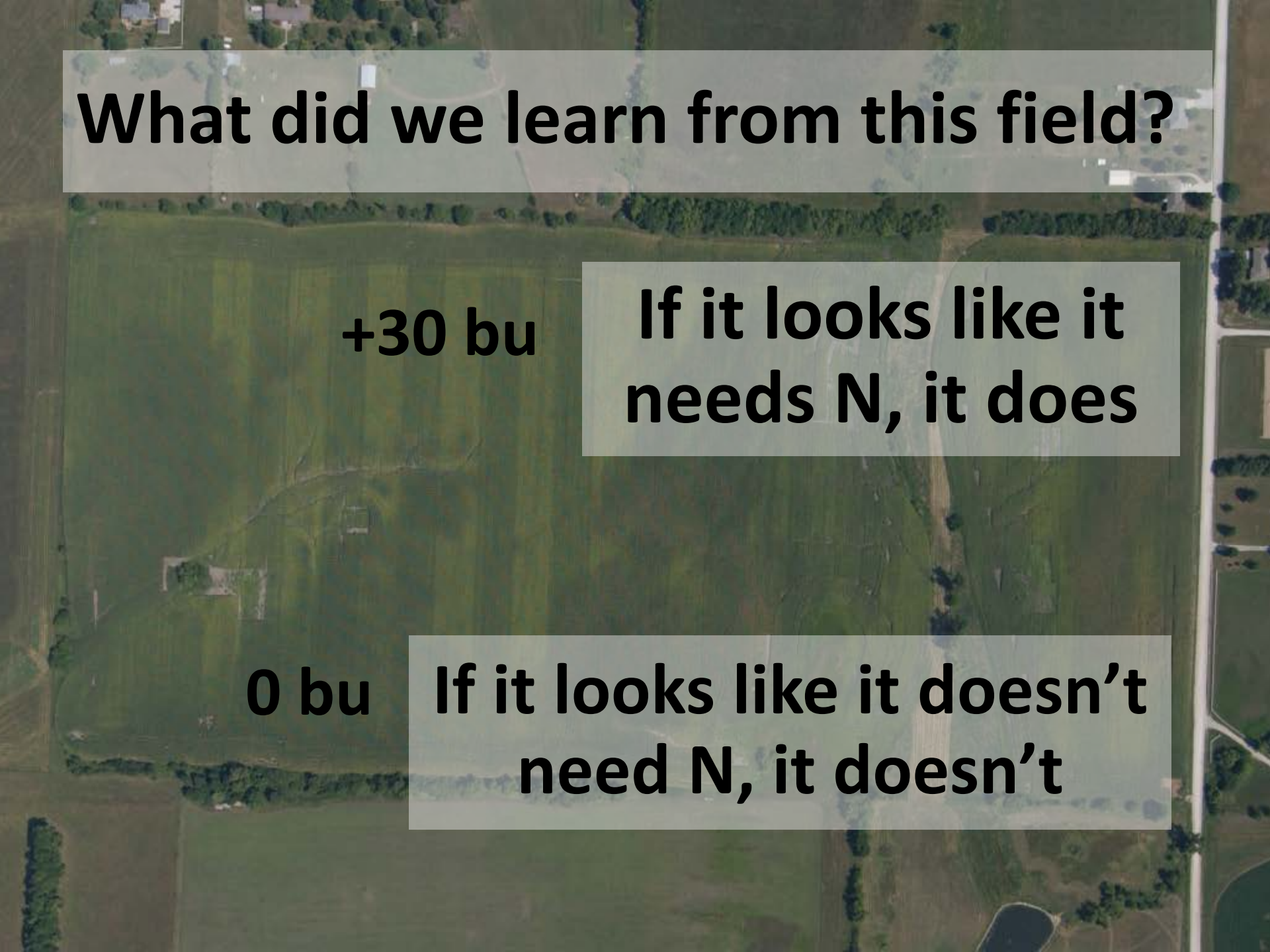
Tasseling is not too late

Rescue N 2015

- 6 fields Audrain, Montgomery, and Warren Counties (July 10-14, 20-80% tasseled)

Fields	Yield response to:	
	50 lb N/ac	200 lb N/ac
All 6	18	33
4 worst-looking (yellowest corn)	28	45

We were on a mission to find corn so bad-looking that it shouldn't be rescued. We failed.


What did we learn from this field?
+30 bu
If it looks like it needs N, it does
0 bu
If it looks like it doesn’t need N, it doesn’t

“Adding late-season N can be like putting on a booster rocket for corn production in a wet year. In dry years, you can save a lot of money by holding off on early-season N applications that don’t pay off”
--Clay Mitchell, Iowa farmer

Dry N is the fastest

60 new machines like this in MO/IL/IA in past 6 years = $20 million

Cheap!

Southern pilots want to apply N to midwestern corn

…but beware of dusty fertilizer—a spinner can't throw dust

- **Fortunately more domestic production of urea is under construction, should increase availability of intact product**
- **Super U spreads beautifully**


Central Missouri 2008:
in-season N kicks butt
+ 44 bu/ac
180 N
at planting
110 N
sidedress knee-high


Central Missouri 2009:
in-season N kicks butt again
+ 68 bu/acre
153 N sidedress
knee-high
180 N
at planting
153
Post
180
Pre


140
PRE
180
PRE
147
SIDE
100
PRE
80 bu difference
Central Missouri 2010:
Can you believe a 3-peat?
0
197
SIDE
124
PRE
202
SIDE

Aerial N application

- About 100,000 acres in northern Missouri in 2015
- Far more than ever before
- Plus at least 70,000 acres in Illinois & 40,000 acres in Kansas
- **NOT ENOUGH**

Now that is how to load a plane fast

3.5 minutes with an auger
0.5 minutes with a bucket & 12” chute

N fertilizer is crucial to agriculture & society

- Human culture is based on agriculture

ncreases
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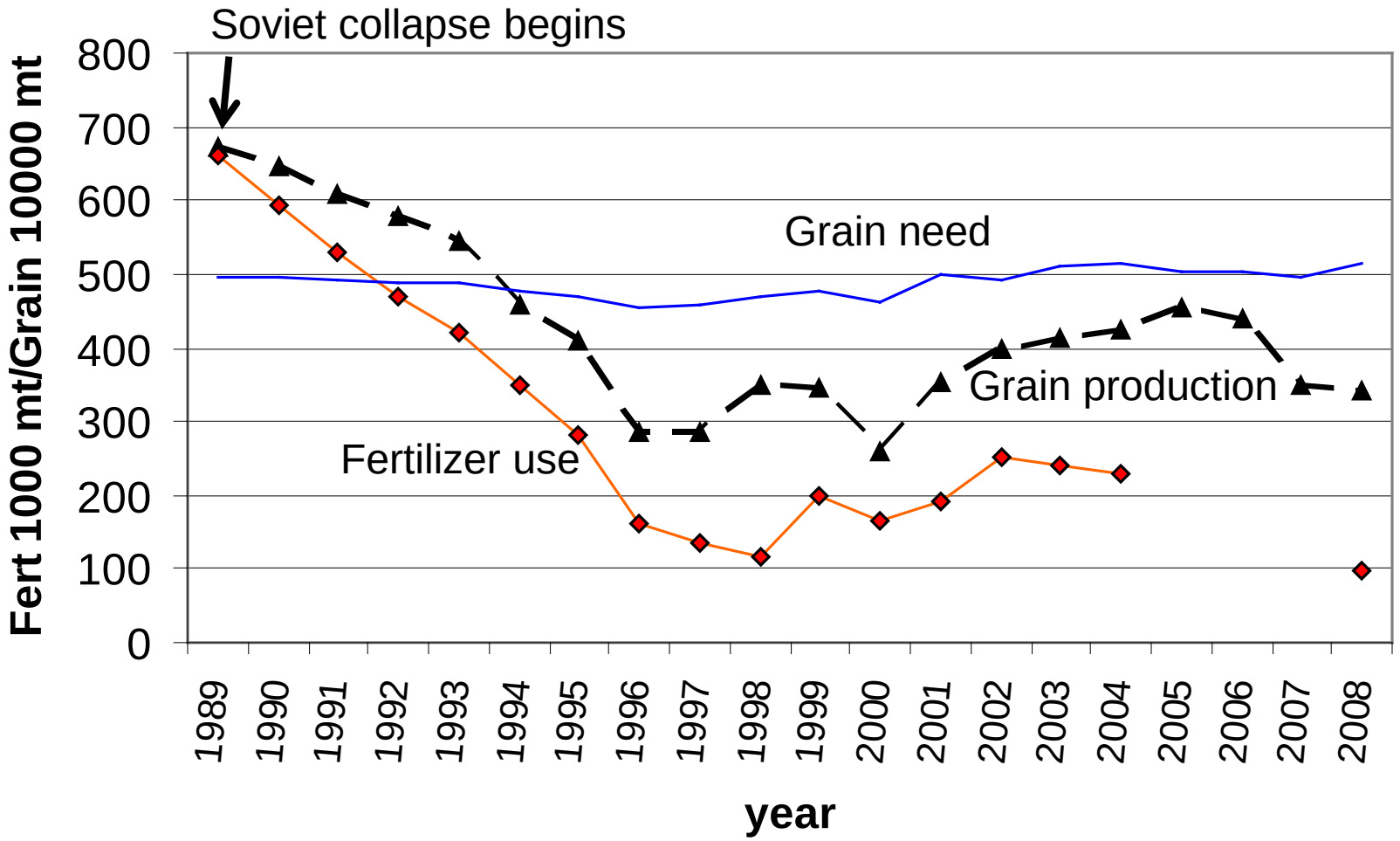
North Korea: an accidental experiment



Varying flow rates is difficult

- Double flow requires 4x pressure
- Highest rate = highest pressure (100 psi?)
- What happens as you drop pressure?
  - Distribution along bar or boom becomes uneven
  - Starts at about ¼ max (25 psi?)
  - N rate = ½ max
- If top rate = 150, bottom rate = 75

Is this good enough?

- Yes, but it would be better to have a wider range
- New nozzle bodies with spring-lo
  - Orifice gets bigger as pressure incr
  - Available from Greenleaf, SprayTar
  - Gives wide rates, even spread, and