Is the MRTN Nitrogen Rate High Enough?

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Emerson Nafziger
Crop Sciences

Dan Schaefer
Illinois Fertilizer & Chemical Association

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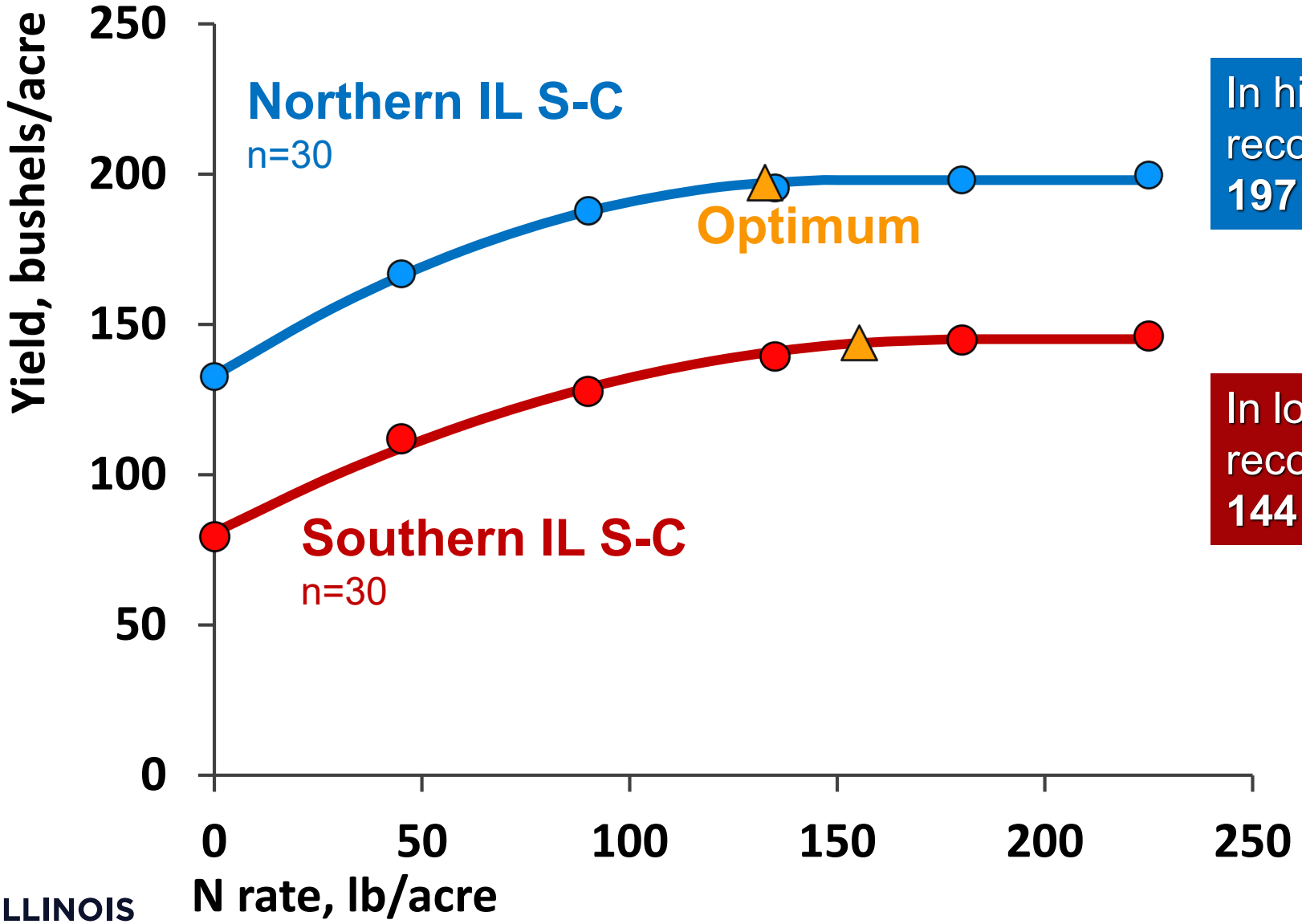
Why not just use expected yield (yield goal) to set N rate?

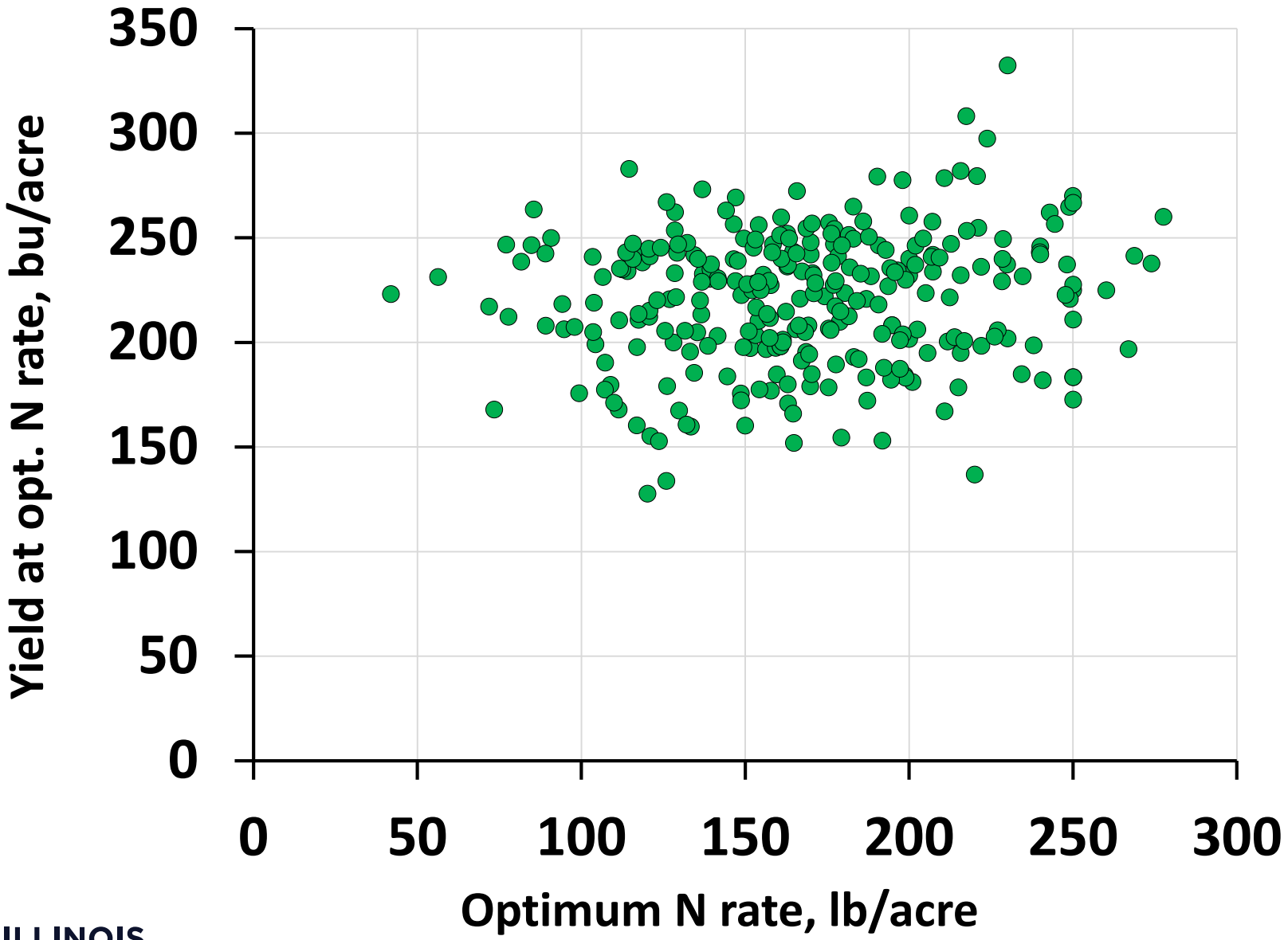
In 1990s it became obvious that yield-goal-based system in place since 1970s was no longer adequate:



In higher-organic matter soils, it recommended using too much N:
197 bu/acre needed 133 lb N

In lower-OM soils (southern IL) it recommended using too little N:
144 bu/acre needed 155 lb N

Yield goal?



Yield and the N rate it took to get to yield were **not correlated** across a lot of trials

How's that possible?

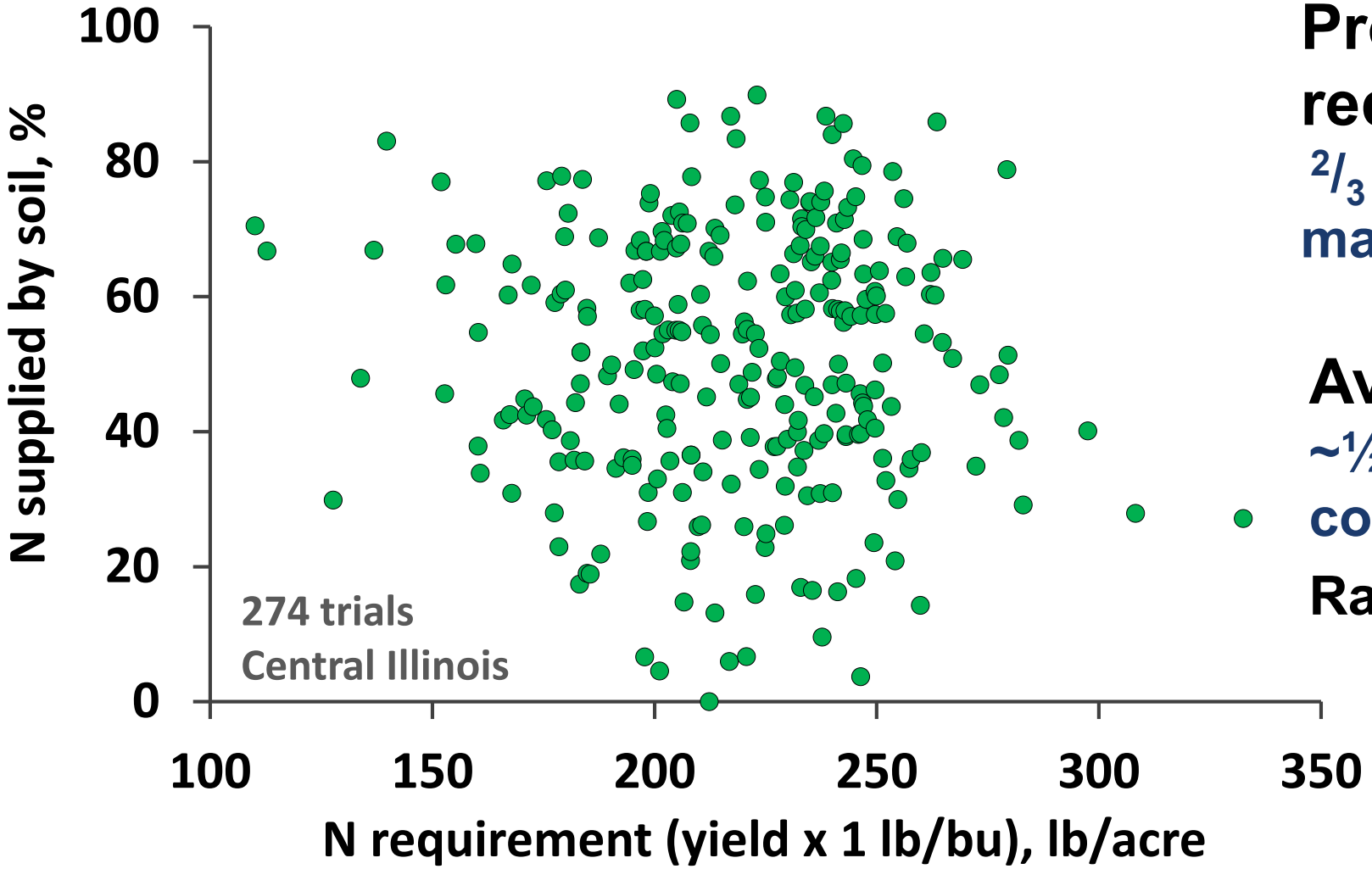
-think soil N

The result:

we can't predict the best N rate even if we KNOW what the yield will be

Why is (fertilizer) N rate so “difficult”?

Tough to predict yield/N need AND soil N supply



Producing 1 bu of grain requires ~1 lb of N

$^{2}/_{3}$ of the N is in the grain at maturity

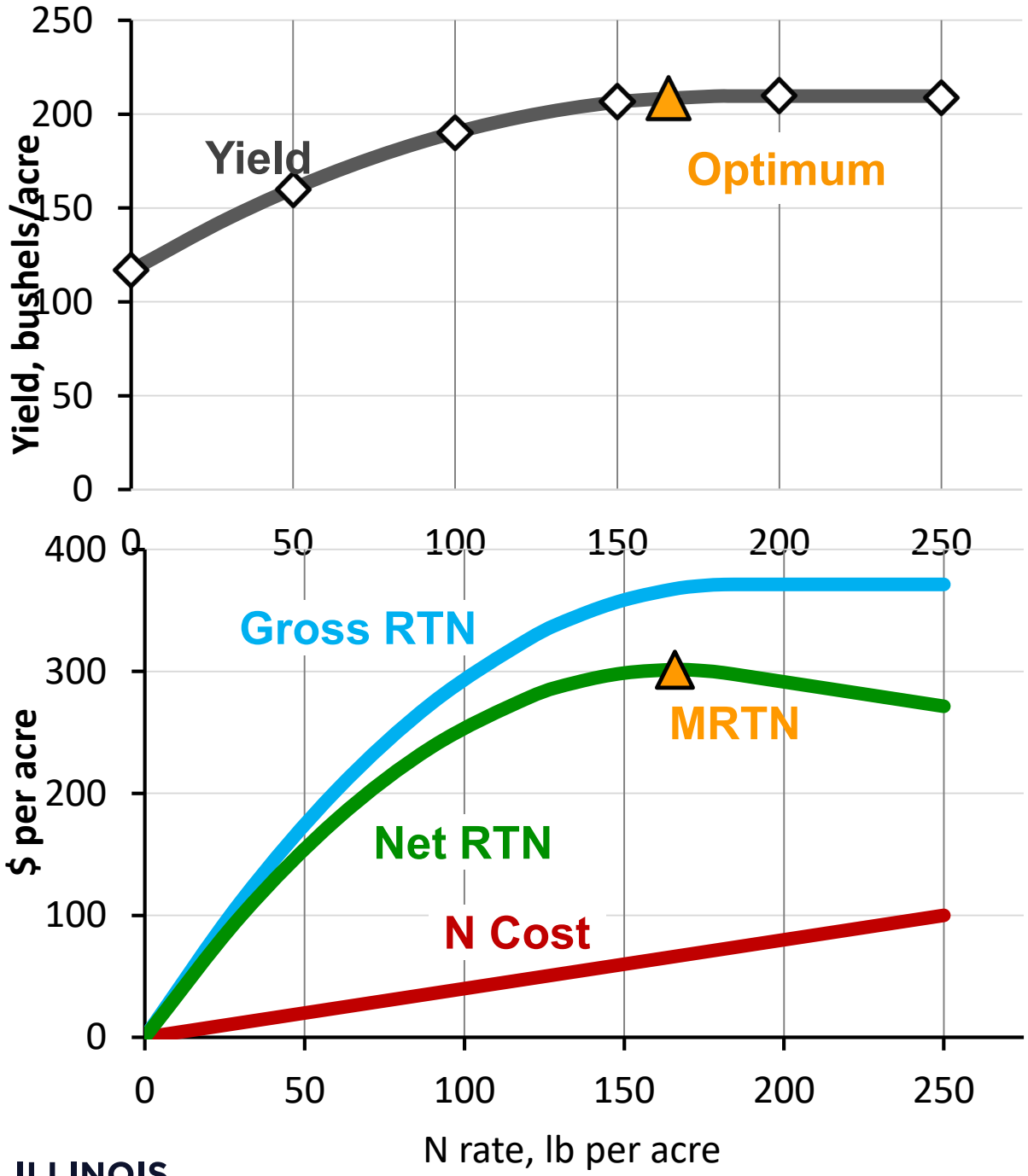
Averaged across trials:

~½ crop’s N requirement comes from the soil

Ranges from <5% to >90%

Maximum Return To Nitrogen (MRTN)

The N rate that **maximizes return** to N at a certain set of corn and N prices across a set of N response trials



The MRTN

The "**economic optimum**" N rate (**EONR**) is the rate that adds just enough yield to pay for the last lb of N applied

N: $0.50/pound

Corn: $5.00/bushel

The last bushel of corn produced by the EONR pays for 10 lb of N

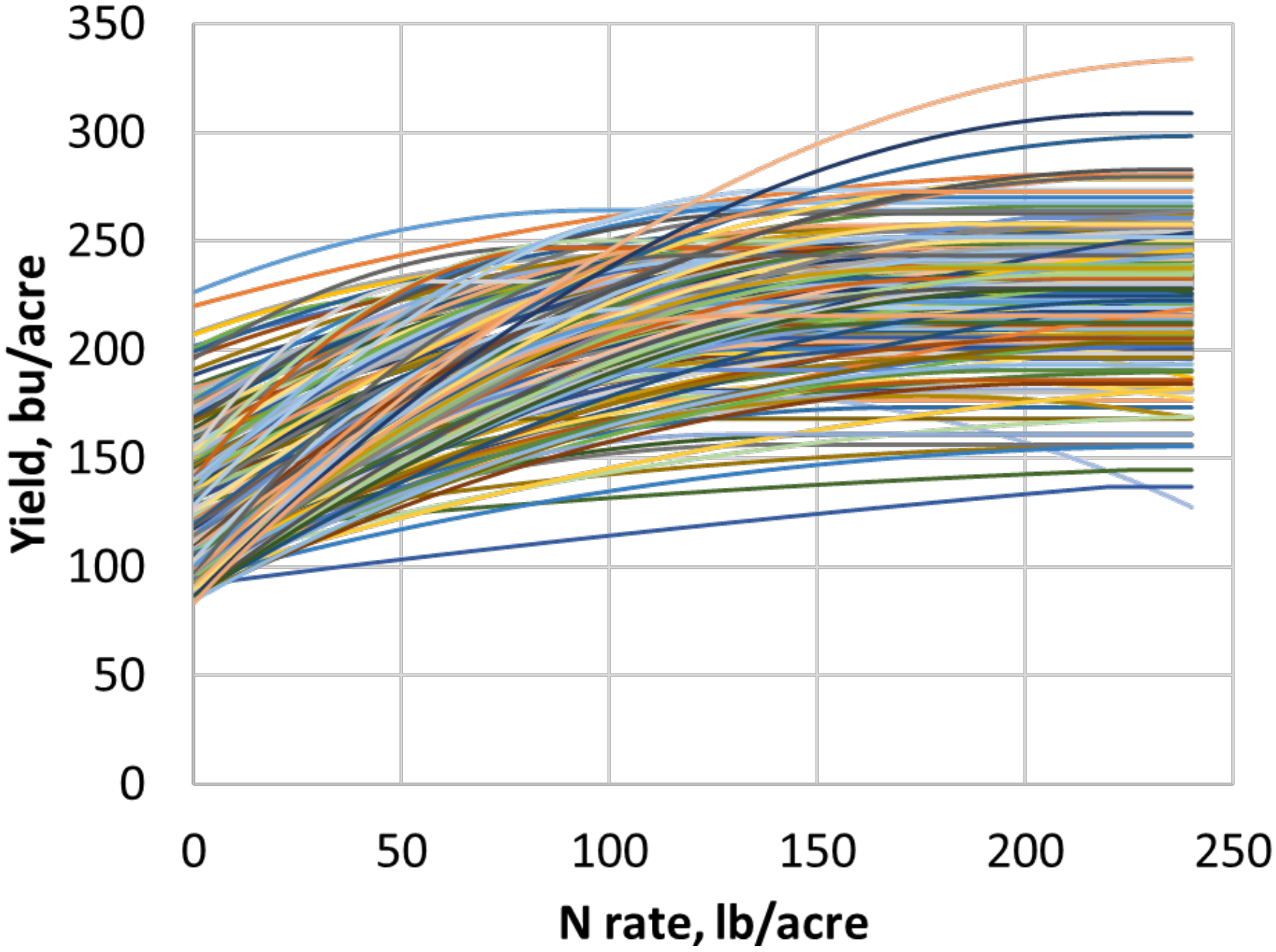
Basis for the MRTN

200 N responses

Soy-Corn

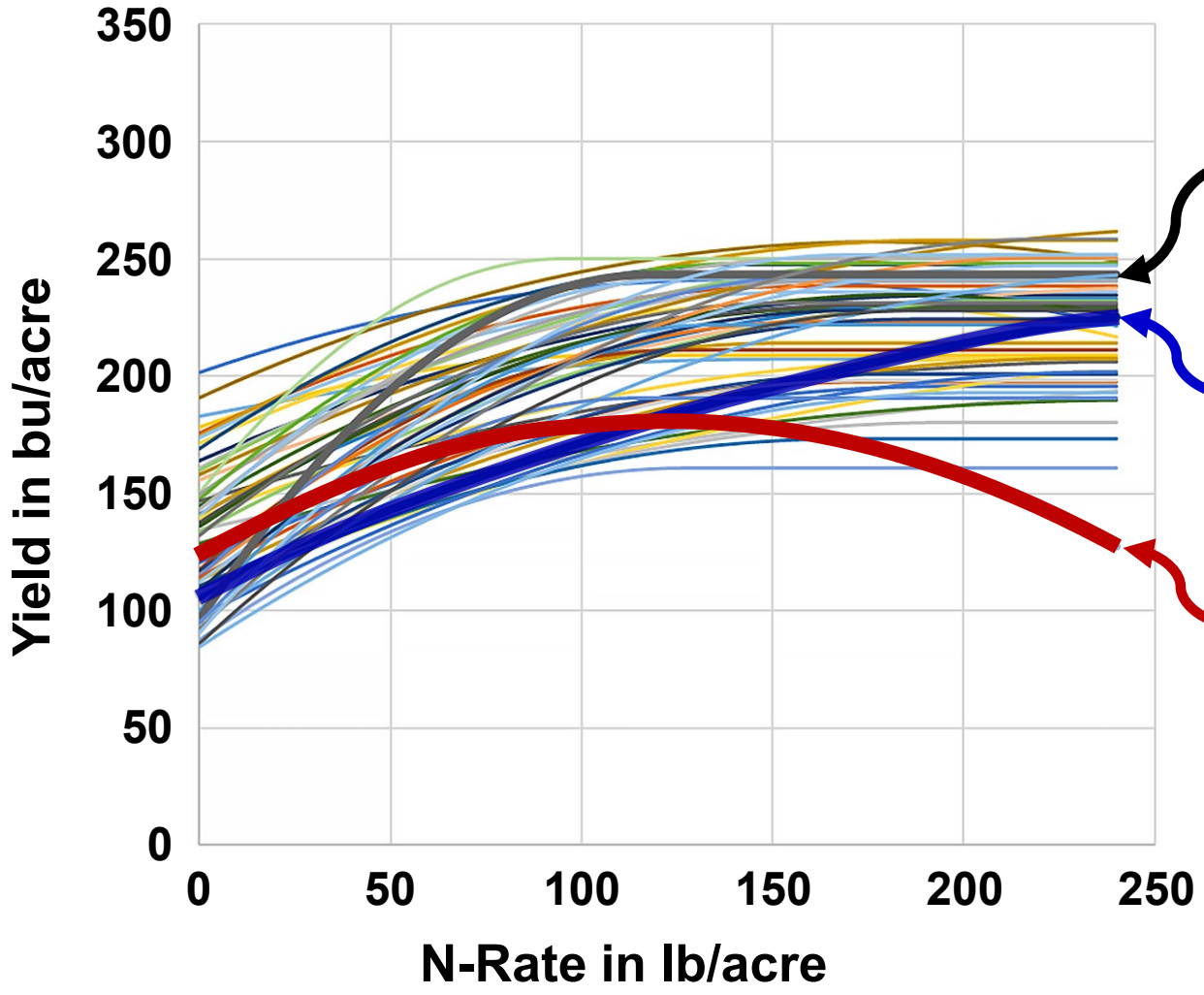
Central IL

Thanks to NREC and IFCA,
we have by far the best
N trial database of any state



N response curves

N responses subset, S-C Central Illinois



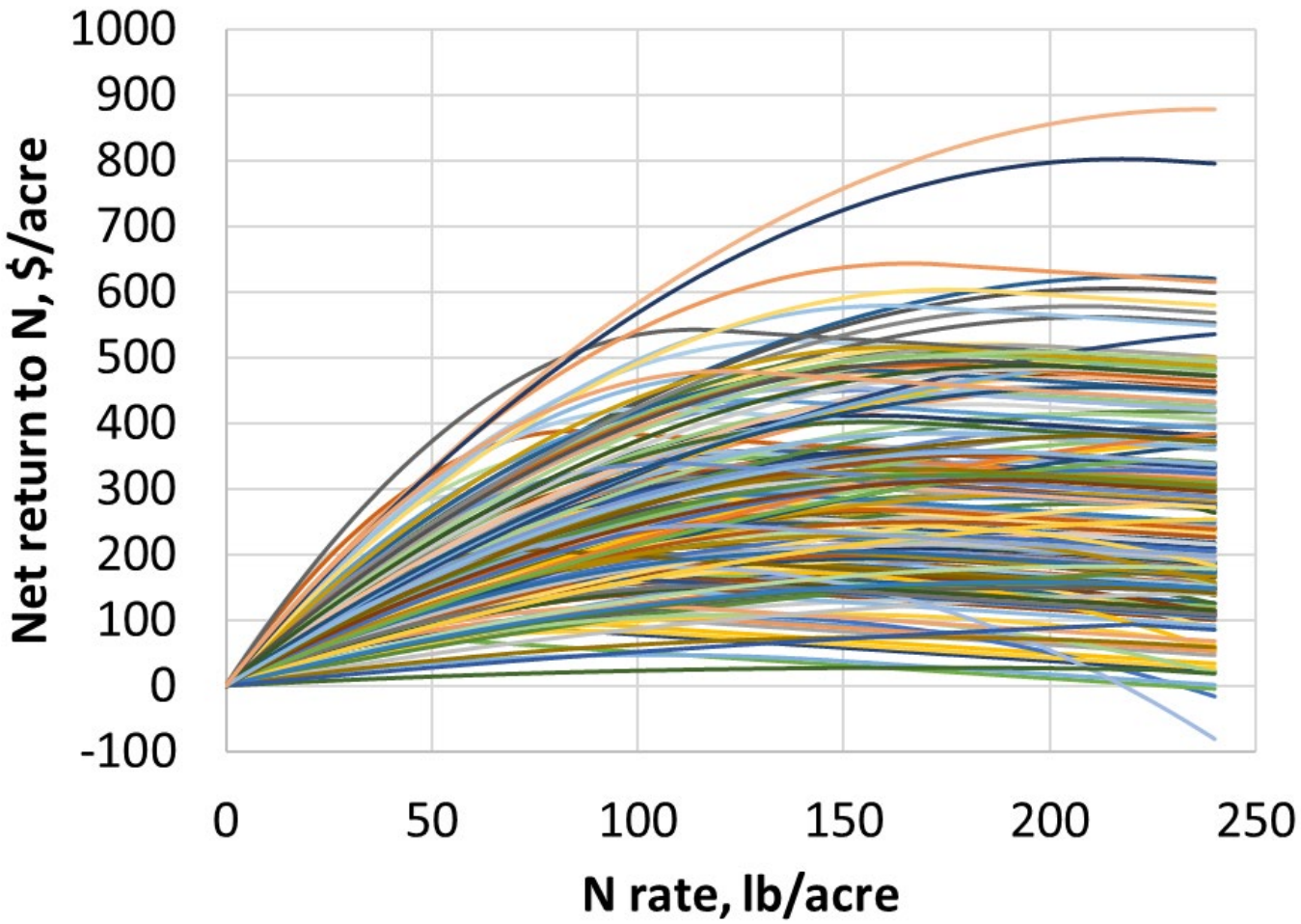
Most curves rise to a maximum (as “plateau”) then level off as N rates go higher

A few keep going up (usually with some curve) and don’t level off

A few rise to a maximum then decline as N rates continue to increase (rare - current hybrids don’t “fall apart” at high N)

Return to N

Net RTN, 200 S-C trials, Central Illinois



Convert yield responses to "return to N" (RTN) responses

- Subtract yield without N in each trial
- Convert yield response to $ response

Gross return

yield (increase) x price/bu

N cost

N rate x cost/lb N

RTN

= gross return minus N cost

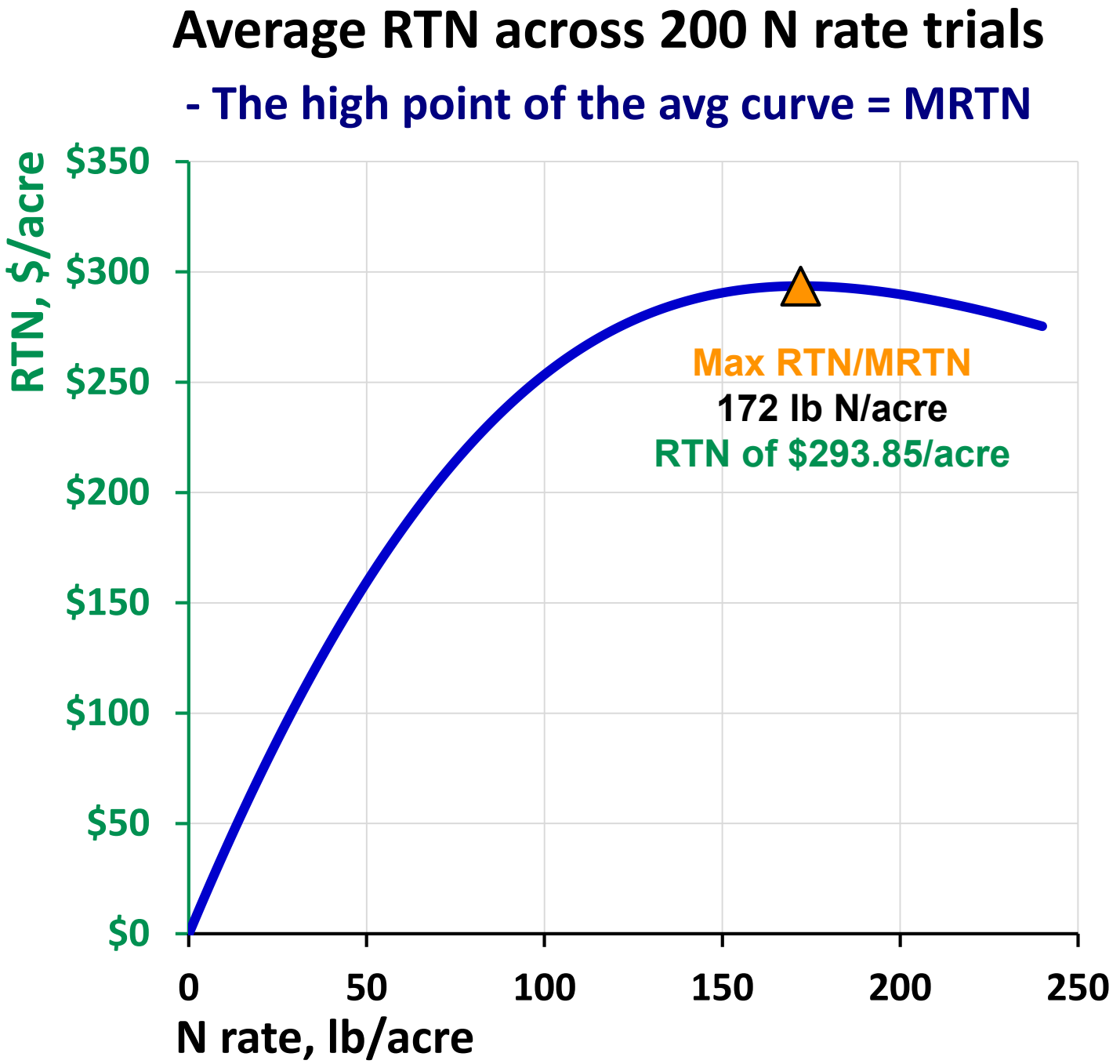
Final step

Average all RTN curves

The high point of the average curve = MRTN

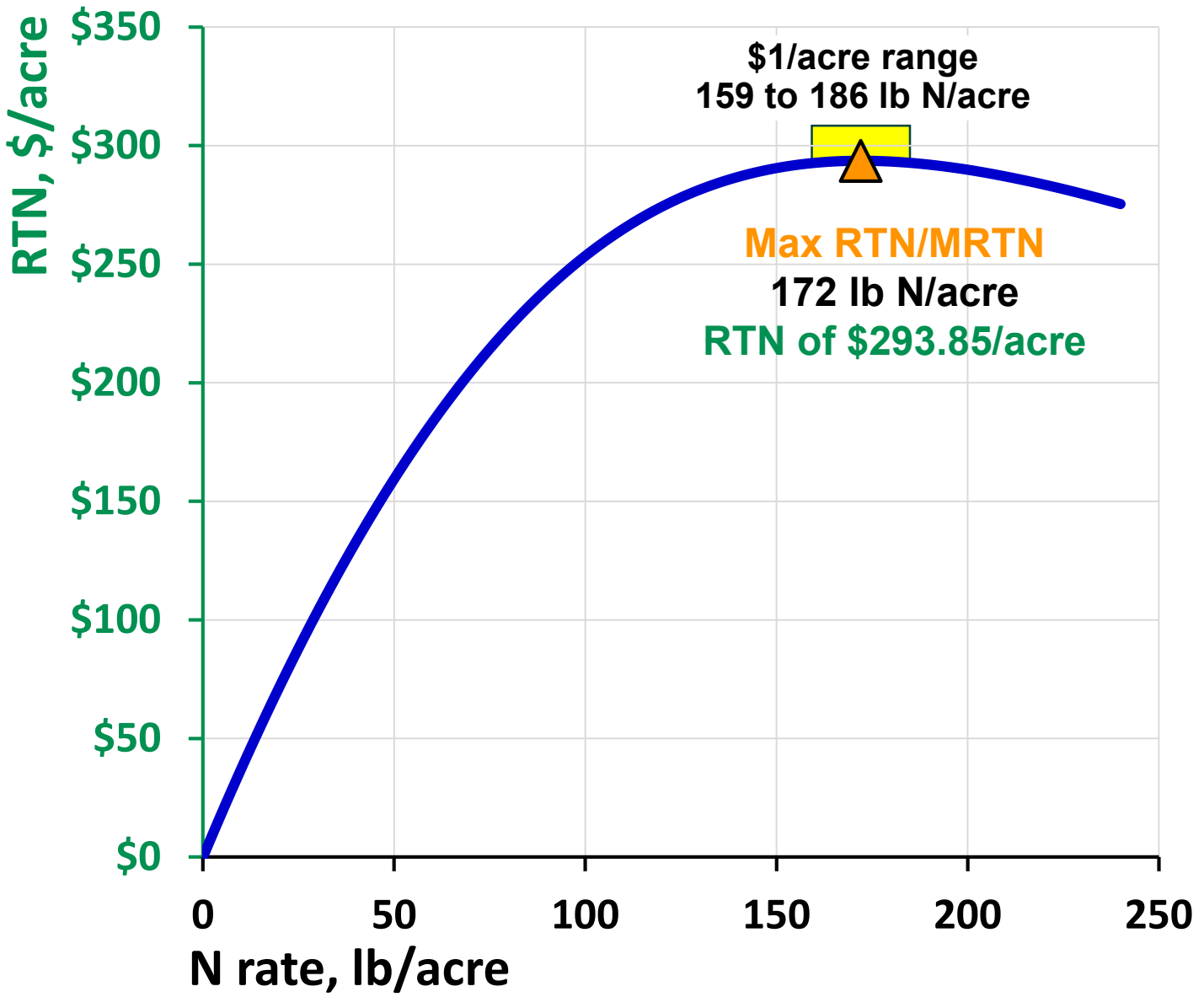
The shape of each curve changes as the N:corn price ratio changes:

- Lower corn/higher N price moves curves to the left (lower MRTN)
- Higher corn/lower N price moves curve to the right (higher MRTN)



One more thing: Ranges

- The RTN curve is relatively flat on top: RTN is not very sensitive to N rate around the MRTN
- So we added a range of rates within which the RTN is within $1/acre of the RTN at the MRTN (N rate)
- Range is typically ~15 lb N on each side of the MRTN



Points about the MRTN

It's based entirely on N response data

- More N response data (sites) are better, but we don't know the number of sites needed for the "best" prediction
- Sites with unusual weather can produce unusual responses: we include these unless there's a good reason not to
- Data from sites with similar soil (texture, depth, topography, drainage) will make a better prediction for that soil

More about the MRTN

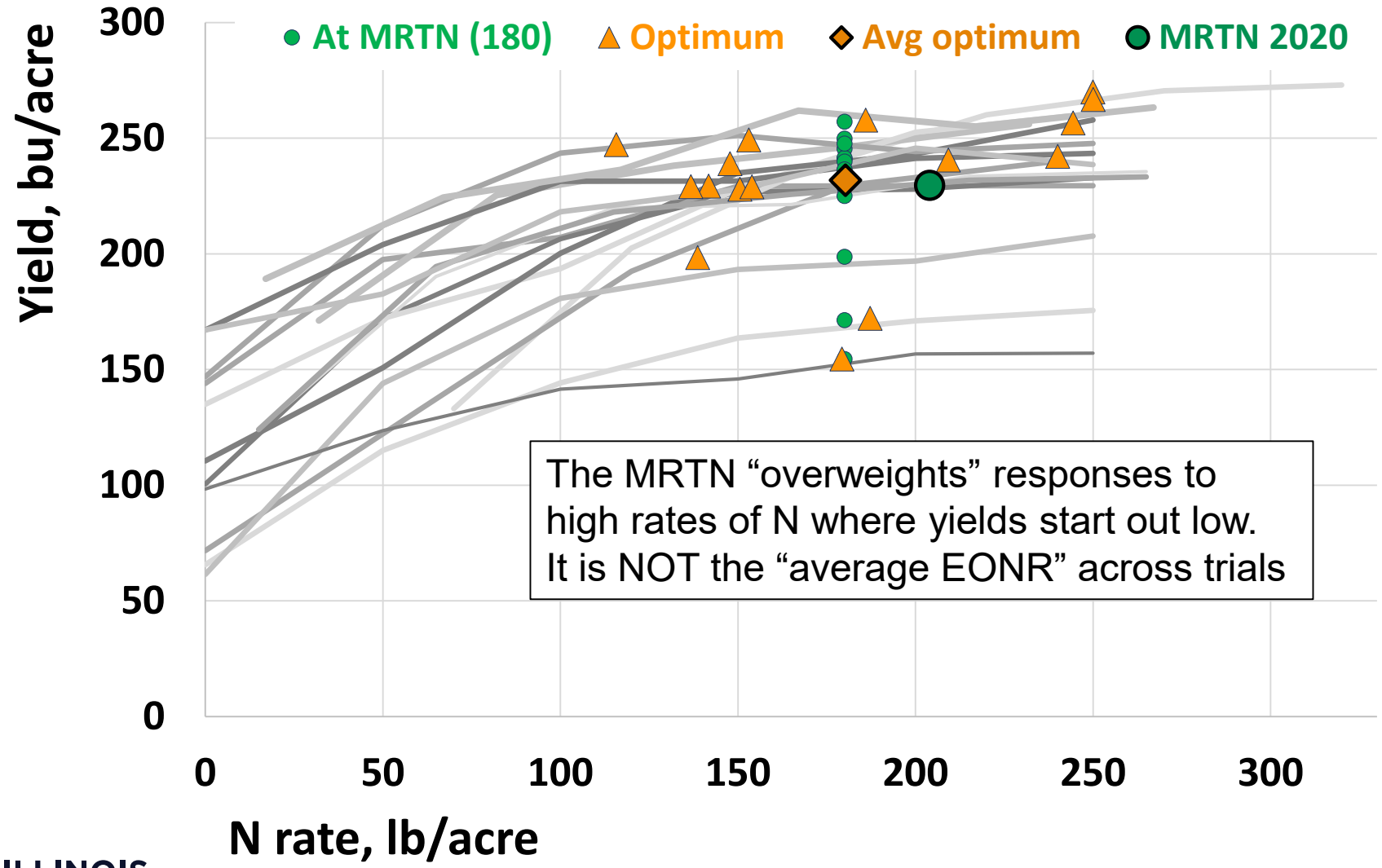
Having it based on data from previous trials means that it can't give a perfect prediction for a given field in a given year:

it is, though, the BEST GUESS we have

Finding best N rates is not a "contest": N responses are not predictable, and we either use results over a lot of trials or we make it up (e.g., "just use plenty of N")

How “imperfect” is the MRTN?

16 Soy-Corn Trials, Central IL, 2020



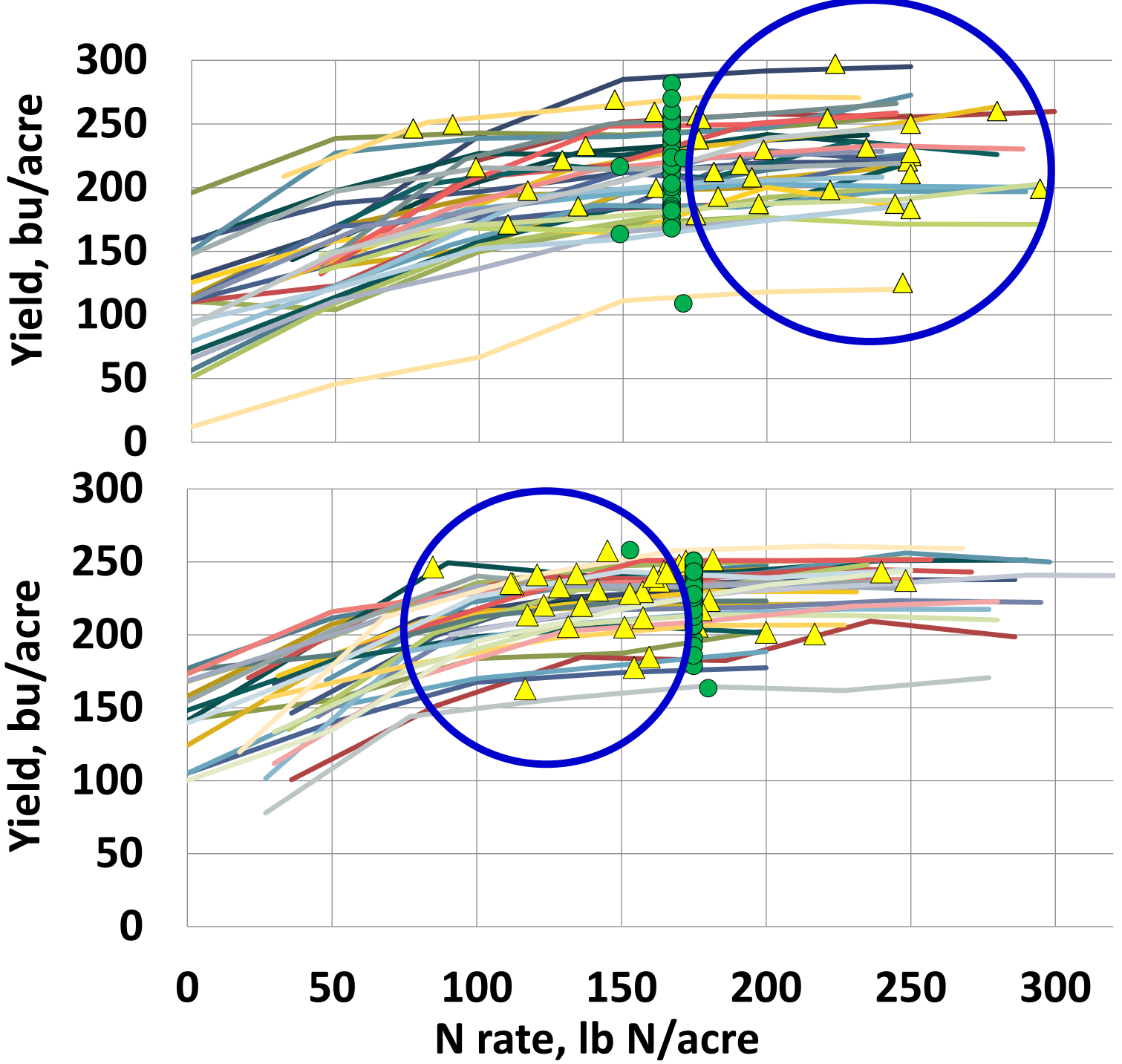
We can assess any set of response data against the predicted MRTN from previous trials

The MRTN based only on only these 16 sites is about 23 lb higher than the prior MRTN

Adding these data into the MRTN database increased the (2021) MRTN slightly

35 on-farm trials
Soy-Corn 2015
Wet June
High N rates needed

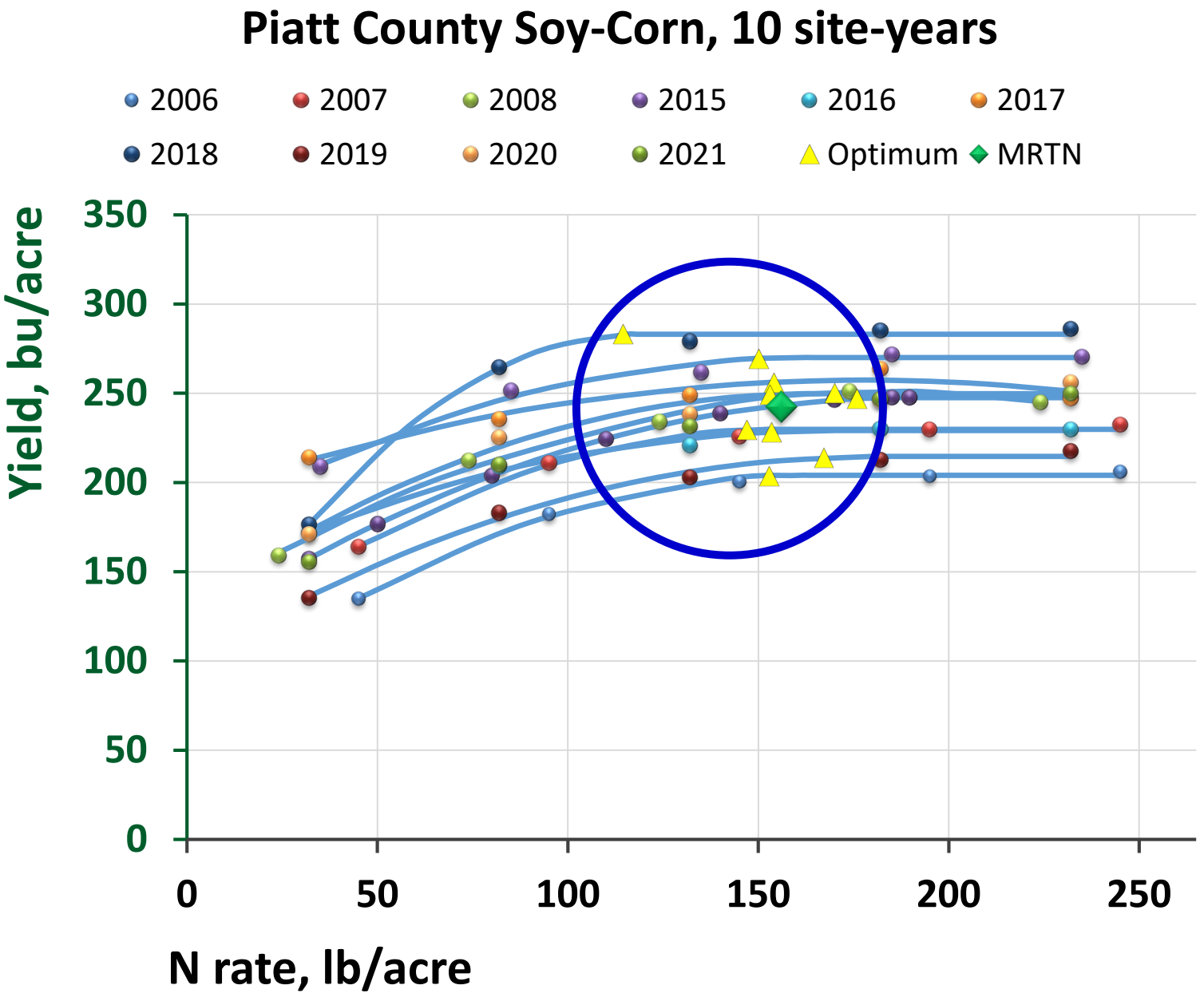
33 on-farm N trials
Soy-Corn 2016
Dry Spring
Low N rates needed



Repeated trials in the same set of fields sometimes show great consistency:

Set of data from a Piatt County cooperator:

- **EONR range:**
  115-176 lb N/acre (avg 154)
- **Y_{EONR} range:**
  204-283 (avg 243) bu/acre
- **MRTN (these data only):**
  156 lb N/acre
- **Yield at MRTN:** 242 bu/acre



Some are less consistent:

EONR range 89 to 250 (avg 162) lb N

Yield at EONR: 220 to 279 (avg 246) bu/acre

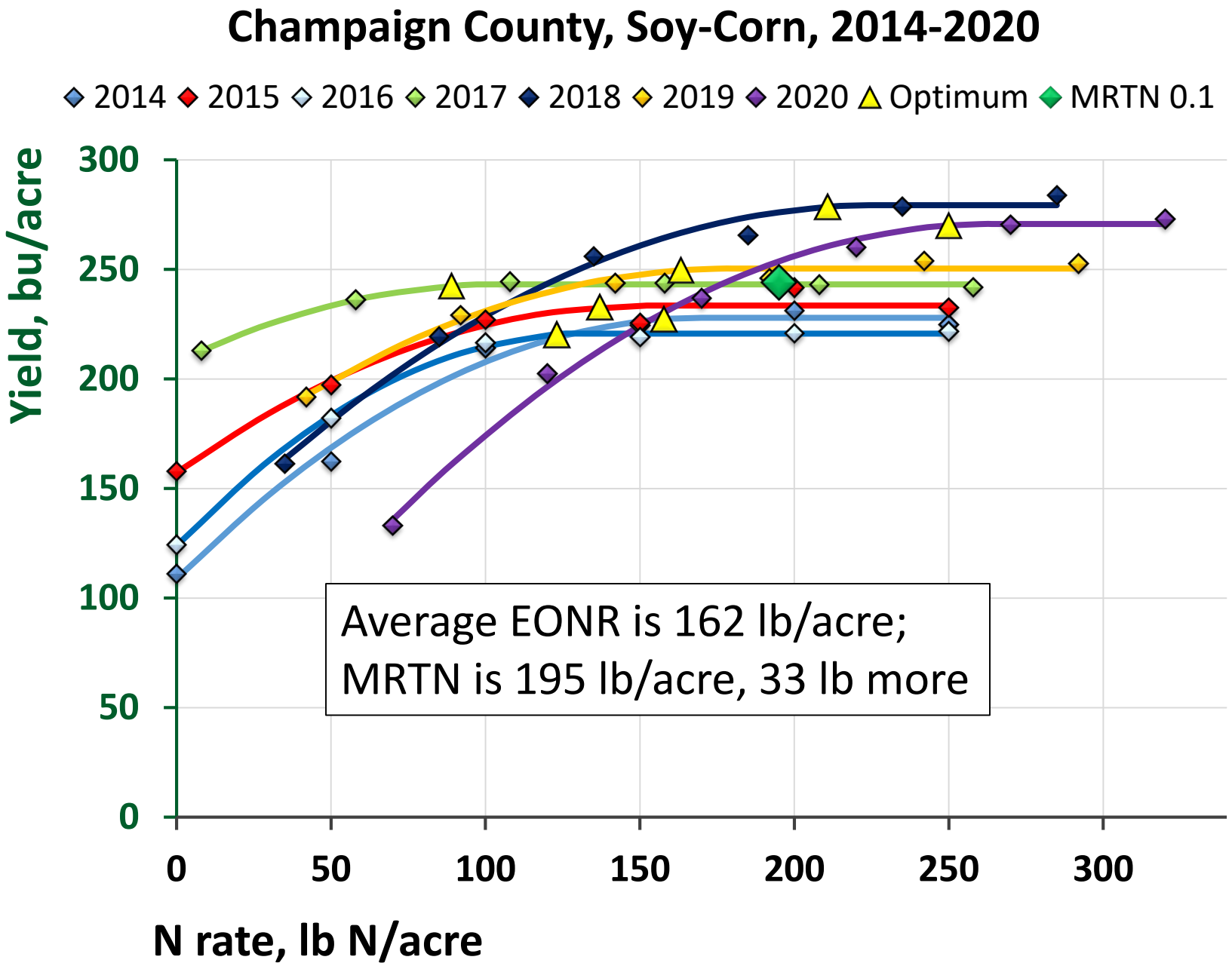
MRTN: 195 lb N/acre

Avg yield at MRTN: 244 bu/acre

MRTN > EONR in 5 of 7 years

Had we known (and used) actual EONR each year:

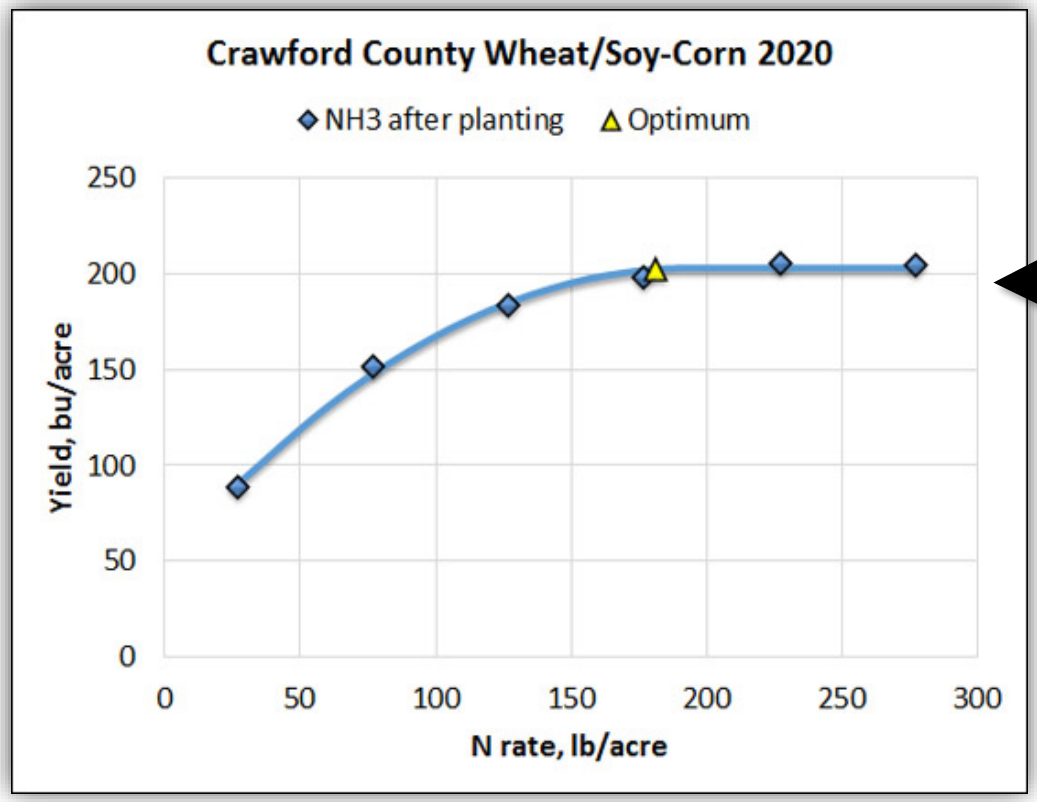
+ 2 bushels/acre
− 33 lb N/acre
+ $26/acre net RTN/acre

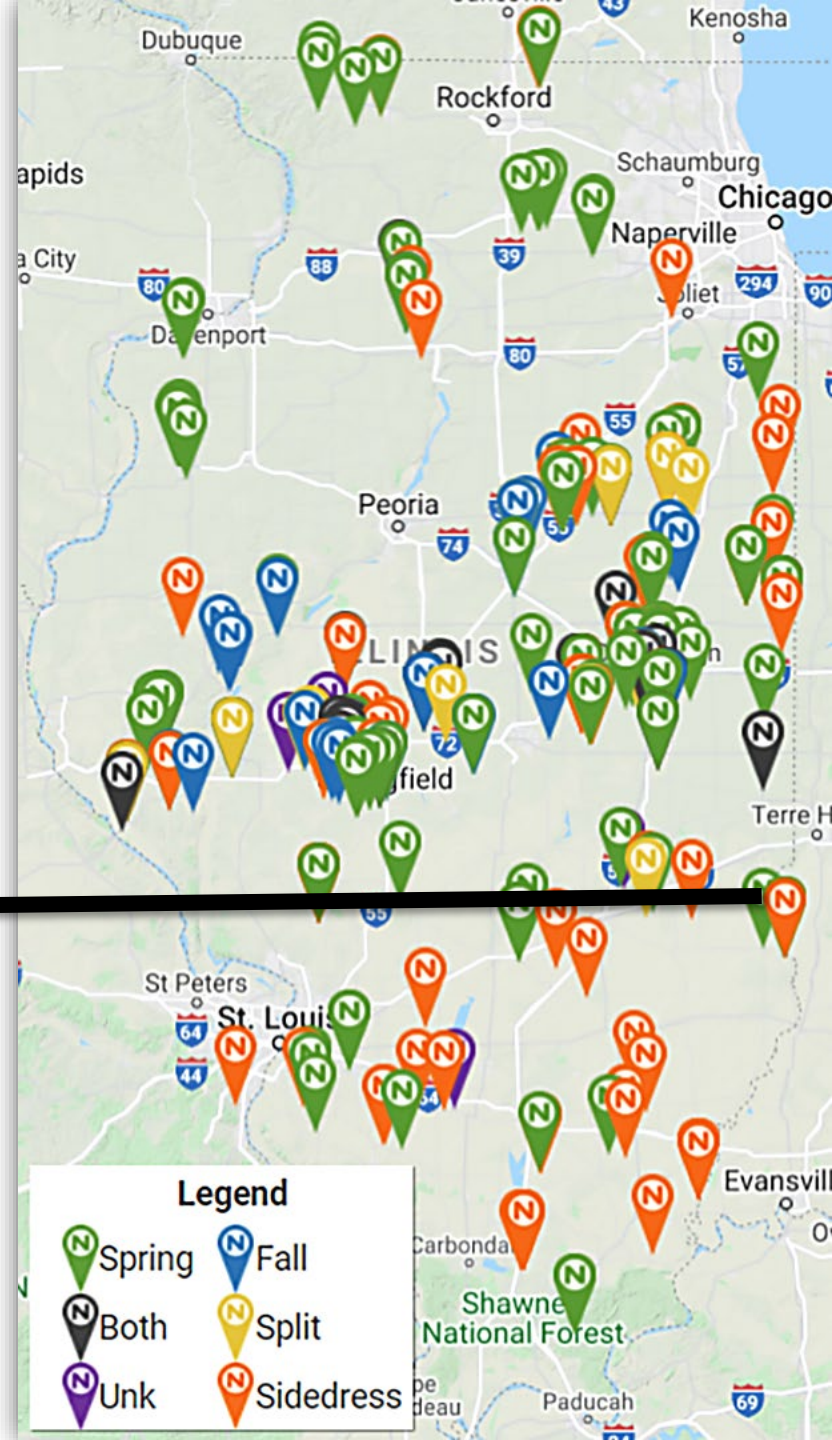


Between 2014 and 2020, we **added 374 N trials** to the MRTN database

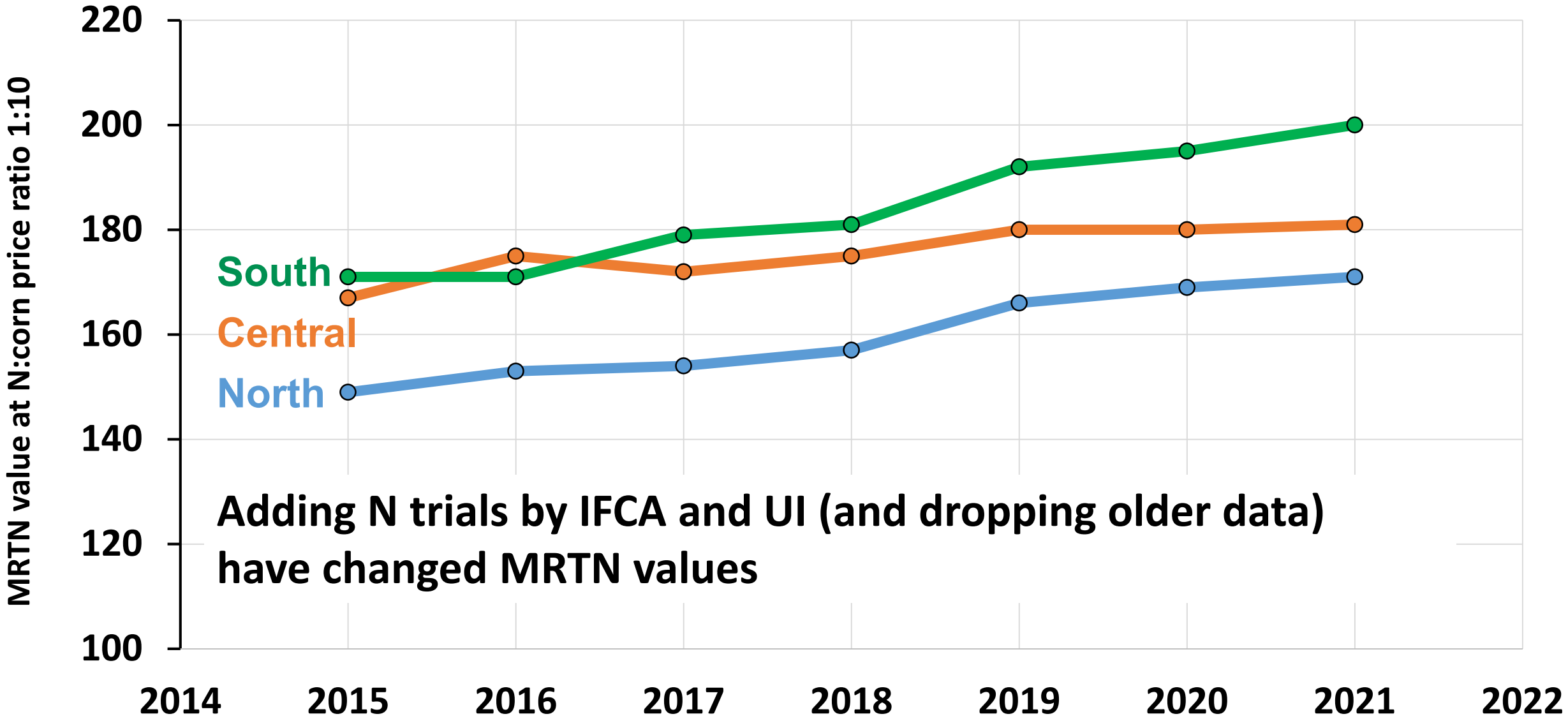
- 266 on-farm (from IFCA)
- 108 from research center trials

Most were funded by NREC.



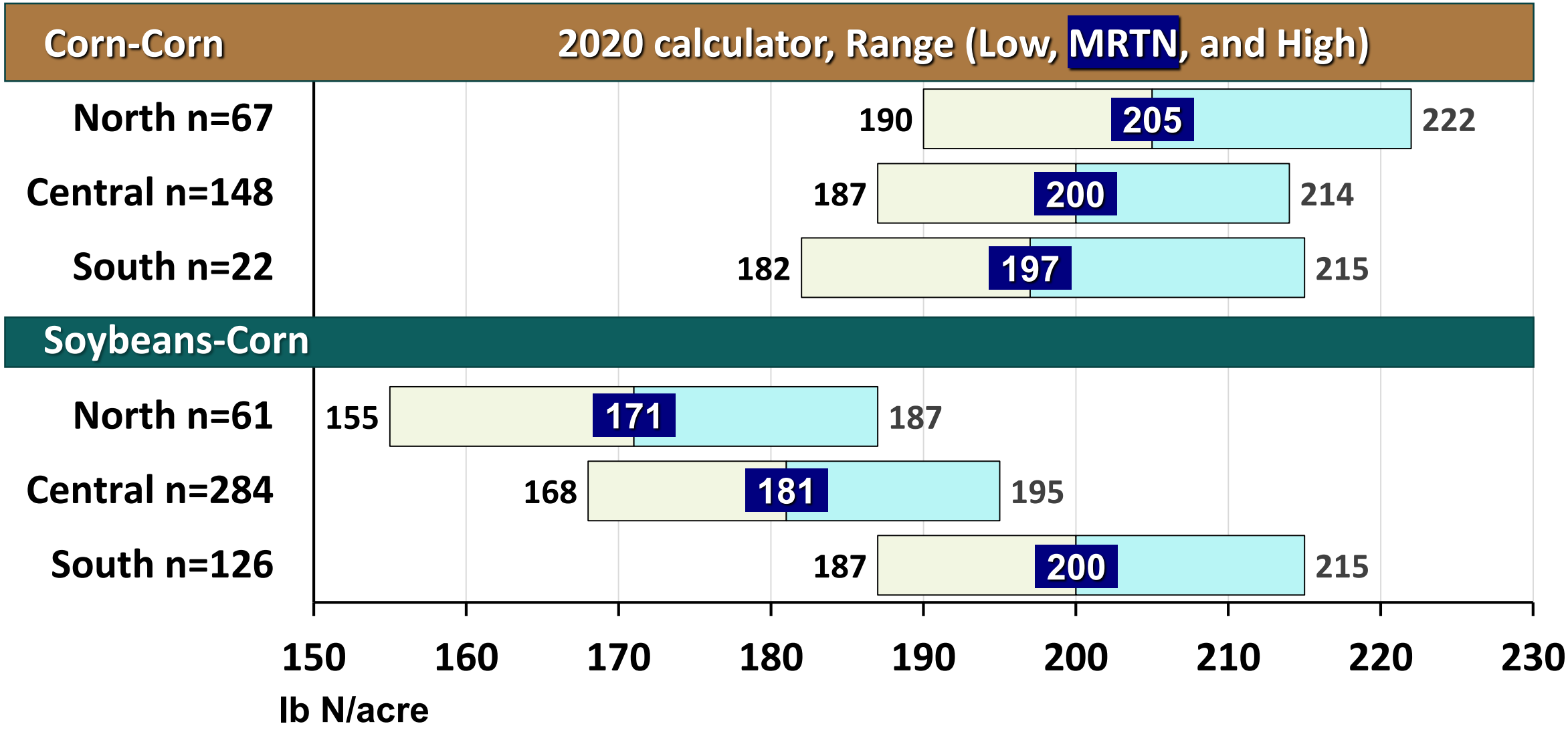


Change in Illinois MRTN, 2015 to 2021



Illinois corn N rate calculator output for 2021

Numbers below at N:corn price ratio of 1:10



http://cnrc.agron.iastate.edu/nRate.aspx

“Knocks” on the MRTN

It’s “one size fits all” without taking into account soils, weather, yields, etc.

- MRTN will (by definition) work better for fields similar to those in the database
- Even knowing yield doesn’t help set N rate
- Weather and its effects are no more predictable than yield
- N loss can be modeled/measured, but may be less important in most fields than root issues (growth pattern or waterlogging)
- The inability to estimate soil N contribution is a major issue, and is likely to remain so

“Knocks” on the MRTN

It doesn’t help with site-specific N rate within fields

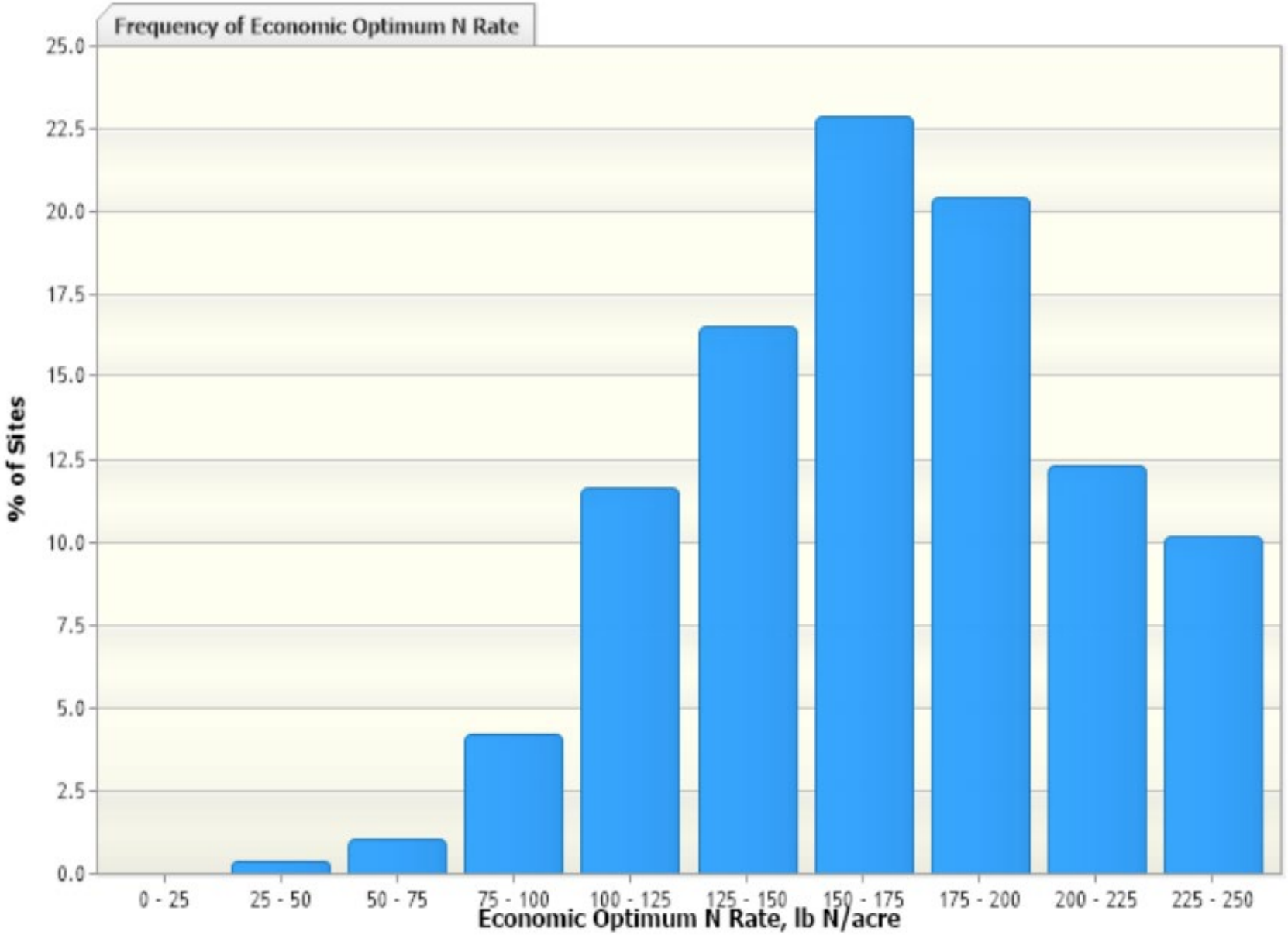
- No method has been shown to consistently set N rates within fields that increase profits compared to a uniform rate across the field

- A “mirror soil OM” application map (higher N rates with lower OM; lower rates with higher OM; floor and ceiling rates) is reasonable, but how it affects yield, N use, and profitability remain open questions

EONR rates vary a lot across trials

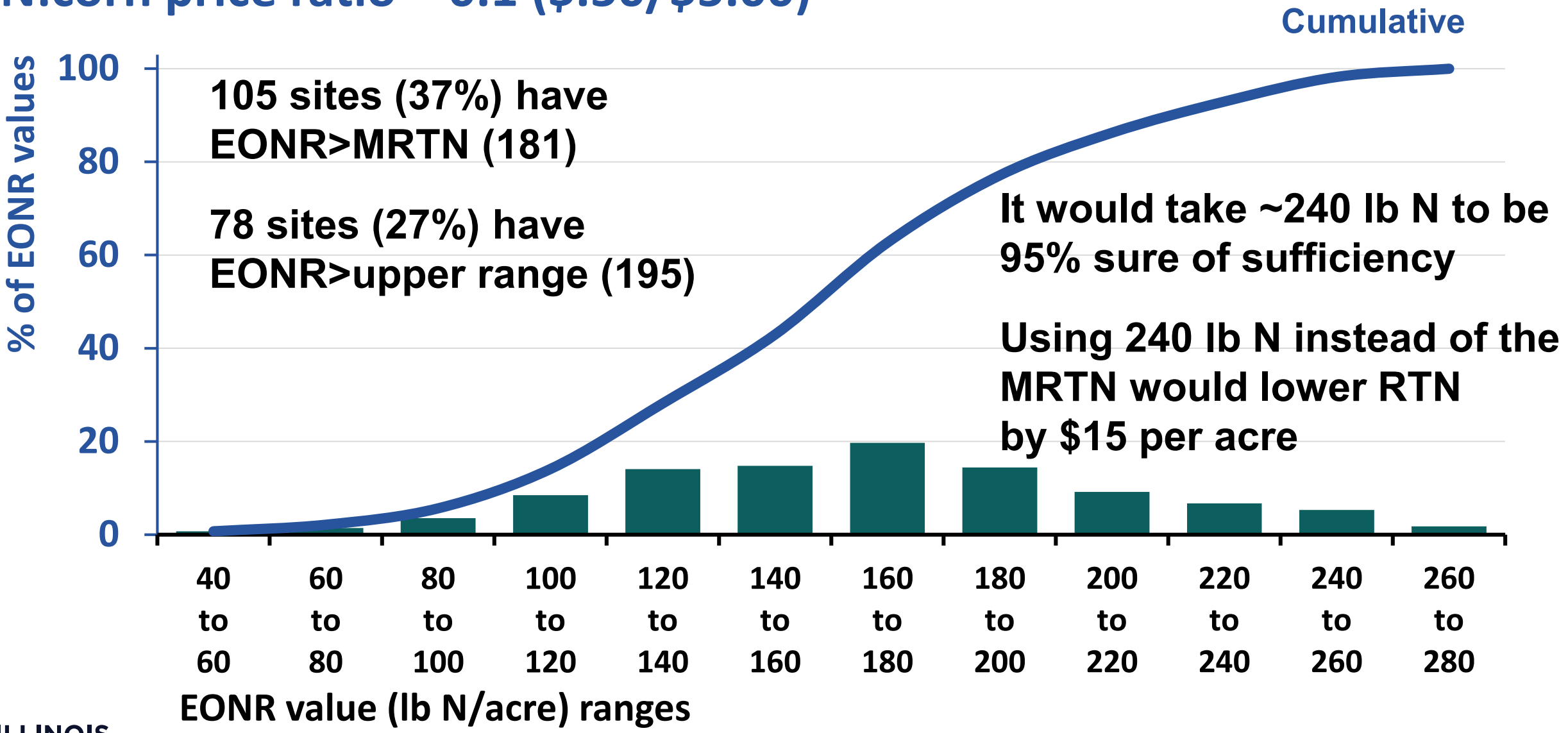
From the N rate calculator website:

Central Illinois
Corn following soybean
284 sites



Central IL soy-corn, 284 trials

N:corn price ratio = 0.1 ($.50/$5.00)



“Knocks” on the MRTN

Using corn and N prices to set N rate might make economic sense, but not agronomic or environmental sense

- The N rate that maximizes yield (“agronomic optimum”) is typically about 20 lb more than the EONR: adding it adds about a bushel more yield and loses half the $ value of that bushel
- Corn and N prices have been moving in the same direction in recent years, so the ratio (and MRTN rates) haven’t moved greatly

Changing MRTN with changing prices, 2021

Corn at $5.00; N price as indicated

		MRTN at N price, $/lb		
IL Region	Rotation	$0.30	$0.40	$0.50
North	Soy-C	194	182	171
	Corn-C	235	218	205
Central	**Soy-C**	**200**	**190**	**181**
	Corn-C	227	211	200
South	Soy-C	225	210	200
	Corn-C	225	211	197

If using more than one source, use the price of the source used for the last (rate-finishing) application to set total rate

Fall of 2020

NH_3 $500/ton, Corn $4.00/bu

N:C ratio 0.076

CIL SC MRTN = 192

Spring 2021

NH_3 $700/ton, Corn $5.25/bu

N:C ratio 0.081

CIL SC MRTN = 189

Fall 2021

NH_3 $800/ton, Corn $5.15/bu

N:C ratio 0.095

CIL SC MRTN = 183

“Knocks” on the MRTN

Yields of 250+ bushels surely need more than 185 lb N

- Hundreds of N response curves say otherwise: the soil supplies on average about half of the N taken up by the crop
- N response curves show that responses diminish as N rates increase:

  It takes about 10 lb of N to add the last bushel up to the yield at the EONR
- Today’s hybrids grow faster and are better at taking up nutrients and water than older hybrids; this makes soil-supplied N a more consistent part of the N supply

To trust the MRTN

We have to trust the soil to supply some of the N;

it doesn't all need to come from fertilizer

And the BIG question:

- How can anyone really know whether the N rate used was too low, about right, or too much?
- Providing more N than the crop needs seldom leaves visible clues: the only way to know if too much N was used is to do a comparison trial with (at least two) different rates in the field
- Applying somewhat less fertilizer N than the crop needs often doesn't produce visible signs of deficiency (except in our imagination)
  - Water in low spots → N-deficient corn, mostly due to root issues not lack of N
  - Corn without N fertilizer is often dark green early; uniform deficiency across entire fields is rare in higher-OM soils with >150 lb N applied

What's next for improving N rate predictions?

- Fewer full-rate trials, many smaller trials more easily (and cheaply) done by producers, to produce data that will BUILD CONFIDENCE in the MRTN:
  - Only two rates, including the one used in a field plus one lower or higher, chosen to form two rates (in the MRTN range and ~50-60 lb higher)
  - Plots 1/2 to 1 acre in size to allow sensing (aircraft, drone, etc.) during the season; YM yields from each rate on each side of each plot
  - On different soils within and across (many) fields
- Sensing & yield monitor data along with weather and soil information can be used to "train" an N prediction model that would improve on the current one
- Dan Schaefer at IFCA will lead the field phase, with cooperation from the Precision Conservation Management program, retailers, and others

Instead of this (in 30-40 IL fields)

Something like this:

In lots of fields

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ednaf@illinois.edu

Dan Schaefer
dan@IFCA.com

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Please submit your questions

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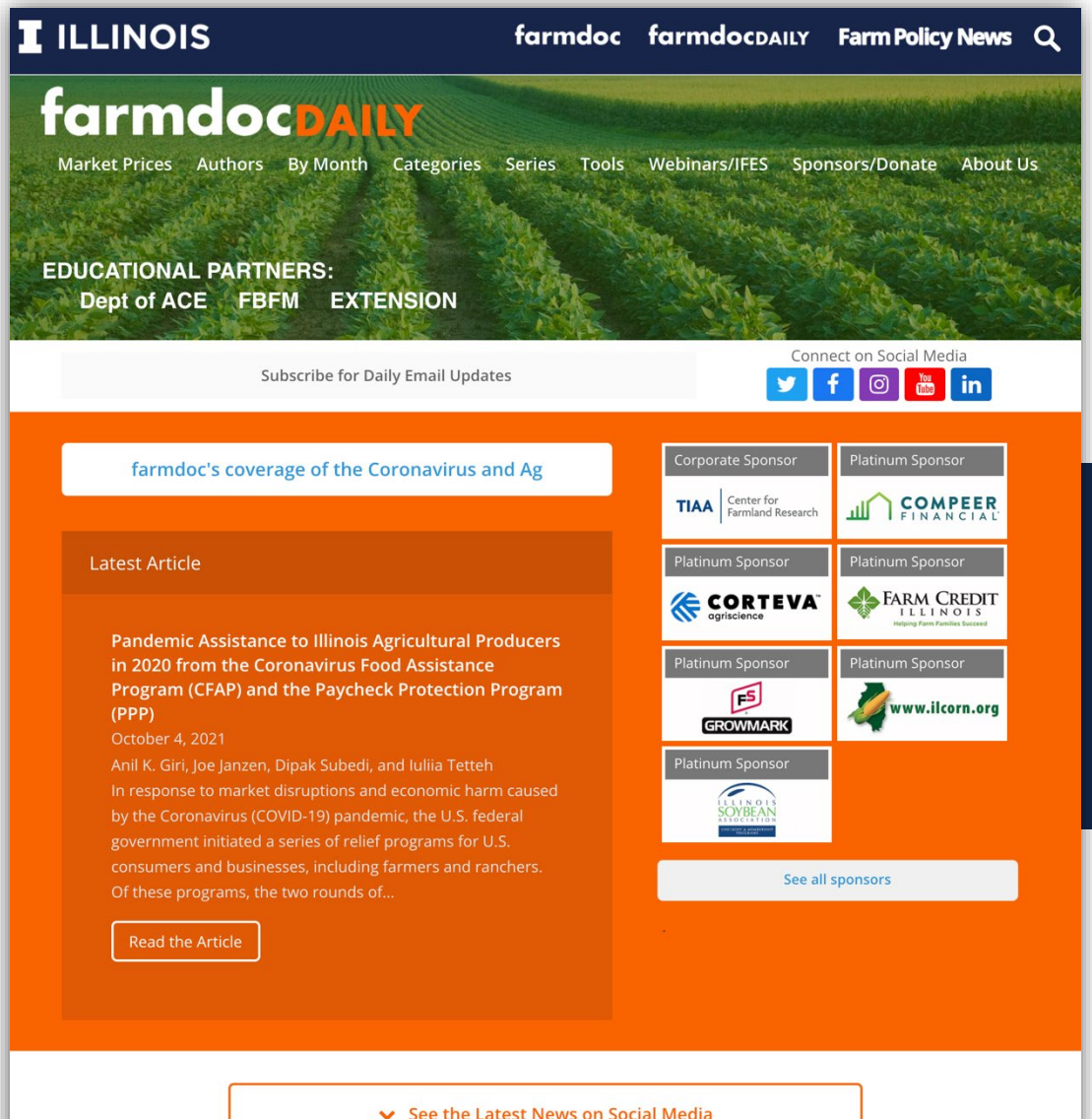

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