How efficient with nitrogen can you be:

Lessons from the Discovery Farms NUE benchmarking project

Abby Augarten
Matt Ruark, Amber Radatz, Kevan Klingberg, Aaron Wunderlin, Todd Prill, Erica Olson & Eric Cooley

Wisconsin Agribusiness Classic

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Challenge: farmers are under extreme pressure to optimize N values

If farmers wanted to adjust N rates, they would base this on:

- trial and error
- UW recommendations
- farmer led groups
- crop consultants/agronomists

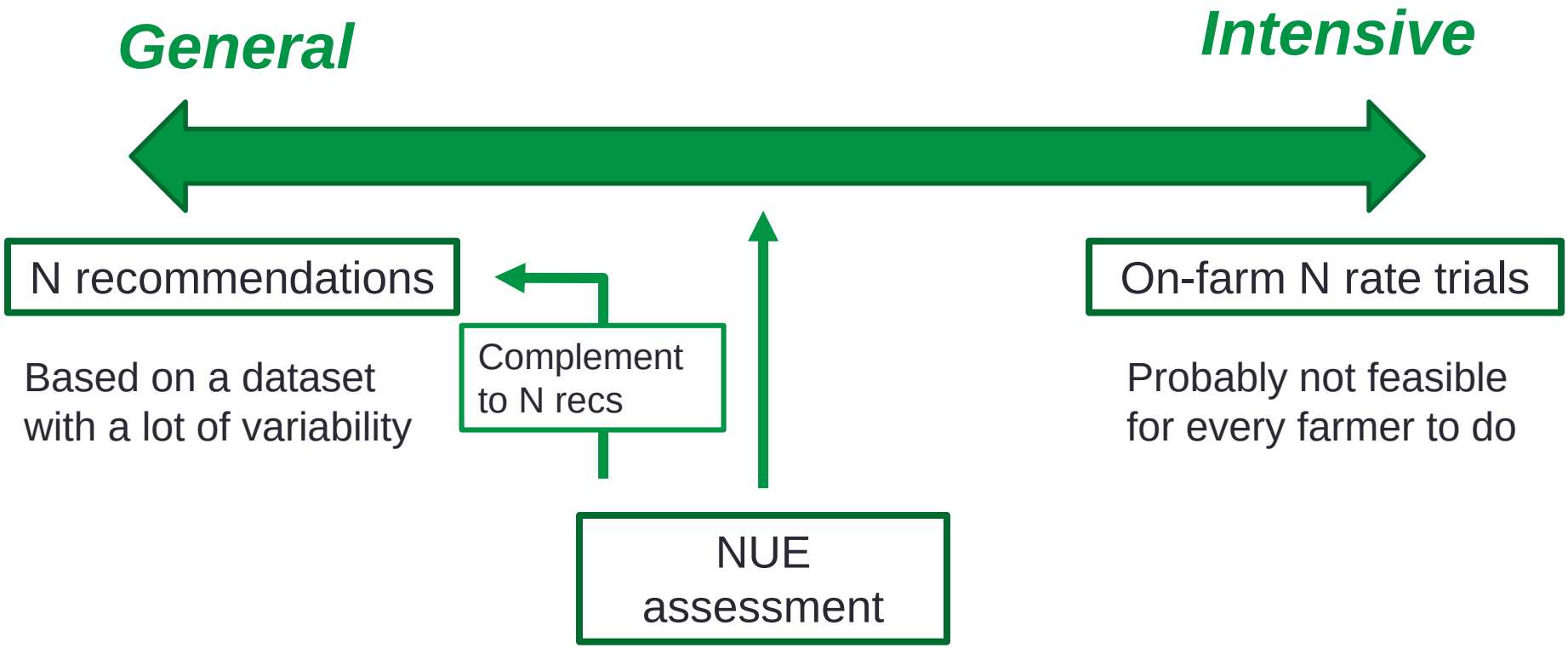
Nitrogen Use Efficiency (NUE) is a self-evaluation tool that can shape these management decisions

There are two simple measures of NUE that are useful for benchmarking and self-evaluation

$$\text{Partial factor productivity (}\mathbf{PFP}\text{)} = \frac{\text{Yield (lb/ac)}}{\text{N applied (lb/ac)}}$$

$$\text{Partial nutrient balance (}\mathbf{PNB}\text{)} = \frac{\text{N removed in harvested crop (lb/ac)}}{\text{N applied (lb/ac)}}$$

NUE is an easy to use assessment tool for farmers, crop consultants and conservationists who want to evaluate current N management



NUE is not about finding the **perfect rate,** lower rate, or higher rate statewide

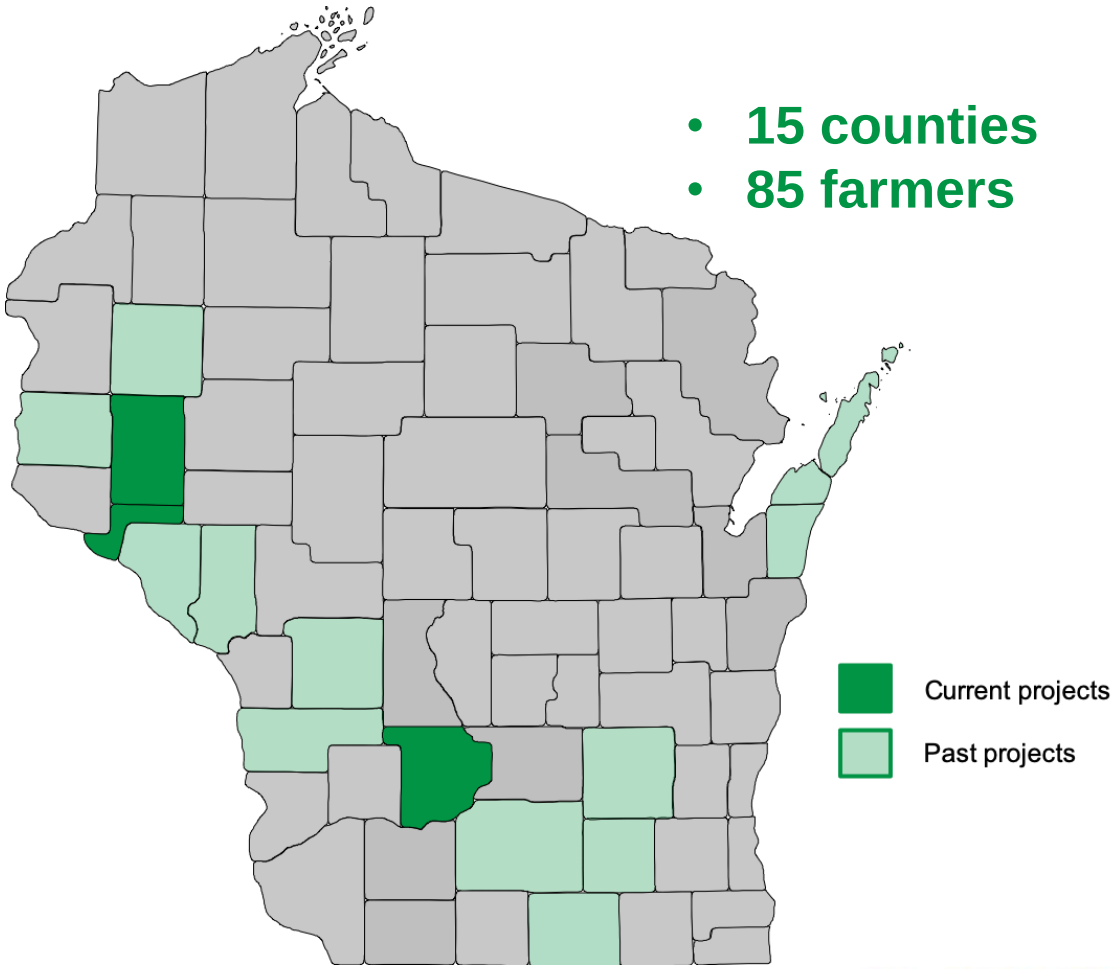
but about providing a tool to assess:

- how N is currently being managed
  - Complement N recs and nutrient management plans
  - Demonstrates field and soil dynamics within a specific farm and system
- if improvements can be made
- evaluate if shifts in management are effective

THE NUE Project began in 2015 with a *Conservation Innovation Grant* to help farmers assess their current N management practices in corn production and how they can improve

1. **Benchmarks for different NUE metrics**: individual farmer assessment tool

2. **Trends in our dataset:** what contributes to higher or lower efficiencies



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Our dataset represents WI's diverse systems

NUE Dataset: Management Styles				
Crop grown	Corn grain		Corn Silage	
	186		110	
Rotation	Continuous Corn	Corn-Alfalfa	Corn-Soybean	Corn-SB-small grain
	32	112	103	28
Manure Use	Manure		No Manure	
	162		134	
Tillage	Conventional Tillage	Reduced Tillage	No-Till (short term)	No-Till (long term*)
	107	44	65	73
Cover Crops	Cover Crops		No cover crops	
	80		216	

*Long-term no-till defined as over 10 years

The majority of fields are well drained, silt loams

Soil Type	
Sand	2
Loamy sand	20
Fine sandy loam	16
Silt loam	212
Loam	10
Silty clay loam	11
Clay loam	1

Drainage Class	
Excessively drained	10
Somewhat excessively drained	6
Well drained	178
Moderately well drained	59
Somewhat poorly drained	23
Poorly drained	15
Very poorly drained	5

NUE is an easy to use assessment tool

1. Calculate NUE
   - PFP and PNB can be done on any field

2. Consult benchmarks to determine the NUE category for that field

3. Follow the decision trees for that category to determine if and what shifts in management would be appropriate

4. Evaluate NUE in future seasons to assess if improvements were made

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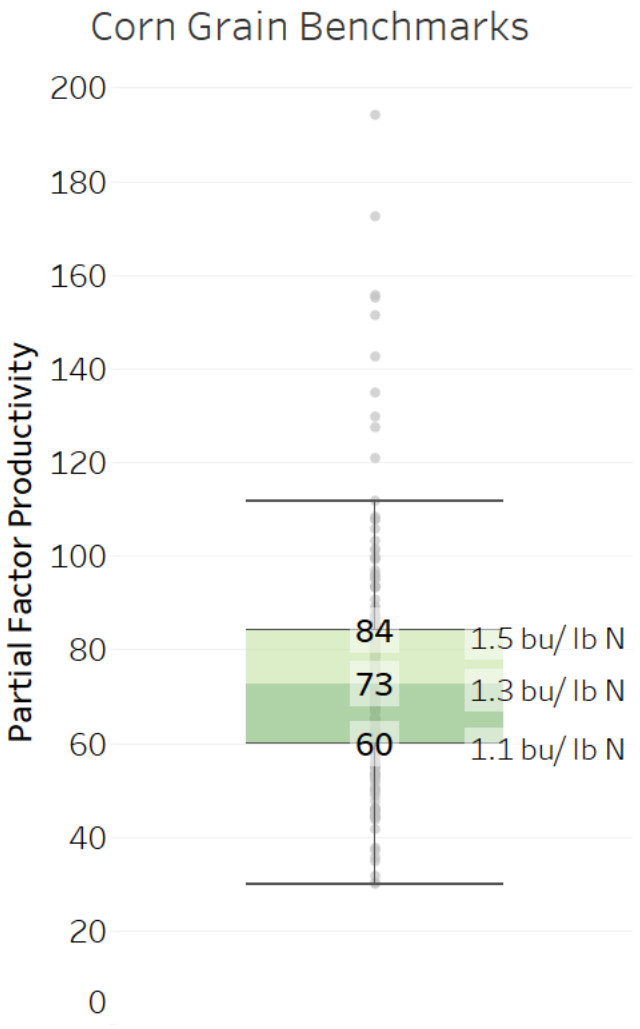
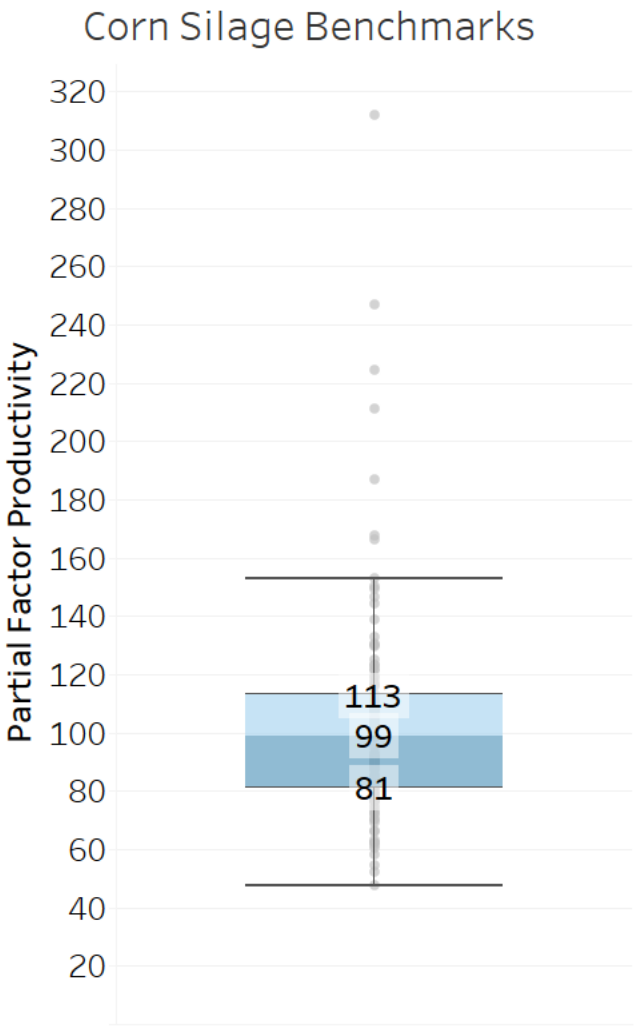
PFP is the first step to assessing the efficiency of N

$$\text{Partial Factor Productivity} = \frac{\text{Yield (lb/ac)}}{\text{N applied (lb/ac)}}$$

- **Manure N** (calculated using manure analysis or book values)
- **Fertilizer N** (calculated using rates and %N)
- **Legume N** (90 lb N/ac for alfalfa stands)

Benchmarks are created for corn grain and corn silage





$$\text{Partial factor productivity (}\mathbf{PFP}\text{)} = \frac{\text{Yield (lb/ac)}}{\text{N applied (lb/ac)}}$$

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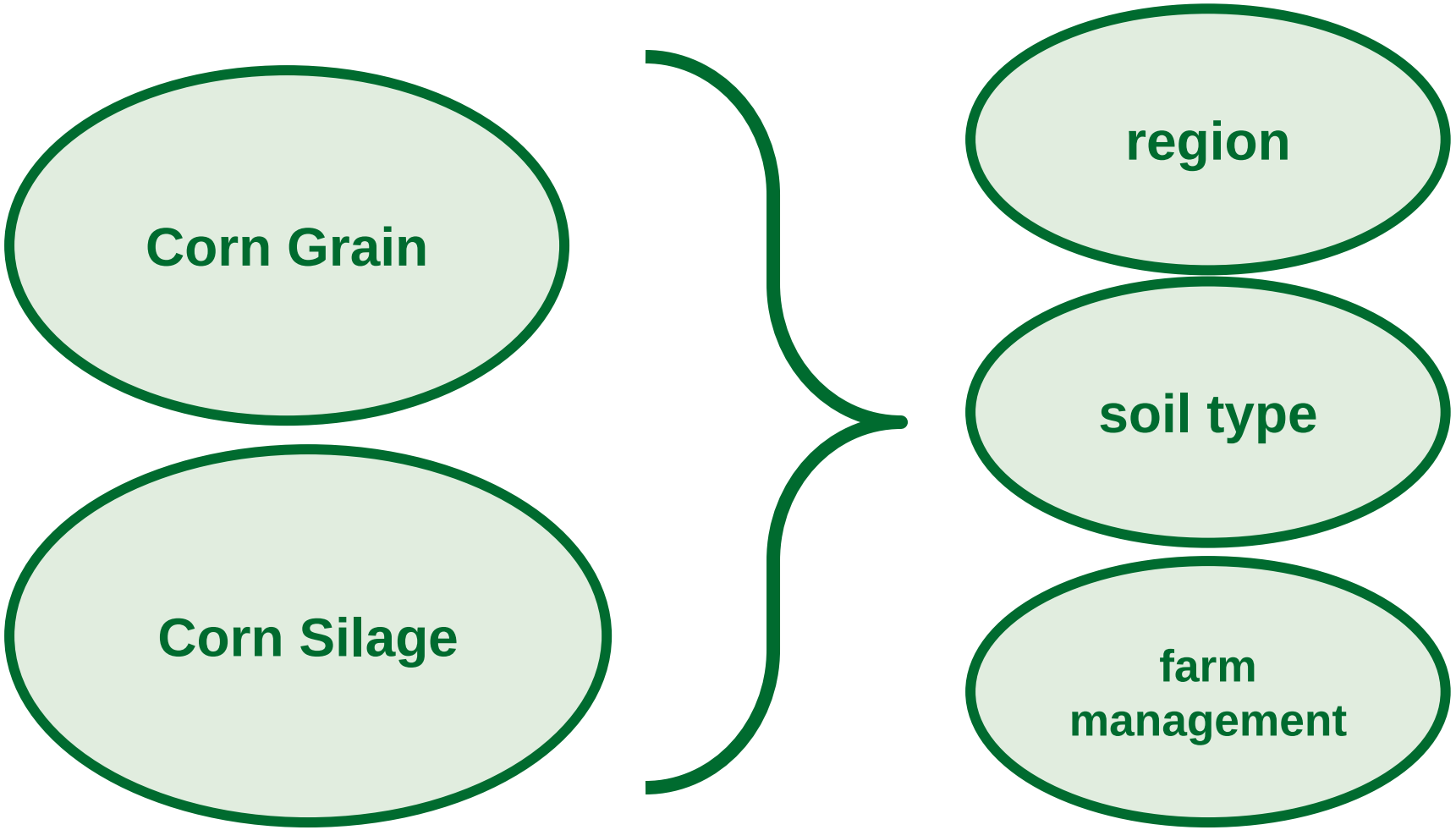
As we expand our database we will look at benchmarks based on region, soil type, or management system



NUE is an easy to use assessment tool

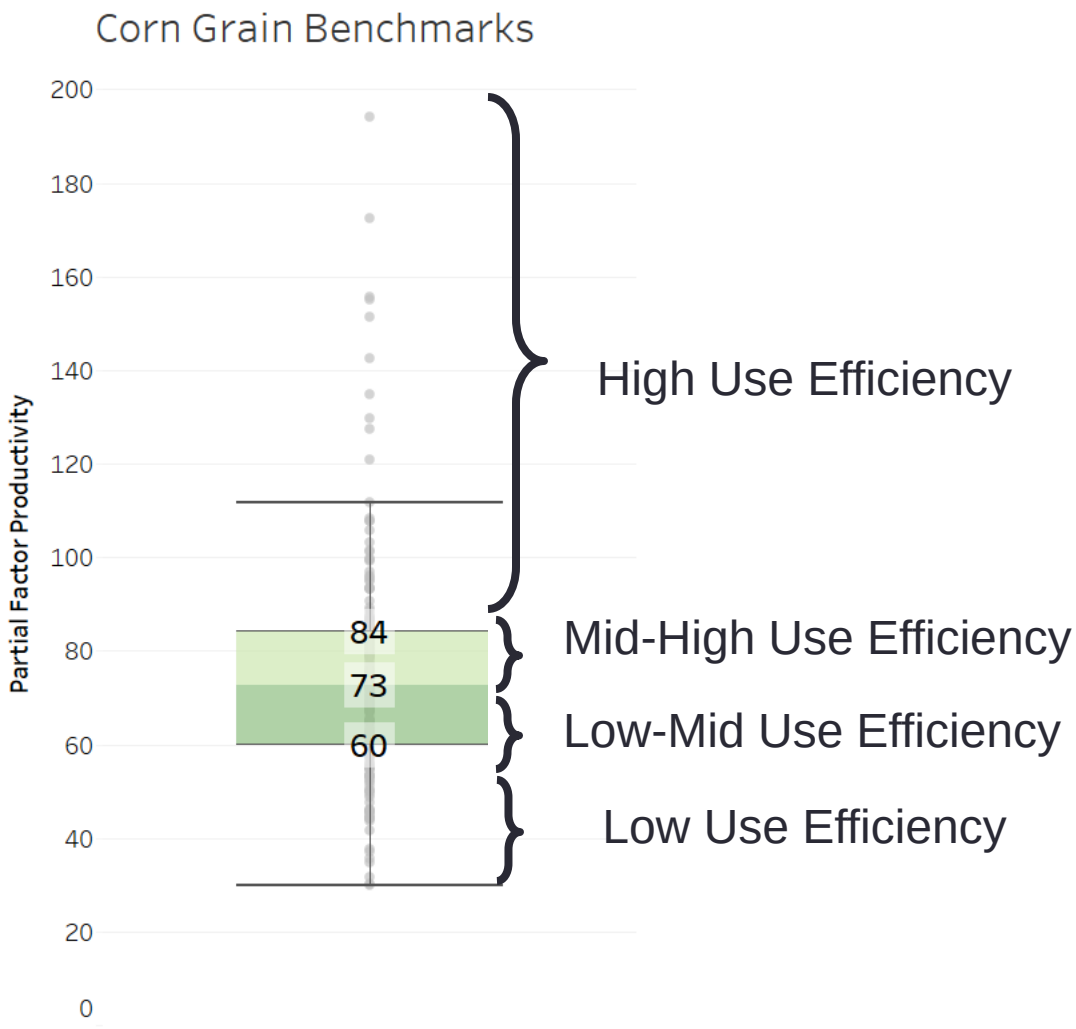
1. Calculate NUE
   - PFP and PNB can be done on any field

2. **Consult benchmarks to determine the NUE category for that field**

3. Follow the decision trees for that category to determine if and what shifts in management would be appropriate

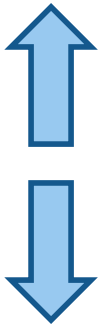
4. Evaluate NUE in future seasons to assess if improvements were made

Four NUE categories were created based off the benchmarks



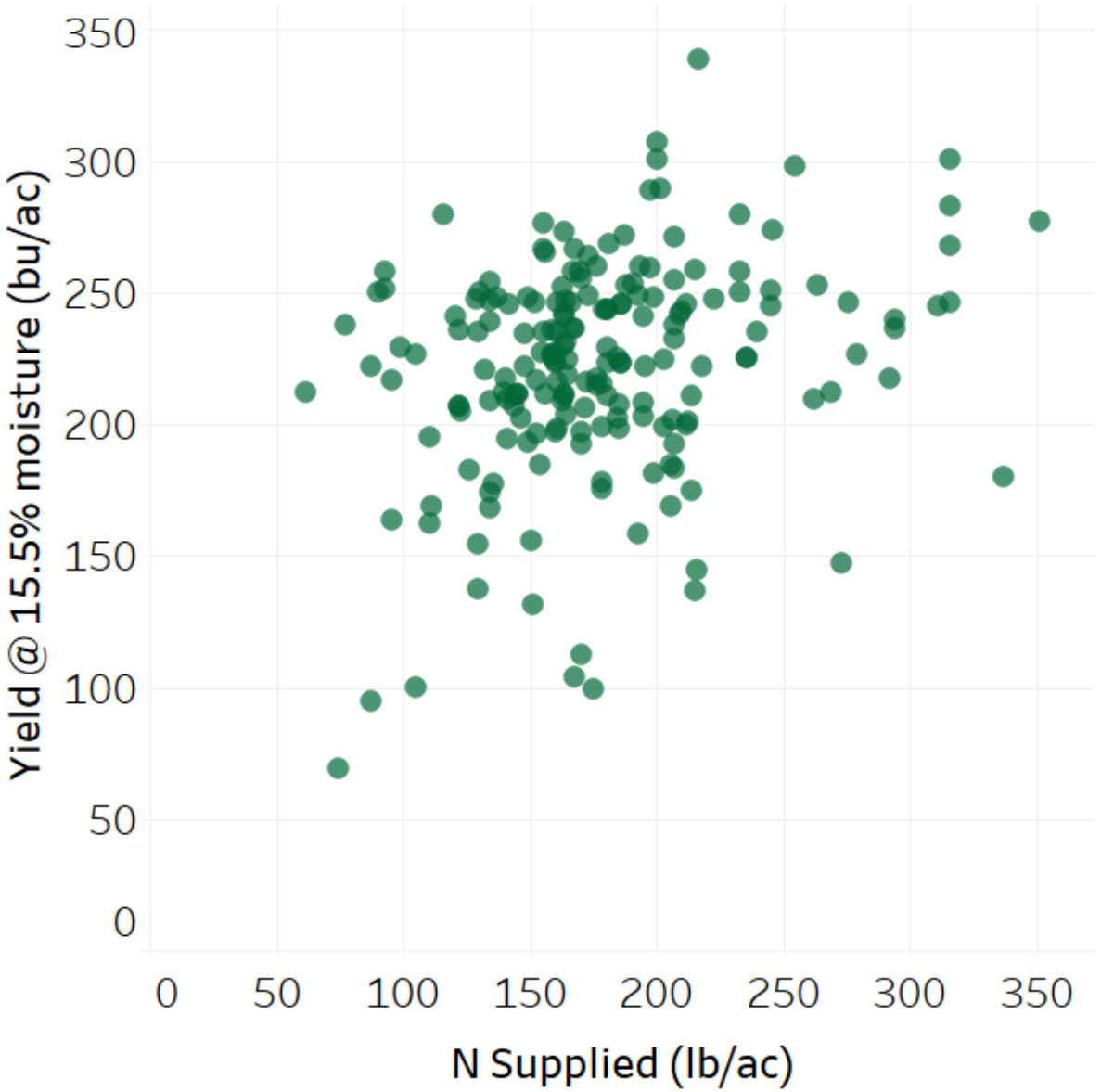
NUE values are ratios of outputs to inputs. To increase efficiency, either **increase the numerator** or **decrease the denominator**

$$\text{Partial Factor Productivity} = \frac{\text{Yield (lb/ac)}}{\text{N applied (lb/ac)}}$$

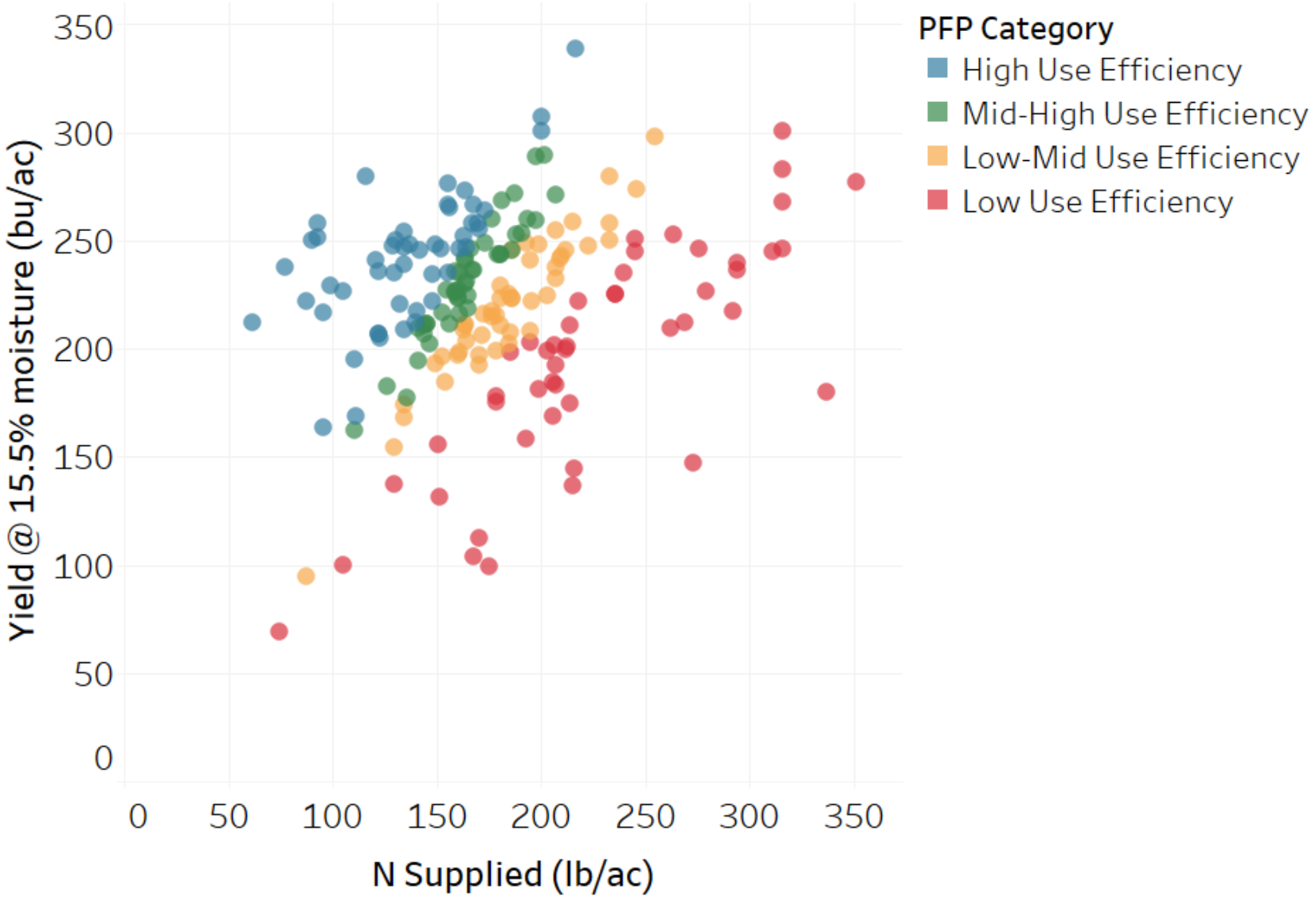


Reducing N applied without an economic loss

There is no relationship between yield and N supplied in our dataset



PFP is influenced by both ***yield*** and ***N supplied***



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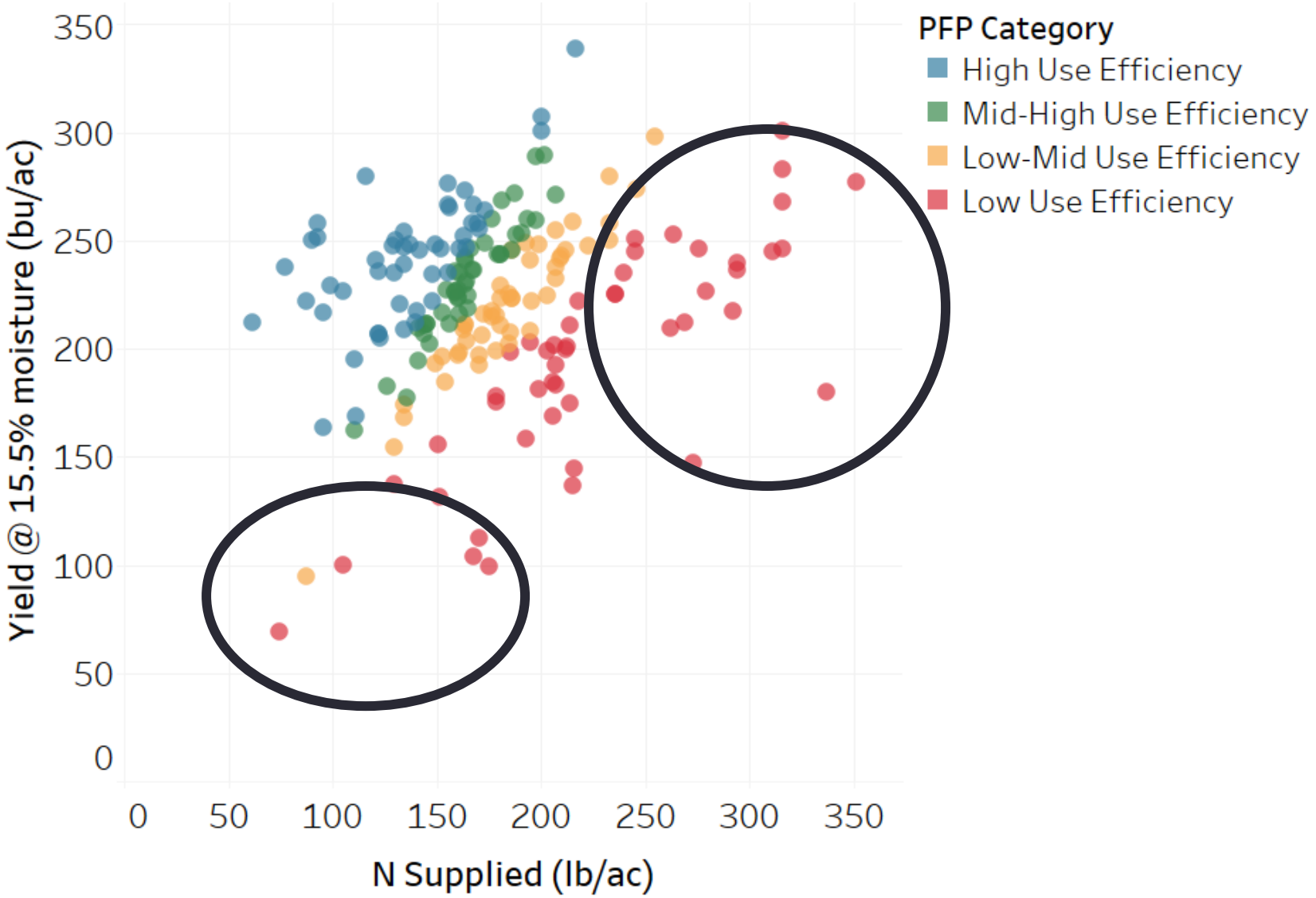
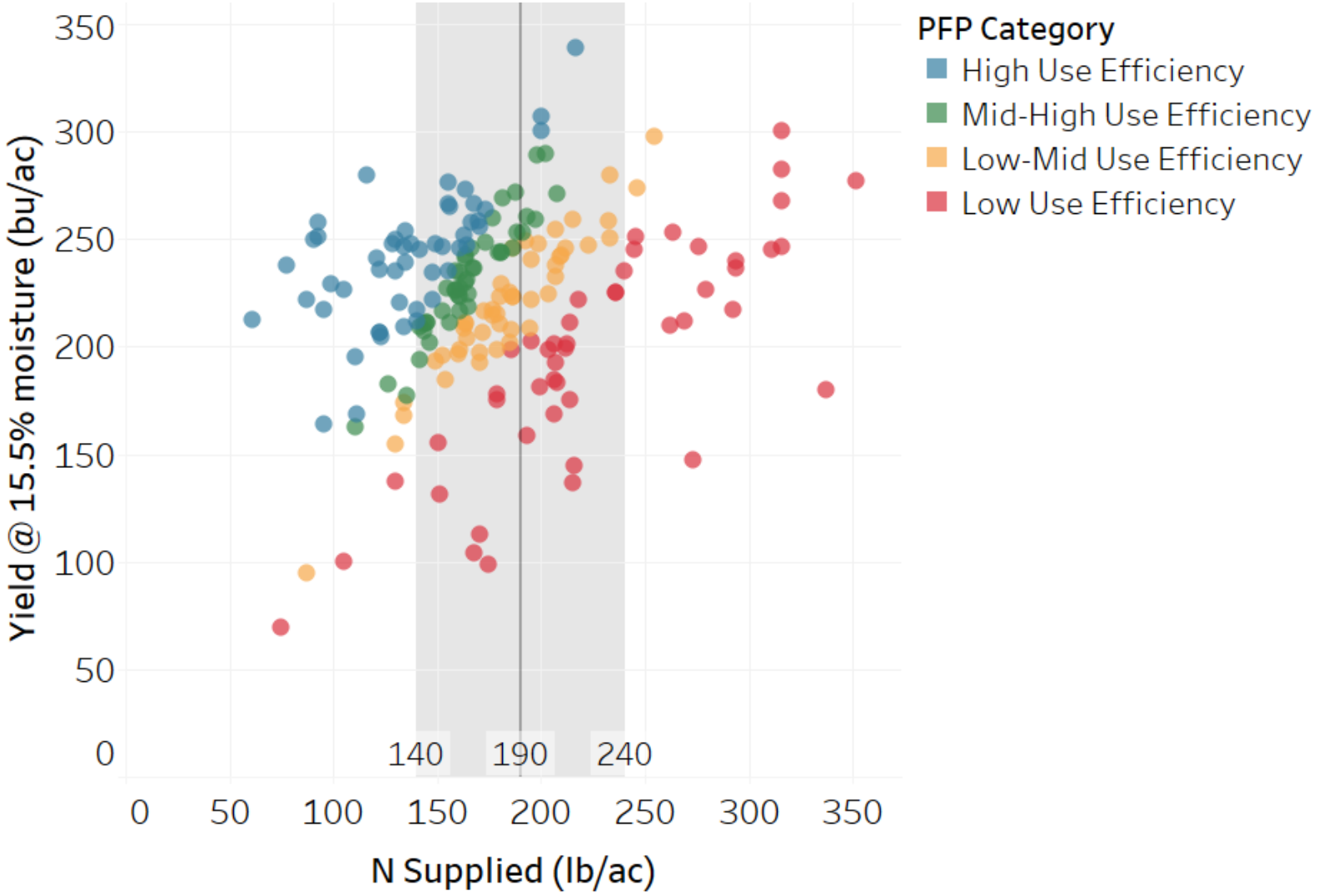
Low Use Efficiency is due to high N rates and/or low yields



But rate isn't everything:

For fields within 50 lb N/ac of the N recs, other factors can influence NUE



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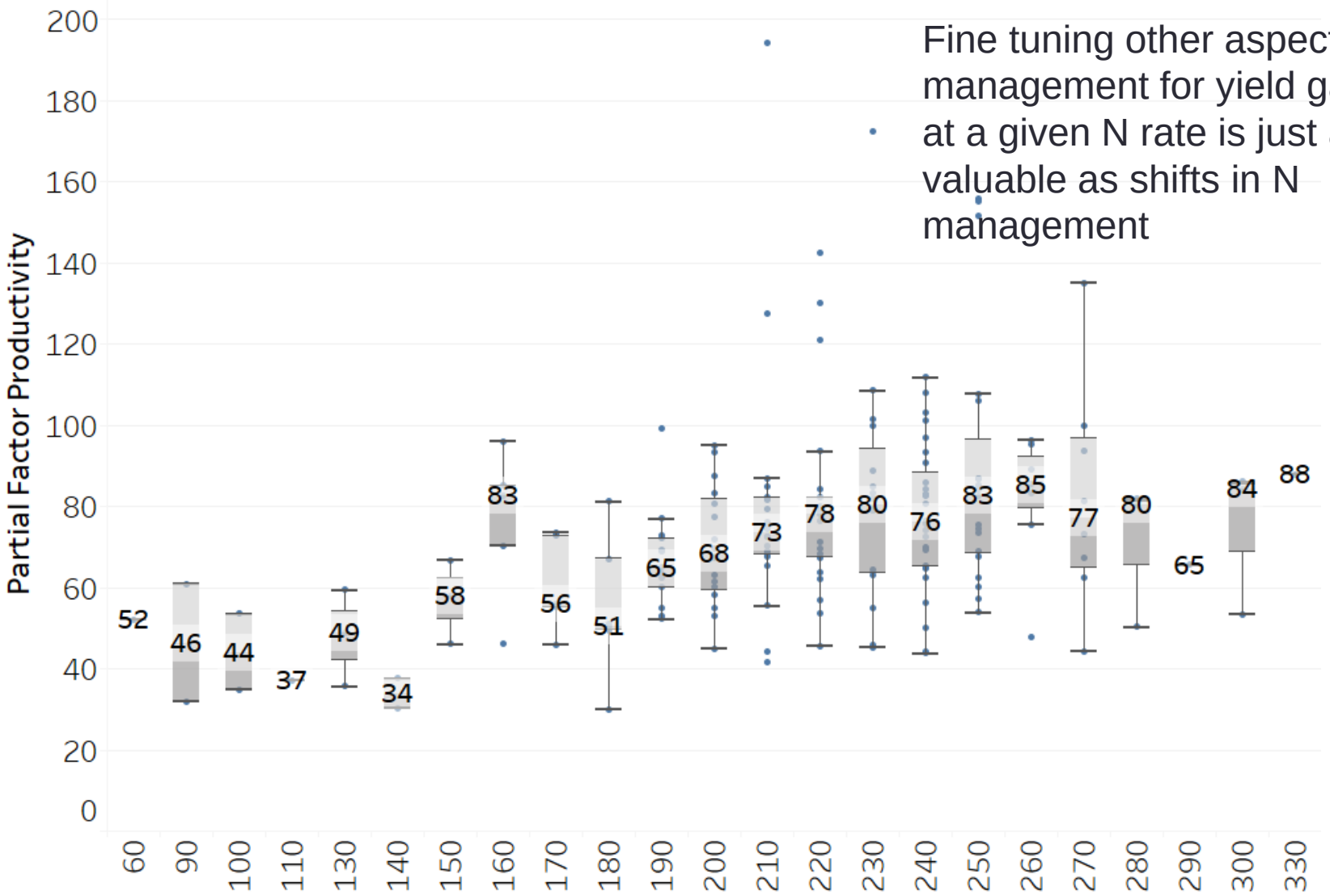
Increasing yield is important to increase NUE



Fine tuning other aspects of management for yield gains at a given N rate is just as valuable as shifts in N management

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NUE is an easy to use assessment tool

1. Calculate NUE
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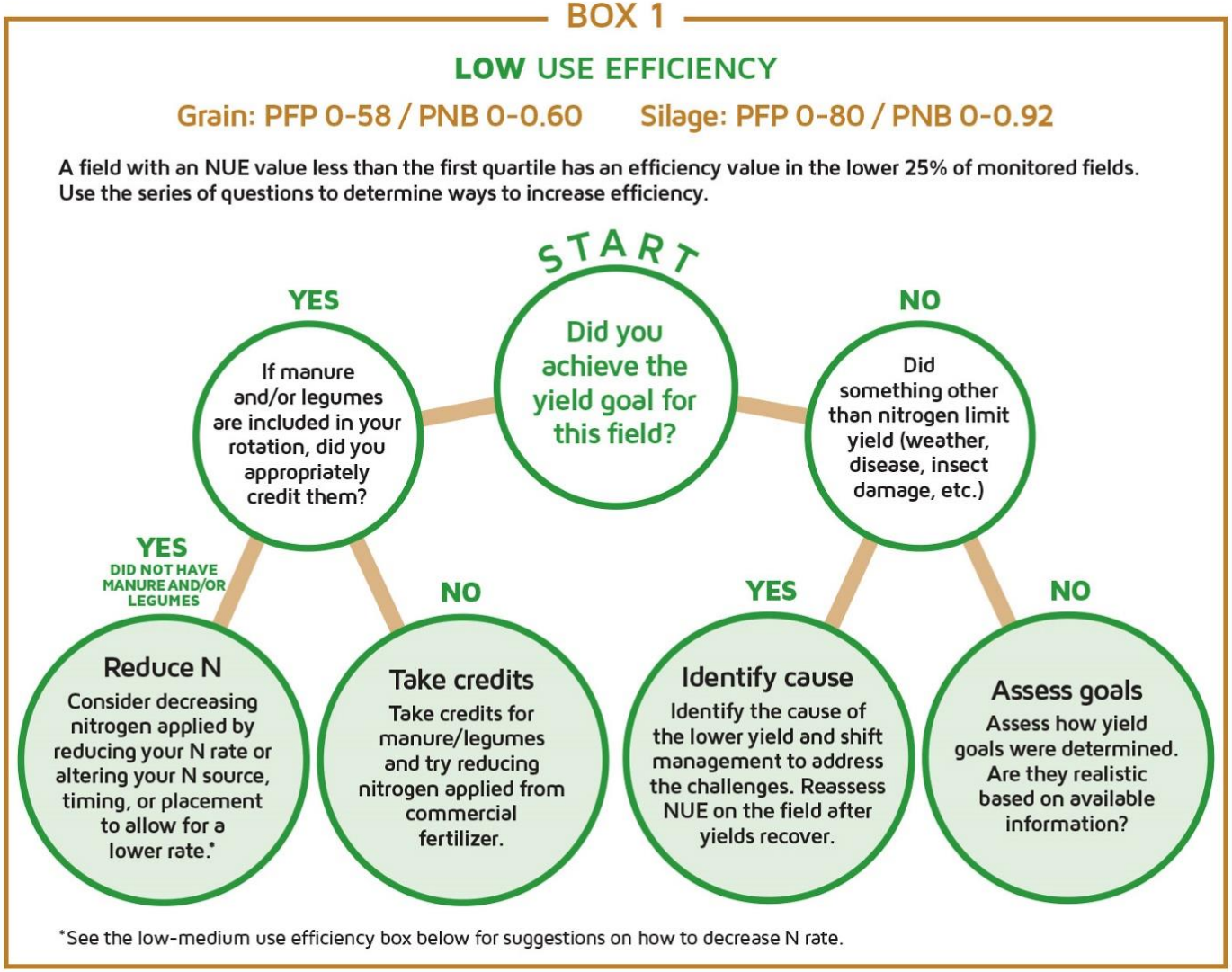
2. Consult benchmarks to determine the NUE category for that field

3. **Follow the decision trees for that category to determine if and what shifts in management would be appropriate**

4. Evaluate NUE in future seasons to assess if improvements were made

LOW USE efficiency fields can benefit from management shifts. Use decision trees to determine what appropriate next steps may be



BOX 1

LOW USE EFFICIENCY

Grain: PFP 0-58 / PNB 0-0.60 Silage: PFP 0-80 / PNB 0-0.92

A field with an NUE value less than the first quartile has an efficiency value in the lower 25% of monitored fields. Use the series of questions to determine ways to increase efficiency.

Achieving a profitable yield is at the base of our decision tree

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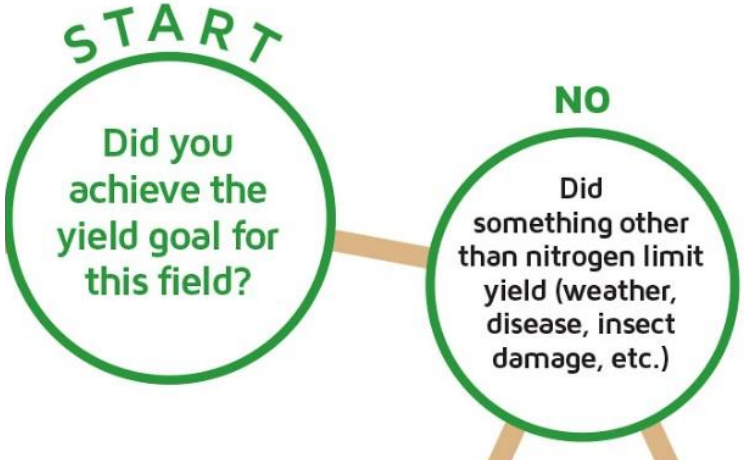

Nitrogen isn't the sole driving force for a low NUE

Evaluate NUE within the context of your field and the season

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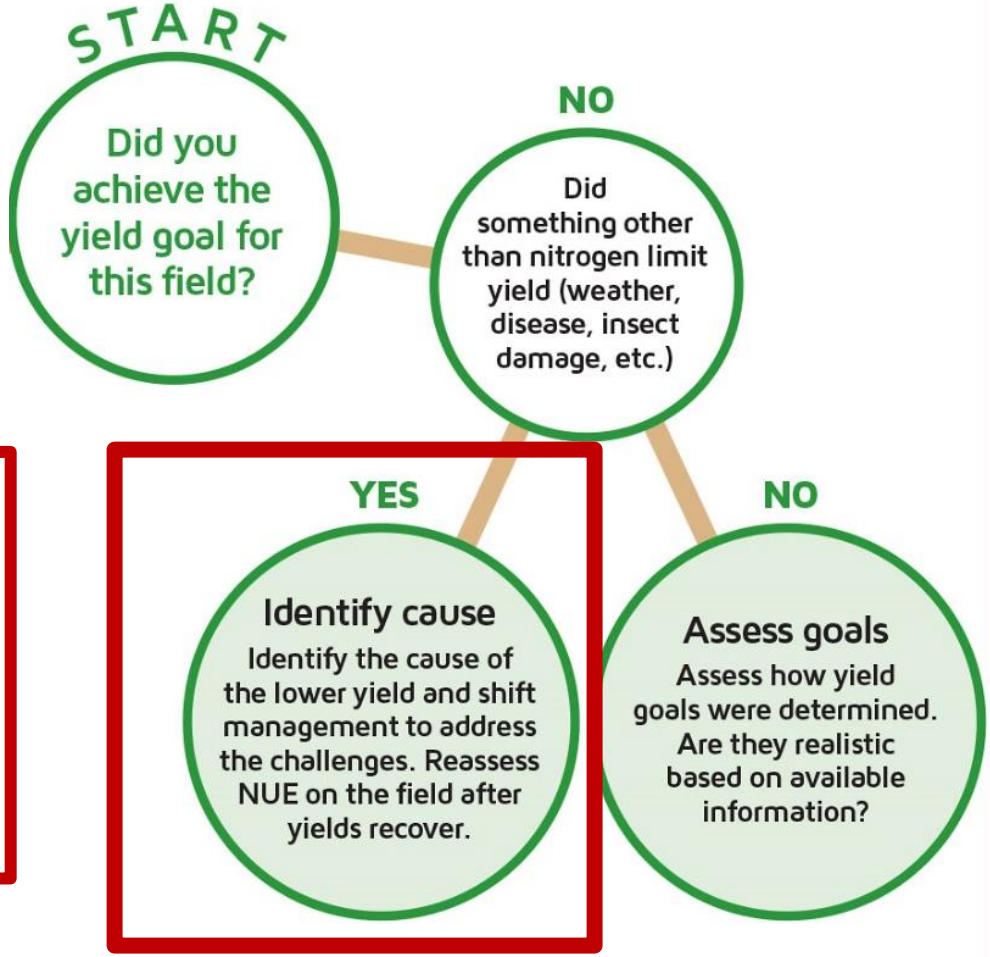

- Weather
- Disease
- Insect damage
- Weed pressure
- Other nutrient deficiency

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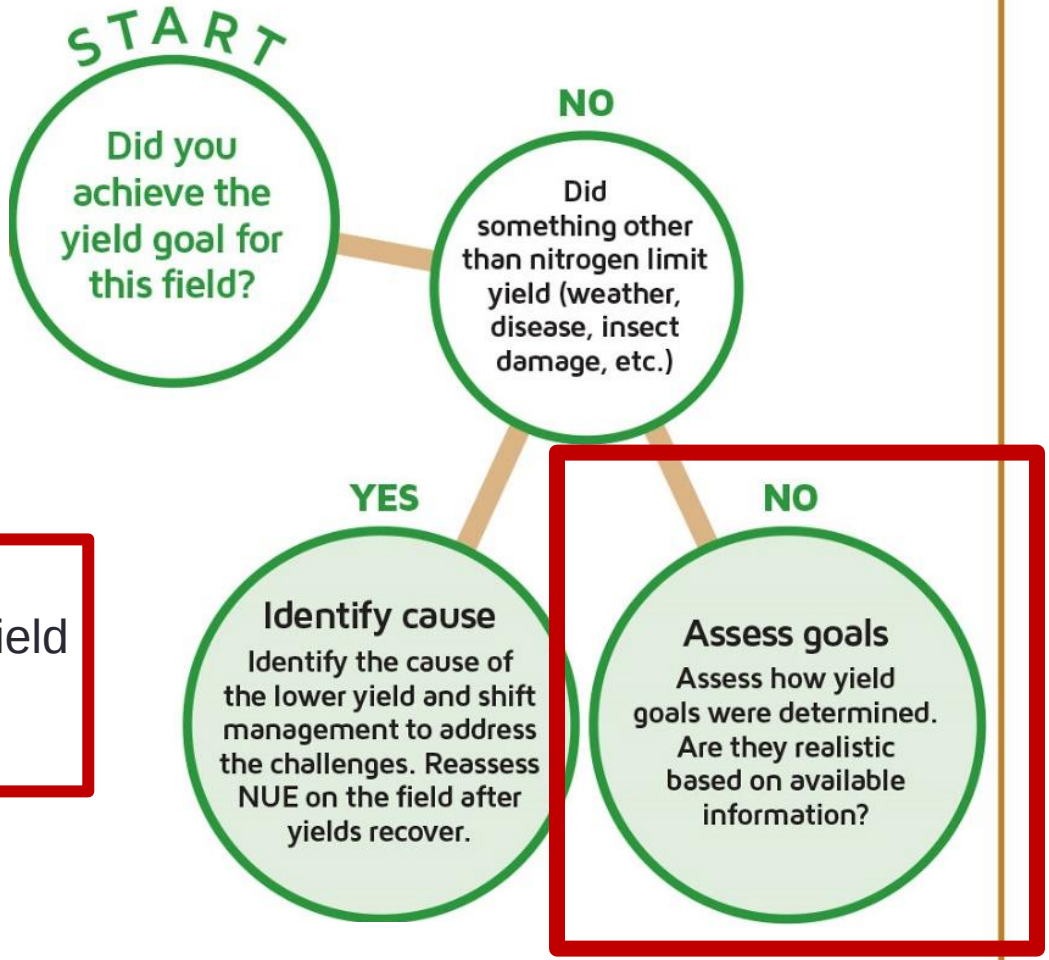

Apply N for a realistic yield goal, not the ideal yield

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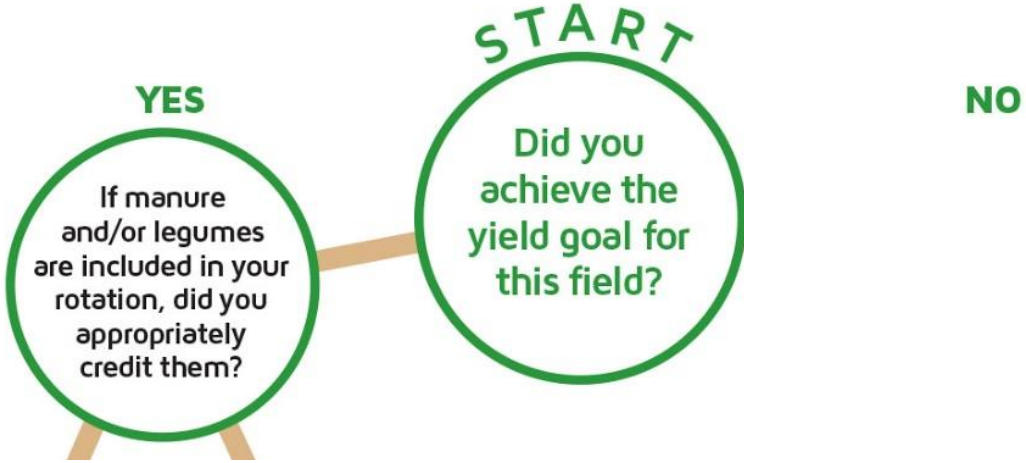

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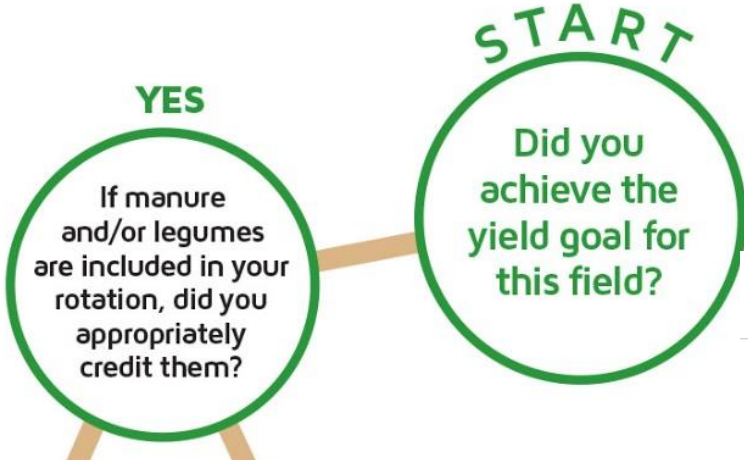

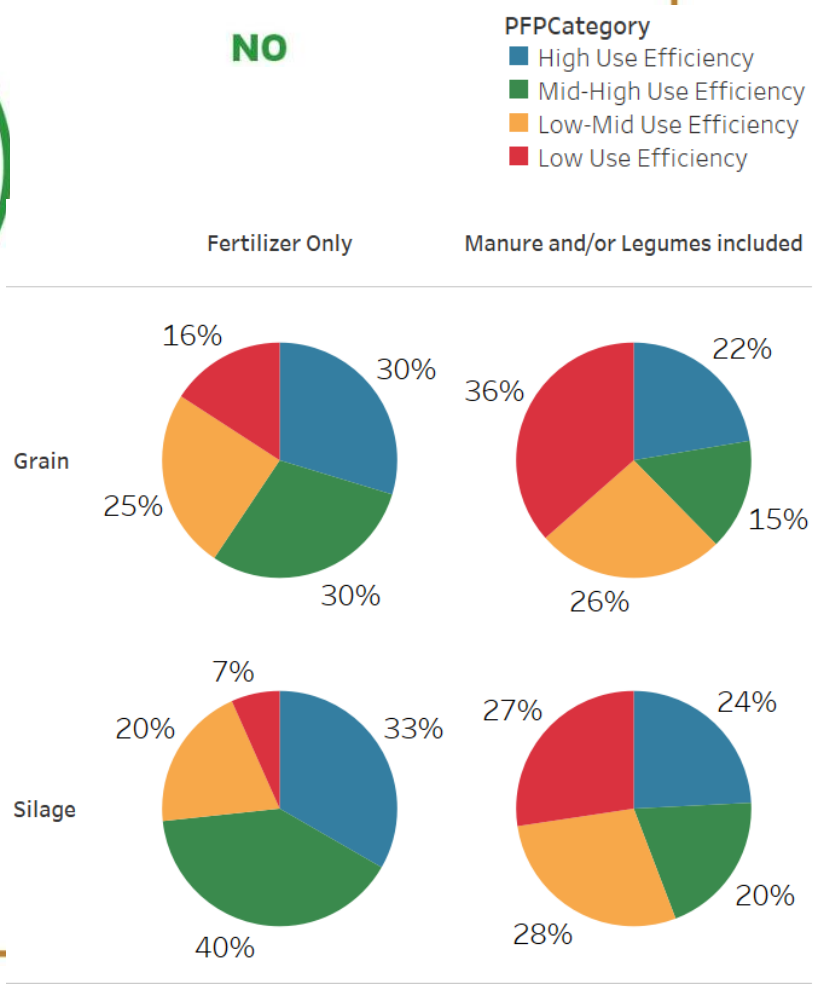

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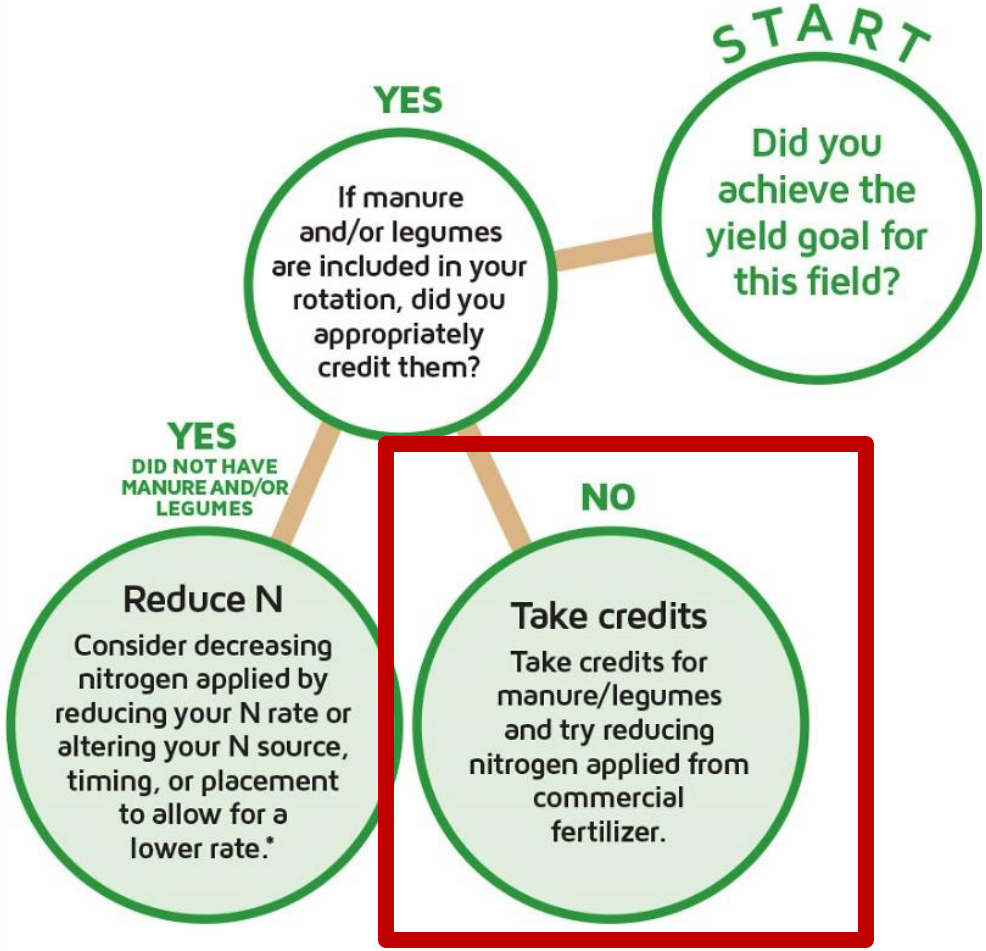

*See the low-medium use efficiency box below for suggestions on how to decrease N rate.

- Crediting manure
  - Manure analysis
  - Know the rate
  - Spread evenly
- Assess alfalfa stand
- Adjust fertilizer rates accordingly
- Adjust management to keep N from organic sources in the field

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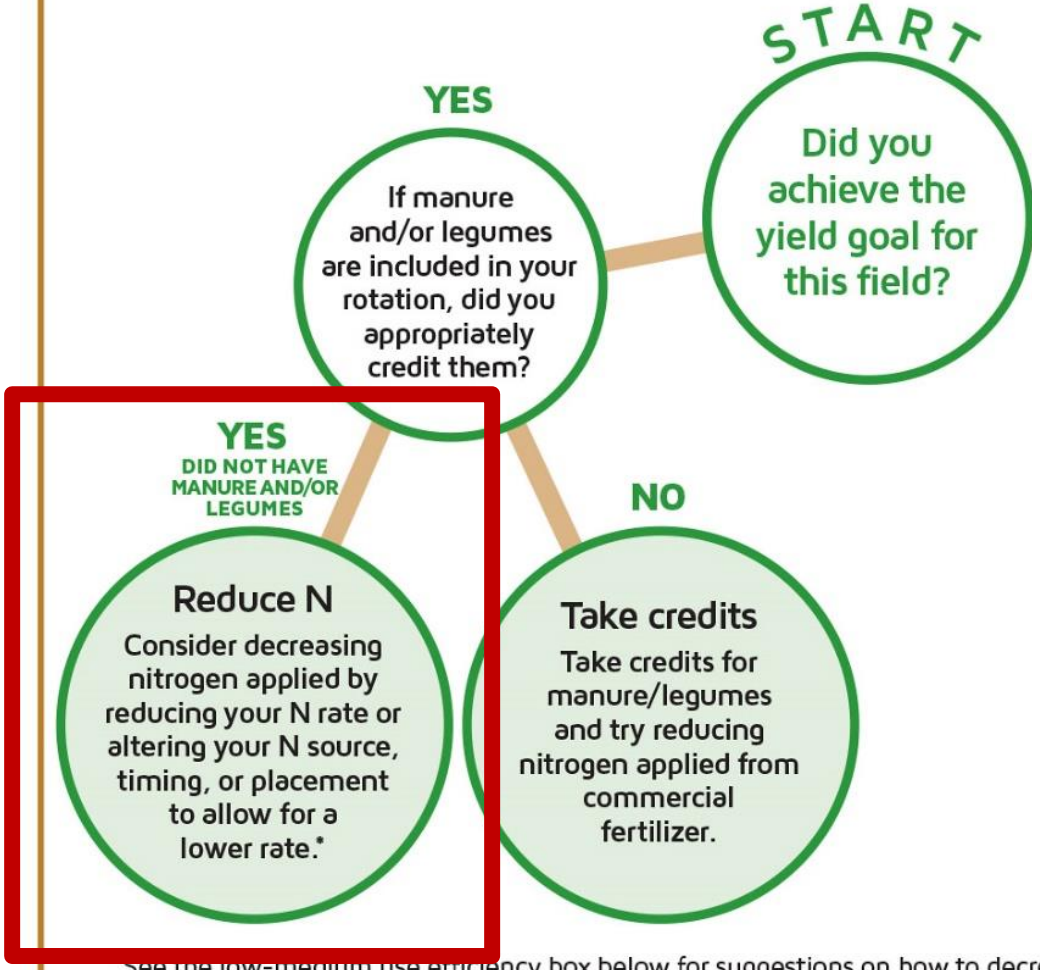

- Adjustments to 4Rs of fertilizer management
- Test reductions in fertilizer by 10-20% and assess NUE gains and impact to yield

See the low-medium use efficiency box below for suggestions on how to decrease N rate.

NUE is an easy to use assessment tool

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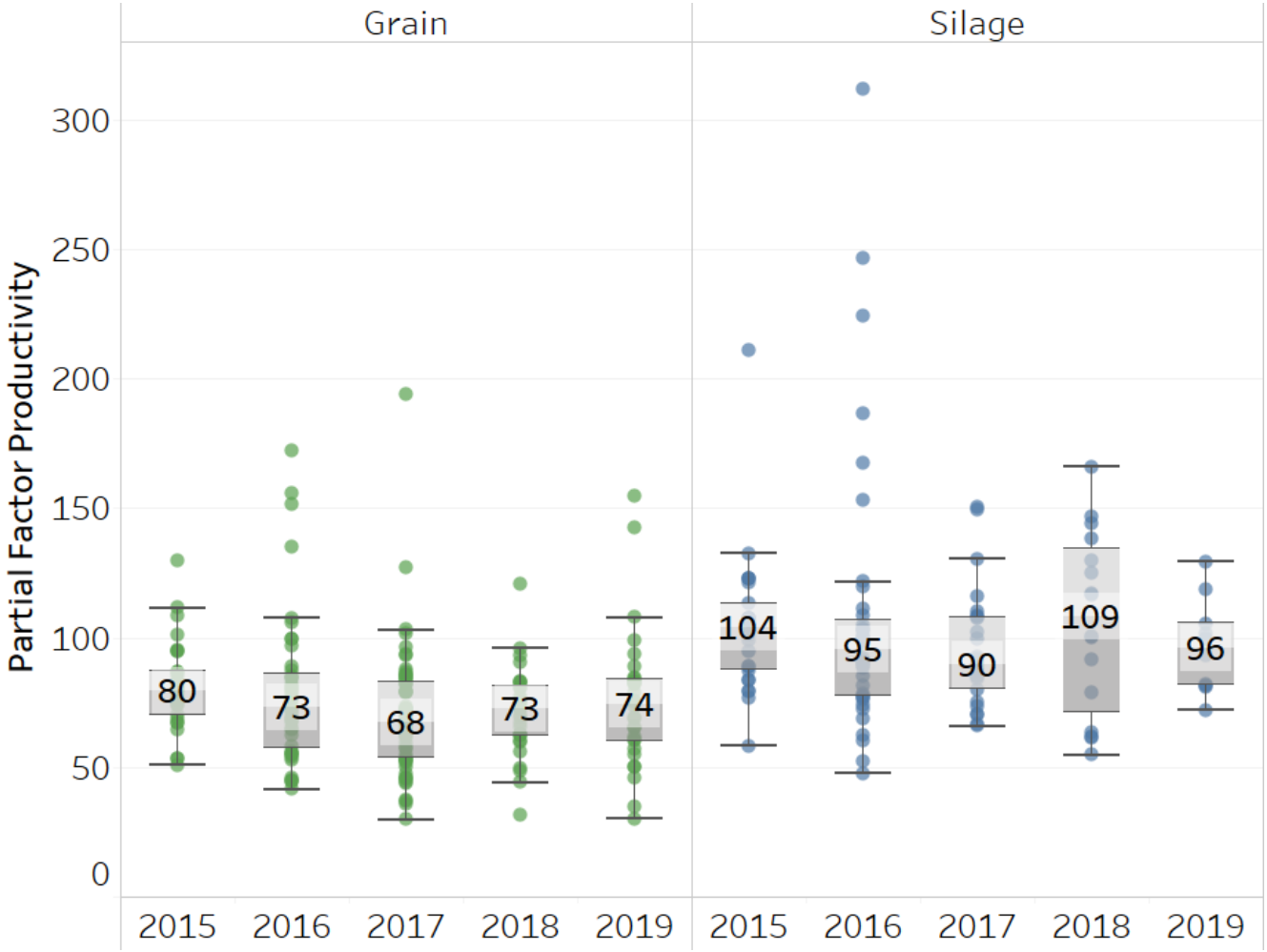
3. Follow the decision trees for that category to determine if and what shifts in management would be appropriate

4. **Evaluate NUE in future seasons to assess if improvements were made**

Annual variation is inevitable, but it has not detracted from value of benchmarking process

For a given field, weather can be a huge driver of NUE.

Evaluate your individual NUE assessment within the context of the season with the decision trees



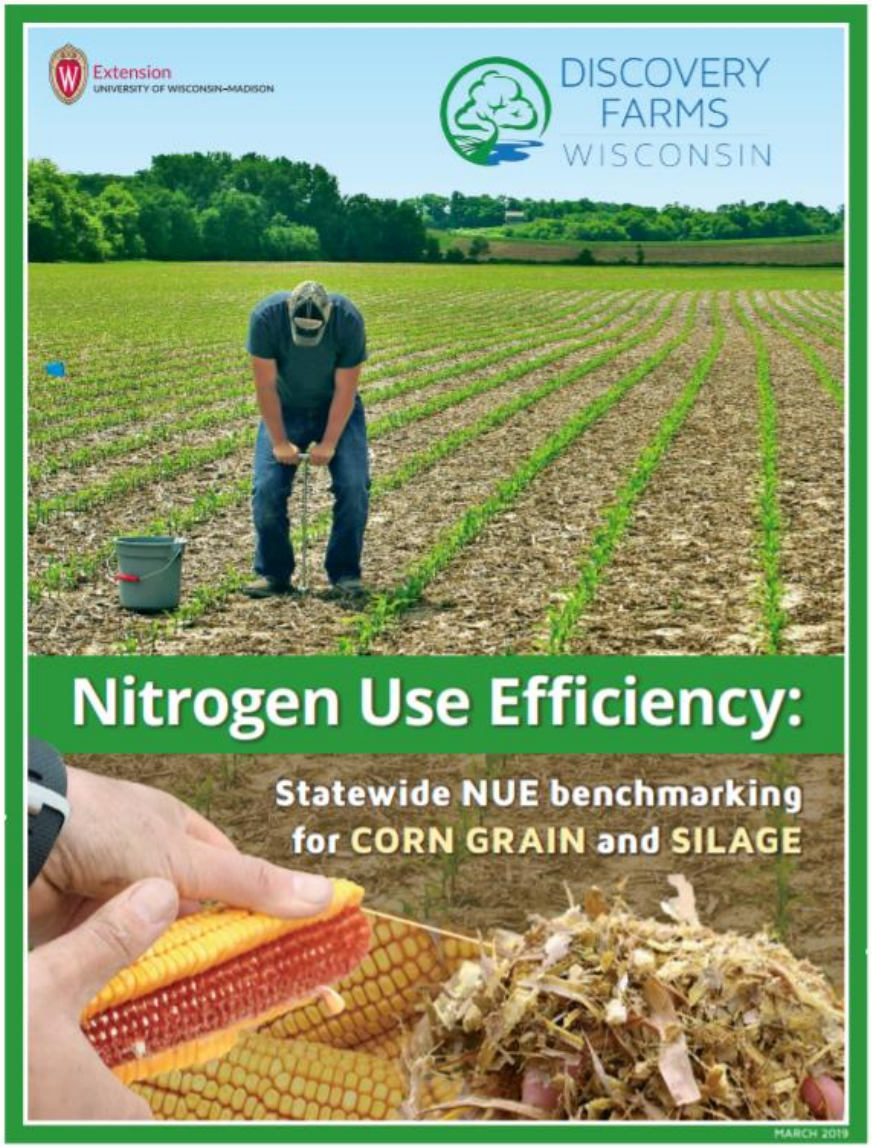
Key Lessons from our dataset

- All fields applying over 250 lb N/ac had **low use efficiency**
  - For fields within a 50 lb N/ac range of recommended rate, N rate is not the sole driver
- Utilizing multiple N sources, especially organic N sources (manure and legumes), can be a challenge to achieve higher efficiencies
  - Fields that utilize these sources would benefit greatly from NUE
- No significant trends found for timing of applications, inhibitors/slow release products, management practices
- Currently, no significant difference in median values by year, region, soil type*, management type (dairy/beef/grain)

*our dataset primarily consists of silt loam soil types. As we gather more data, we will revaluate benchmarks based on soil type

See publication for more info

- equations of NUE calculations
- summary of the dataset
- WI corn grain and corn silage benchmarks
- NUE categories, and recommendations for N management



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Extension Pub: A4167

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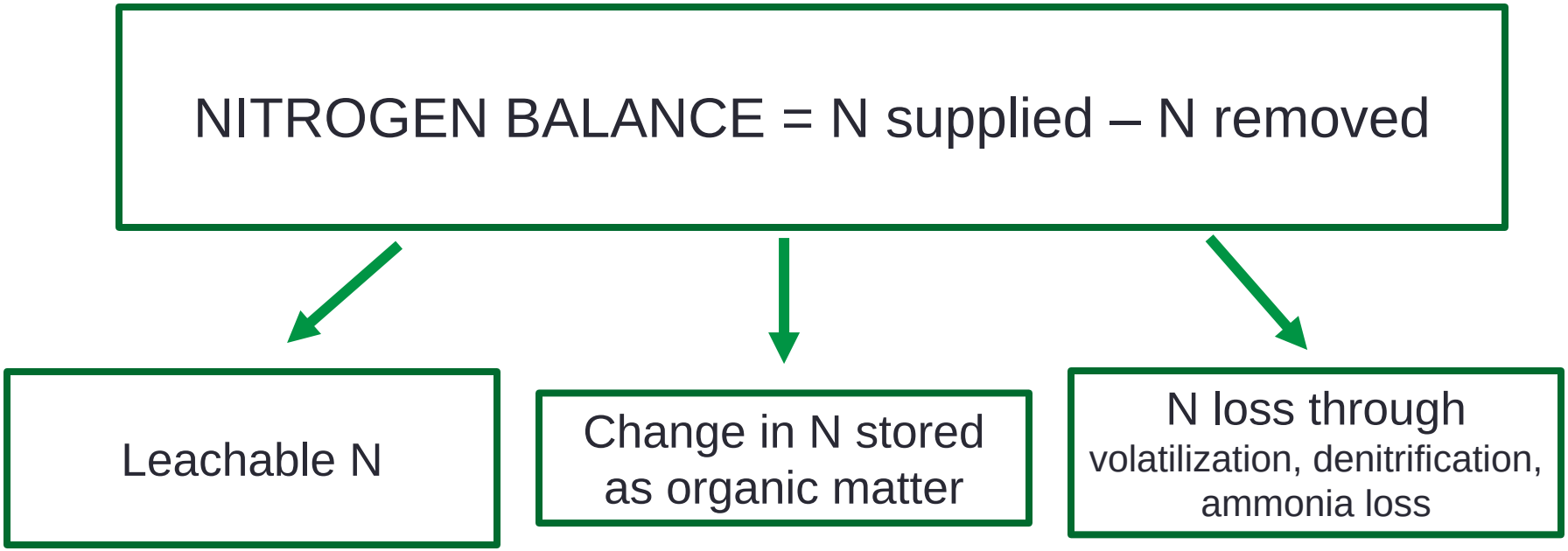
Discovery Farms has partnered with agronomists & crop consultants, county Land + Water conservationists, extension agents, and producer led watershed groups to monitor NUE in their area.

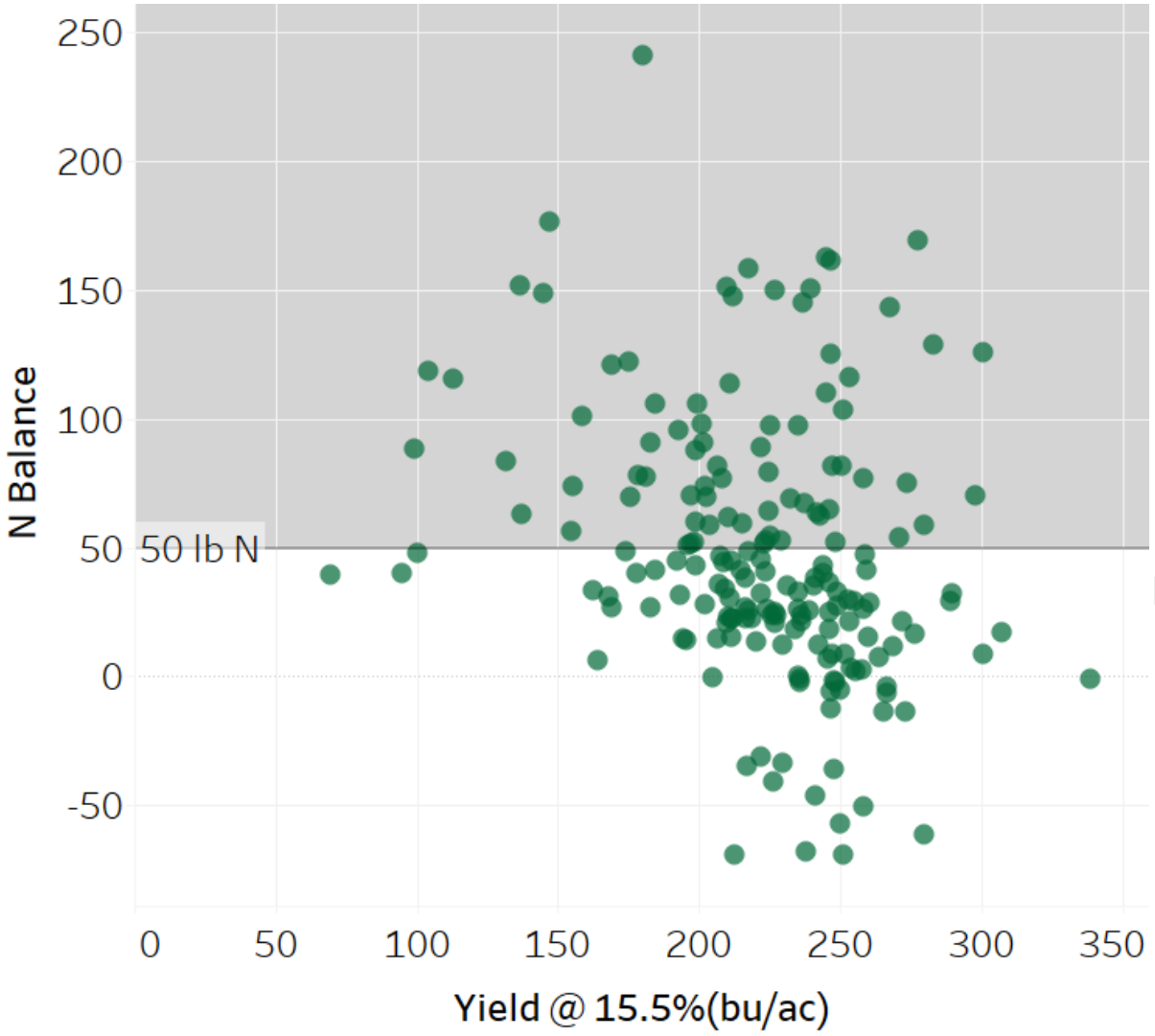
Contact Discovery Farms to participate!

Abby Augarten ● Nitrogen Use Efficiency Project Coordinator
914-844-2146 ● abigail.augarten@wisc.edu

Nitrogen balance is an indicator for **potentially leachable N**



An **N Balance below 50 lb N** would be a manageable goal that would have benefits to ***water quality***



DF median is 40 lb N

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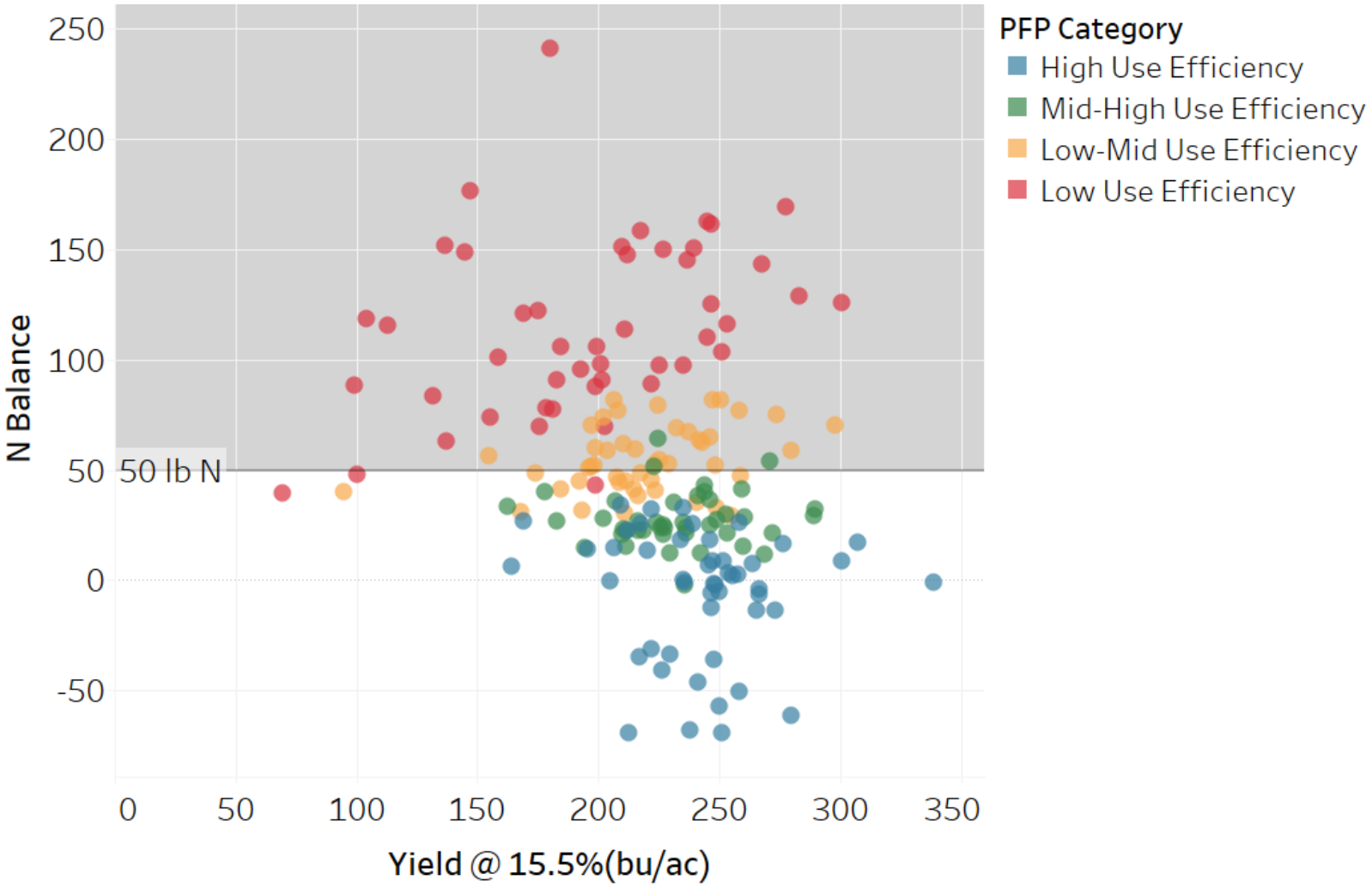
Having a **low use efficiency** demonstrates a need to improve management to protect water quality



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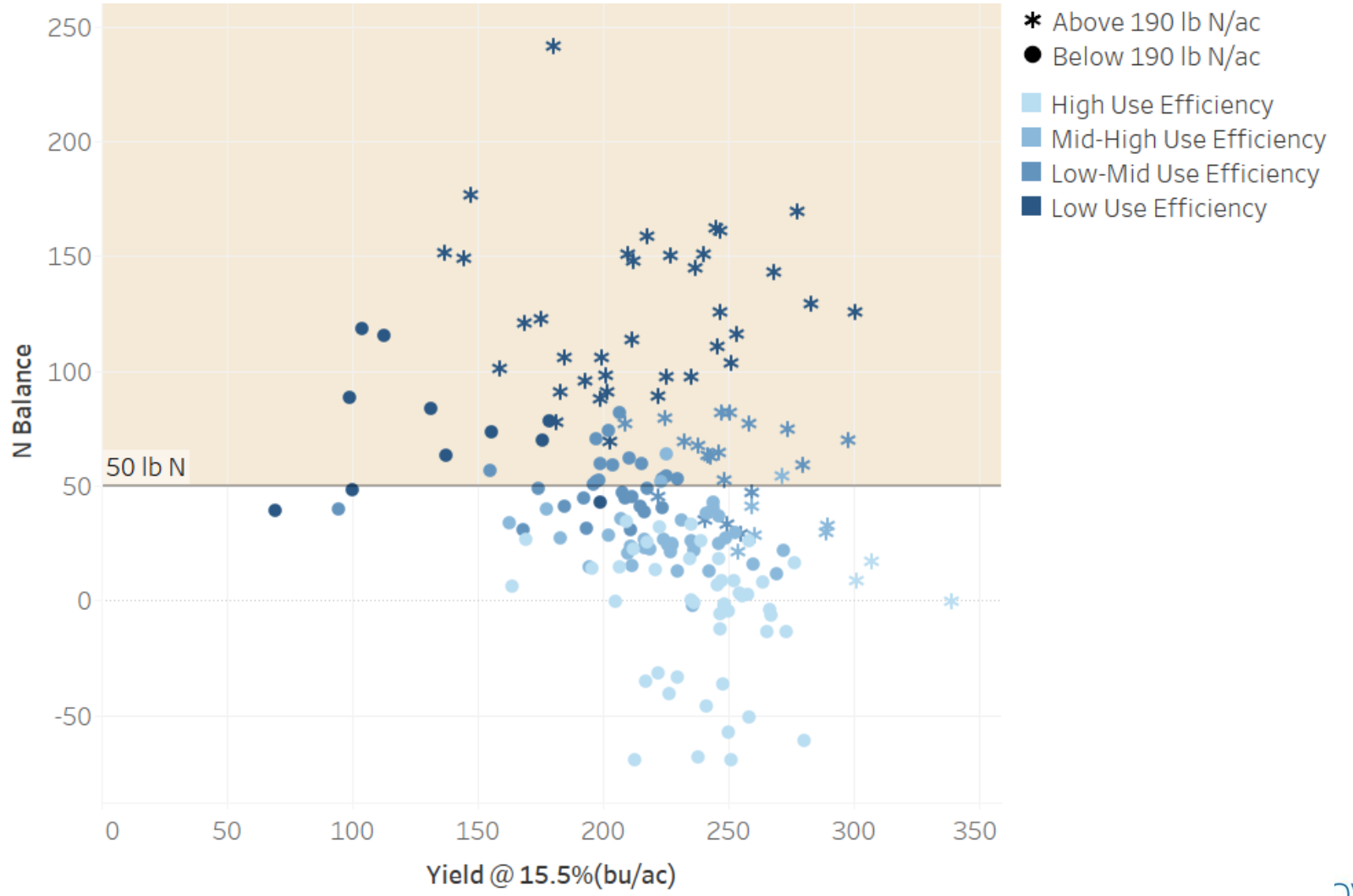
Most fields that applied under the N recommendation fall under the 50 lb N threshold



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We work with farmers to monitor and understand their impact on surface water quality. The intersection of water quality and agriculture is complicated.

Every farm and every management system has areas that can be improved. Farmers are seeking continuous improvement.

Improvement depends on a balance of practices that protect both surface water and groundwater.

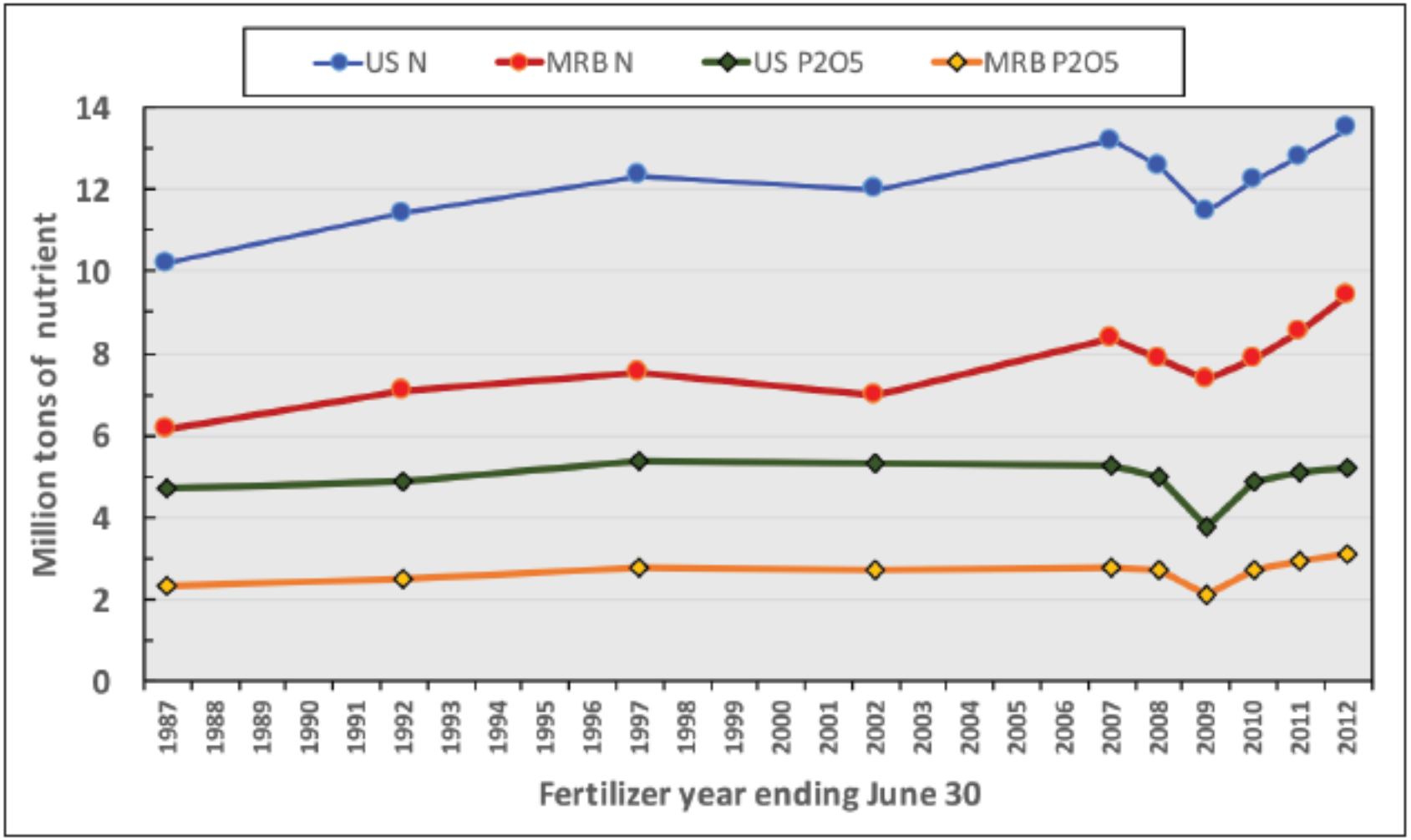


Figure 2. Consumption of fertilizer nitrogen (N) and phosphate (P_2O_5) within the Mississippi River Basin (MRB) from 1987 to 2012 constitutes a large portion of U.S. total consumption between 1987 to 2012. Source: AAPFCO, 2017; IPNI, 2012b.

Zero-N strips tell us about the true value of applied N

- Quantify how much N is supplied by the soil
- Show how much N is actually used by the crop- and **how much N is at risk of being lost to the environment**
- Measure the true economic value of the N applied in that year

Zero N test strip

Photo courtesy of NUE partic

NUE can be measured with a zero N test strip by comparing the outputs on the plot to the entire field

$$\text{Agronomic Efficiency (AE)} = \frac{\text{Yield} - \text{Yield of zero N test strip(lb/ac)}}{\text{N supplied- N supplied of zero N test strip (lb/ac)}}$$

How much did the fertilizer improve productivity?

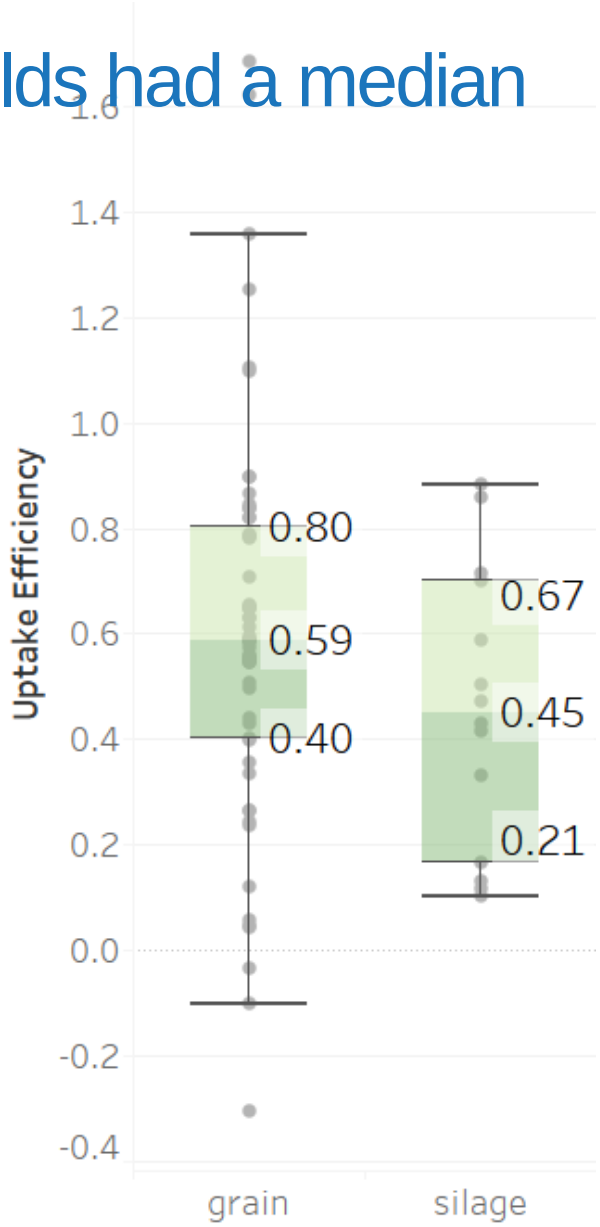
$$\text{Uptake Efficiency (UE)} = \frac{\text{N uptake} - \text{N uptake of zero N test strip (lb/ac)}}{\text{N supplied- N supplied of zero N test strip (lb/ac)}}$$

How much of the N applied was taken up by the plant?

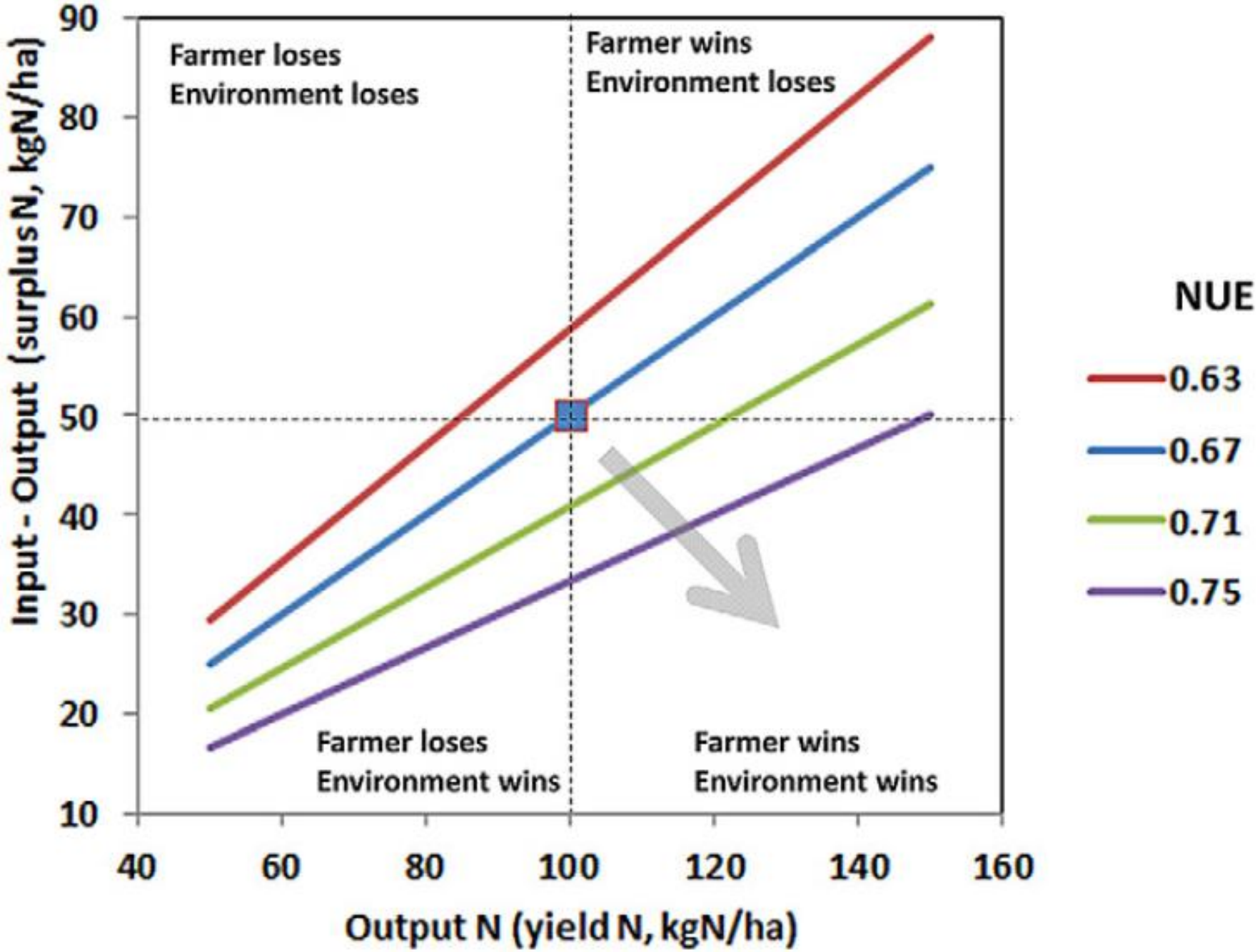
Intensively monitored corn grain fields had a median **Uptake Efficiency (UE)** of 59%

How much of the N applied was taken up by the plant?

How much N could be lost?



$$\text{Uptake Efficiency (}\mathbf{UE}\text{)} = \frac{\text{N uptake (lb/ac)} - \text{N uptake of zero N strip (lb/ac)}}{\text{N applied (lb/ac)} - \text{N applied of zero N strip (lb/ac)}}$$


Farmer loses
Environment loses
Farmer wins
Environment loses
Farmer loses
Environment wins
Farmer wins
Environment wins
Input - Output (surplus N, kgN/ha)
Output N (yield N, kgN/ha)
90
80
70
60
50
40
30
20
10
40
60
80
100
120
140
160
NUE
0.63
0.67
0.71
0.75