Extension
UNIVERSITY OF WISCONSIN-MADISON

Green County LWCD
GREEN COUNTY LAND AND WATER CONSERVATION DEPARTMENT

Nitrogen Use Efficiency Project Results from Green County 2024

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Outline

- Why Study Nitrogen
  - How this project got started
- What is Nitrogen Use Efficiency (NUE)
- About the Farms
- Local Results
- Improving NUE
- What we learned
- How to conduct your own NUE assessment
- Take home points

Why Study Nitrogen?

- Farmer perspective
  - Am I using too much or too little nitrogen?
  - How can I tell if my nitrogen program is working and the most bang for the buck I’m spending
  - Will my soil grow any corn without additional nitrogen?

Why Study Nitrogen?

- Land & Water Conservation/Water Coalition Group perspective
  - Are farmers over applying nitrogen to grow corn?
    - How much of the over application of nitrogen contributes to nitrates in groundwater?
    - What are the trends in groundwater testing showing for the county?

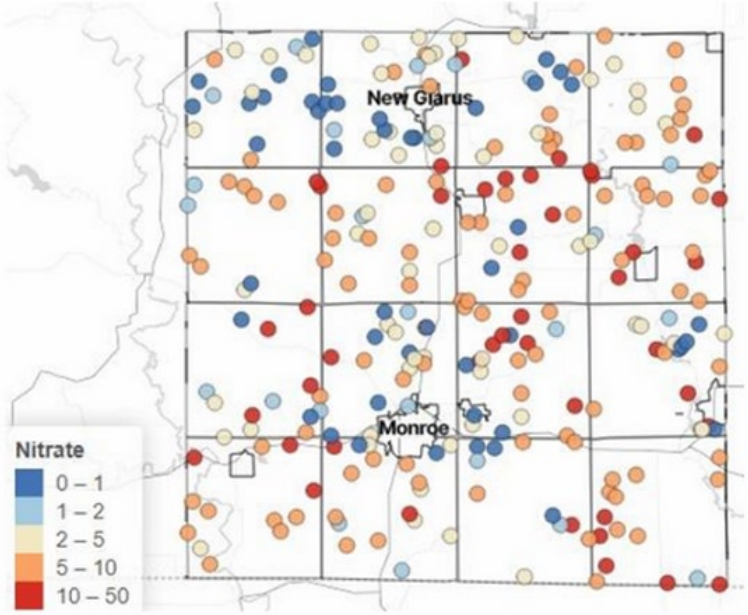
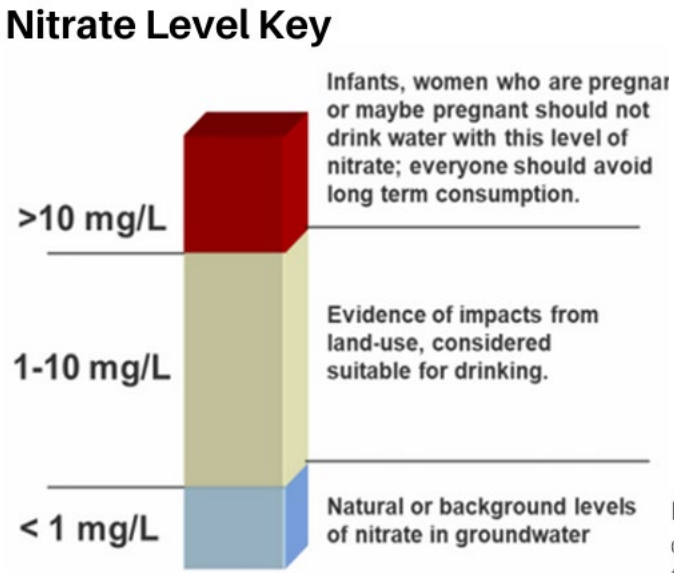


Figure 1: Nitrate-nitrogen results for Year 5 (2023) of the Green County Well Water Monitoring Project.



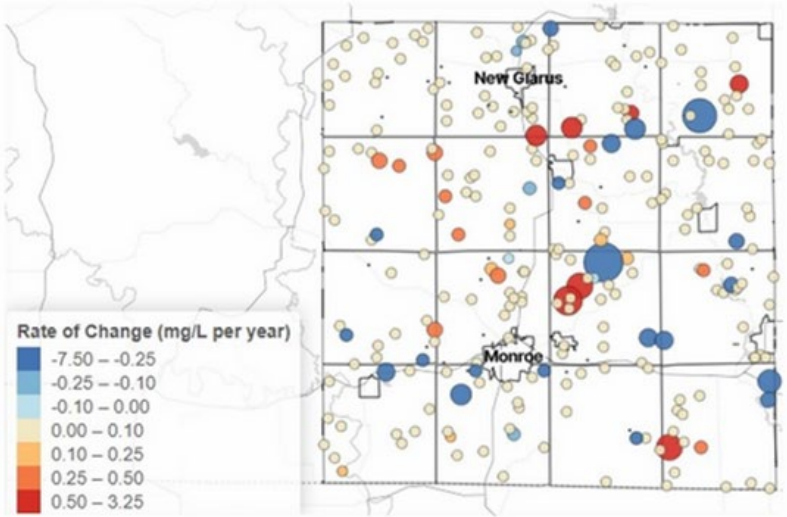
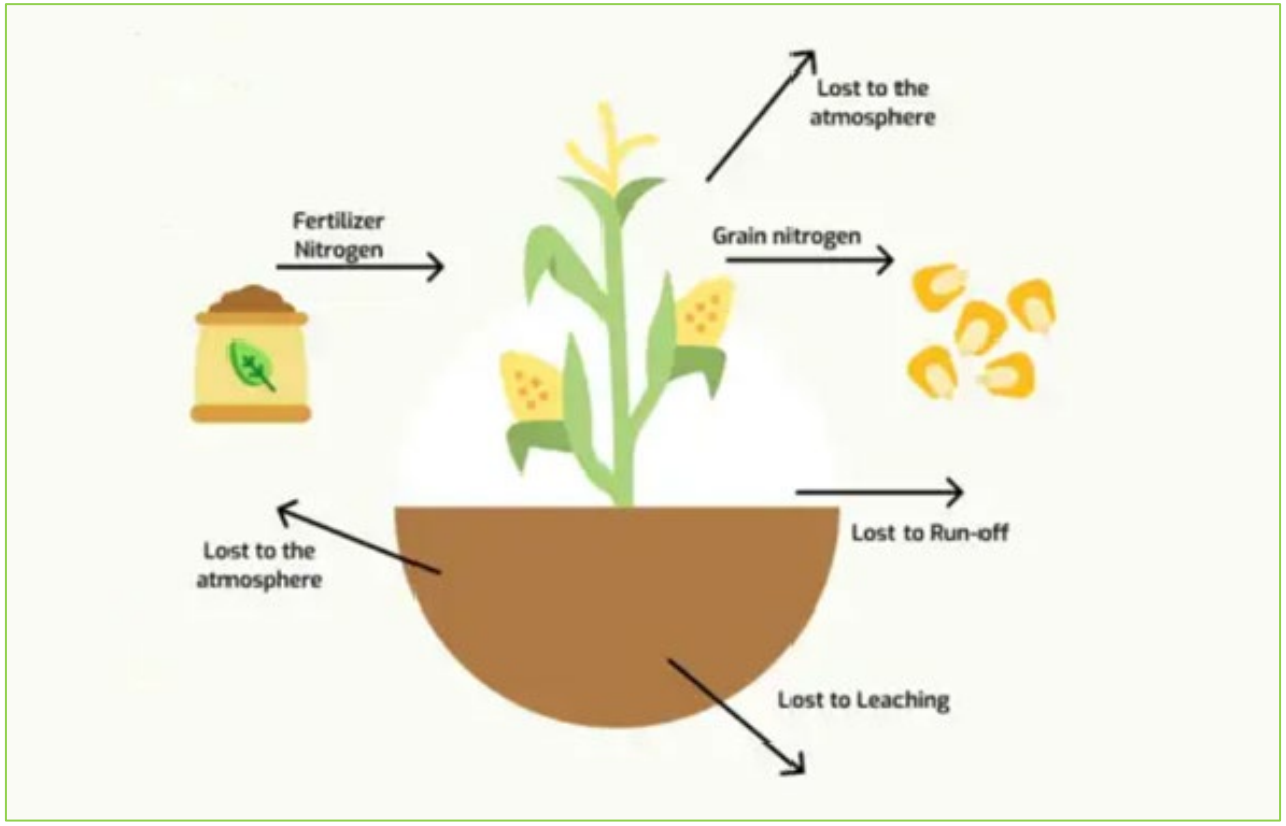


Figure 2: Year 5 (2023) nitrate-nitrogen trends for wells with five continuous years of data. Data shows 9% (26 wells) detected increasing trends, 10% (24 wells) detected decreasing trends, and 81% (219 wells) that did not detect a trend in nitrate-nitrogen concentrations.

Nitrogen Use Efficiency (NUE)

- An assessment tool farmers can use to compare the effectiveness of their current N management plans with that of other farms in the state



NUE Measurements

STANDARD

Is this cropping system productive for the amount of nitrogen applied?

Partial Factor Productivity (PFP) =

$$\frac{\text{Yield (lbs/ac)}}{\text{N applied(lbs/ac)}}$$

What is the ratio of nitrogen removals and additions?

Partial Nutrient Balance (PNB) =

$$\frac{\text{N content of harvested portion (lbs/ac)}}{\text{N applied (lbs/ac)}}$$

INTENSIVE

Did the nitrogen applied help improve my productivity?

Agronomic Efficiency (AE) =

$$\frac{\text{Yield of strip with N application} - \text{Yield of 0 N strip (lbs/ac)}}{\text{N applied in field with application (lbs/ac)}}$$

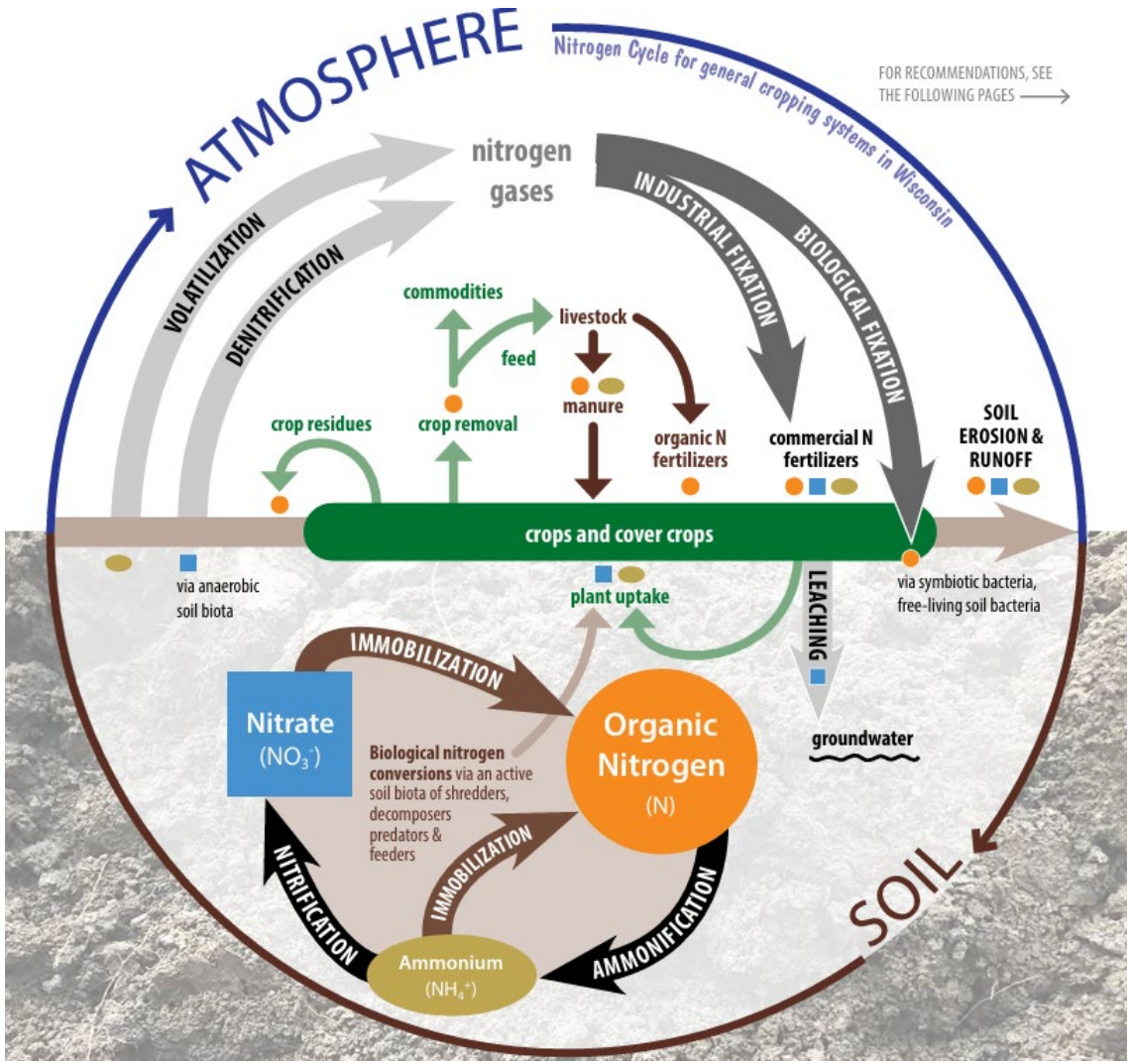
How much nitrogen applied was taken up by the entire crop?

Uptake Efficiency (UE) =

$$\frac{\text{N uptake in aboveground biomass in N strip (lbs/ac)} - \text{N uptake in aboveground biomass in 0 N strip (lbs/ac)}}{\text{N applied in field with application (lbs/ac)}}$$

Factors Affecting NUE

- Soil type
  - Sandy soils – prone to leaching
  - Poorly drained soils – prone to denitrification
  - Higher organic matter – supplies more N
- Weather
  - N movement in the soil
  - Crop yield
- Residual N
  - How much was leftover from the previous season
  - Pre-plant nitrate samples can help account for this



Wisconsin's Benchmarks

- Established by the Discovery Farms network

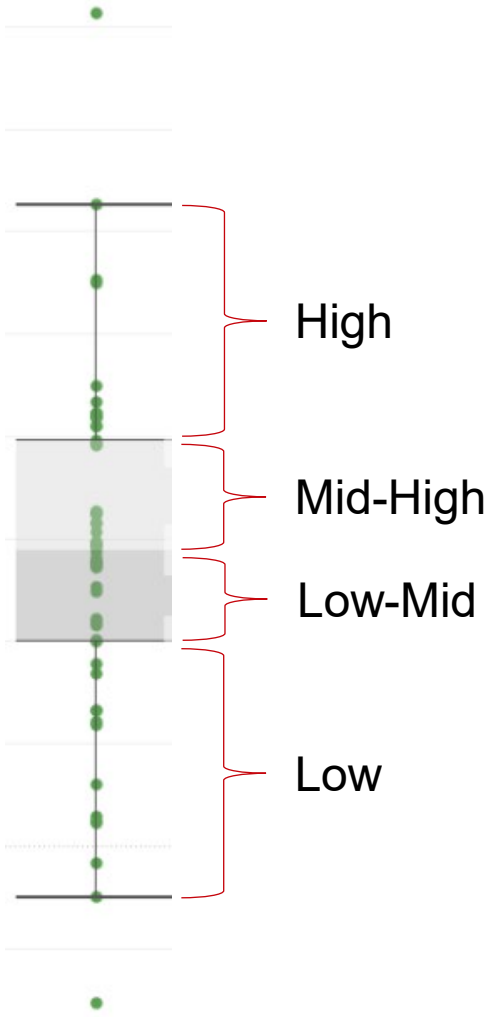


Table 2. Corn grain benchmark efficiency ranges

CORN GRAIN BENCHMARKS								
	LOW USE EFFICIENCY (DECISION TREE BOX 1)		LOW-MID USE EFFICIENCY (DECISION TREE BOX 2)		MID-HIGH USE EFFICIENCY (DECISION TREE BOX 3)		HIGH USE EFFICIENCY (DECISION TREE BOX 4)	
	PFP	PNB	PFP	PNB	PFP	PNB	PFP	PNB
lb grain/lb N at 15.5% moisture	0-58	0-0.60	59-72	0.61-0.77	73-85	0.78-0.88	>85	>0.88
bu grain/lb N at 15.5% moisture	0-1.04		1.05-1.29		1.30-1.52		>1.52	

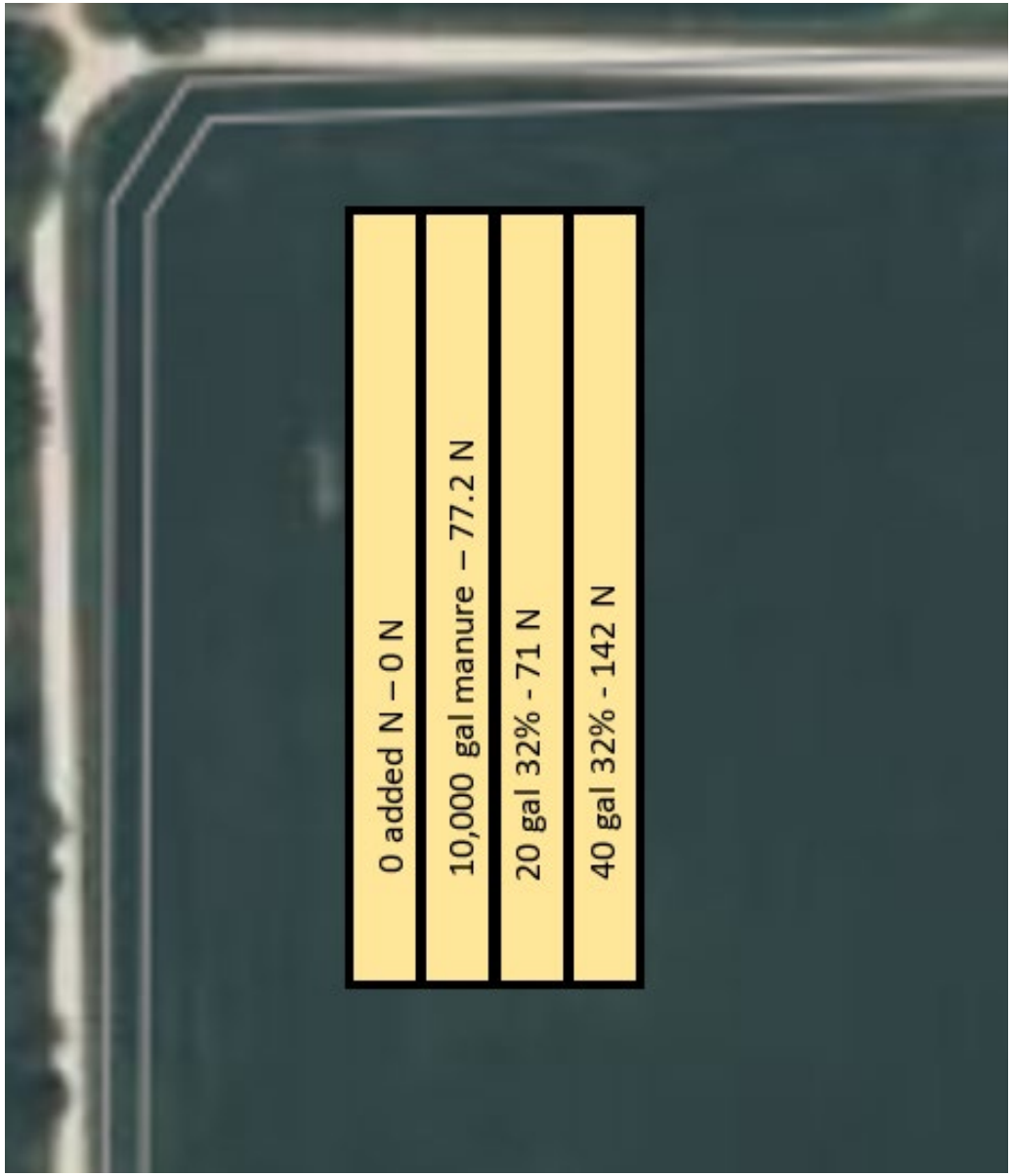
About the Farms

- Clark
  - Transitioning from dairy to cash grain
  - C-B
  - Tillage
  - VRT Potash
  - No cover crop
  - Single app N
    - Preplant incorporated
  - Soil tests
    - pH: 7.2
    - OM: 3.5
    - P: 45
    - K: 181
- Faessler
  - Cash grain
  - C-B-W-cc
  - No till
  - Fall DAP & Potash
  - Rye cover crop
  - Split app N
    - Broadcast urea
    - Sidedress 32%
  - Soil tests
    - pH: 6.7
    - OM: 2.6
    - P: 13
    - K: 123
- Feller
  - Beef & grain
  - C-B-cc
  - Vertical till
  - Rye + hairy vetch
  - Split app N
  - Soil tests
    - pH: 7.2
    - OM: 3.6
    - P: 96
    - K: 288

Clark NUE Plot

- Treatments
  - 0 N
  - 10,000 gal manure ► 77.2 N
  - 20 gal 32% ► 71 N
  - 40 gal 32% ► 142 N

- All applied pre-plant incorporated

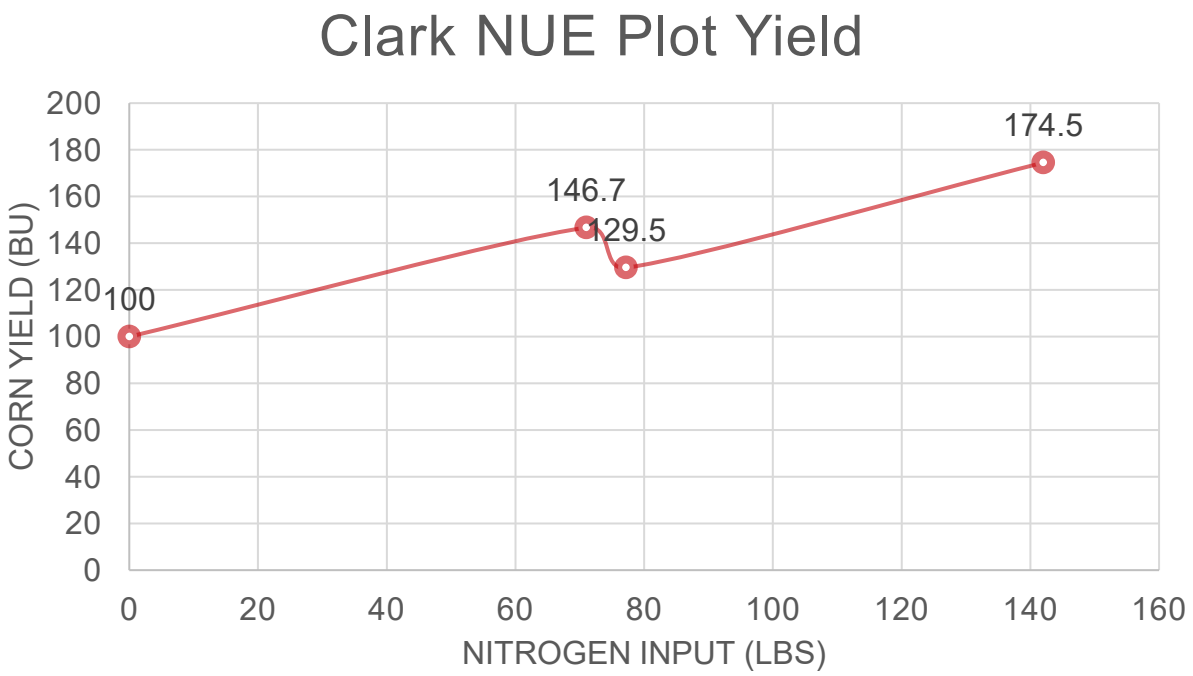


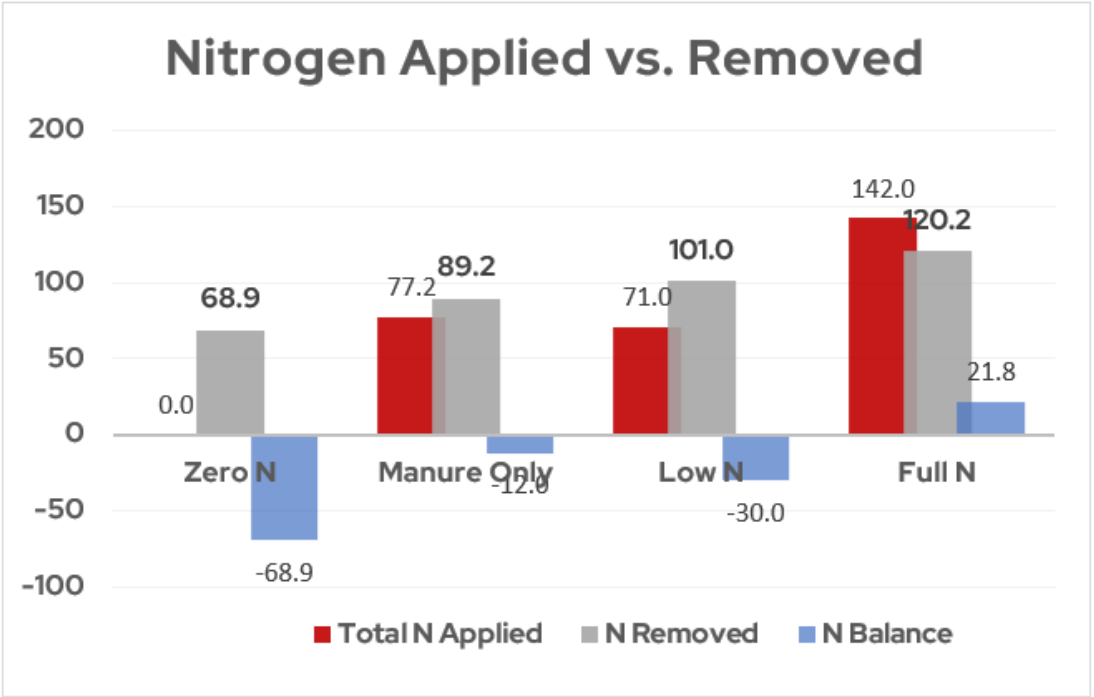
Clark NUE Plot

Local Results – Clark

MEASUREMENT	QUESTION ANSWERED	CALCULATION	RESULTS	WHAT DOES IT MEAN?
Partial Factor Productivity (PFP)	How productive is this field compared to its N input?	$\frac{\text{Yield (lb/ac)}}{\text{N supplied (lb/ac)}}$	68.82 Low-Mid	There was 68.82 lbs of grain produced per lb of N (1.22 bu/ lb N)
Partial Nutrient Balance (PNB)	How much N is removed in relation to the amount of N applied?	$\frac{\text{Plant N removal (lb/ac)}}{\text{N supplied (lb/ac)}}$	0.85 Mid-High	More N was applied than removed
Agronomic Efficiency (AE)	How productive was the additional N input?	$\frac{\text{Yield w/ N} - \text{Yield 0 N}}{\text{N supplied} - \text{0 N supplied}}$	29.38	The full N rate produced an additional 29.38 lb of grain (0.53 bu) per additional lb of N applied relative to the 0 N strip

Local Results – Clark





- Excess moisture affected yields here
- Manure treatment yielded less than low rate UAN

- Nitrogen that was applied was well utilized

Faessler NUE Plot

- Treatments
  - DAP only ► 30 N
  - DAP + 10 gal 32% ► 65 N
  - DAP + 20 gal 32% ► 101 N
  - DAP + 100 lb urea + 26 gal 32% ► 147 N
  - DAP + 200 lb urea + 26 gal 32% ► 214 N

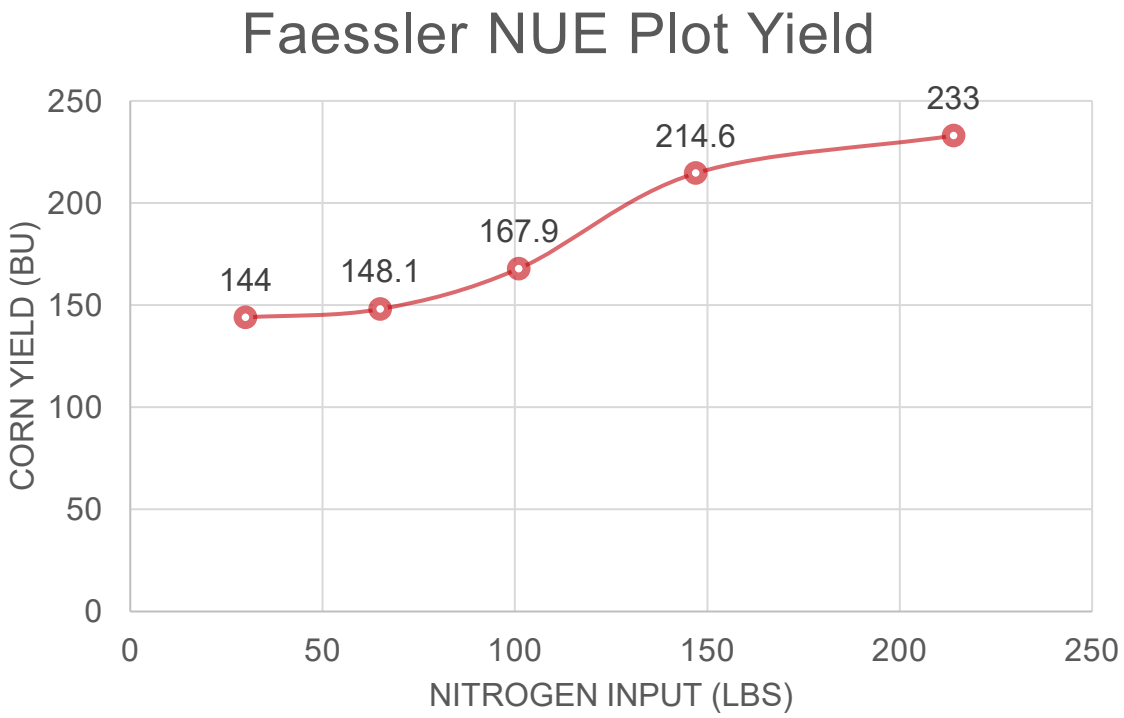
- Fall-applied DAP
- Urea broadcast preplant
- 32% sidedress @ V6

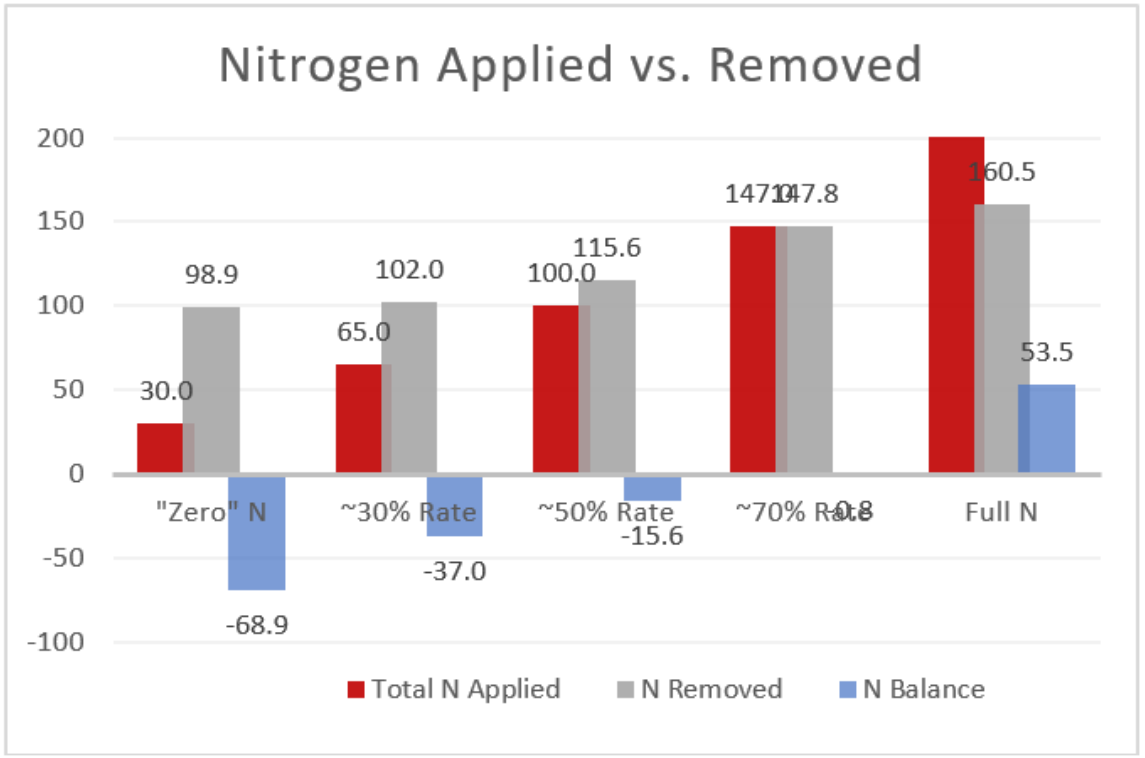
Faessler NUE Plot

Local Results – Faessler

MEASUREMENT	QUESTION ANSWERED	CALCULATION	RESULTS	WHAT DOES IT MEAN?
Partial Factor Productivity (PFP)	How productive is this field compared to its N input?	$\frac{\text{Yield (lb/ac)}}{\text{N supplied (lb/ac)}}$	60.97 Low-Mid	There was 60.97 lbs of grain produced per lb of N (1.09 bu/ lb N)
Partial Nutrient Balance (PNB)	How much N is removed in relation to the amount of N applied?	$\frac{\text{Plant N removal (lb/ac)}}{\text{N supplied (lb/ac)}}$	0.75 Low-Mid	More N was applied than removed
Agronomic Efficiency (AE)	How productive was the additional N input?	$\frac{\text{Yield w/ N} - \text{Yield 0 N}}{\text{N supplied} - \text{0 N supplied}}$	27.09	The full N rate produced an additional 27.09 lb of grain (0.48 bu) per additional lb of N applied relative to the 0 N strip

Local Results – Faessler



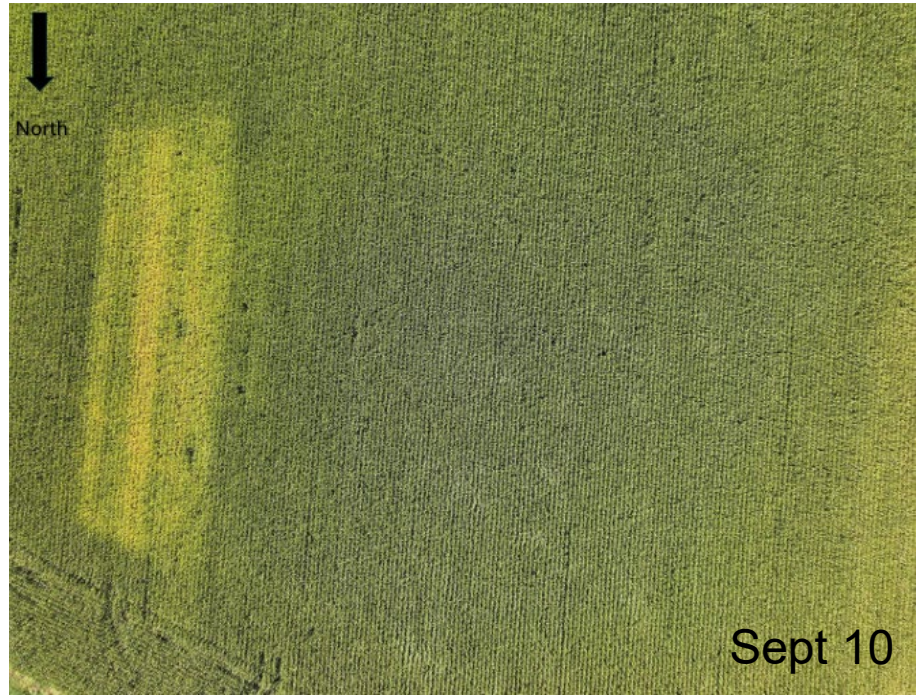


- Did the fall-applied N stick around?
- Considerations for excess N

Feller NUE Plot

- Treatments
  - 5 gal 7-21-3 + 1 gal foliar 25-0-0 ► 6.5 N
    - “base treatment”
  - Base + 5 tons manure ► 22.5 N
  - Base + 5 tons manure + 25 gal 29% blend at sidedress ► 103.7 N
  - Base + 5 tons manure + 40 gal 29% blend split app ► 210 N
- Chemical rye termination 2 weeks before planting
- Manure application
- Vertical tillage before planting
- Starter at planting
- UAN split app
- Foliar N w/ fungicide @ VT

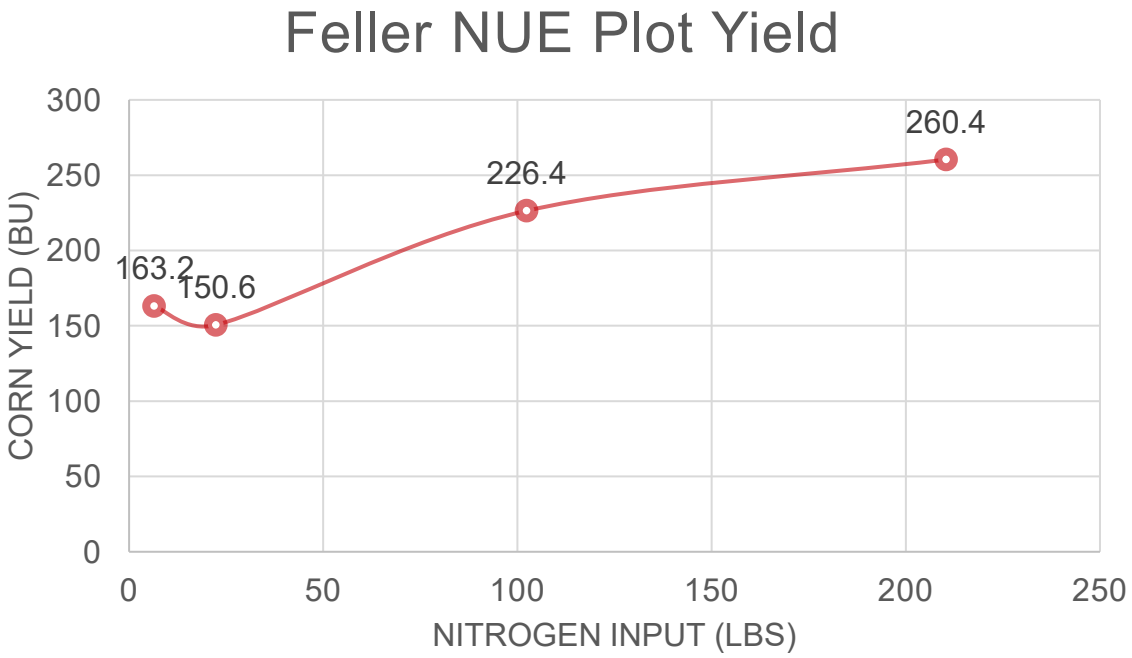
Feller NUE Plot

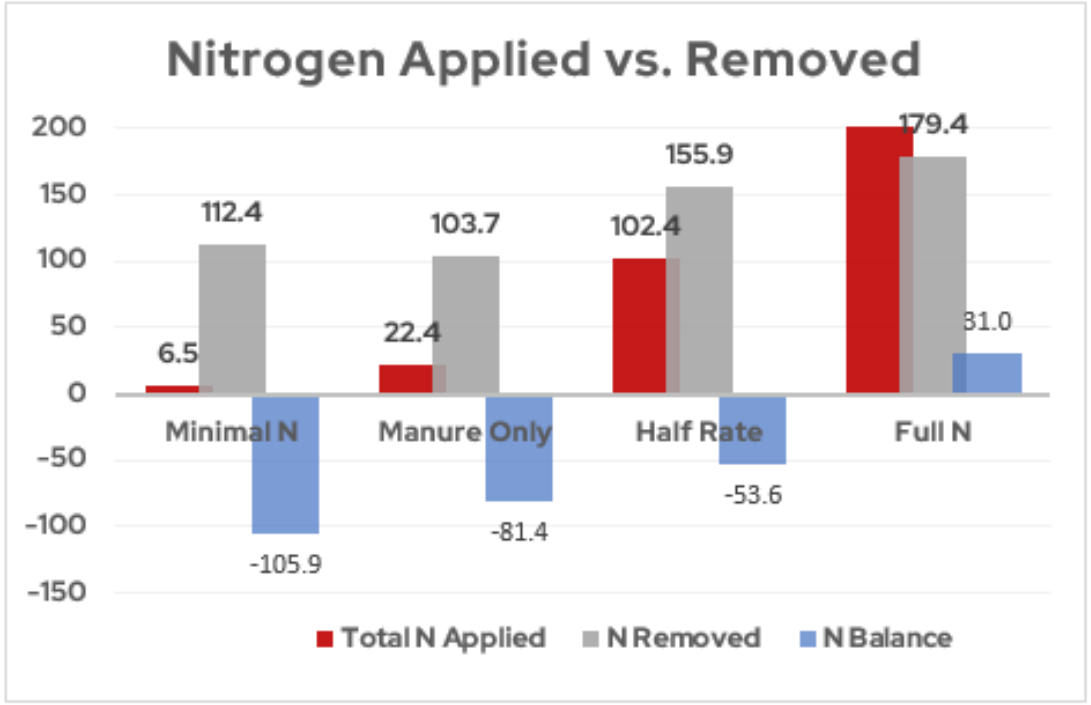


Local Results – Feller

MEASUREMENT	QUESTION ANSWERED	CALCULATION	RESULTS	WHAT DOES IT MEAN?
Partial Factor Productivity (PFP)	How productive is this field compared to its N input?	$\frac{\text{Yield (lb/ac)}}{\text{N supplied (lb/ac)}}$	69.32 Low-Mid	There was 69.32 lbs of grain produced per lb of N (1.24 bu/ lb N)
Partial Nutrient Balance (PNB)	How much N is removed in relation to the amount of N applied?	$\frac{\text{Plant N removal (lb/ac)}}{\text{N supplied (lb/ac)}}$	0.85 Mid-High	More N was applied than removed
Agronomic Efficiency (AE)	How productive was the additional N input?	$\frac{\text{Yield w/ N} - \text{Yield 0 N}}{\text{N supplied} - \text{0 N supplied}}$	26.7	The full N rate produced an additional 26.7 lb of grain (0.48 bu) per additional lb of N applied relative to the 0 N strip

Local Results – Feller

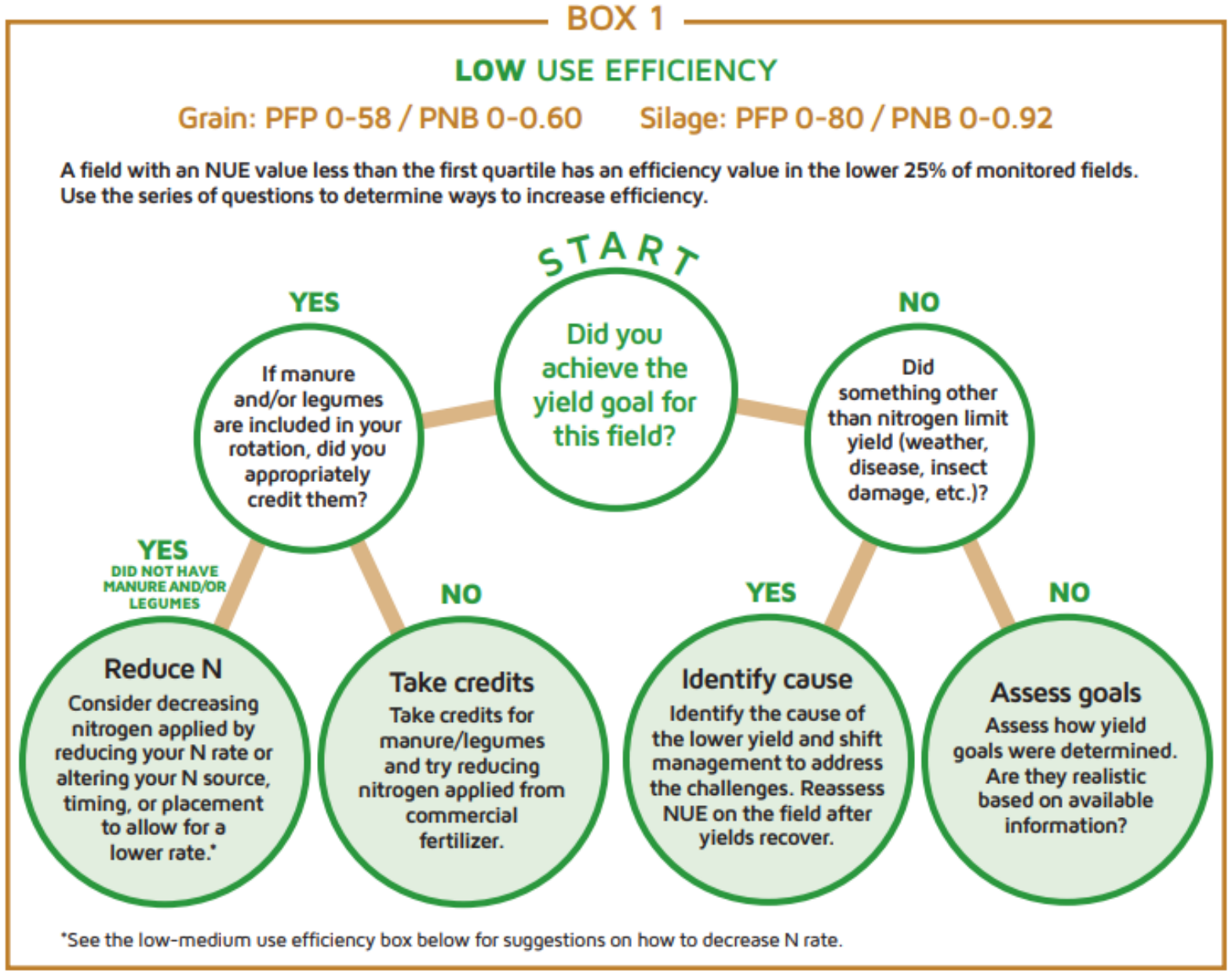




- Manure only treatment yielded less than zero N – C:N ratio tie up?

- Very productive soil
- Is it ok to have such a large negative nitrogen balance?

Improving NUE



Improving NUE

BOX 2

LOW-MEDIUM USE EFFICIENCY

Grain: PFP 59-72 / PNB 0.61-0.77 Silage: PFP 81-95 / PNB 0.92-1.08

A field with an NUE value between the first quartile and the median has an efficiency value in the lower 25%-50% of monitored fields. In this context, the majority of farm fields have greater NUE suggesting that there are opportunities to improve.

NUE can be increased by reducing N rates through changes in nitrogen or general field management, as long as yields aren't decreased below yield goals. Try to reduce rates by implementing one of the following practices.

- Move fall applications of N to spring or in-season and avoid applications on frozen soil.
- Split spring nitrogen into more than one application.
- Use N inhibitor products when appropriate.
- Consider using controlled release N on sandy soil.
- Test small reductions (10-20%) in N applications.
- Evaluate other management practices (soil and pest) and their impacts on yield.

With continued NUE assessments on this field, you can monitor the impacts of the new management on NUE.

BOX 3

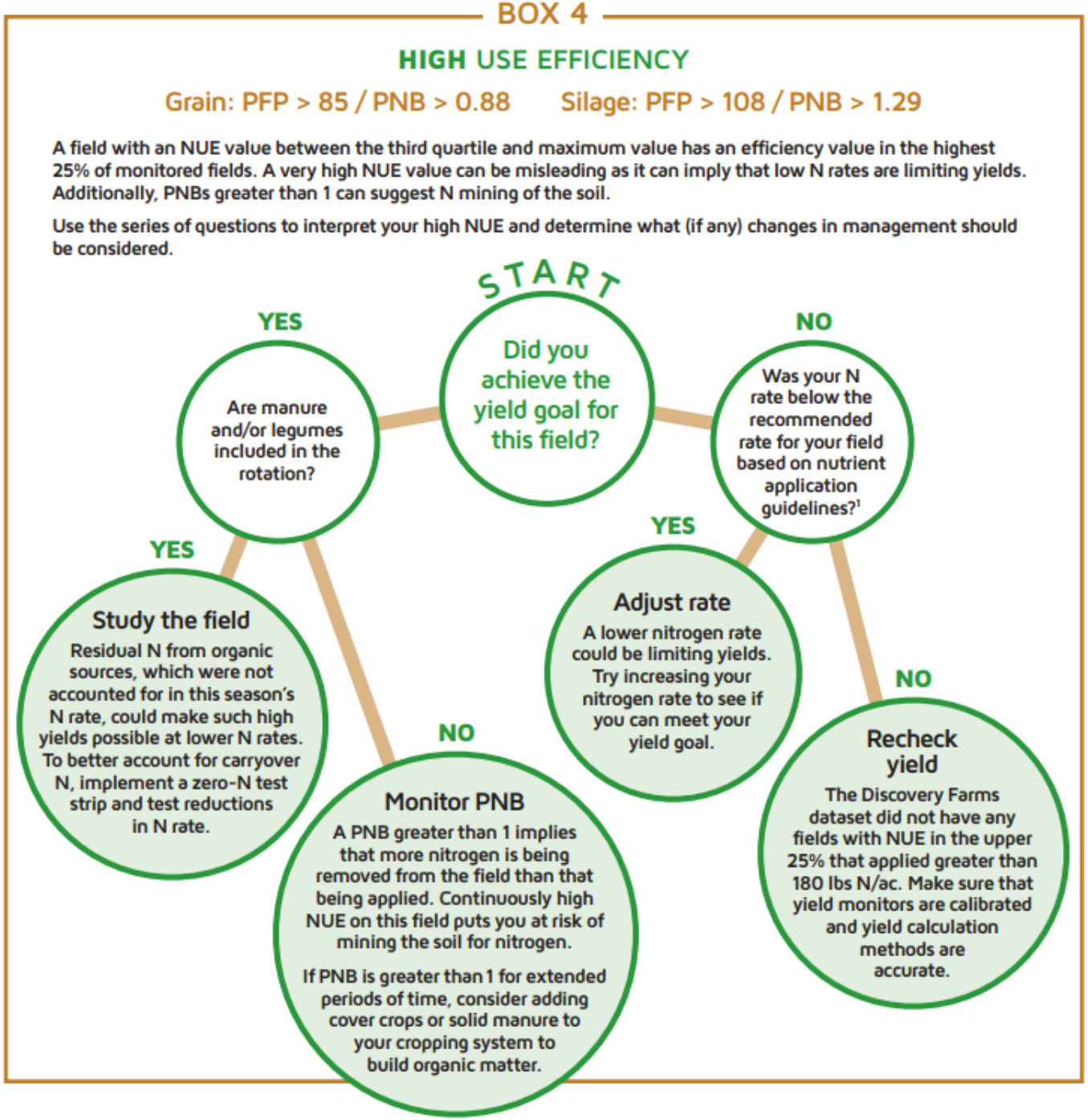
MEDIUM-HIGH USE EFFICIENCY

Grain: PFP 73-85 / PNB 0.78-0.88 Silage: PFP 96-108 / PNB 1.08-1.29

A field with an NUE value between the median and the third quartile has an efficiency value in the upper 50%-75% of monitored fields. With an above average NUE, this is a good range to fall within.

Changes in the 4Rs should be evaluated in small areas and costs associated with management changes should be considered along with potential cost savings of N. These fields should have periodic NUE assessments for continued evaluation to assess impacts of weather or any management shifts made from year to year.

Improving NUE



Financial Impact

Scenario 1: Yield Increase

- Increasing PFP from 65 to 80
  - 65 = 1.16 bu/lb of added N
  - 80 = 1.43 bu/lb of added N
- Gain of 0.27 bu/lb N x 100 lbs N/ac = 27 bu/ac
- 27 bu/ac x $4.50/bu = $32.81/ac

Financial Impact

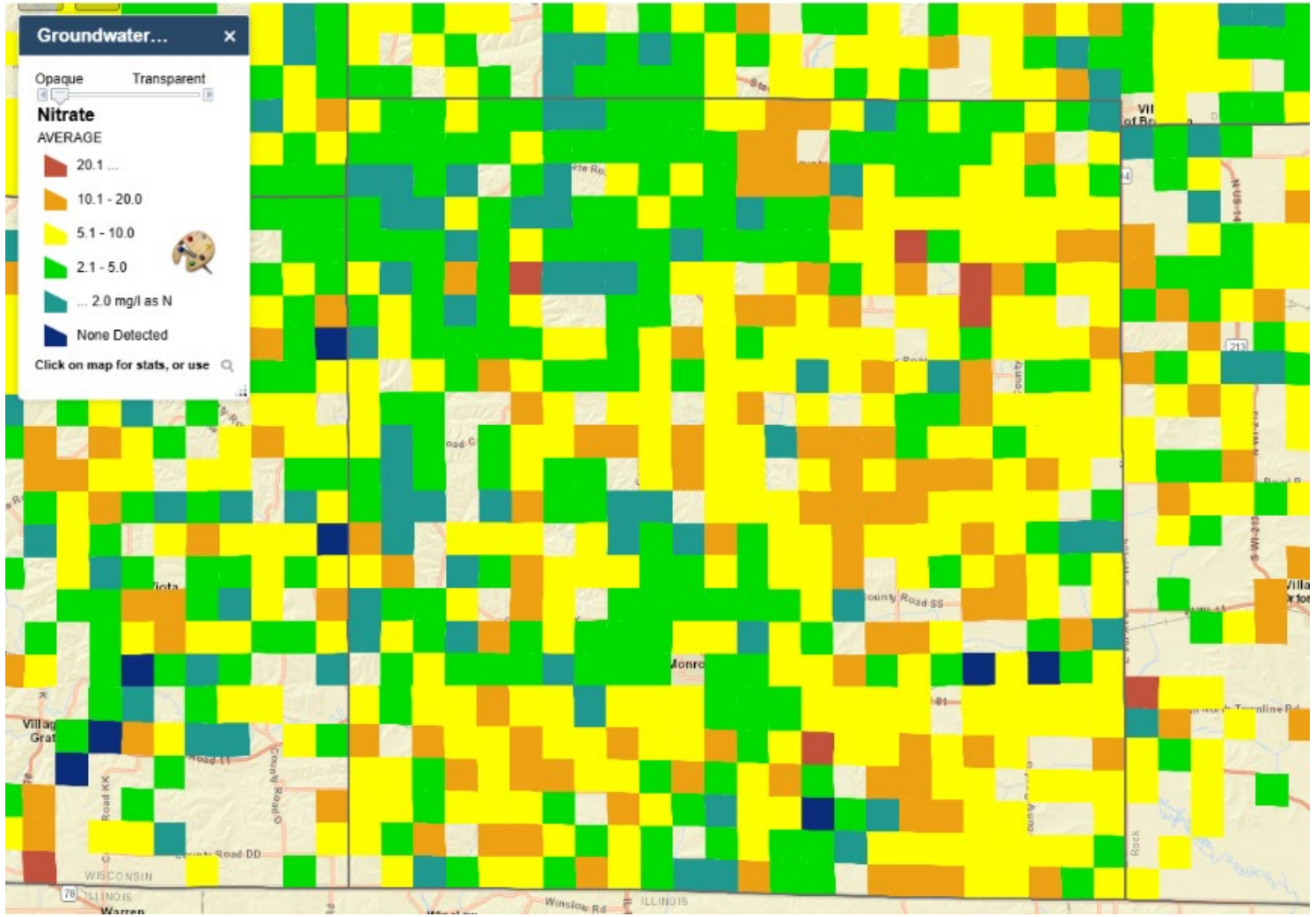
Scenario 2: Reducing N Input

- PFP = 65
  - 244 bu Corn is achieved with 210 lbs N
- Increase to PFP = 80
  - 244 bu Corn can be achieved with only 171 lbs N

- 39 lb N reduction x $0.55/lb N = $21.45/ac savings

Environmental Impact

- Improving nitrogen use by crops and removal reduces nitrate leaching to groundwater
- Public health concern
- Disrupts the balance of the ecosystem



What We Learned

- There’s always room for improvement
- Farmers are surprised by their Nitrogen Use Efficiency
  - Often lower than expected
- Need to take more ownership of cropping practices (factors we can control) to manage risk
- Nutrient Management Plans are a good starting place for figuring nitrogen rates and accounting for all nitrogen sources

Conduct Your Own NUE

- Choose fields you suspect could be improved

- Standard assessment
  - Nitrogen inputs & yield
  - Nitrogen content of grain (optional)
- Intensive assessment
  - 0 added nitrogen strip
  - Nitrogen content of aboveground biomass (optional)

- Track values to monitor effect of management changes

Conduct Your Own NUE

- Make sure there's no hybrid changes in your plot area
- Size the plot for your equipment
  - Planter, nitrogen application, & harvest equipment
- Mark your plots with flags and GPS points
- If using your yield monitor for data
  - CALIBRATE
  - Try to have a minimum plot length of 500'
- Ask for help!
  - Extension & Land Conservation Department are great resources

Take Home Points

- Nitrogen Use Efficiency assessments are an easy way to evaluate nitrogen use on your farm

- Efficient nitrogen utilization can improve profitability & protect the environment

- You can’t manage what you don’t measure!

Thank you!

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