VARIABLE RATE NITROGEN MANAGEMENT

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WHY USE VARIABLE RATE N ?

- Adjust N rates to = crop N need throughout each field
- Benefits:
  - Avoids applying too much or too little N
  - Increase profits
  - Reduce environmental risk

ENVIRONMENTAL ISSUES

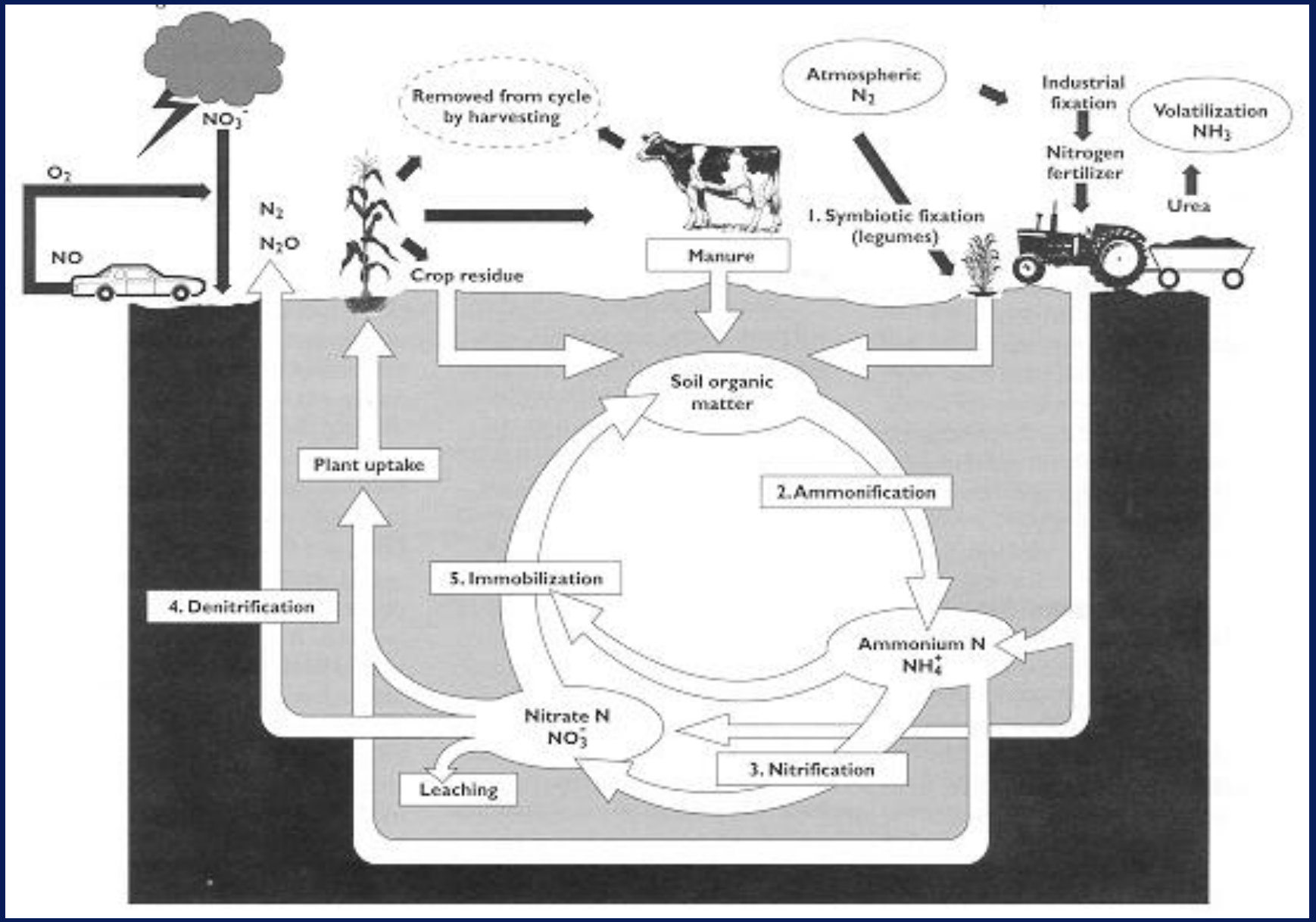
- Nitrate leaching
  - Nitrate in ground water
  - Nitrate in tile drain outflow
- Nitrate contributions to Gulf of Mexico hypoxia

NEEDS FOR USING A VARIABLE RATE N APPROACH

- Predict economic optimum N rate on a site specific (sub-field) basis
- Apply N at variable rates within fields to meet predicted crop N needs

PREDICTING OPTIMUM N RATES

- Nitrogen availability is affected by many factors
- Numerous attempts to develop diagnostic criteria to predict optimum N rates


NO_3^-
O_2
NO
N_2
N_2O
Removed from cycle by harvesting
Crop residue
Manure
Atmospheric N_2
1. Symbiotic fixation (legumes)
Industrial fixation
Nitrogen fertilizer
Volatilization NH_3
Urea
Soil organic matter
Plant uptake
2. Ammonification
5. Immobilization
4. Denitrification
Ammonium N NH_4^+
Nitrate N NO_3^-
3. Nitrification
Leaching

DETERMINING FERTILIZER N RATES

- Yield goal
- Soil-specific recommendations
- Delta yield approach

Mass Balance Approach to Nitrogen Recommendations

Crop N use = Sum of avail. N x Effic.

N Sources:

- **Soil N mineralization**
- **Legume and manure N**
- **Residual profile nitrate**
- **Fertilizer N**

TYPICAL YIELD GOAL APPROACH TO N RECOMMENDATIONS

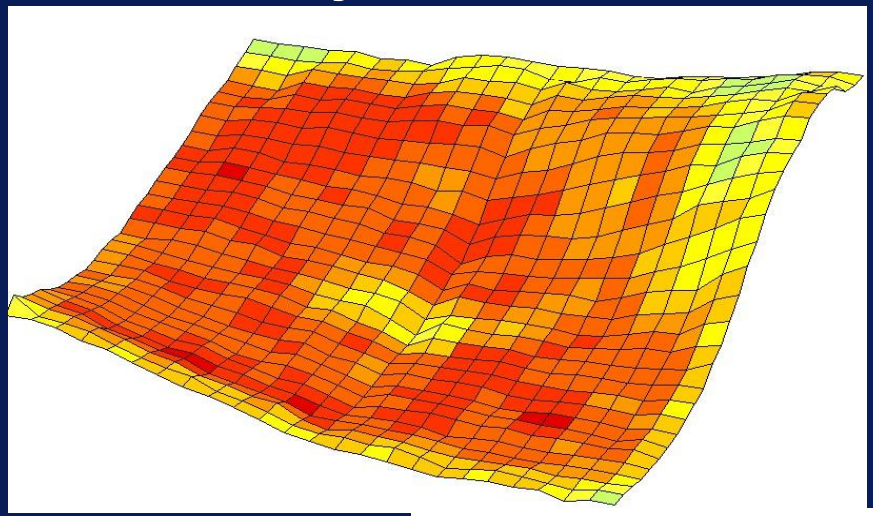
N recommendation = target yield x 1.2 – N credits

Concerns with yield goal-based nitrogen recommendations

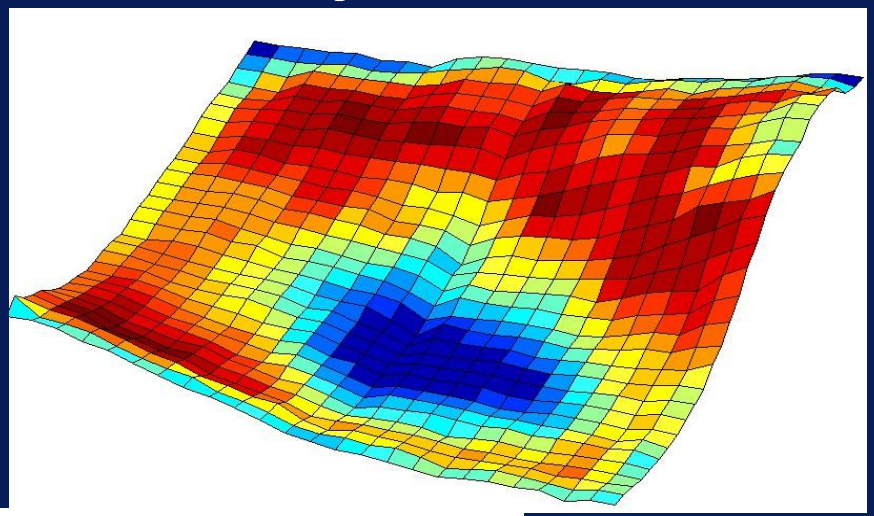
- Selection of unrealistic yield goals
  - Unprofitable N rates
  - Environmentally undesirable N rates
- Uncertainty on how yield goals should be determined
- Poor relationship between optimum N rates and recommendations

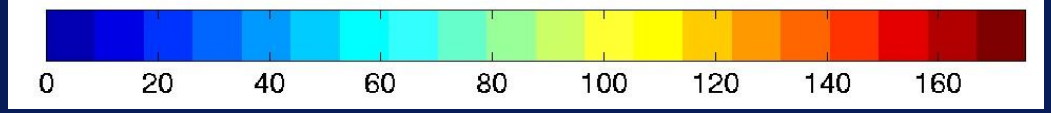
Year to year differences in corn yield in the same field

Corn yield in 1999



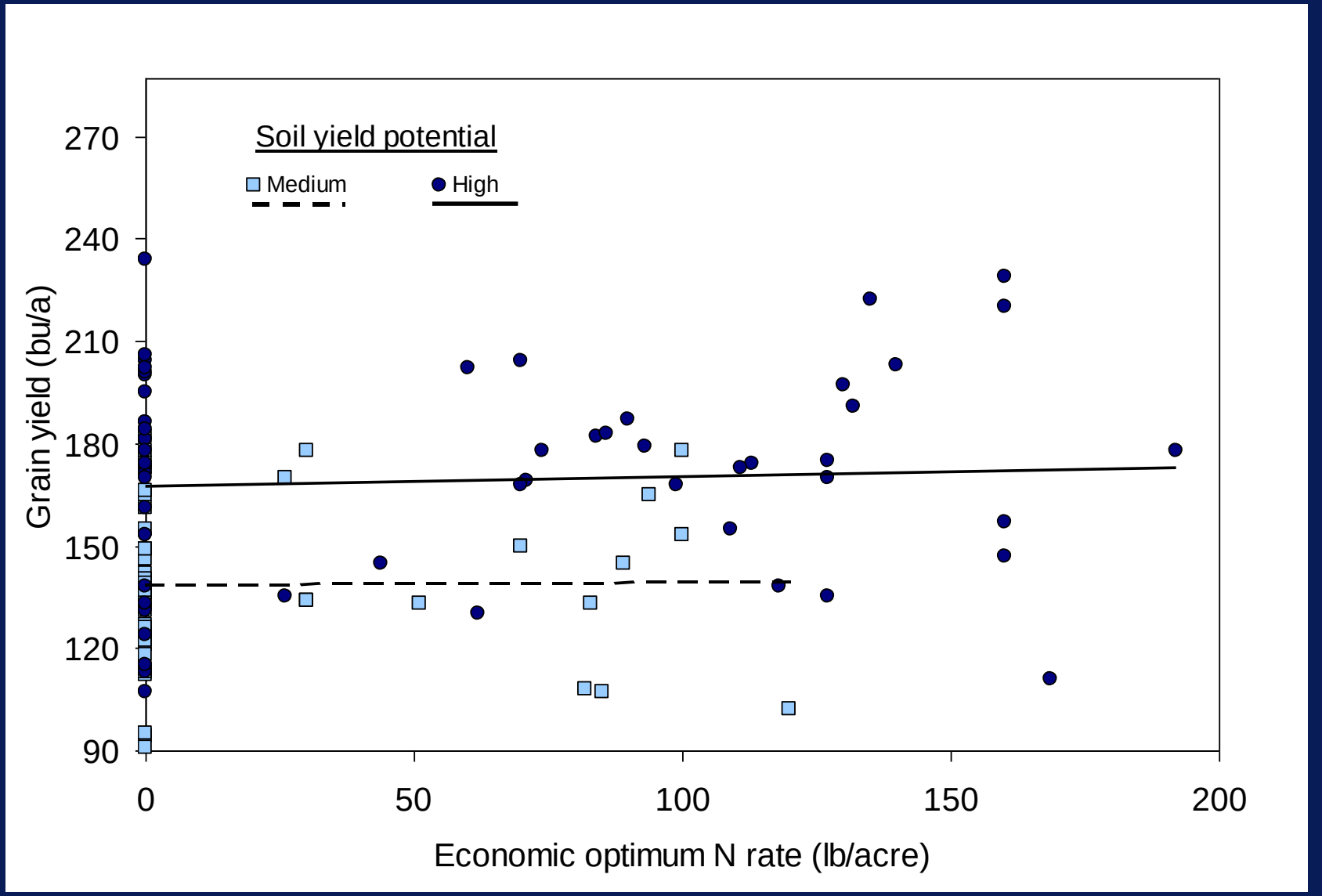
Corn yield in 2000



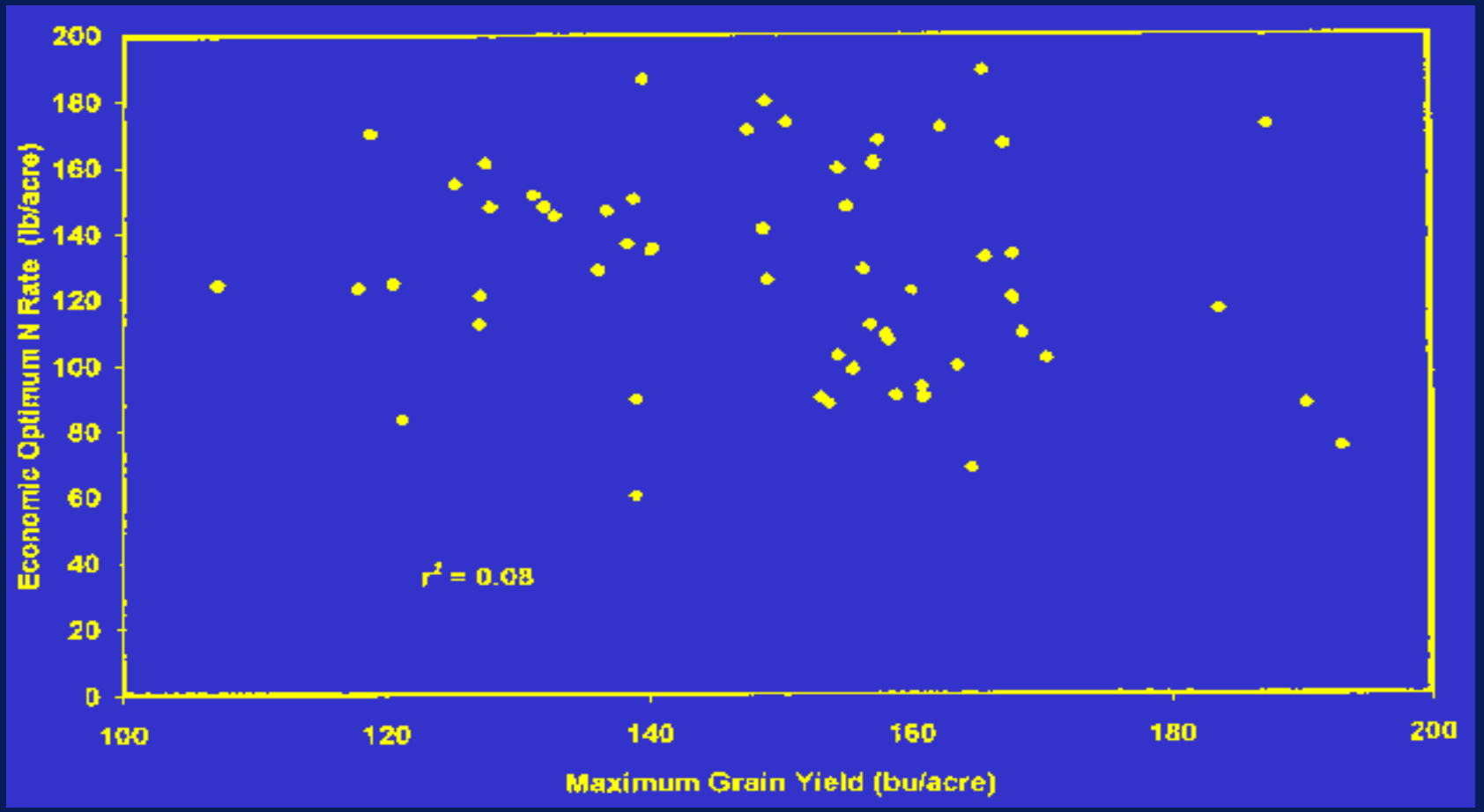


Bushels per acre

Relationship between optimum N rate and yield – Wis.

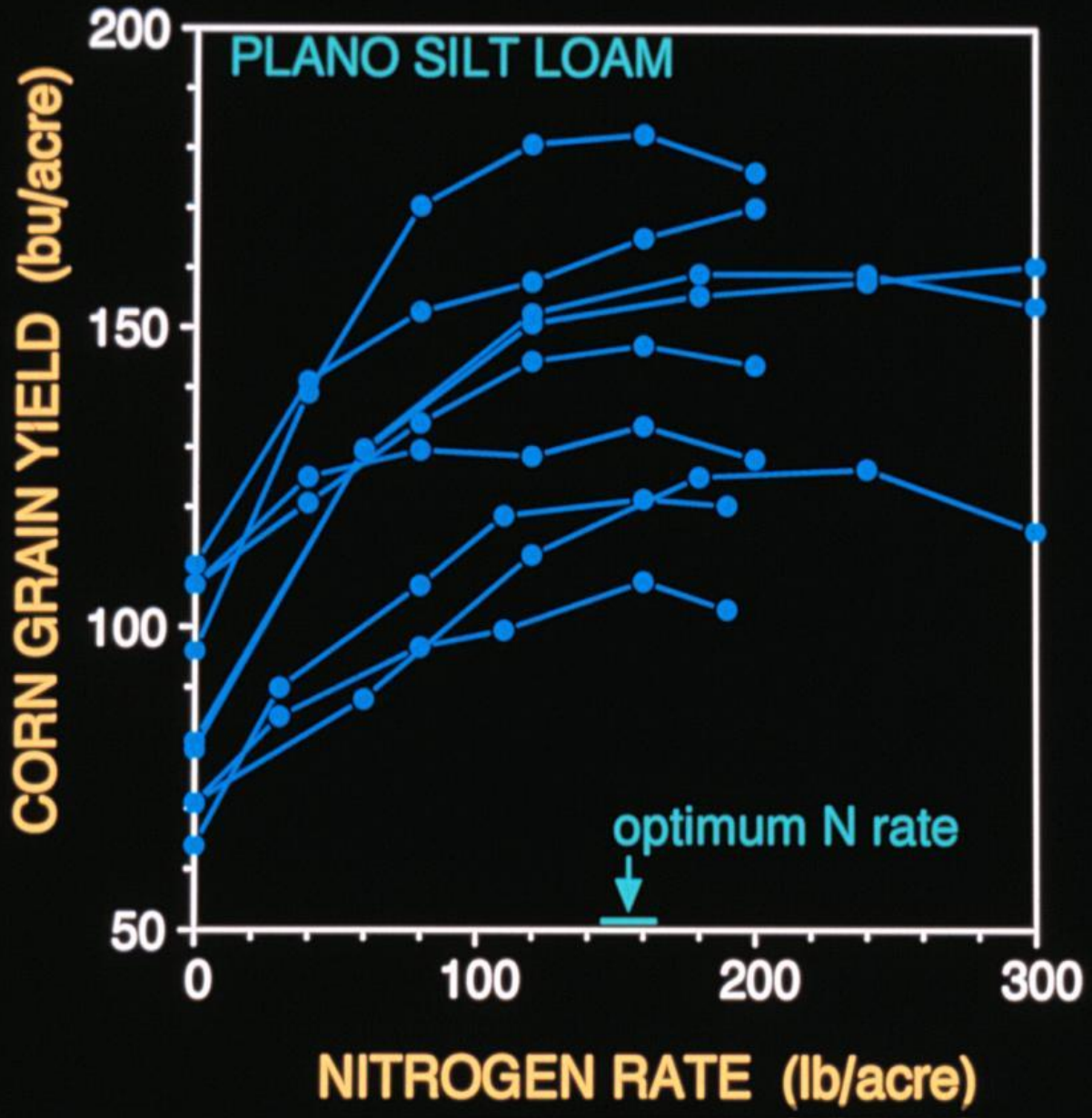


Relationship between corn yield and optimum N rate, Pennsylvania.



Optimum N rate for corn

- Soil-specific characteristic
- Not affected by annual variations in yield
- Year-specific adjustments for soil nitrate and organic N inputs needed


PLANO SILT LOAM
CORN GRAIN YIELD (bu/acre)
200
150
100
50
0
100
200
300
optimum N rate
NITROGEN RATE (lb/acre)

Major Soil Regions used for Corn Production in Wisconsin

Adapted from Hole, F.D., 1976, Soils of Wisconsin, University of Wisconsin Press, Madison

DELTA YIELD APPROACH TO N RECOMMENDATIONS

- Measures yield increase from added N
- Delta yield = Yield at opt. N rate – Yield with no N

DELTA YIELD APPROACH TO N RECOMMENDATIONS

- Requires information on size of N response in each production unit
- Year to year or within field variation is likely

DEVELOPING VARIABLE RATE N MANAGEMENT

- What measurements will be used to identify within-field variation in N supply or availability?
- What N recommendation or base N rate will be used?

STRATEGIES TO GUIDE VARIABLE RATE N APPLICATIONS

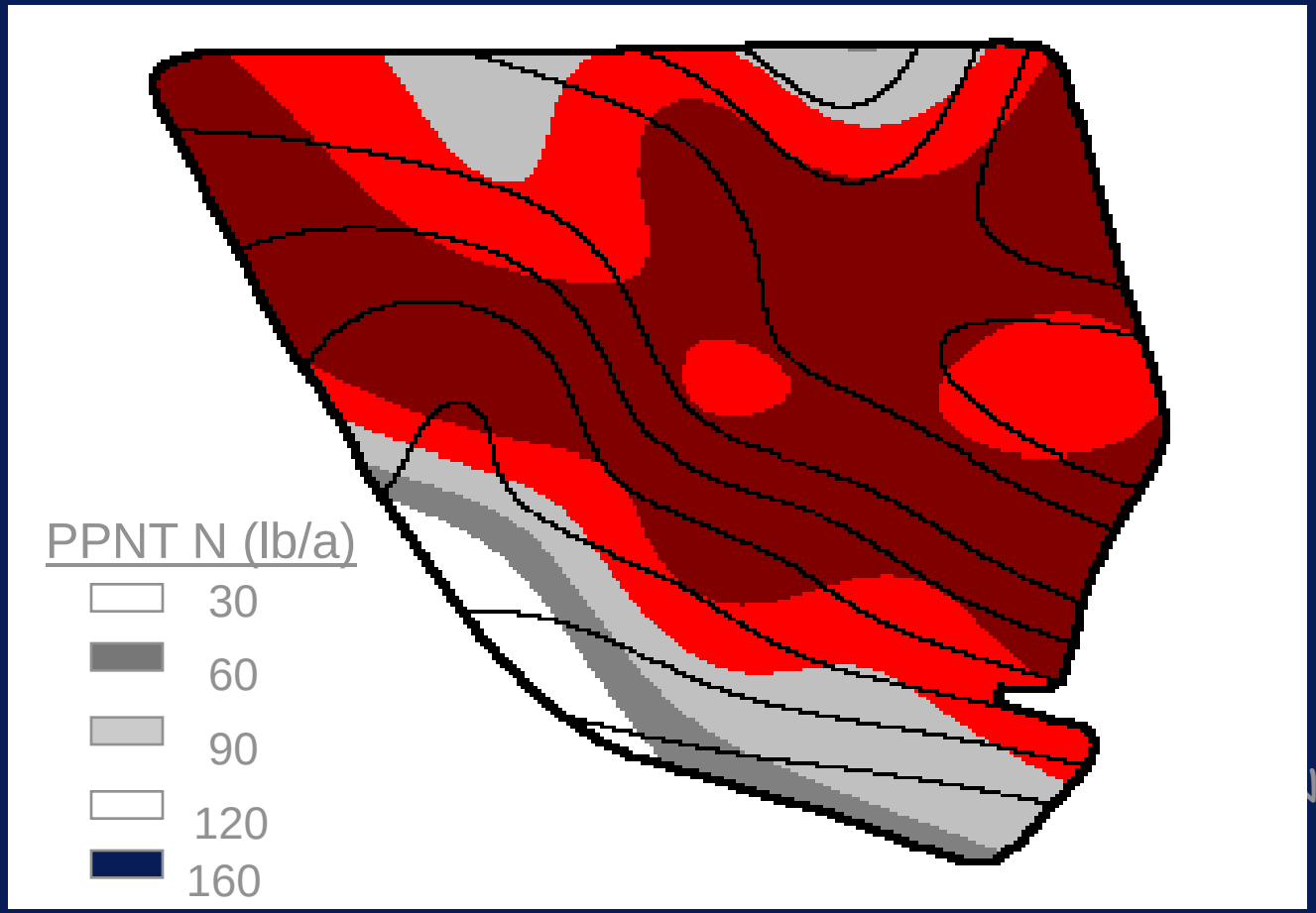
- Before the growing season (proactive)
- During the growing season (reactive)

Doerge (2001)

Before the growing season (proactive) approach

- Divide fields into sub-units
- Apply diagnostic tools
- Develop N rate prescription map for the field
  - ✓ e.g. grid sampling, soil nitrate tests, field map showing variable N rate to apply

PPNT BASED N RATE AT THE TREINEN FIELD, 1997



Wolkowski, 1998

Before the growing season (proactive) strategies

- Soil nitrate testing
- Remote sensing of crop and soil properties
- Site-specific data from yield monitors
- Soil electrical conductivity maps

During the growing season (reactive) strategies

- Monitor crop N status in the field
- Apply N at variable rates to meet crop needs

During the growing season (reactive) strategies

- Plant or canopy reflectance
- Chlorophyll measurements
- On-the-go or remotely sensed crop canopy imagery
- In-field reference strip may be needed

Reference Strips for Chlorophyll Meter

Field trials with variable rate N, Wisconsin (Wolkowski, 1998-99

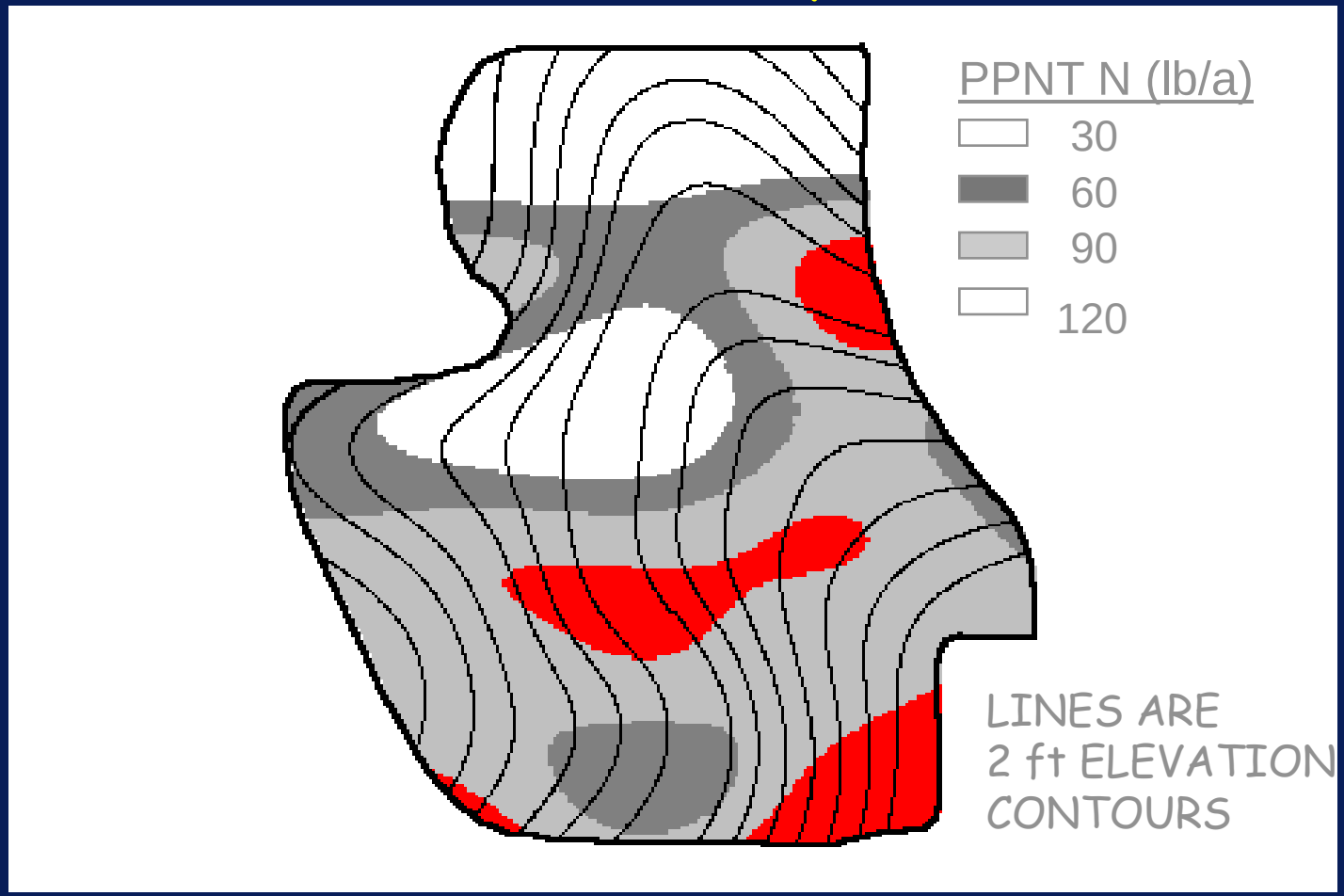
- THREE LOCATIONS
- GEO-REFERENCED 1 ACRE PREPLANT N TEST
- DEVELOP N RECOMMENDATION
- APPLY FIELD LENGTH STRIPS OF UNIFORM FULL RATE OR VARIABLE - 28%
- OTHER: PSNT, ELEVATION, PSA
- HARVEST STRIPS WITH YIELD MONITOR EQUIPPED COMBINE

Preplant soil nitrate tests and N recommendations, 1997-1998

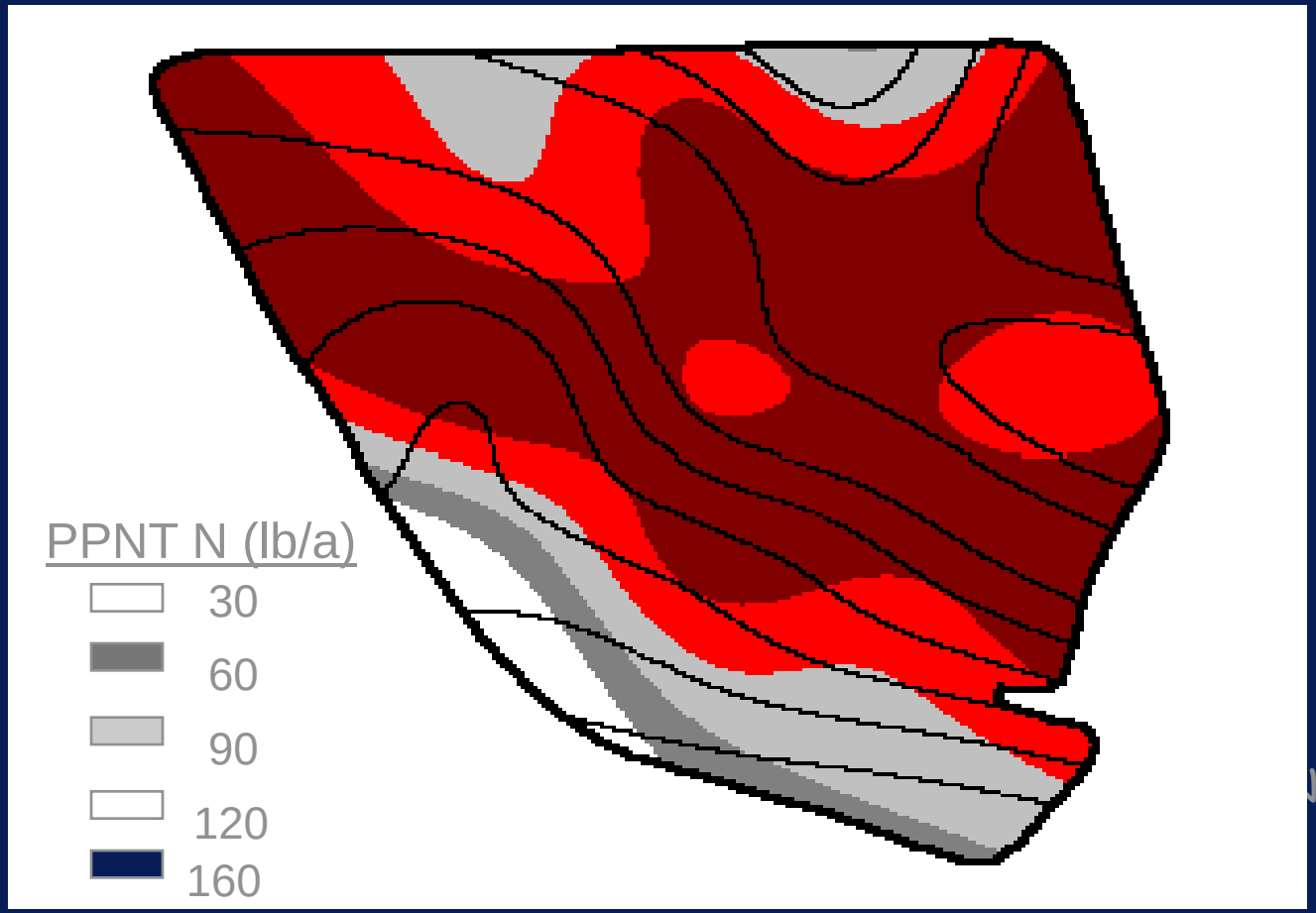
	PPNT		N REC.	
SITE	1997	1998	1997	1998
	-lb NO_3/3ft.-		---lb N/A ---	
SCHEUER	120	63	57	107
STEIGER	110	122	104	49
TREINEN	99	81	111	128

* *STEIGER N REC. INCLUDES 40 lb/a SOYBEAN CREDIT*

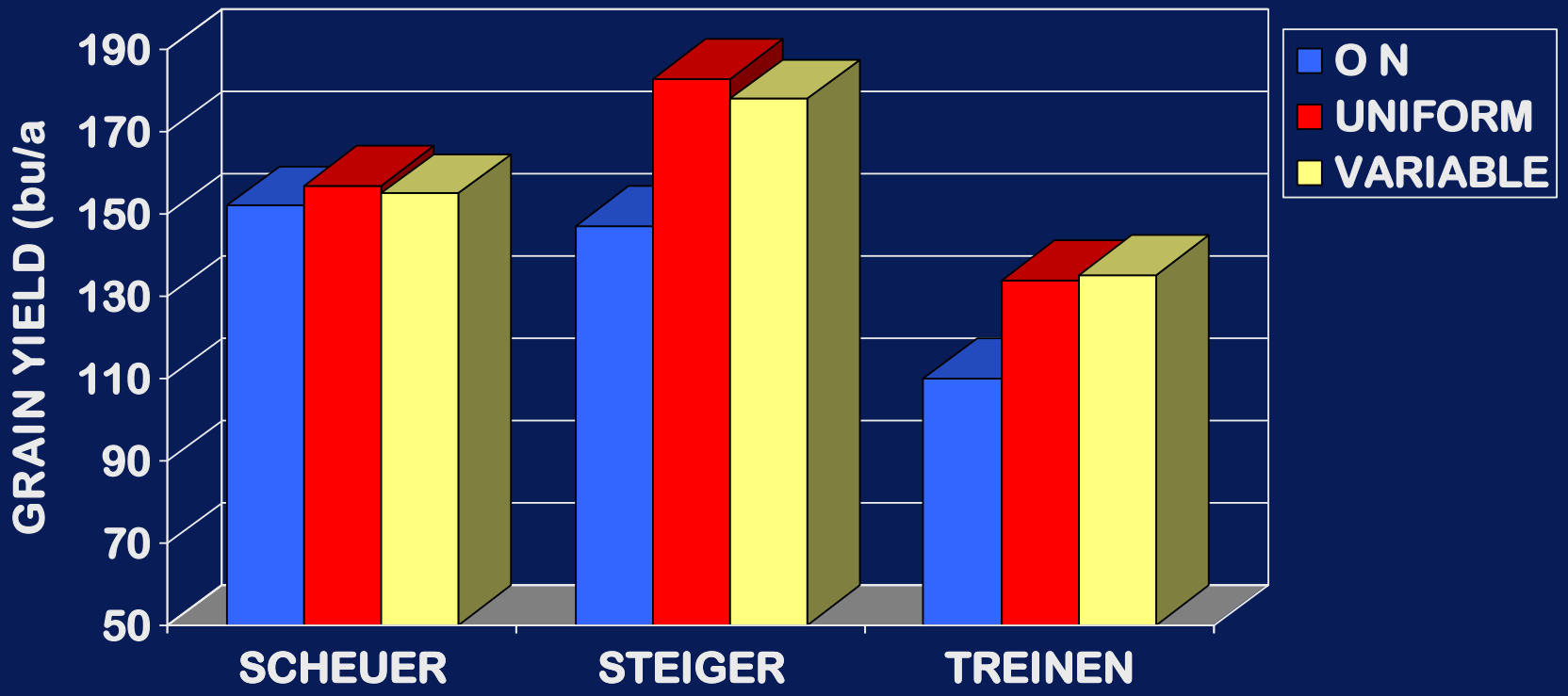
PPNT BASED N RATE AT THE SCHEUER FIELD, 1997



PPNT BASED N RATE AT THE TREINEN FIELD, 1997



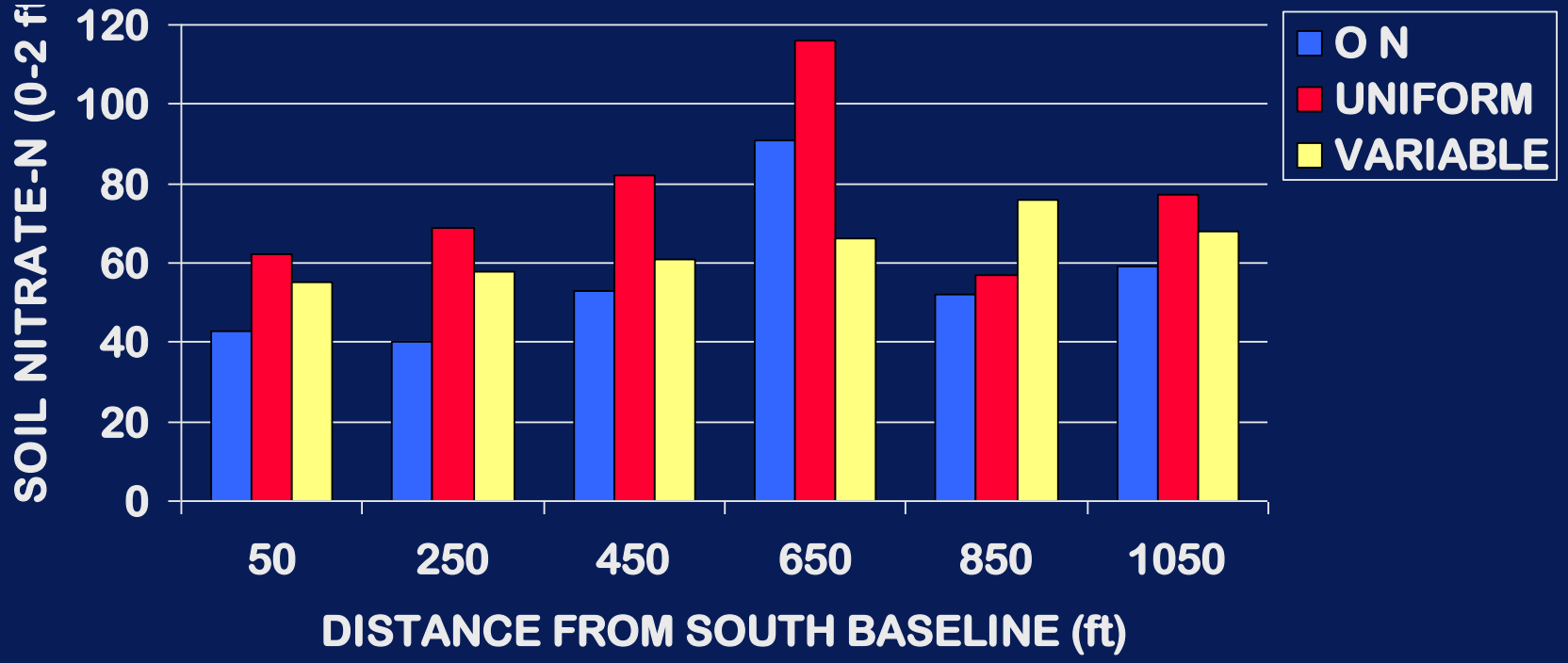
EFFECT OF UNIFORM AND VARIABLE N ON CORN YIELD, 1997



PARTIAL BUDGET FOR VARIABLE N MANAGEMENT

	SCHEUER		STEIGER		TREINEN	
	UNF	VRT	UNF	VRT	UNF	VRT
	----- $/a -----					
GROSS RETURN	393	388	458	445	335	338
N MGT. COST	32	36	42	47	42	49
RETURN ABOVE COST	361	352	416	398	293	289

EFFECT OF N MANAGEMENT ON POST HARVEST SOIL NITRATE



SCHEUER, 1997

PARTIAL BUDGET FOR VARIABLE N MANAGEMENT, 1998

	SCHEUER		STEIGER		TREINEN	
FACTOR	UNF	VAR	UNF	VAR	UNF	VAR
	$/a					
RETURN	278	335	513	508	448	438
COST	32	48	33	34	42	53
NET	246	287	480	474	406	385

ASSUMES $2.50/bu; $0.24/lb N

Within-field variation of optimum N rates

- Substantial variation: <30 to >200 lb N/acre (Malzer, Minn.)
- Very little variation on medium-textured soils (Bundy, Wis.)
- Spatial patterns of optimum N rates within the same field can vary from year to year.

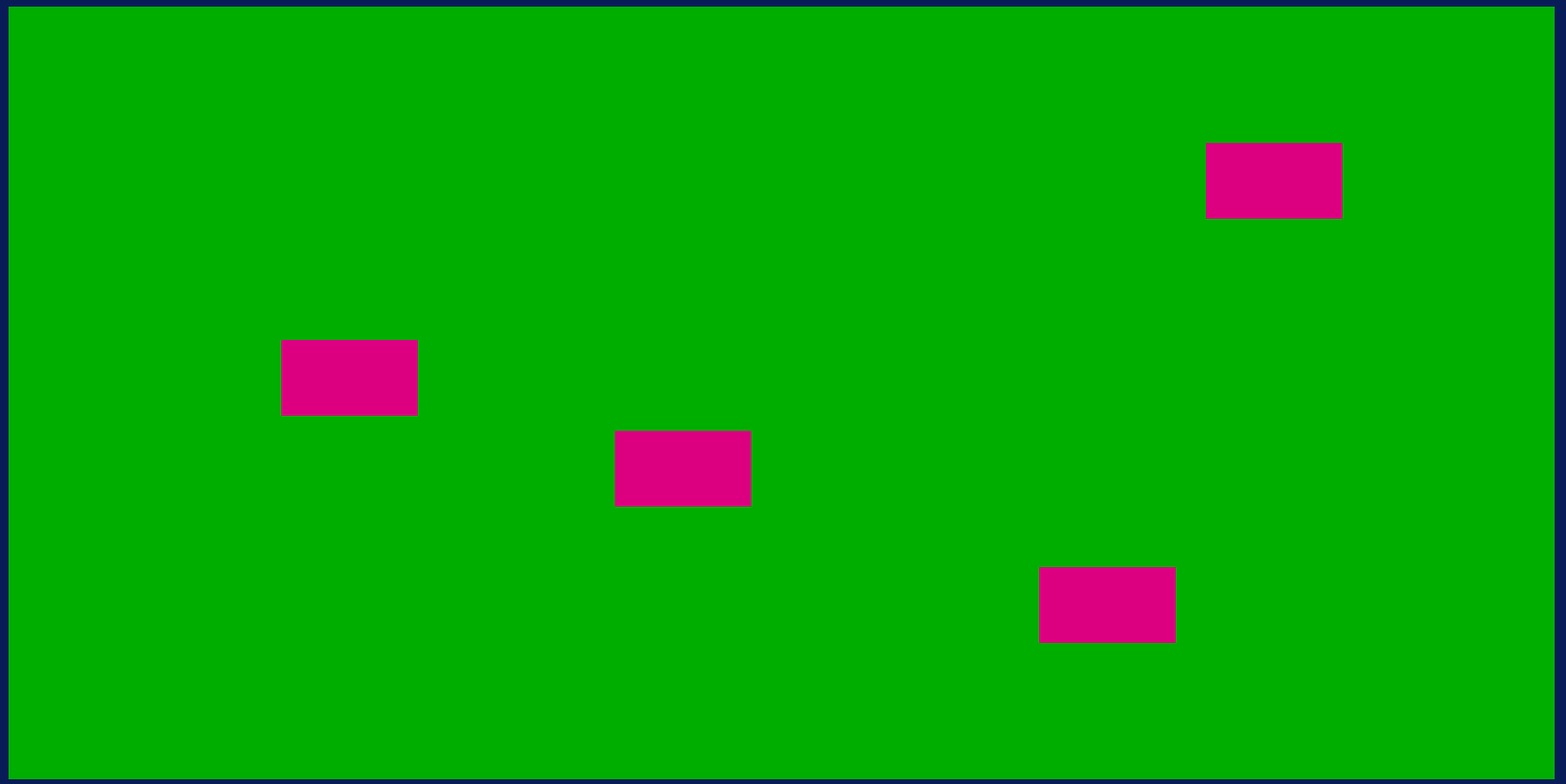
Variable Rate N Management Studies

Field Locations:

Dane Co. - Sun Prairie
Grant Co. - Bloomington
Wood Co. - Marshfield

Design: Four N rate trials in each field
(0 to 210 lb N/acre,
30 lb N/acre increments)

Typical distribution of small plot experiments in variable rate N study fields.



Optimum N rates at four locations in corn fields

	Optimum N rate		
Location	Dane	Grant	Wood
	---------- lb N/acre ----------		
1	127	130	0
2	127	130	0
3	127	109	0
4	127	130	0
Prev. crop	Corn	Corn	Alf.-corn

Recent Work to Develop Variable Rate N Management

- Hendrickson & Han (2000)
  - Used infrared aerial photos
  - Three N rates applied
  - Prepared N stress field maps
  - Variable rate N applied just before silking

Recent Work to Develop Variable Rate N Management

- Hendrickson & Han (2000)
  Results:
  - Yields at 7 sites were equivalent to N applied at emergence
  - One site with wet spring had higher yields with the variable rate

Work to Develop Variable Rate N Management (Scharf & Lory, 2000)

- On-the-go sensing of crop N status
- Radiometer- green:near infrared reflectance
- Compare readings with well-fertilized strip
- Predict optimum sidedress N rates

Obstacles/Challenges for variable rate N management

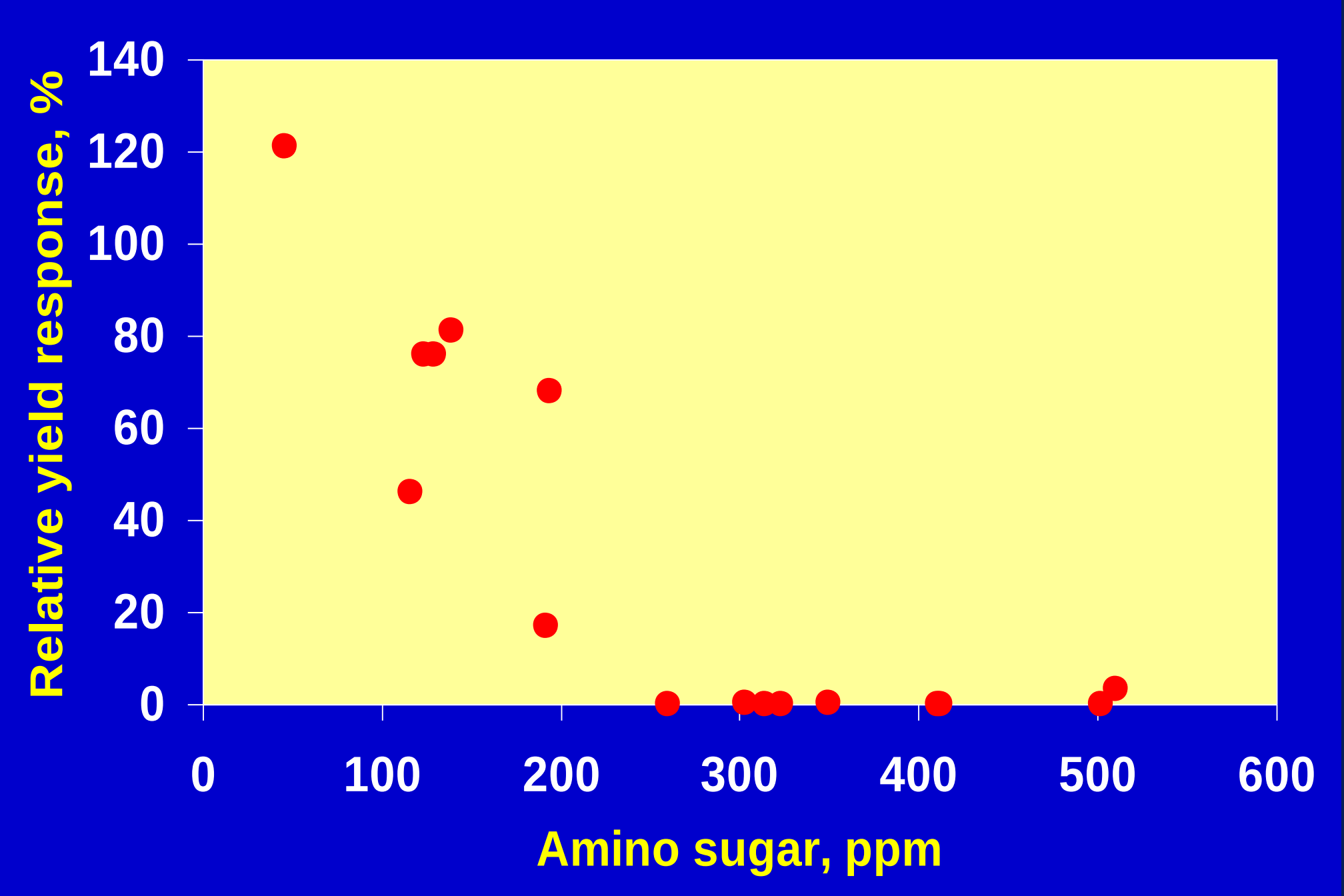
- Reliable method to identify within-field variation in crop N supply
- Absence of yield, profitability, or environmental benefits in comparisons
- Small differential between potential profit increases and costs of variable rate management

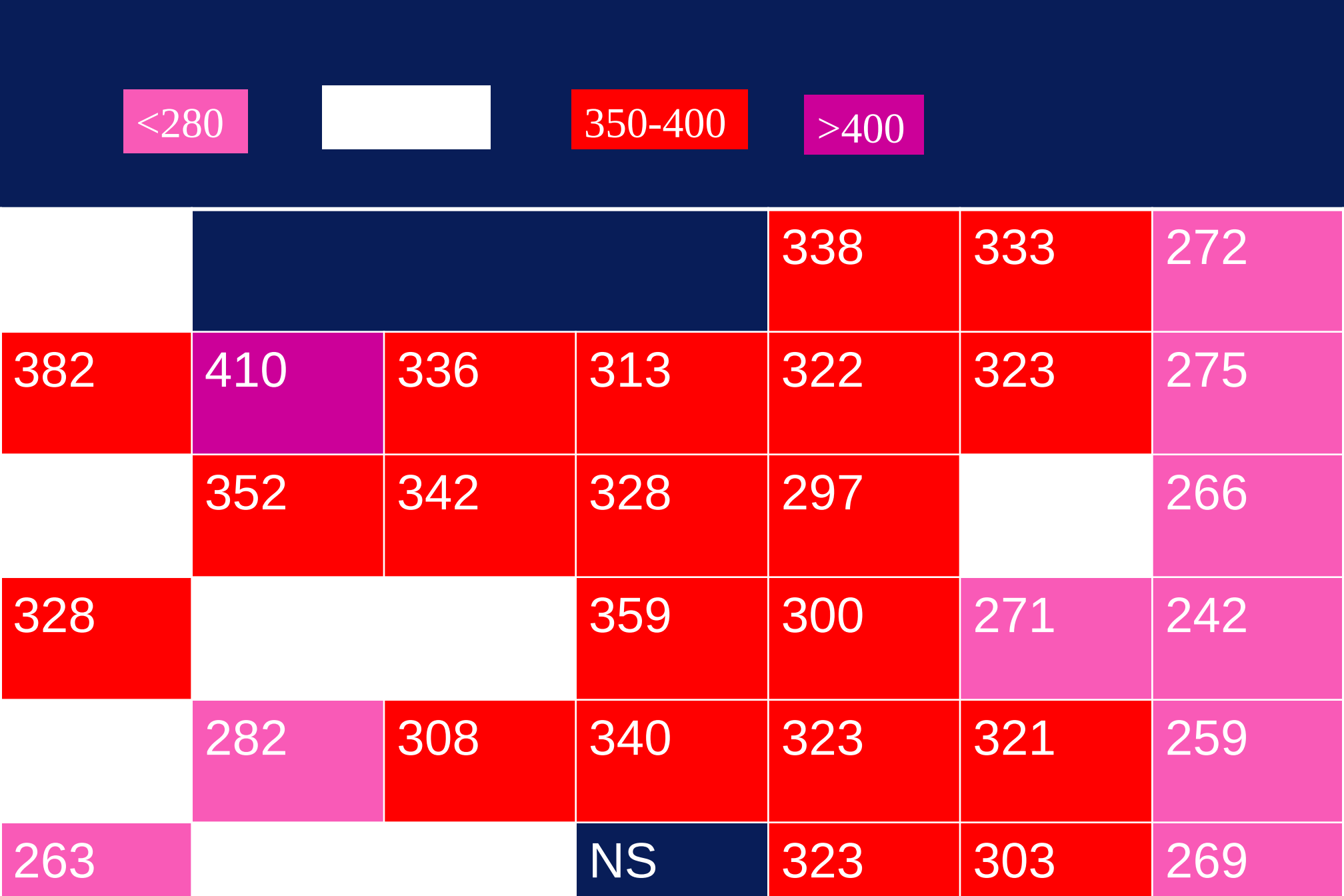
Future Developments for Variable Rate N

- New diagnostic tests for N
  - ✓ e.g. : Illinois N test
  - ✓ Simple, inexpensive
  - ✓ Identifies optimum N rate and in-field variation

THE ILLINOIS NITROGEN SOIL TEST (Mulvaney, et al.)

- RATE OF MINERALIZATION APPEARS TO BE RELATED TO AMINO-SUGAR N
- ILLINOIS SOIL TEST DETECTS AMINO SUGAR N
- TEST IS SIMPLE, INEXPENSIVE, AND CONVENIENT
- NITRATE IS NOT INCLUDED


Relative yield response, %
140
120
100
80
60
40
20
0
0
100
200
300
400
500
600
Amino sugar, ppm


<280
350-400
>400
338
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323
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352
342
328
297
266
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359
300
271
242
282
308
340
323
321
259
263
NS
323
303
269

Future Developments for Variable Rate N

- Remote of in-field sensing of plant N status
  - Interpretation of photos
  - Reflectance measurements in field
  - Incorporation of climatic & crop data