Field-scale Variation in Nitrogen Use Efficiency and the Agronomic Performance of Wheat

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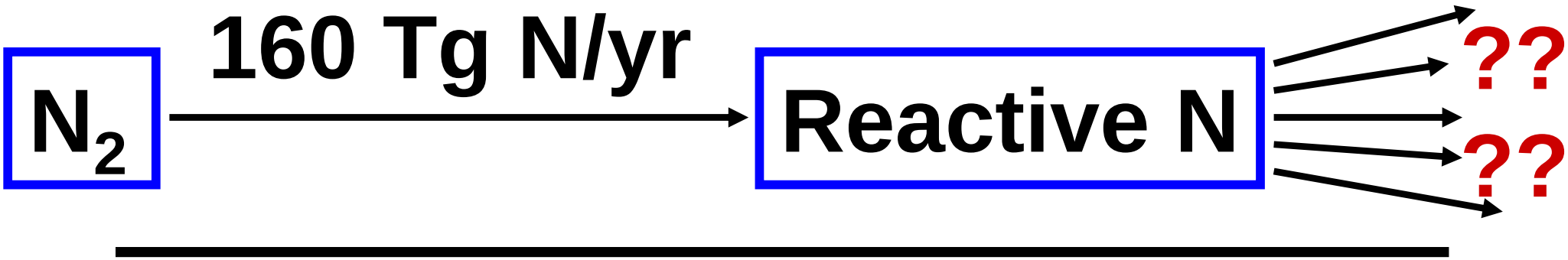
Center for Sustaining Agriculture & Natural Resources

CLIMATE FRIENDLY FARMING™

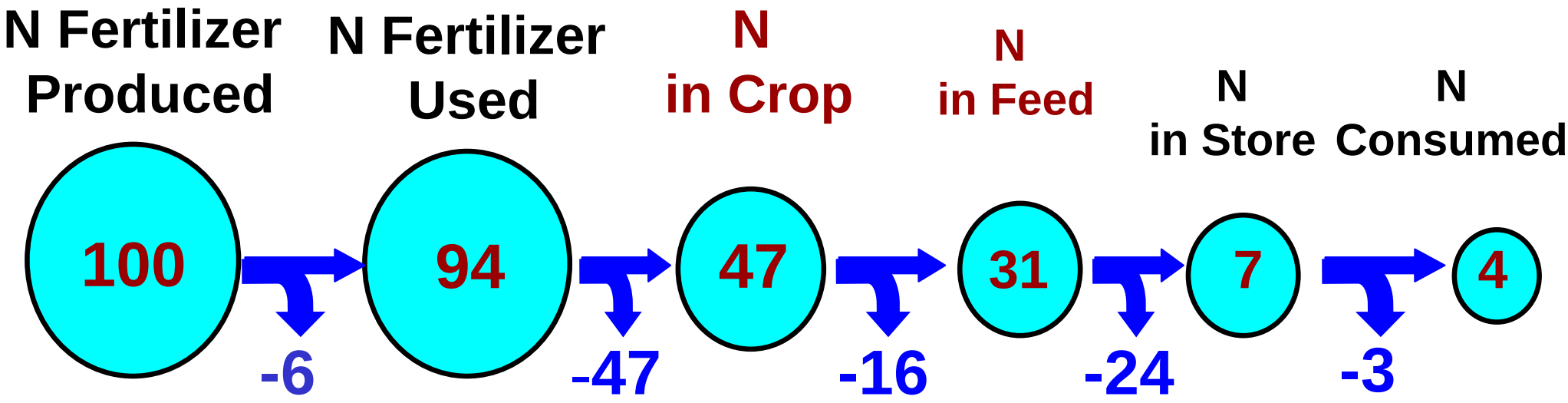
The Nitrogen Cascade



- **Reactive N accumulating in atmosphere, terrestrial and aquatic ecosystems**

Effects: Greenhouse Gas Emissions, Ozone Depletion, Agroecosystems, Surface and Ground, Costal and Ocean Waters

Fate of Haber-Bosch Nitrogen



4% of the N produced in the Haber-Bosch process and used for animal production enters the human mouth.

Galloway and Cowling, 2002

Leaky Cropping Systems

Efficiency of N Fertilizer Recovery

Crop	Region	No. of farms	Avg N rate, kg/ha	Rec. %
Maize	NC USA	56	103	37
Rice	Asia-farmer	179	117	31
	Asia-researcher	179	112	40
Wheat	India-poor weather	23	145	18
	India-good weather	21	123	49

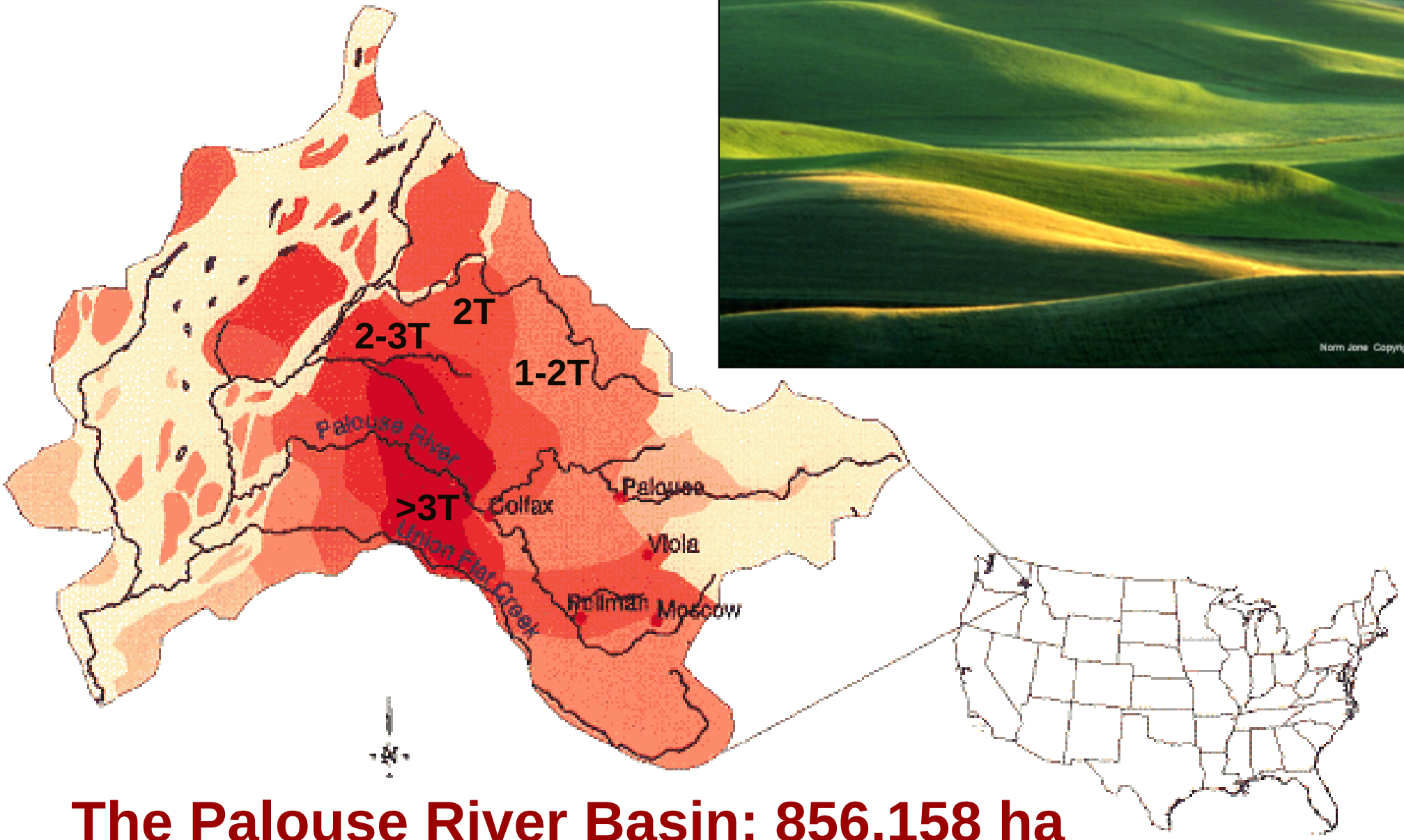
Cassman et al., 2002

Green House Gas Emission Sources: Agriculture

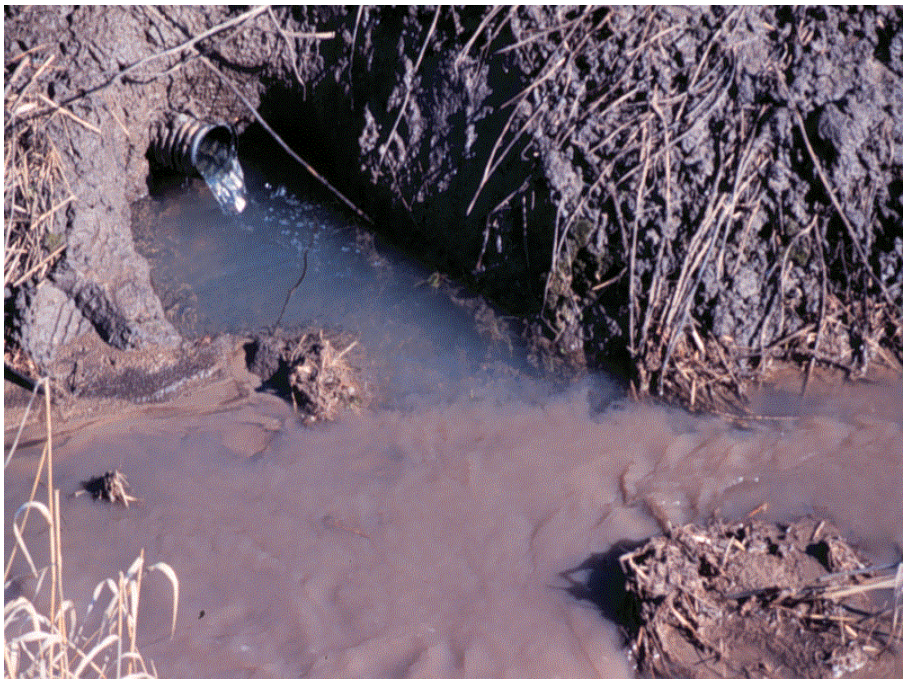
Gas	Emissions, %
CO_2	3
CH_4	41
N_2O	56

Improving N use efficiency identified is a major agricultural goal (CAST, 2004).

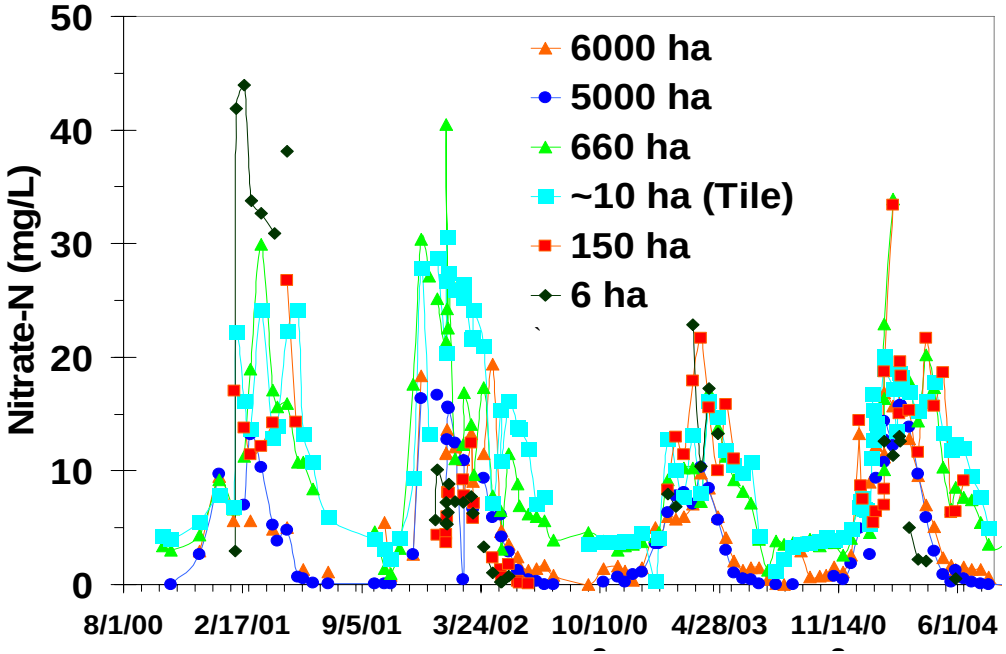
The Palouse Region of E. Wash. and N. Idaho

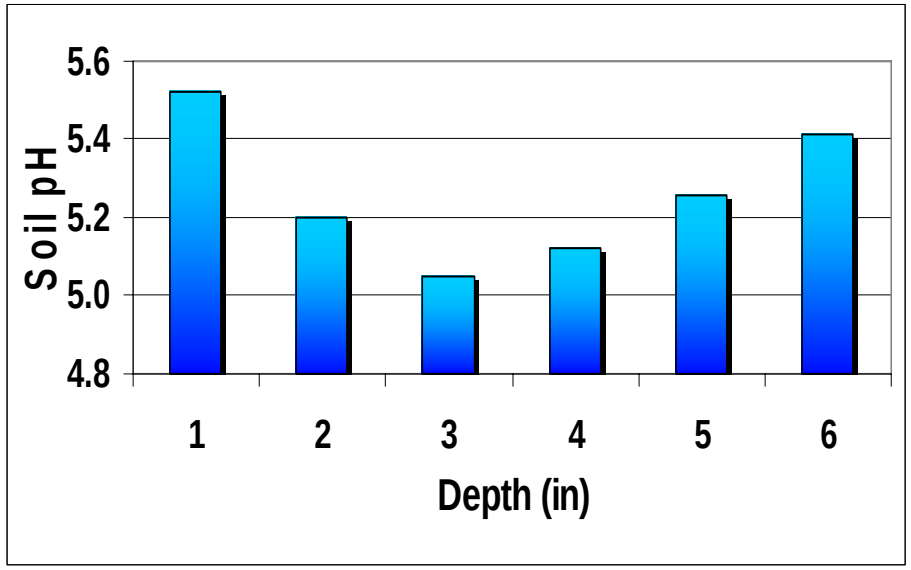


The Palouse River Basin: 856,158 ha



Water and Soil Resource Degradation



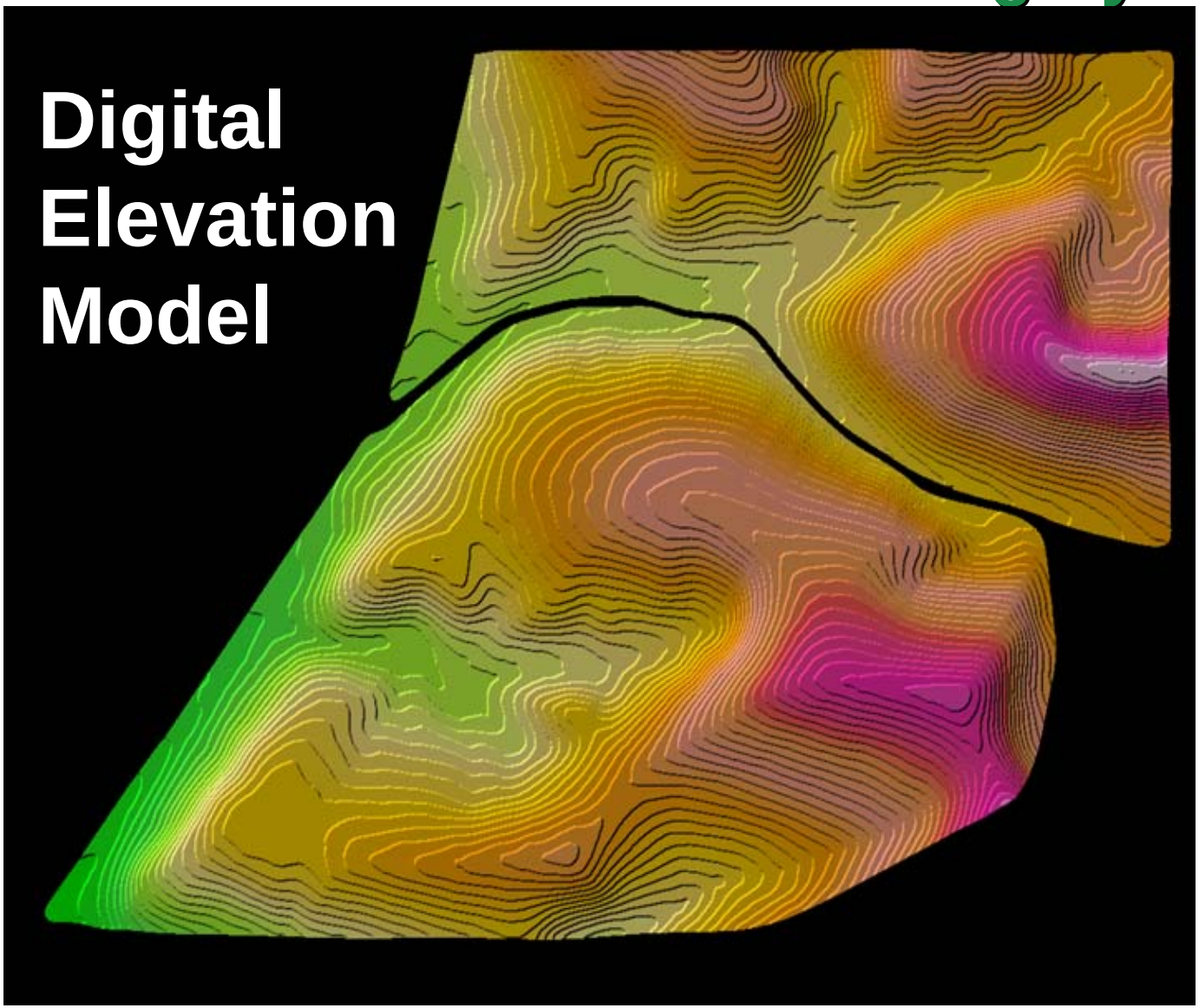


Objectives

- Assess field-scale variability in N use efficiency
- Devise precision N management strategies
- Initiate grower-oriented field-scale evaluation of NUE

Cunningham Agronomy Farm

Direct Seed and Precision Farming Systems



Develop principles and strategies that reduce risk, increase profits and improve environmental quality

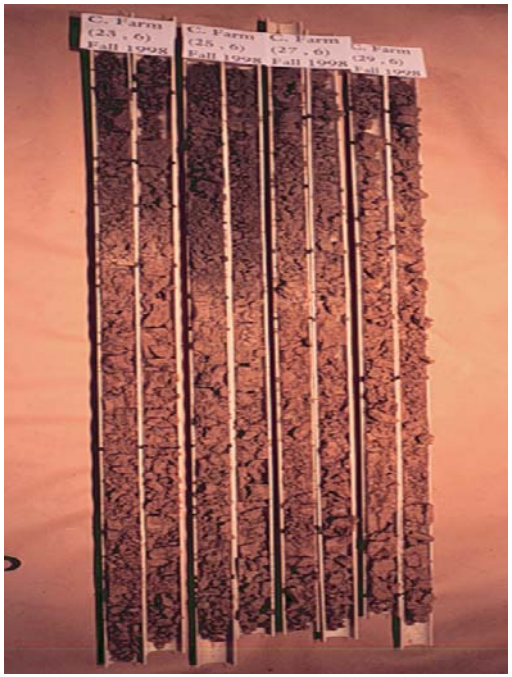
System Inquiry

SYSTEM

- Field Scale
- Direct Seed
- Precision Ag.

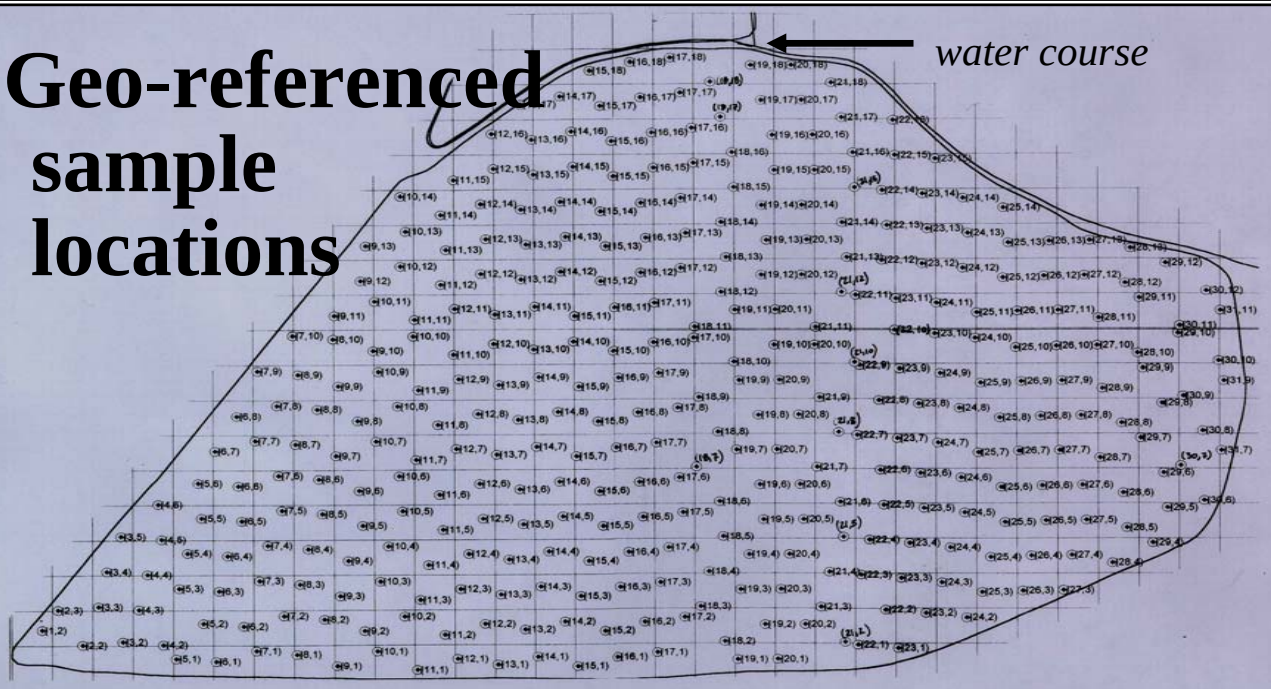
WSU Cunningham Agronomy Farm Working Group

Pattern Analysis

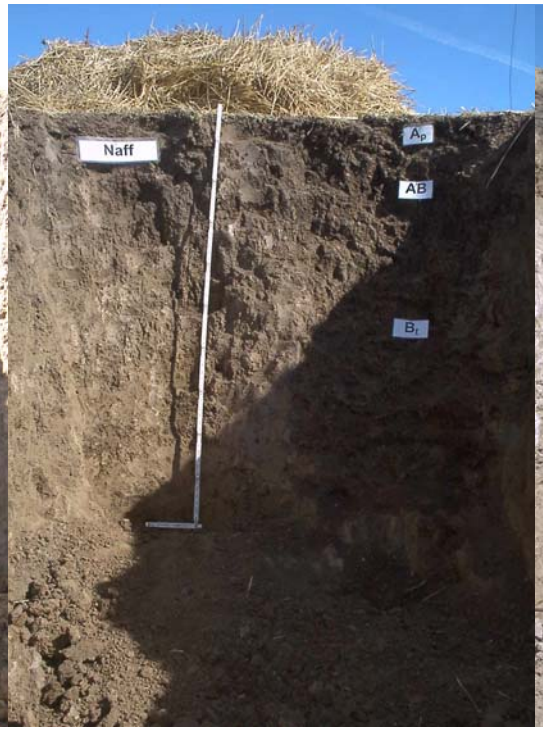


Non-aligned grid sampling scheme

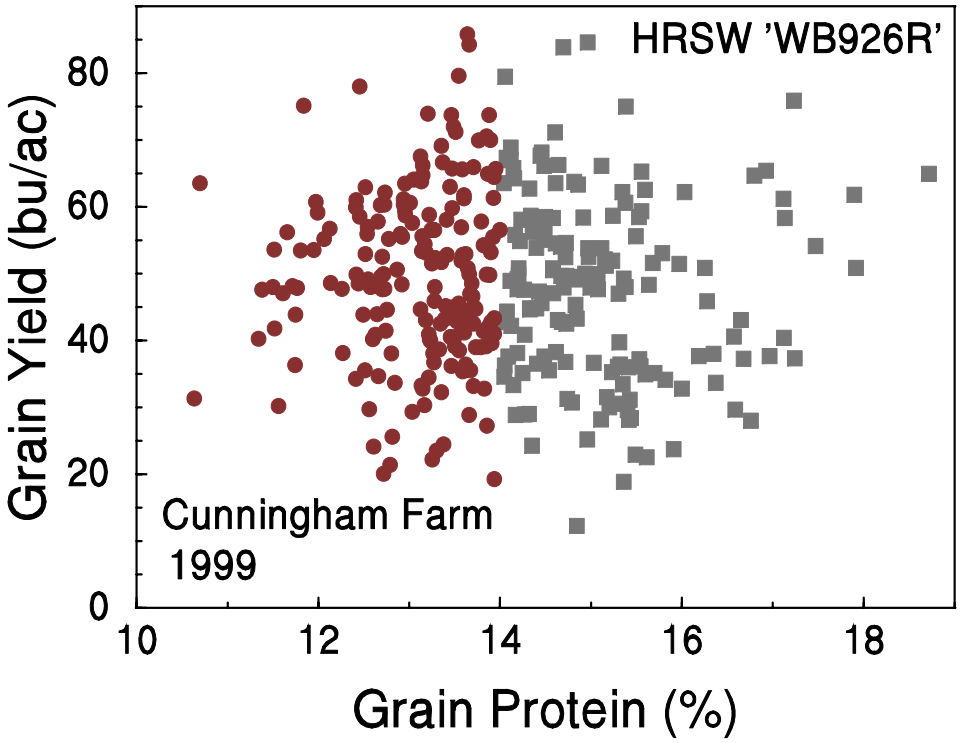
Geo-referenced sample locations

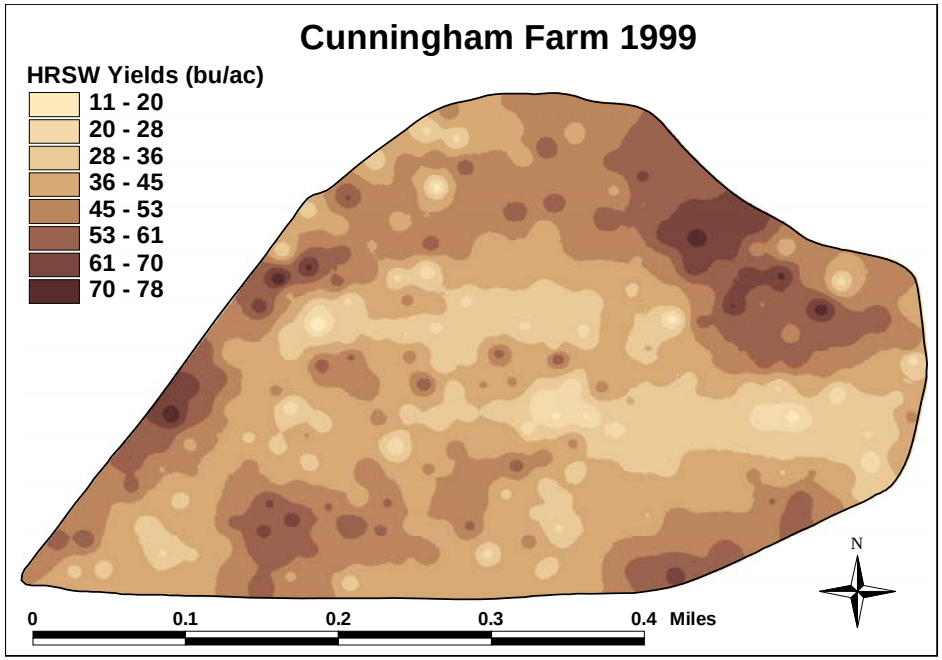


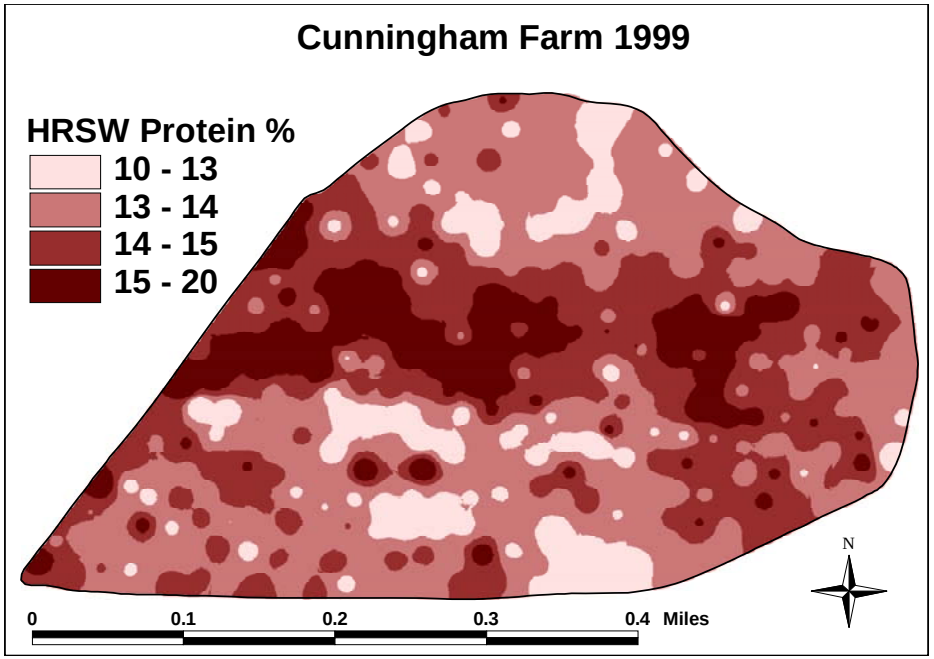
Soils of the Cunningham Agronomy Farm



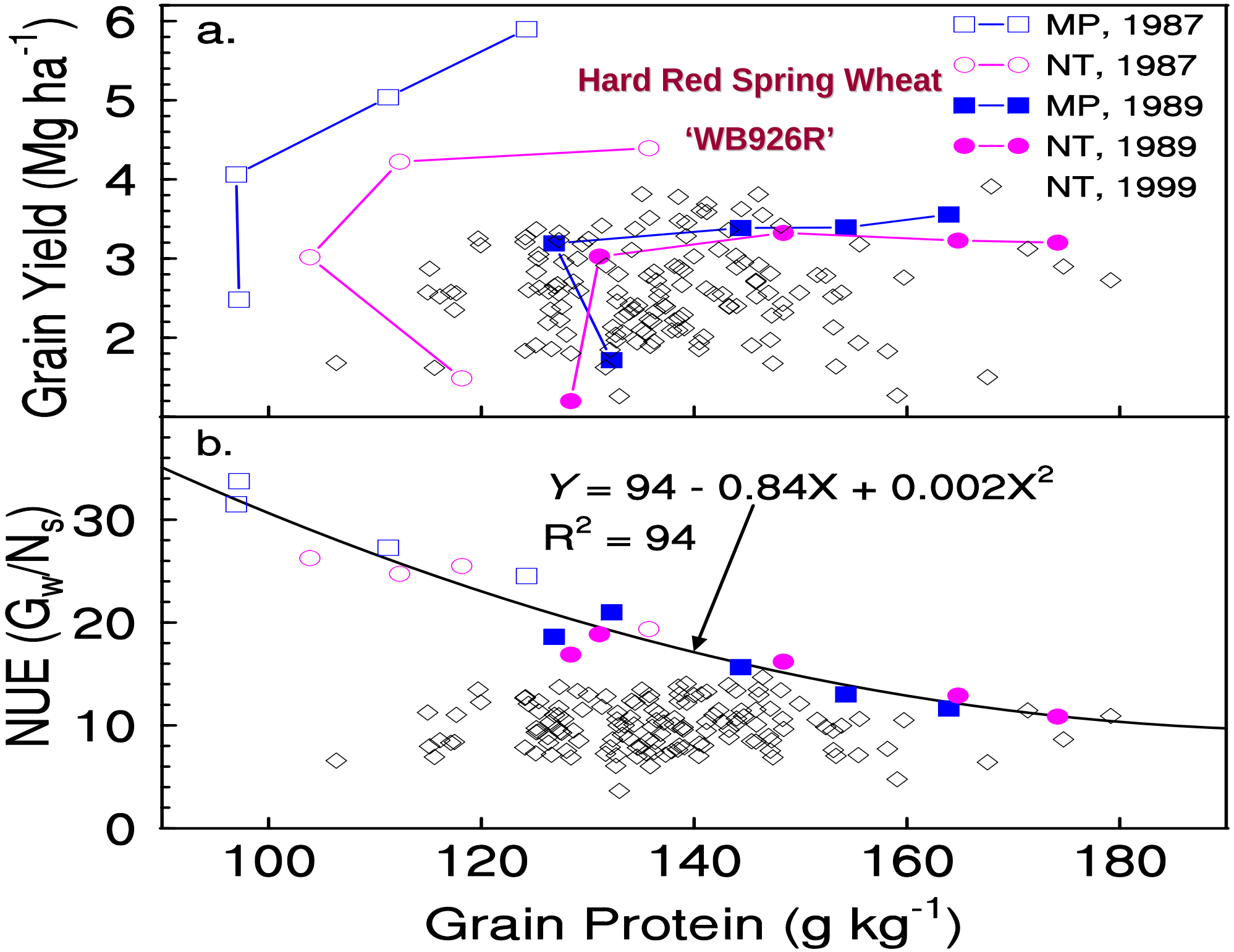
Precision Conservation Management: NUE

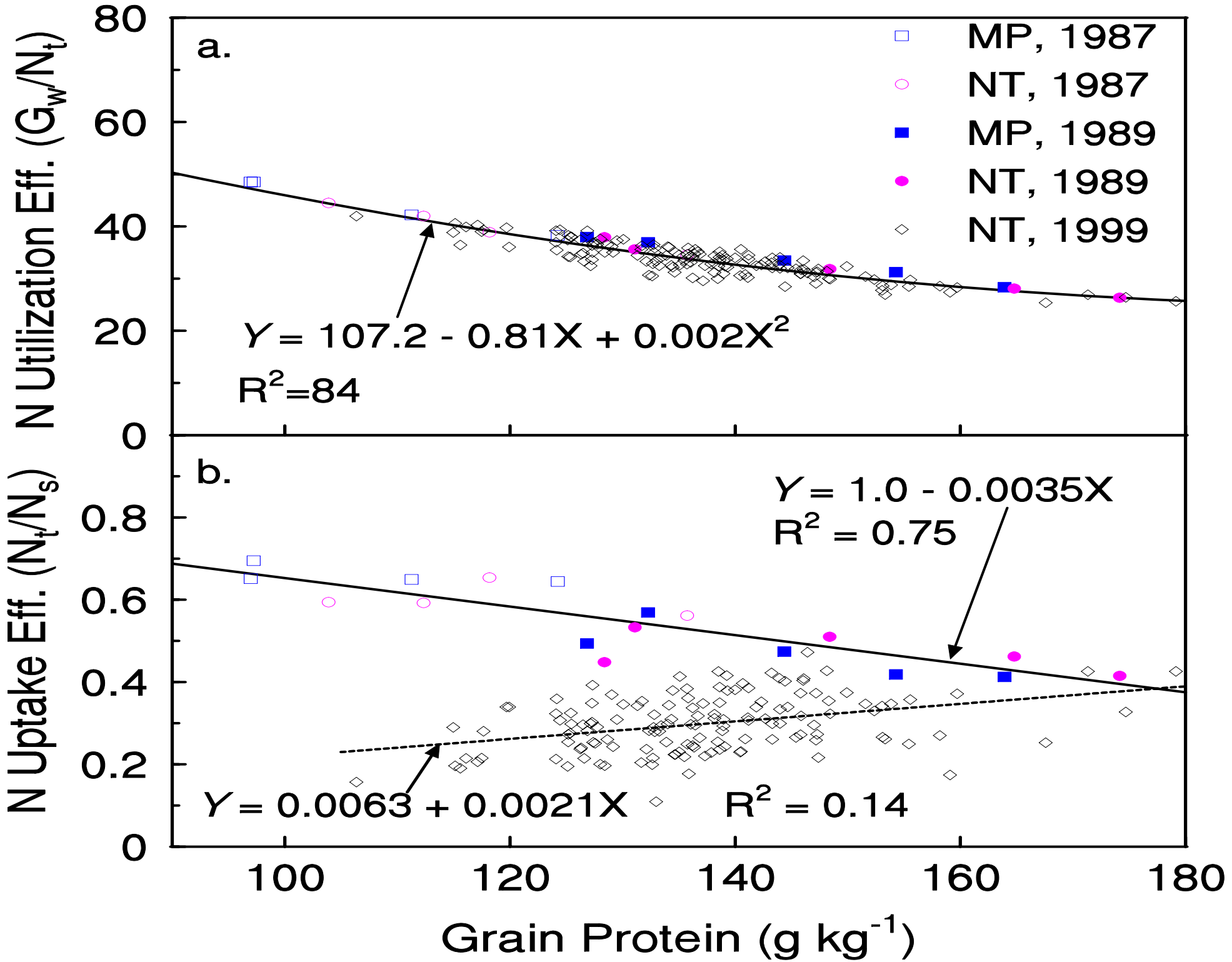






Also: Reynes et al., 2000
Walley et al., 2001
Skerritt et al., 2002


a.
Hard Red Spring Wheat
'WB926R'
MP, 1987
NT, 1987
MP, 1989
NT, 1989
NT, 1999
Grain Yield (Mg ha-1)
6
5
4
3
2
b.
Y = 94 - 0.84X + 0.002X2
R2 = 94
NUE (GW/Ns)
30
20
10
0
100
120
140
160
180
Grain Protein (g kg-1)

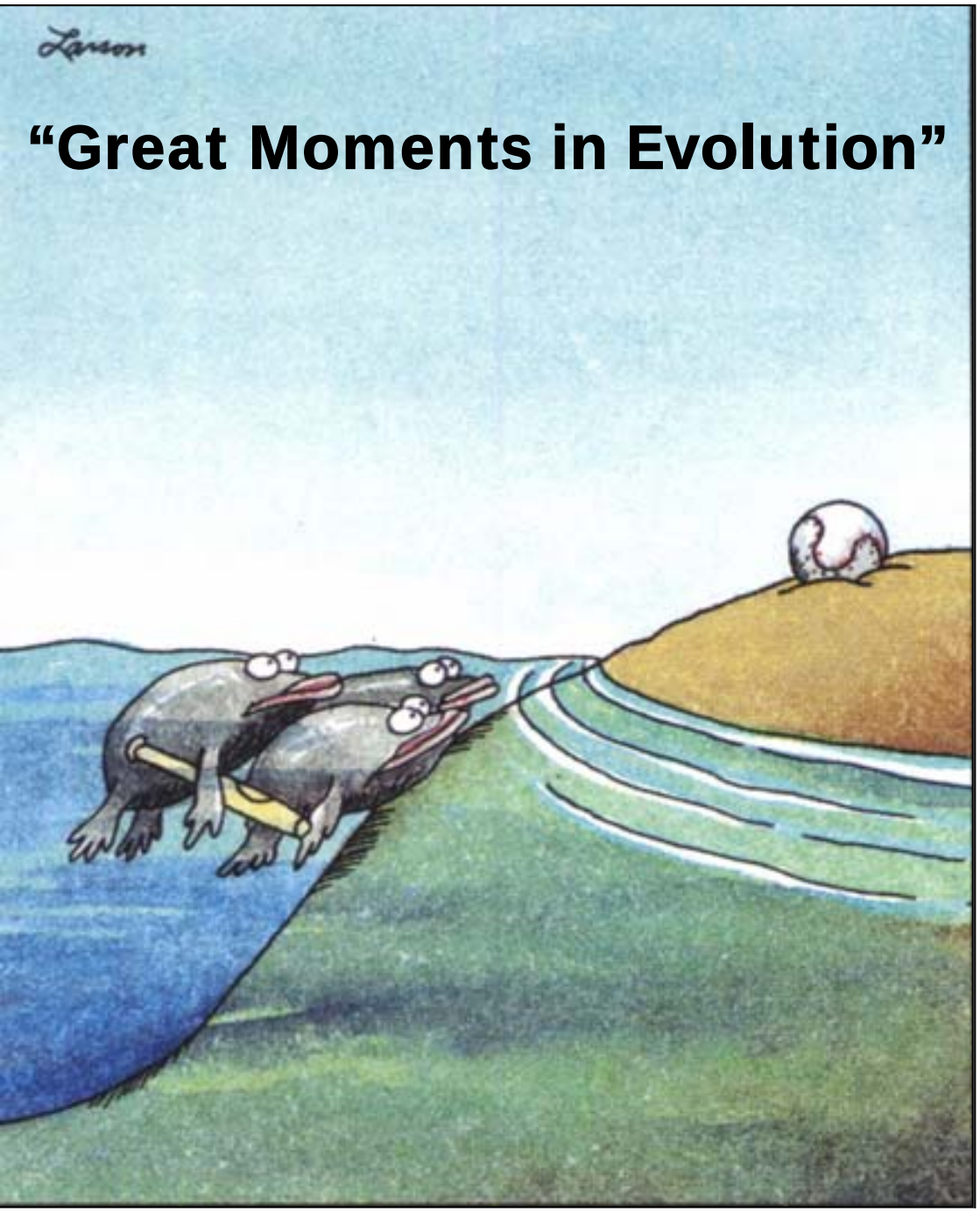

a.
MP, 1987
NT, 1987
MP, 1989
NT, 1989
NT, 1999
Y = 107.2 - 0.81X + 0.002X²
R²=84
N Utilization Eff. (Gw/Nt)
80
60
40
20
0
b.
Y = 1.0 - 0.0035X
R² = 0.75
Y = 0.0063 + 0.0021X
R² = 0.14
N Uptake Eff. (Nt/Ns)
0.8
0.6
0.4
0.2
0
100
120
140
160
180
Grain Protein (g kg-1)

N Use Efficiencies: HRSW

- **Research Plots** (Huggins and Pan, 1993):
  - N uptake efficiency about 50%
  - N retention efficiency: 80%
  - N balance index: 60%

- **Field-scale** (Huggins and Pan, unpublished):
  - N uptake efficiency: 12-48%
  - N retention efficiency: 20-100%
  - N balance index: 11-76%

Conclusions, so far….

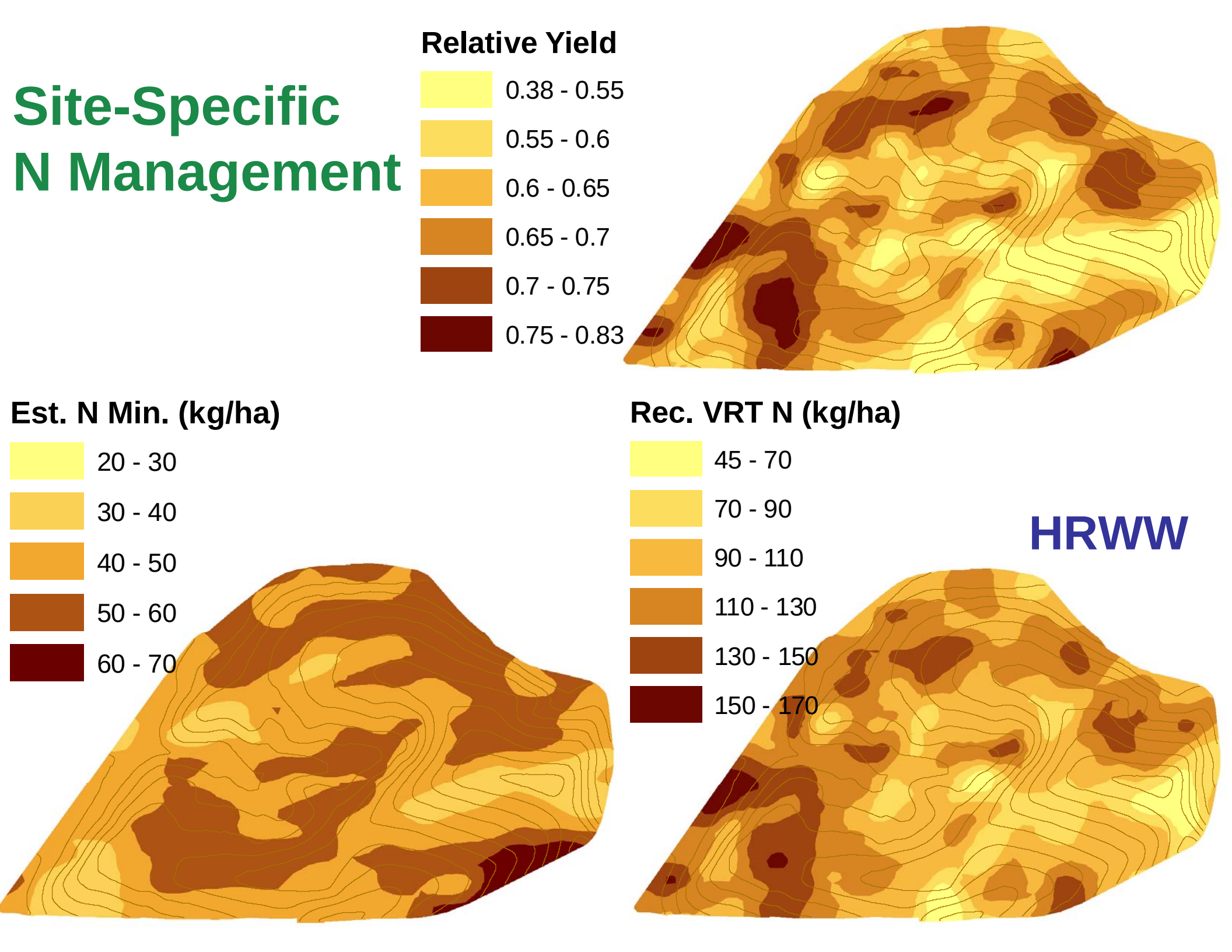


- Small-plot data cannot be extrapolated to field scale
- Uniformly applied N not likely to achieve goals
- Suitability concerns
- Need different approach

What's needed?

- **Integration of precision technologies**
  - **Variable rate application**
  - **Yield monitoring**
  - **Grain protein monitoring**
  - **Decision Support Tools**

Site-Specific N Management



Uniform - VRT, kg N/ha

-20 - 0

0 - 20

20 - 40

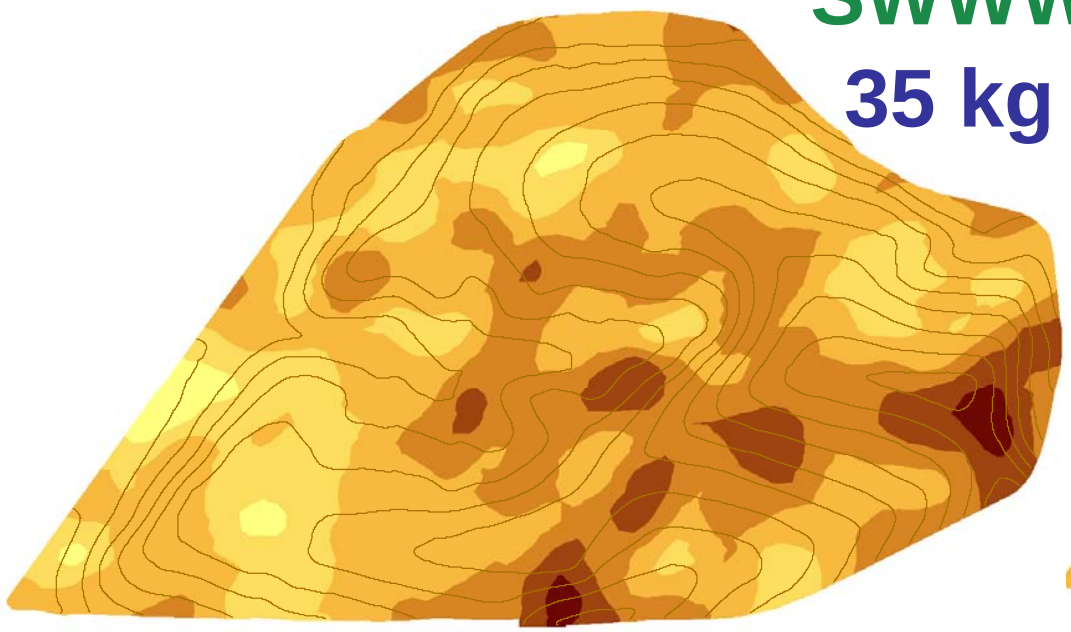
40 - 60

60 - 80

80 - 100

SWSW

23 kg N/ha

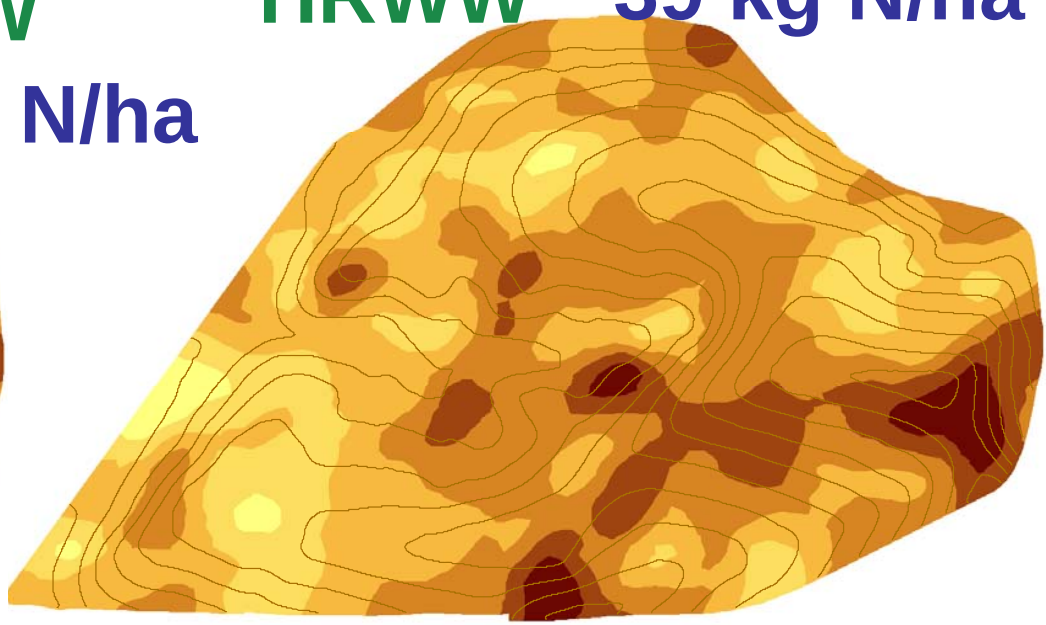


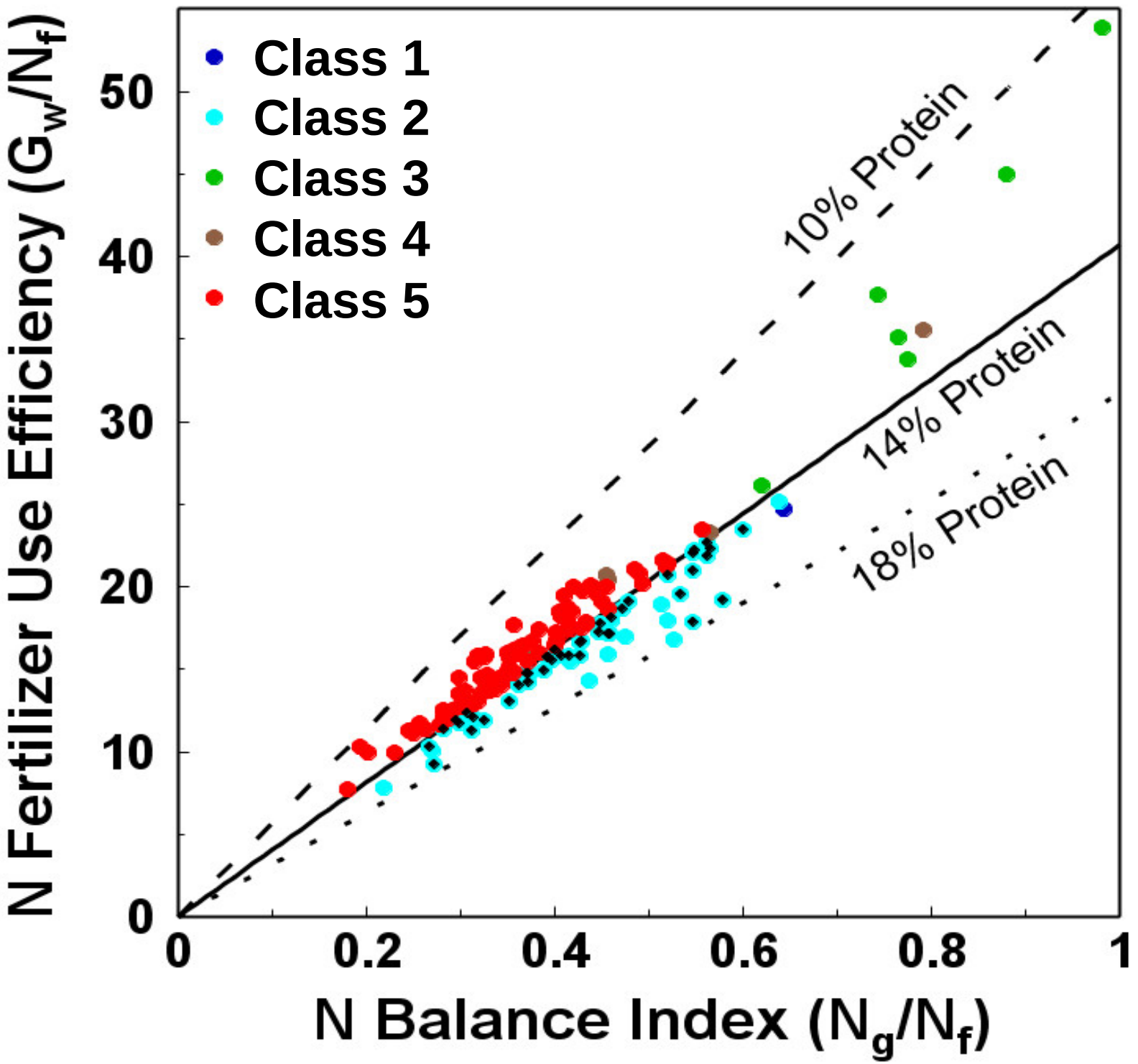
SWWW

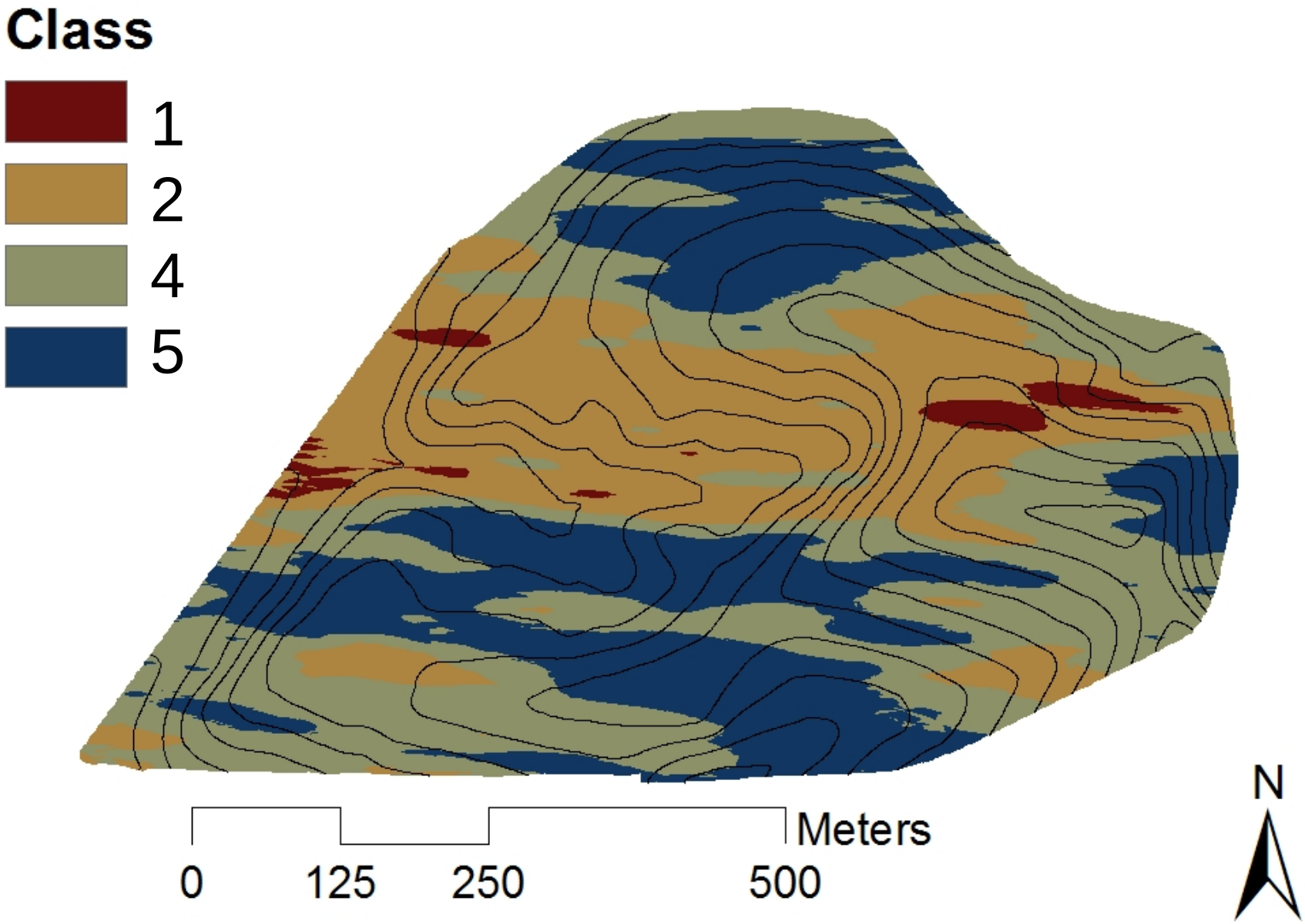
35 kg N/ha

HRWW

39 kg N/ha




Class 1
Class 2
Class 3
Class 4
Class 5
10% Protein
14% Protein
18% Protein
N Fertilizer Use Efficiency (G_w/N_f)
N Balance Index (N_g/N_f)
0
10
20
30
40
50
0
0.2
0.4
0.6
0.8
1


Class
1
2
4
5
Meters
0
125
250
500
N

More Conclusions

- **NUE indices can be used to diagnose and evaluate field-scale crop performance**
- **Supports shift from classical plots with multiple N treatments to field-scale studies**