Straw Management and Crop Rotation Alternatives to Stubble Burning: Assessing Economic and Environmental Trade-offs

Co-Principle Investigators

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Farmer incentives for burning stubble include:

- Facilitating the establishment of the next crop
- Decreasing incidence of soil-borne disease
- Decreasing nutrient (e.g. N) tie-up by decomposing cereal residues
- Positive response of crop growth, yield and economic return

Grower disincentives to burning stubble can be difficult to quantify

- Negative impacts on overall soil organic matter levels
- Loss of nutrients (e.g. N, P and S)
- Increased hazard of soil erosion if burning is combined with too much tillage

Assessing trade-offs has not adequately addressed:

- Quantities of residues and associated nutrients (eg. N, P, S) lost via burning
- Field burning impacts on labile soil organic matter that effect crop nutrient availability (e.g. N, P, S)
- Soil-borne disease or straw toxicity effects
- Field-scale variation and site-specific effects (Precision Ag. Applications)

Project Objectives (1)

- (1) Document and economically assess wheat stubble burning effects on:
  - Soil organic matter
  - Site-specific soil erosion estimates
  - Soil condition index (SCI)
  - Residue C and nutrient (N, P, S) losses

Cook Agronomy Farm

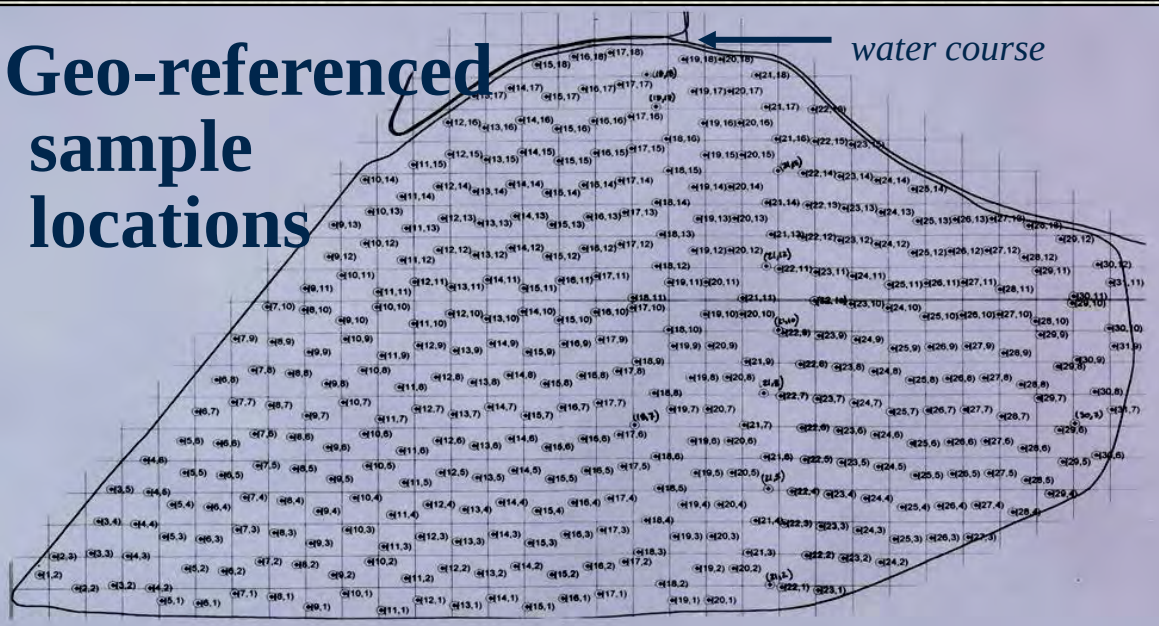
Direct Seed and Precision Farming Systems

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

Pattern Analysis

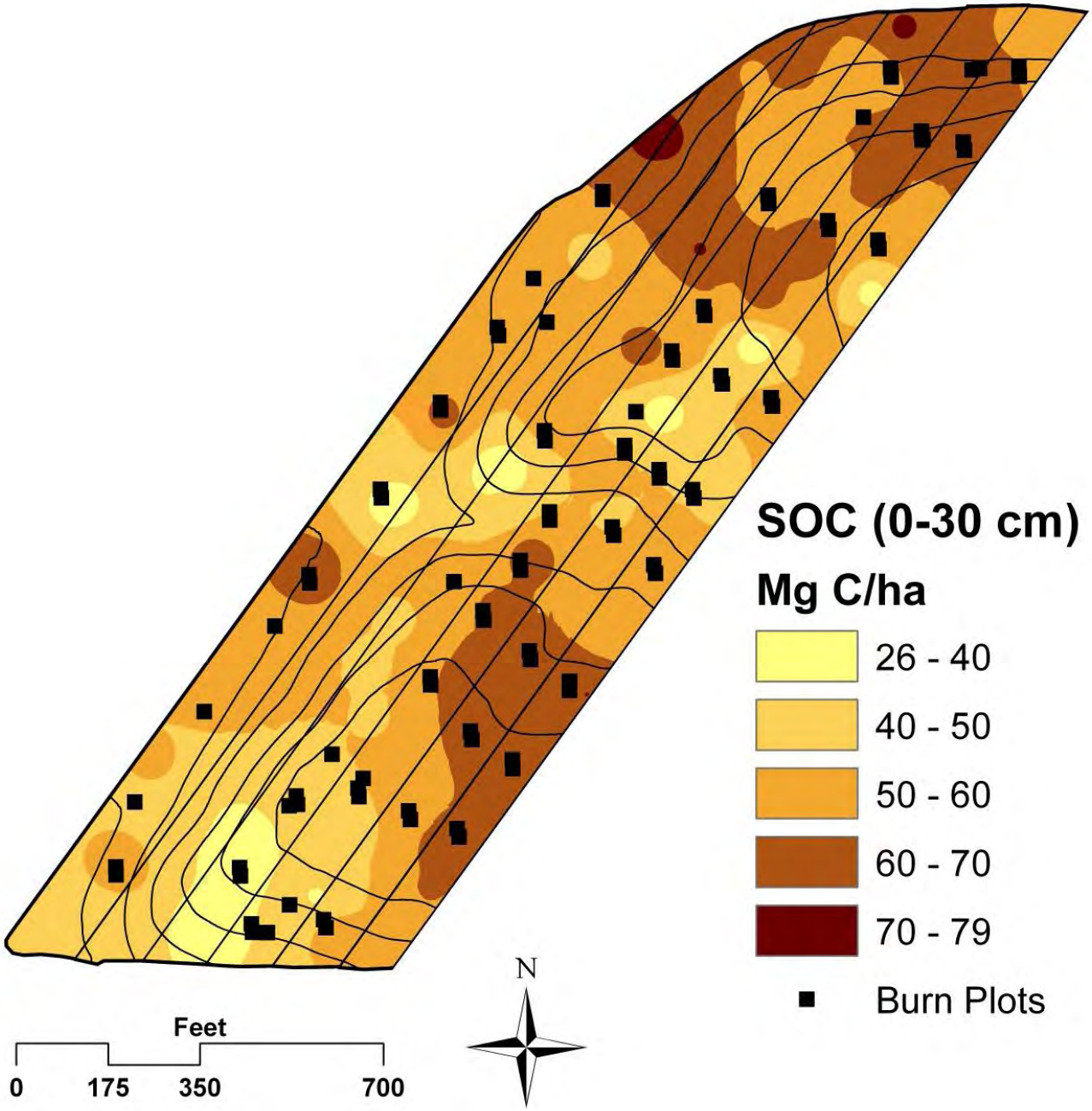
Non-aligned grid sampling scheme

Geo-referenced sample locations



Methods (Objective 1)

- Evaluate the loss of C and nutrients (N, P, S) from residue burning:
  - (1) fall burning of winter wheat residues
  - (2) spring burning of winter wheat residues
  - (3) no burning of winter wheat residues
- 15 locations


SOC (0-30 cm)
Mg C/ha
26 - 40
40 - 50
50 - 60
60 - 70
70 - 79
Burn Plots
N
Feet
0
175
350
700

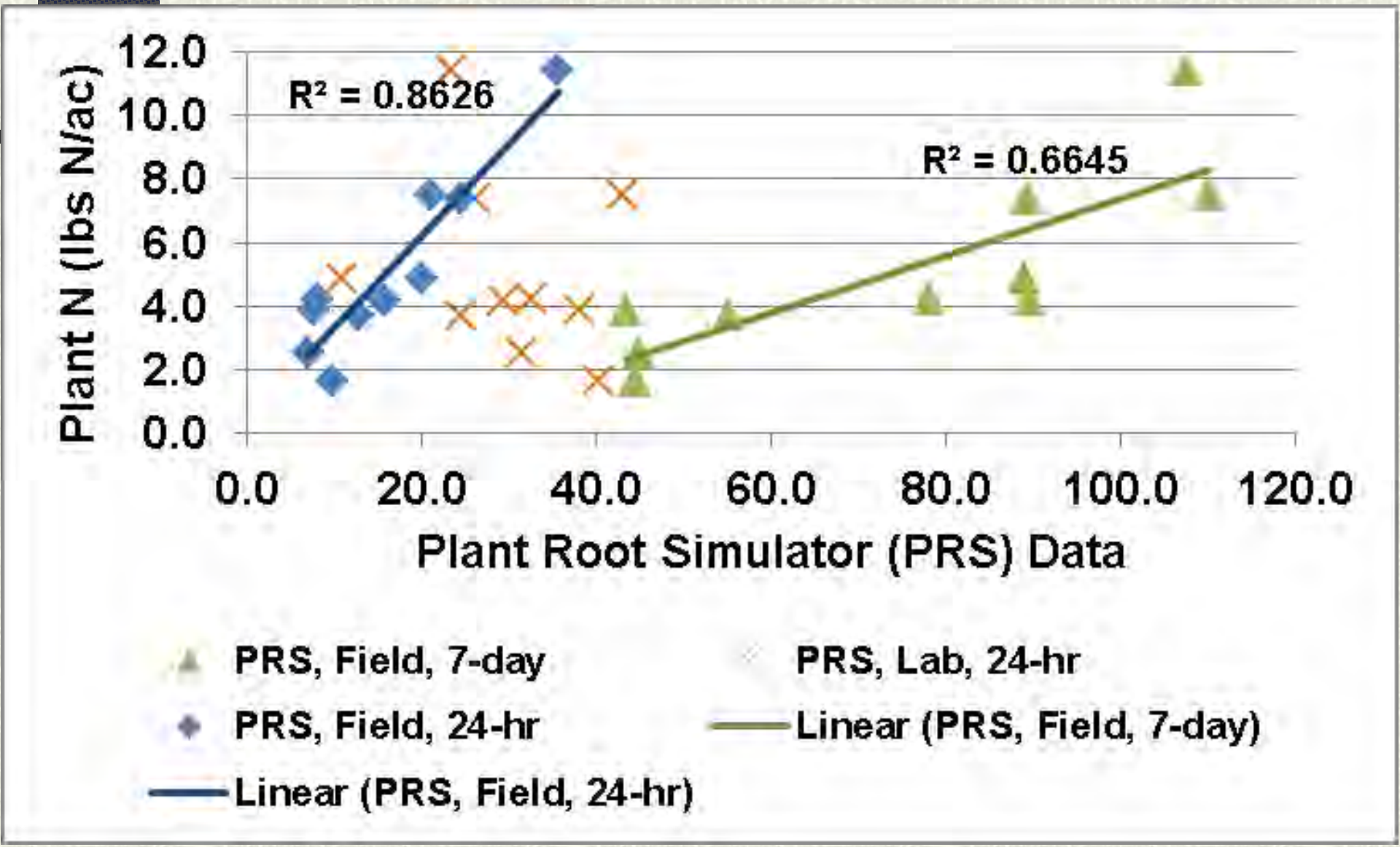
Winter Wheat Residue	Fall Burn		Spring Burn	
	Pre-burn	Post-burn	Pre-burn	Post-burn
Residue lbs/ac	8093a	3059c	5168b	2354c
Residue N (%)	0.44d	0.78a	0.52c	0.69b
Residue C (%)	39.9b	39.9b	43.0a	40.5b
Residue C/N	92.0a	54.5b	84.6a	59.5b
Residue N lbs/ac	35.9a	24.2c	27.3b	16.3d
Residue C lbs/ac	3228a	1218c	2226b	955c

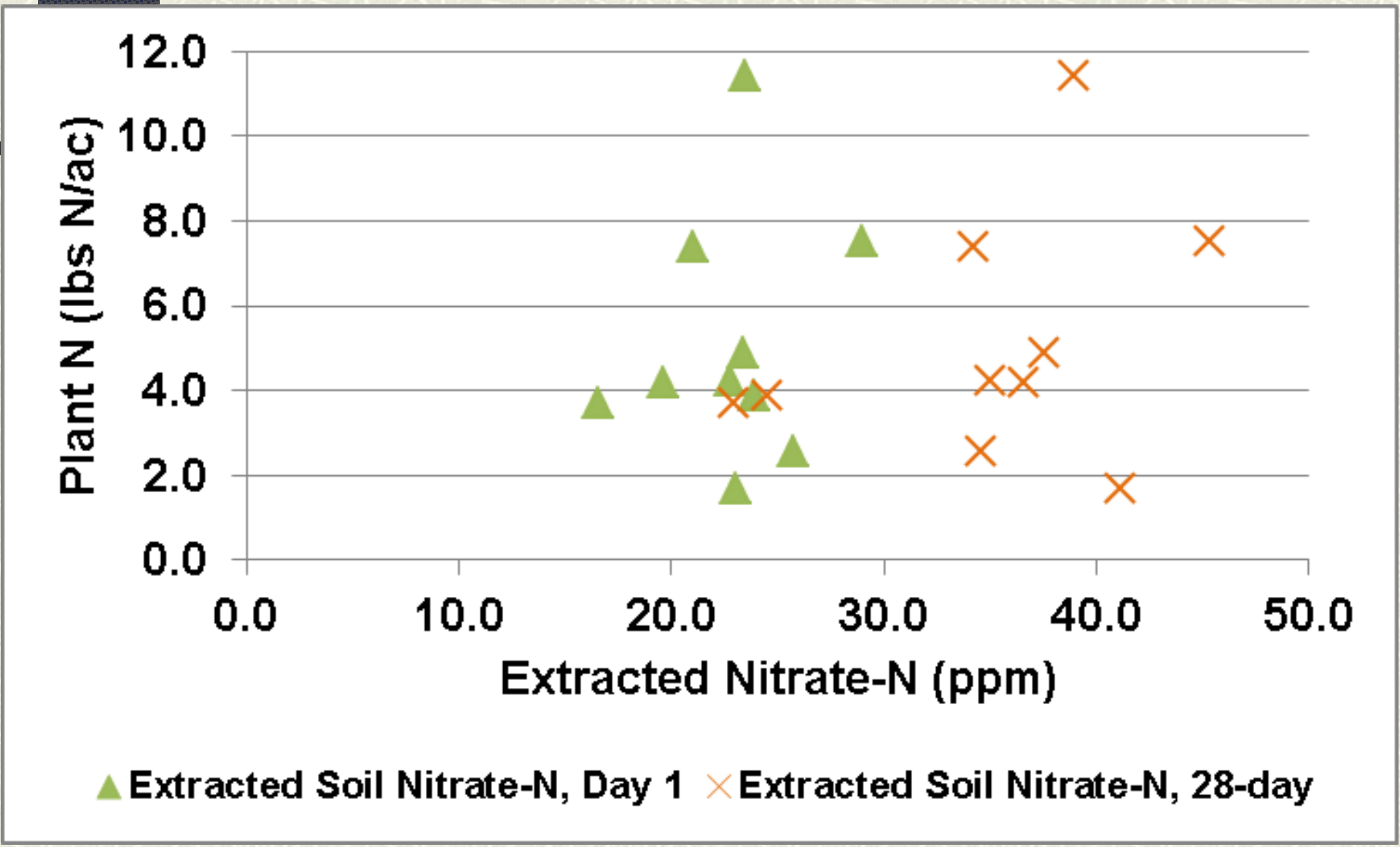
Soil Property	Control	Fall Burn	Spring Burn
Soil N (%)	0.15a	0.16a	0.16a
Soil C (%)	1.84a	1.88a	1.80a
Soil C/N Ratio	11.84a	11.92a	11.48a
Bulk Density (g/cm^3)	1.33a	1.34a	1.34a
Soil pH	6.04a	6.18a	6.03a
PON (%)	2.27b	2.58a	2.27b
POC (%)	32.2b	36.9a	32.0b
POM C/N Ratio	14.3a	14.3a	14.2a

Spring Wheat	Control		Fall Burn		Spring Burn	
	N Applied	No N Applied	N Applied	No N Applied	N Applied	No N Applie
Grain Yield (bu/ac)	**59a**	**47b**	**57a**	**53a**	**53a**	**45b**
Grain Protein (%)	11.0a	9.1b	11.4a	8.9b	11.4a	8.8b
Crop Residue N (lbs/ac)	22.9a	8.3b	25.3a	10.6b	23.7a	9.1b
Crop Residue C (%)	44.6a	44.5a	44.5a	44.6a	44.4a	44.5a
Crop Residue C (lbs/ac)	2282a	1240c	2246a	1578b	2188a	1413b

Plant Root Simulator (PRS) Probes

Spring Wheat and Soil Properties	Control	Fall Burn
Main Stem Leaves (no)	3.94b	4.53a
Tillers (no)	1.26a	1.61a
Plant N (%)	3.3b	3.9a
Plant Dry Weight (lbs/ac)	96b	176a
Plant N (lbs/ac)	3.3a	7.0b
Extracted Soil NO_3-N, Day 1, (ppm)	21.5a	24.1a
PRS probe Nitrate-N, Day 1, Field, (µg 10 cm^{-2} $24hr^{-1}$)	10.7a	21.8a
PRS probe Nitrate-N, 7 Days, Field, (µg 10 cm^{-2} $7days^{-1}$)	62.5b	87.8a
PRS Probe P, Day 1, Field, (µg 10 cm^{-2} $24hr^{-1}$)	0.80a	0.56a
PRS Probe S, Day 1, Field, (µg 10 cm^{-2} $24hr^{-1}$)	19.6a	19.6a


Plant N (lbs N/ac)
12.0
10.0
8.0
6.0
4.0
2.0
0.0
R² = 0.8626
R² = 0.6645
0.0
20.0
40.0
60.0
80.0
100.0
120.0
Plant Root Simulator (PRS) Data
PRS, Field, 7-day
PRS, Lab, 24-hr
PRS, Field, 24-hr
Linear (PRS, Field, 7-day)
Linear (PRS, Field, 24-hr)


12.0
10.0
8.0
6.0
4.0
2.0
0.0
Plant N (lbs N/ac)
0.0
10.0
20.0
30.0
40.0
50.0
Extracted Nitrate-N (ppm)
Extracted Soil Nitrate-N, Day 1
Extracted Soil Nitrate-N, 28-day

Key Findings

- Fall burning reduced surface winter wheat residue mass by 62% whereas spring burning reduced residue mass by 55%.
- Overall, 2,010 lbs C/ac were lost from fall burning while 1,271 lbs C/ac were lost during the spring burn.
- The average amount of N lost by burning was similar with 12 lbs N/ac lost during the fall burn and 11 lbs N/ac lost during the spring burn.

Key Findings

- Winter wheat residue N lost during the spring burn was 40% and for fall burn 33% of total; N losses from burning were appreciably lower than the previously reported losses of nearly 100% (laboratory studies).
- Residue burning had little impact on: soil N%, soil C%, soil C/N ratio, bulk density, soil pH and particulate organic matter (POM) C/N ratio, for this one year study.

Key Findings

- Fall burning of winter wheat residue increased early season (wheat tillering stage) soil N availability, spring wheat growth and development and spring wheat N uptake.
- Aboveground spring wheat N uptake (tillering) was 112% greater in fall burned as compared to control plots.
- Field deployed PRS probes had 40% more µg N 10 cm^{-2} 7 $days^{-1}$ in fall burned as compared to control plots.

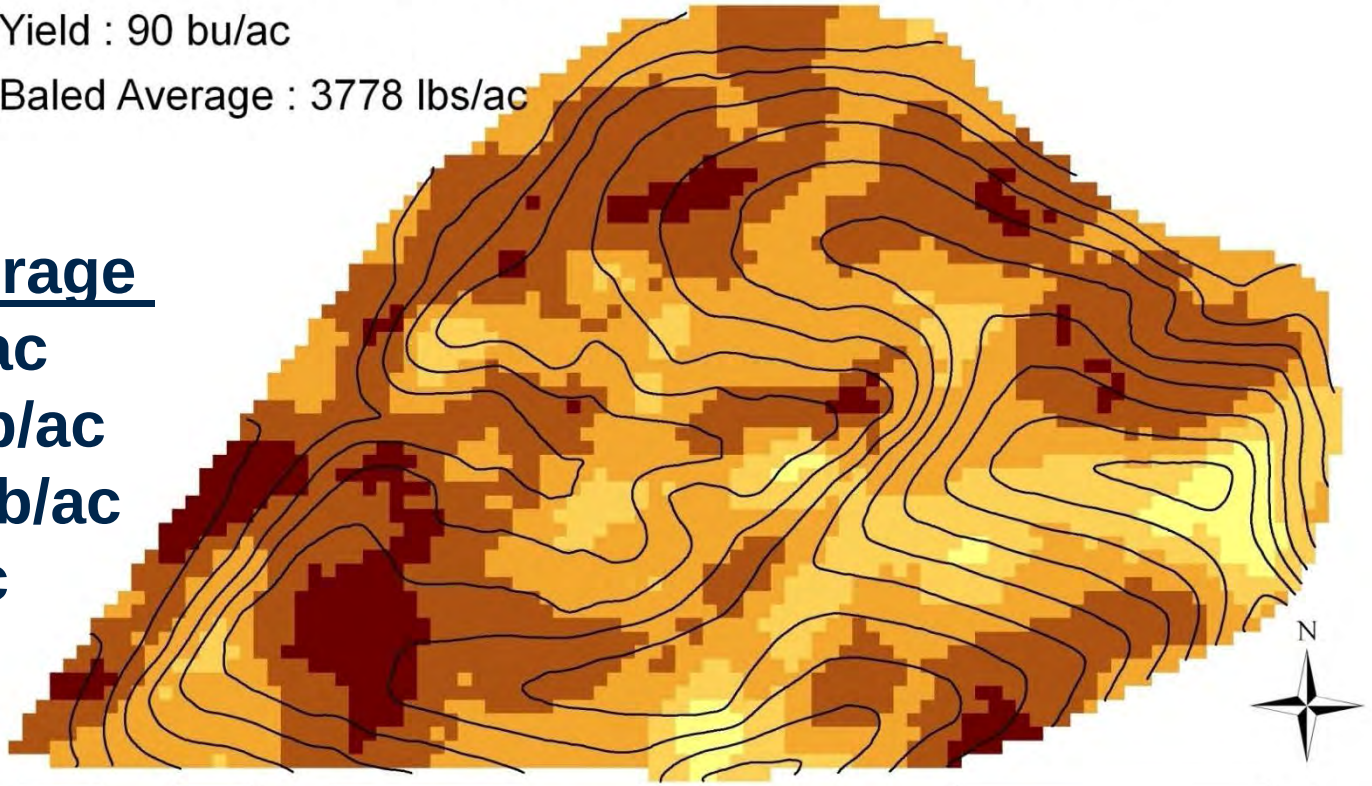
Next Steps

- Analyses of crop residues: S and P
- Economic analyses: (1) the loss of N, P and S; (2) treatment differences in net N mineralization and the dollar value associated with an equivalent amount of N fertilizer.
- The potential for soil erosion and evaluation of the Soil Conditioning Index for the 92 acre field.

Nutrient Removal in Baled WW Straw

Yield : 90 bu/ac

Baled Average : 3778 lbs/ac



Field average

N: 14 lb/ac

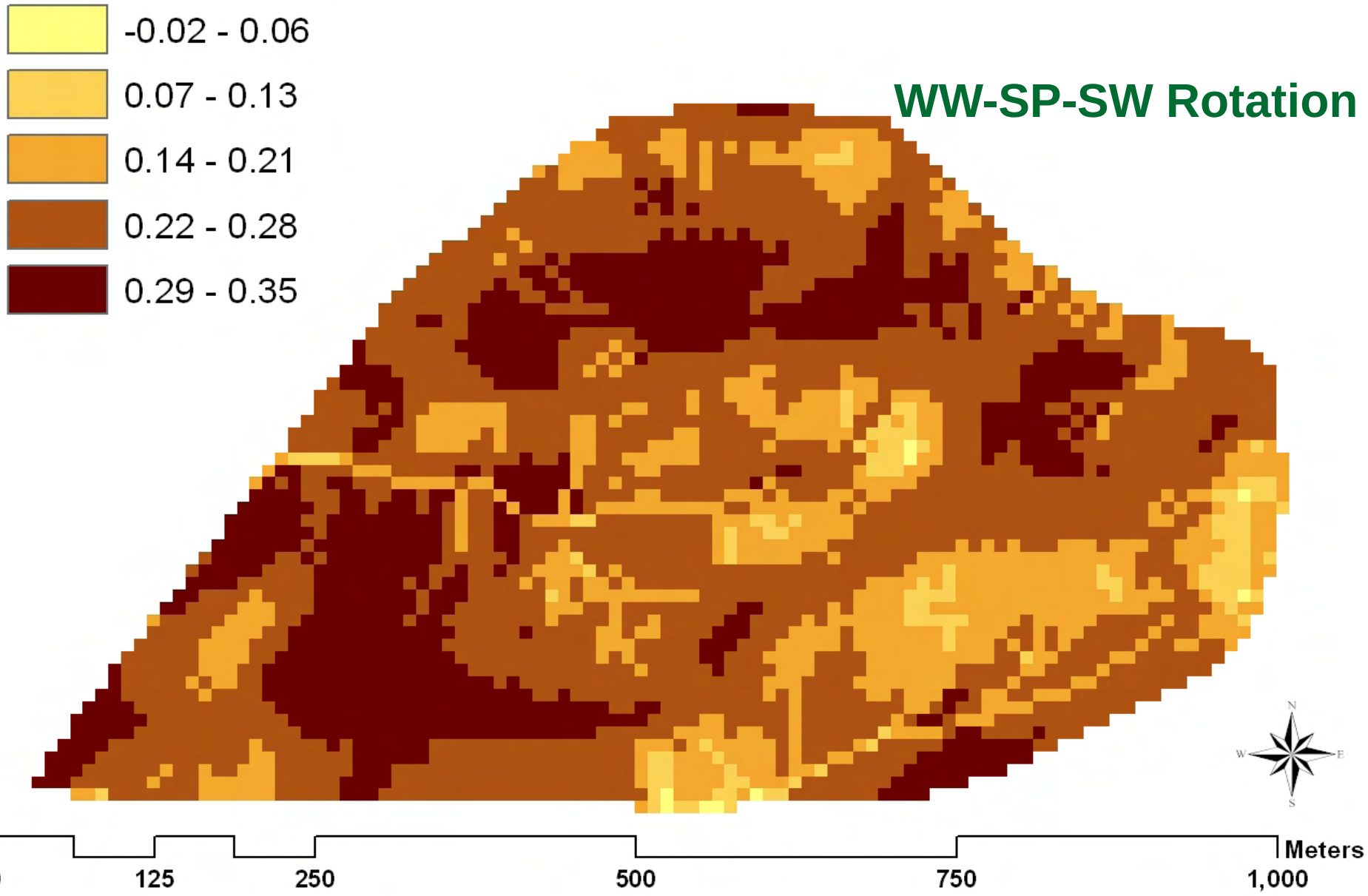
P_2O_5: 6 lb/ac

K_2O: 33 lb/ac

S: 3 lb/ac

WW N (lbs/ac)	WW P2O5 (lbs/ac)	WW K2O (lbs/ac)	WW S (lbs/ac)
8.53 - 10.54	3.39 - 4.18	19.87 - 24.53	1.83 - 2.26
10.54 - 12.54	4.18 - 4.98	24.53 - 29.20	2.26 - 2.69
12.54 - 14.55	4.98 - 5.77	29.20 - 33.87	2.69 - 3.12
14.55 - 16.55	5.77 - 6.57	33.87 - 38.53	3.12 - 3.55
16.55 - 18.56	6.57 - 7.36	38.53 - 43.20	3.55 - 3.98

SCI, No-till, Baled Straw



Project Objectives (2)

- (2) Identify and economically assess crop rotations and sequences that benefit from retaining winter wheat residues in direct-seed systems

Crop	Control	Fall Burn
Winter Wheat Yield following Winter Wheat, (bu/ac)	82a	82a
Garbanzo Bean Yield following Winter Wheat, (lbs/ac)	1624a	1634a
Spring Barley Yield following Winter Wheat, (lbs/ac)	4733b	5234a

DOE 3 Field Study Parameters

- 2 different rotations:
  - continuous ww
  - ww-legume
- 3 types of planting:
  - conventional
  - cross slot
  - Horsh
- 4 replicates

Rotation W - continuous winter wheat

W-1 CT	Conventional Tillage
W-2 FBCS	Fall Burn, Cross Slot
W-3 NBCS	No Burn, Cross Slot
W-4 NBH	No Burn, Horsh

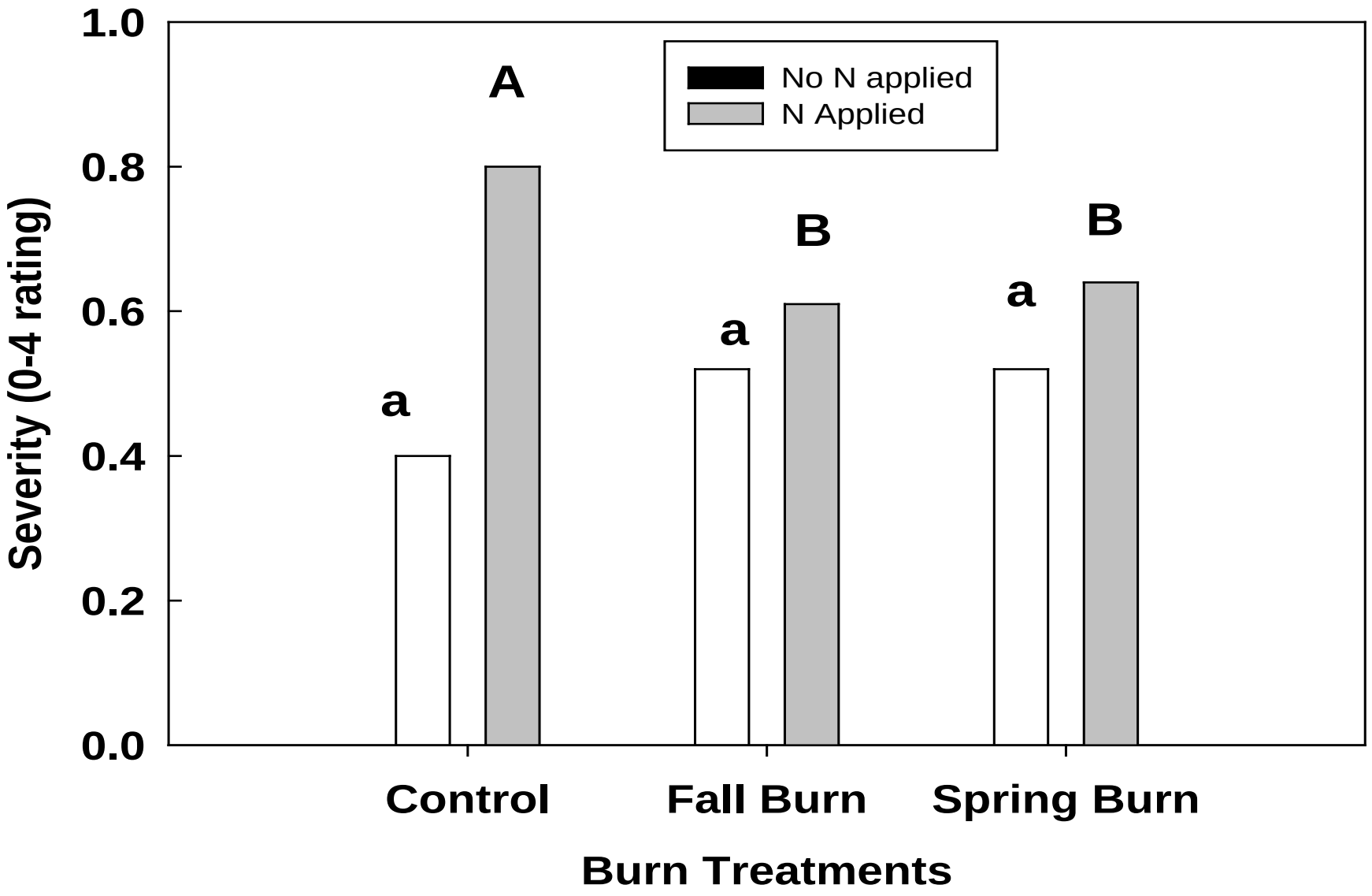
Rotation W-L - winter wheat-legume

W-L-1 CT	Conventional Tillage
W-L-2 FBCS	Fall Burn, Cross Slot
W-L-3 SBCS	Spring Burn, Cross Slot
W-L-4 NBCS	No Burn, Cross Slot
W-L-5 NBH	No Burn, Horsh

Project Objectives (3)

- (3) Document effects of wheat straw management and rotation alternatives on root pathogens

Effect of burn and N treatments on Fusarium Crown Rot (Severity 0-4 rating)



Key Finding: Objective 3

- In spring wheat, less Fusarium Crown Rot occurred in treatments with burning, and higher disease occurred with N fertilizer.

Project Objectives (4)

- (4) Convey project findings through electronic and print media, field days, conferences and research site tours

Outreach

Large-scale field studies
‘Seeing is believing’

People: creative force behind global solutions

Field Days

Outdoor Classroom

Budget

Budget (September 1, 2011 through June 30, 2013)	
Salaries (0.75 FTE Assoc. in Res. 2 yrs.)	$28,534
Benefits @ 28.4%	8,105
Total salaries, wages, and benefits	$36,639
Supplies and Services for lab anal.	2,250
Total Direct Costs	**$38,889**
Total F and A @ 8.00%	**9,042**
Total Costs	**$47,931**