



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

DOE Presentation – Feb 7, 2012

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Project Objectives

Continue the 2009-2010 study, documenting:

- (1) wheat stubble burning impacts (SOM; C, N, P losses);
- (2) crop rotations and sequences that benefit from retaining winter wheat residues in DS systems;
- (3) effects of wheat straw management and rotation alternatives on root pathogens.
- (4) enterprise budget for economic analyses

Field Studies and Lab Analyses

DOE-1 Field Study (12 x 12 ft plots)

- 15 sites with 6 treatments (Fall '11 Burn, Spg. '12 Burn, Control, Fertilized/Nonfert.)
- Collect residue after each harvest.

DOE-2 Field Study (12 x 12 ft plots)

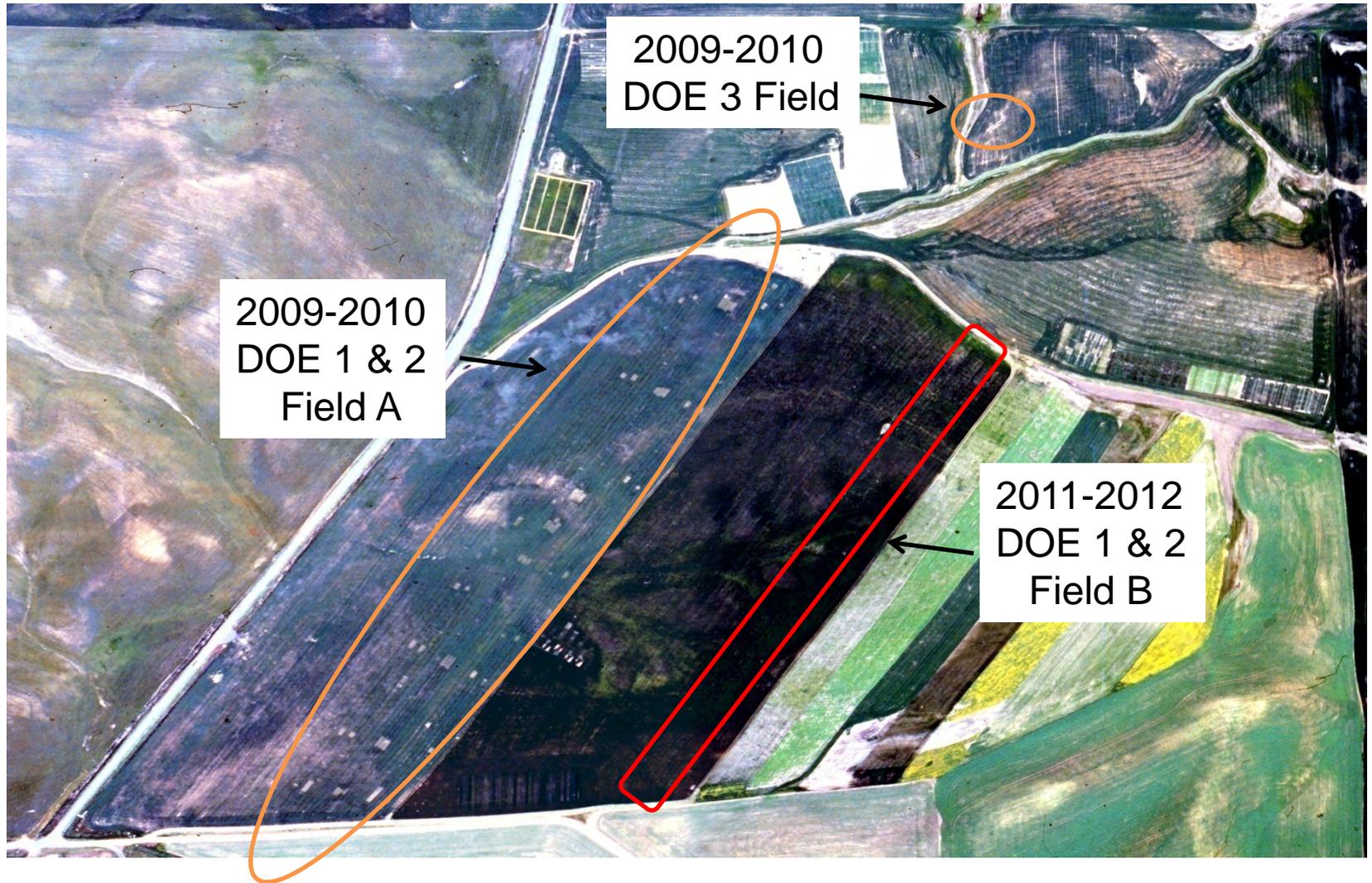
- Rotations after Fall Burn: (1) ww-sb-sw; (2) ww-cp-sw; (3) ww-ww-sw.

DOE-3 Field Study (10 x 50 ft plots)

- 2 rotations (ww and ww-l) and 3 tillage

Cook Agronomy Farm

Direct Seed and Precision Farming Systems



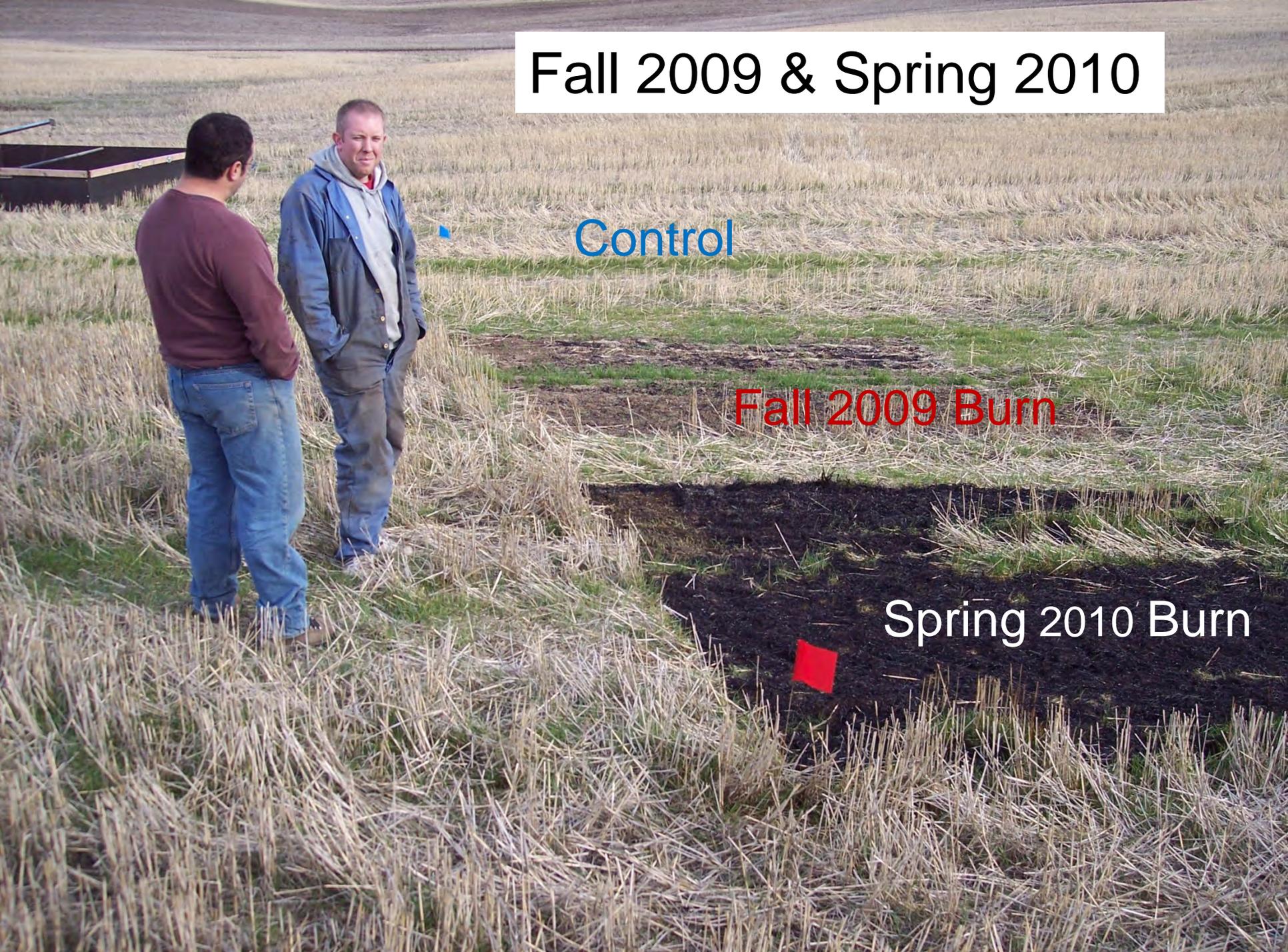
Location of Field Studies based on the 3 Objectives

Fall 2009 & Spring 2010

Control

Fall 2009 Burn

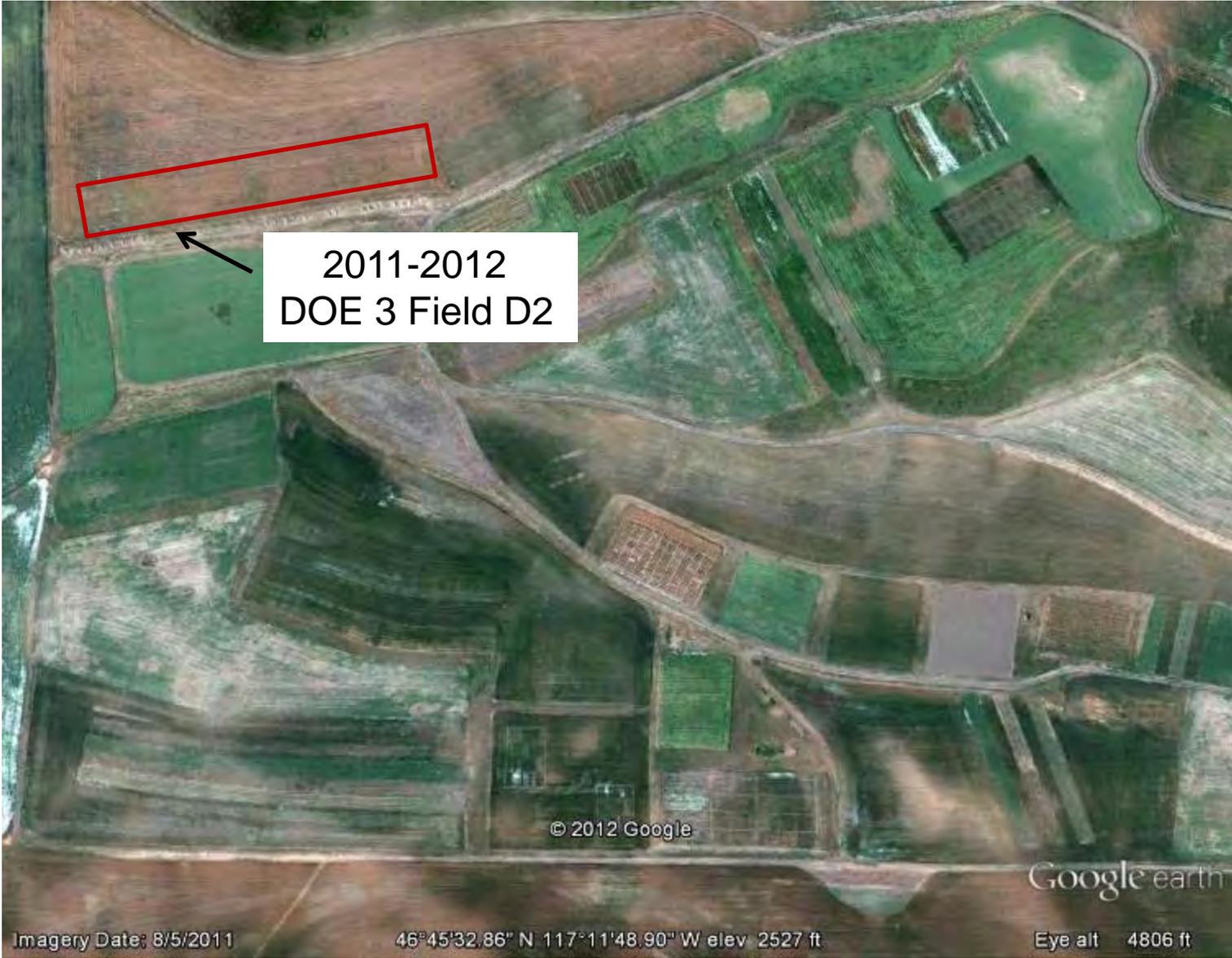
Spring 2010 Burn



DOE 1: Fall 2011 Burn Plots



USDA Palouse Conservation Field Station



DOE 3 Field Study Parameters

- 10 x 50 ft test plots
- 2 different rotations:
 - continuous ww
 - ww-legume
- 3 types of tillage:
 - conventional
 - cross slot
 - Horsh
- 4 replicates taken

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

Repeated Methodology Used to Accomplish the Objectives

- Measure soil chemical and physical characteristics (soil pH, POM, bulk density, water content, nutrient contents).
- Assess the residue loads (biomass, yields, C and N contents, net collected weights).
- Compute C, N, and P losses (mass balance on soil, plants, and residue).
- Evaluate micronutrient fluxes (PRS probes).

Soil sampling done for each of the test plots.



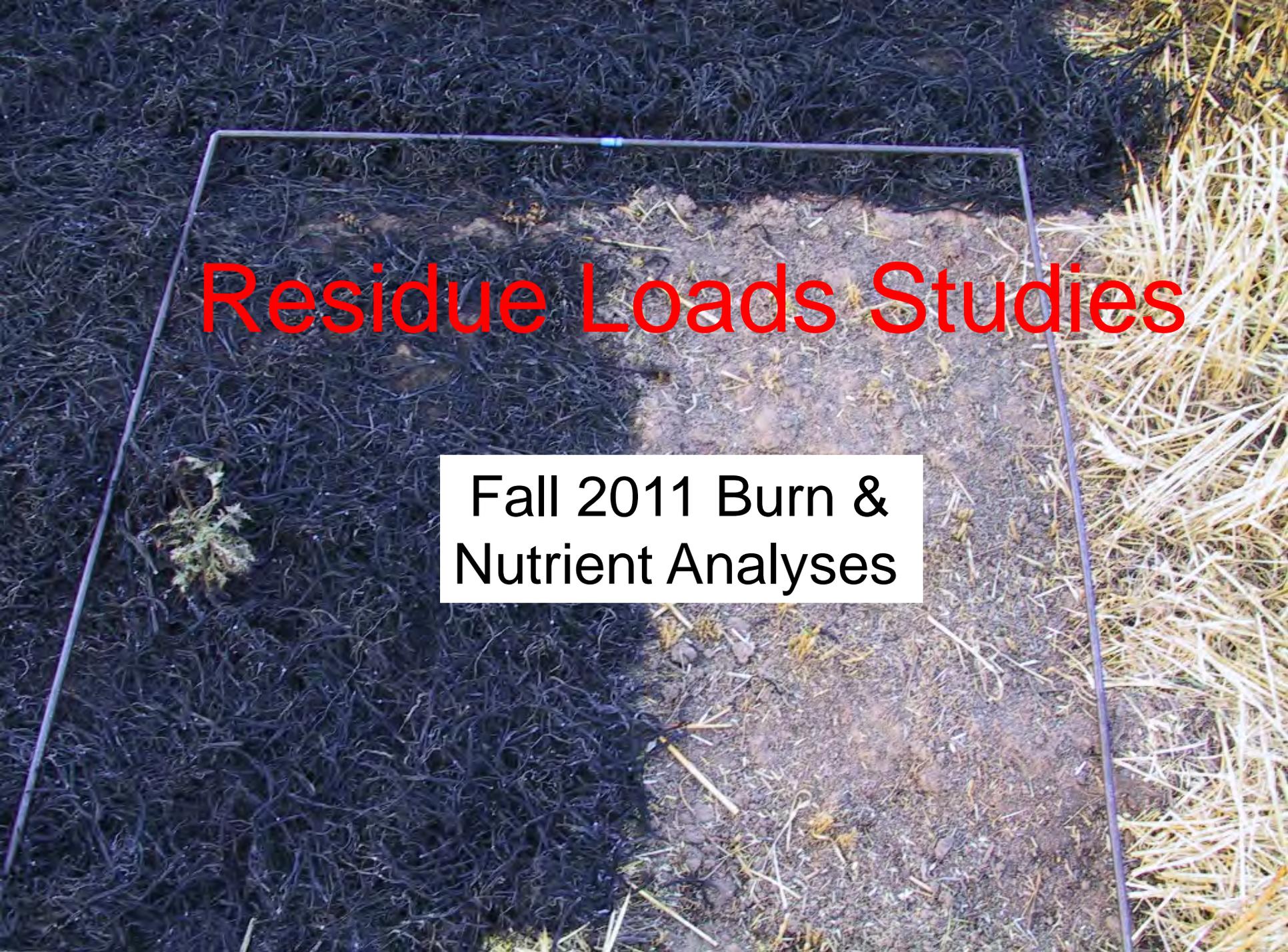
Soil, Residue, & Plant Chemical and Physical Characteristics

Results were presented at June 14th meeting:

- **Soil** (pH, bulk density, POM, nutrient content)
- **Residue** (C & N, loads) for both spg./wtr. wheat
- **Plant** (N, biomass, staging data, yield, protein)

Report findings from residue P, K, and S content (separation process protocol improvement).

The residue load data for August 2011 was analyzed and compared to previous data (residue C & N content will soon be determined).

A photograph showing a field with a metal frame around a section of charred ground and unburned vegetation. The ground is dark and charred, with some unburned vegetation visible. The frame is made of metal rods. The text "Residue Loads Studies" is overlaid in red, and "Fall 2011 Burn & Nutrient Analyses" is overlaid in a white box.

Residue Loads Studies

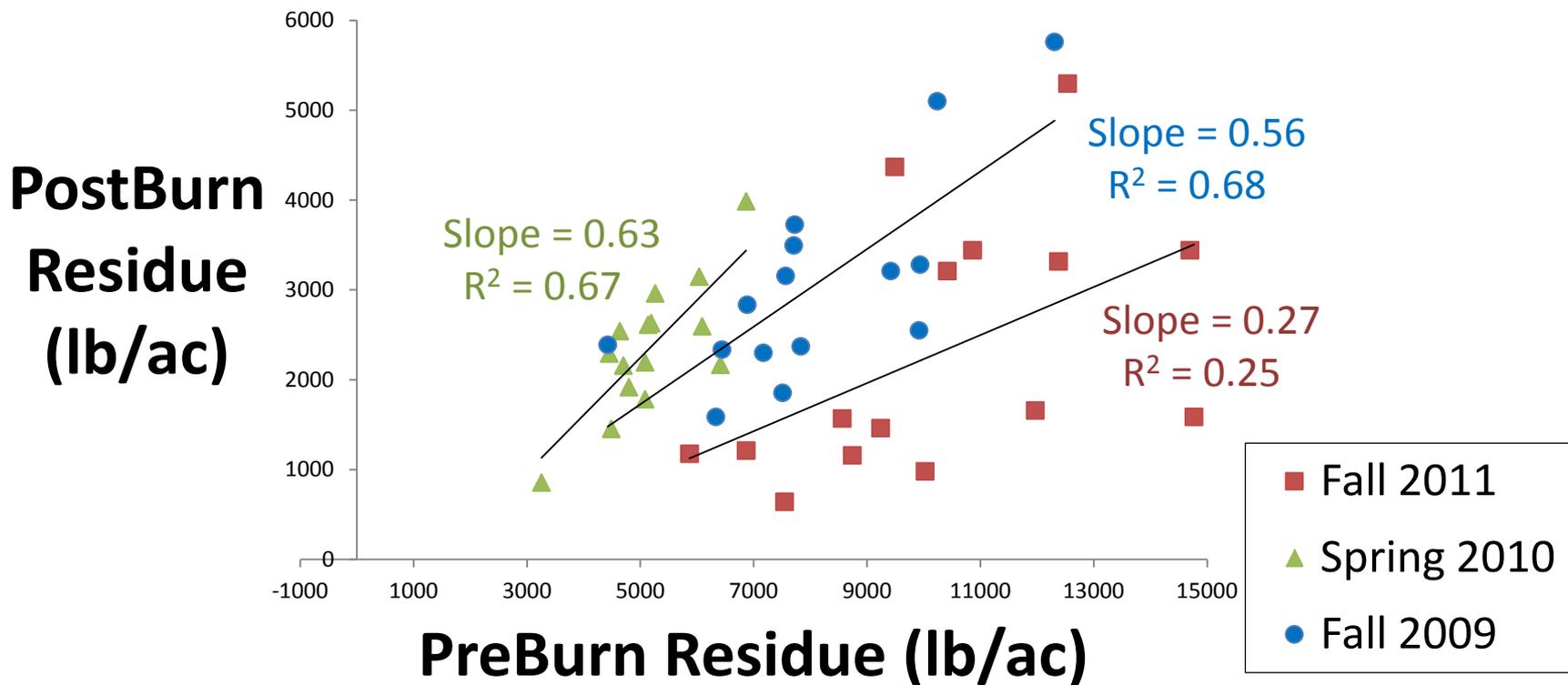
Fall 2011 Burn &
Nutrient Analyses

Residue Loss from Fall 2011 Burn

- Residue mass lost to burning ranged 54 – 91%.
- Average residue lost to burning for 15 sites was 78% (compared to 64% for fall 2009 and 56% for spring 2010).
- In plotting the residue consumed from burning, the slope and linear correlation were much lower than previous burn data.

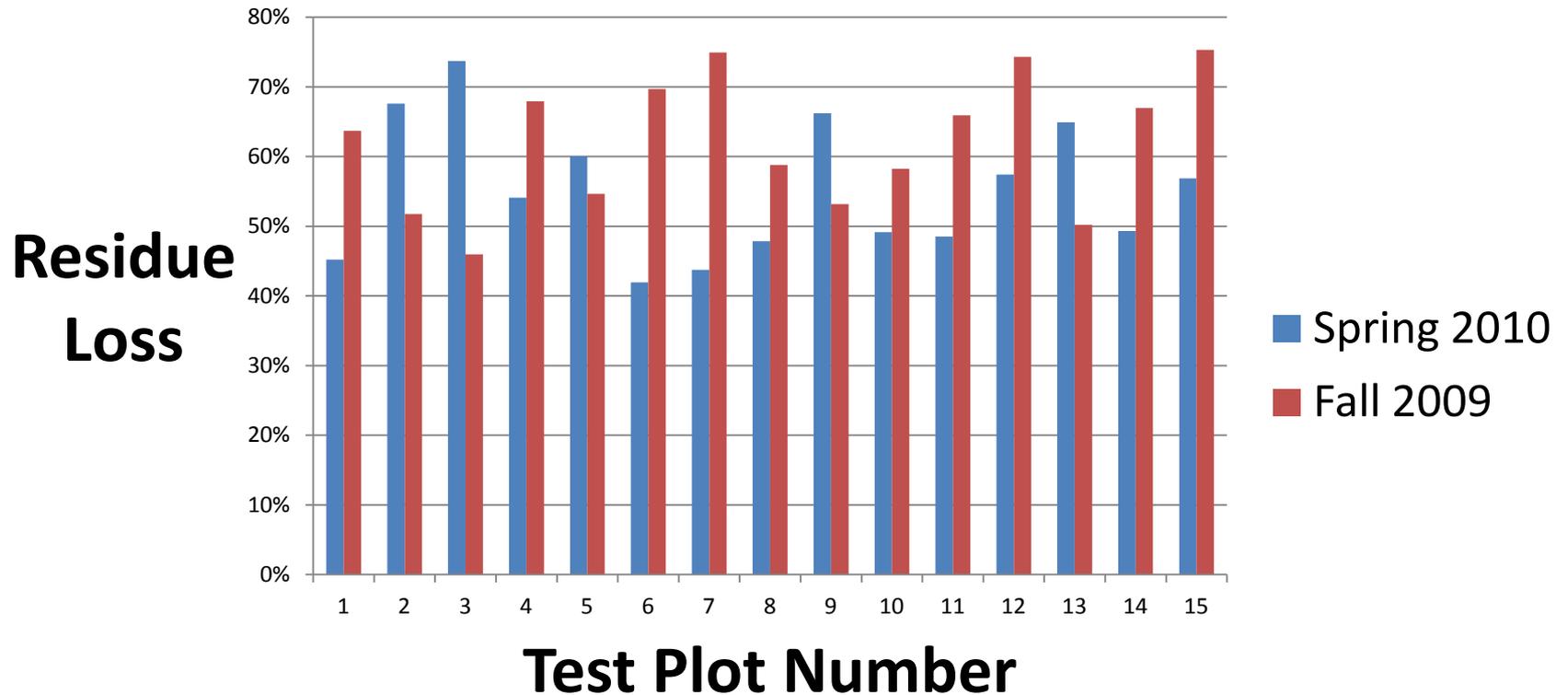
Residue Loads for Fall 2009, Spring 2010, and Fall 2011 Burns

Residue Remaining after Burning



Residue Loss from Prior Burns

Percentage Residue Loss to Burning





Refinement of residue collection and processing.

Economic Assessment of Nutrient Loss (Fall 2009 & Sgp 2010 Burns)

- Fertilizer replacement cost for nutrient loss during burning of winter wheat:

	<u>Fall Burn (\$/ac)</u>	<u>Spring Burn (\$/ac)</u>
➤ N	5.27	4.95
➤ K ₂ O	20.40	2.83
➤ P ₂ O ₅	1.72	1.20
➤ S	1.23	0.66

Total Nutrient Replacement Cost: \$29/ac (fall burn)

\$10/ac (spring burn)

Residue Nutrient Content Values

Analyses of S, Ca, Mg, P, K

- nitric digestion method (ICP analysis)
- for Fall 2009, Spring 2010, and Control
- combined the low and high residue weights

Amount of Nutrient Loss from Burning:

Burn Treatment	Nutrient Loss (lb/ac)				
	Calcium	Potassium	Magnesium	Phosphorus	Sulfur
Fall 2009	-30	-50	-8	-2	-5
Spring 2010	-10	-7	-3	-1	-2

Items to Complete (next 6 mon.)

- Analyze residue C & N contents for Fall 2011 Burn (30 samples).
- Conduct soil sampling in spring for testing.
- Plan for possible PRS probe deployment.
- Analysis of previous data (nutrient loss relationships for burn vs. non-burn sites).
- Soil erosion and condition index estimates.
- Biofuels economic assessment of lost residue.



Soil sampling to assess impact of burn treatment.



Fertilizing half of each treatment effect (split-plot).

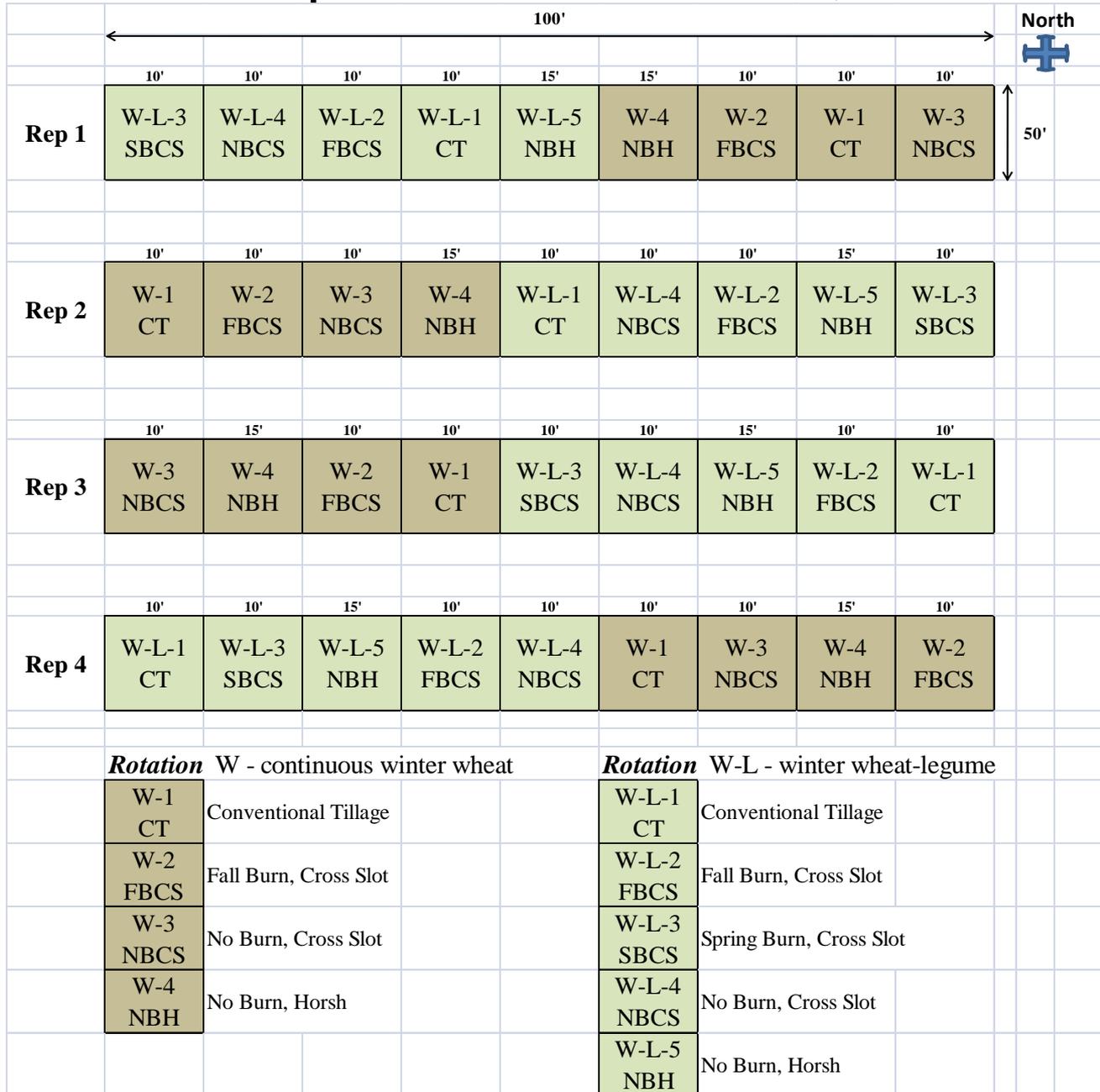


Deployment of PRS probes to monitor nutrient flux.

Presentation Back-up Information



DOE 3 Plot Map SY2011-HY2012, PCFS Field



Residue Load Impacts from Burn Treatments

Winter Wheat Residue	Fall 2009 Burn		Spring 2010 Burn	
	Pre-burn	Post-burn	Pre-burn	Post-burn
Residue Load (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 Characteristics from Burn Treatments

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

Grain and Residue Properties for 6 Treatments

Spring Wheat	Control		Fall Burn		Spring Burn	
	N Applied	No N Applied	N Applied	No N Applied	N Applied	No N Applied
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

Soil and Plant Properties from Burning

Spring Wheat and Soil Properties	Control	Fall Burn
Main Stem Leaves (number)	3.94b	4.53a
Tillers (number)	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

Crop Yield Impacts from Burning

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

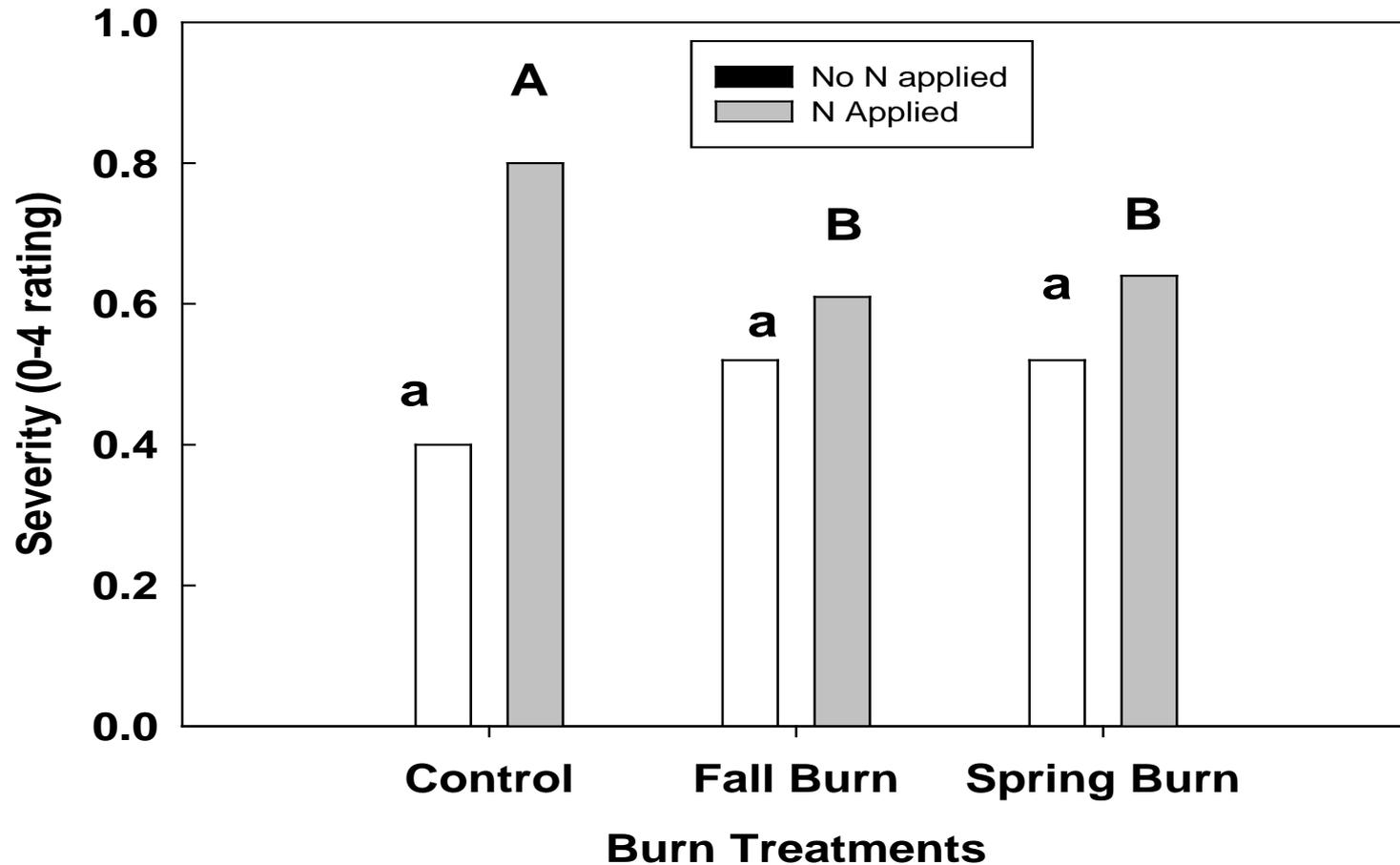
June 2011 Reported Findings

- Fall burning impact:
 - 62% reduction in winter wheat residue mass
 - 2,010 lbs C/ac & 12 lbs N/ac
- Spring burning impact:
 - reduced residue mass by 55%
 - 1,271 lbs C/ac & 11 lbs N/ac
- Residue burning had little impact on soil properties (N%, C%, bulk density, pH ,POM).

June 2011 Reported Findings

- N losses from burning were lower (40% for spring and 33% for fall) than the previously reported laboratory studies of nearly 100%.
- Fall burning of ww residue increased early season soil N availability, spring wheat growth and development and spring wheat N uptake.
- Field deployed PRS probes had 40% more $\mu\text{g N } 10 \text{ cm}^{-2} 7 \text{ days}^{-1}$ in fall burned as compared to control plots.

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



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