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

Co-Principle Investigators

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Tim Paulitz, Plant Pathologist

Kate Painter, Ag. Economist

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

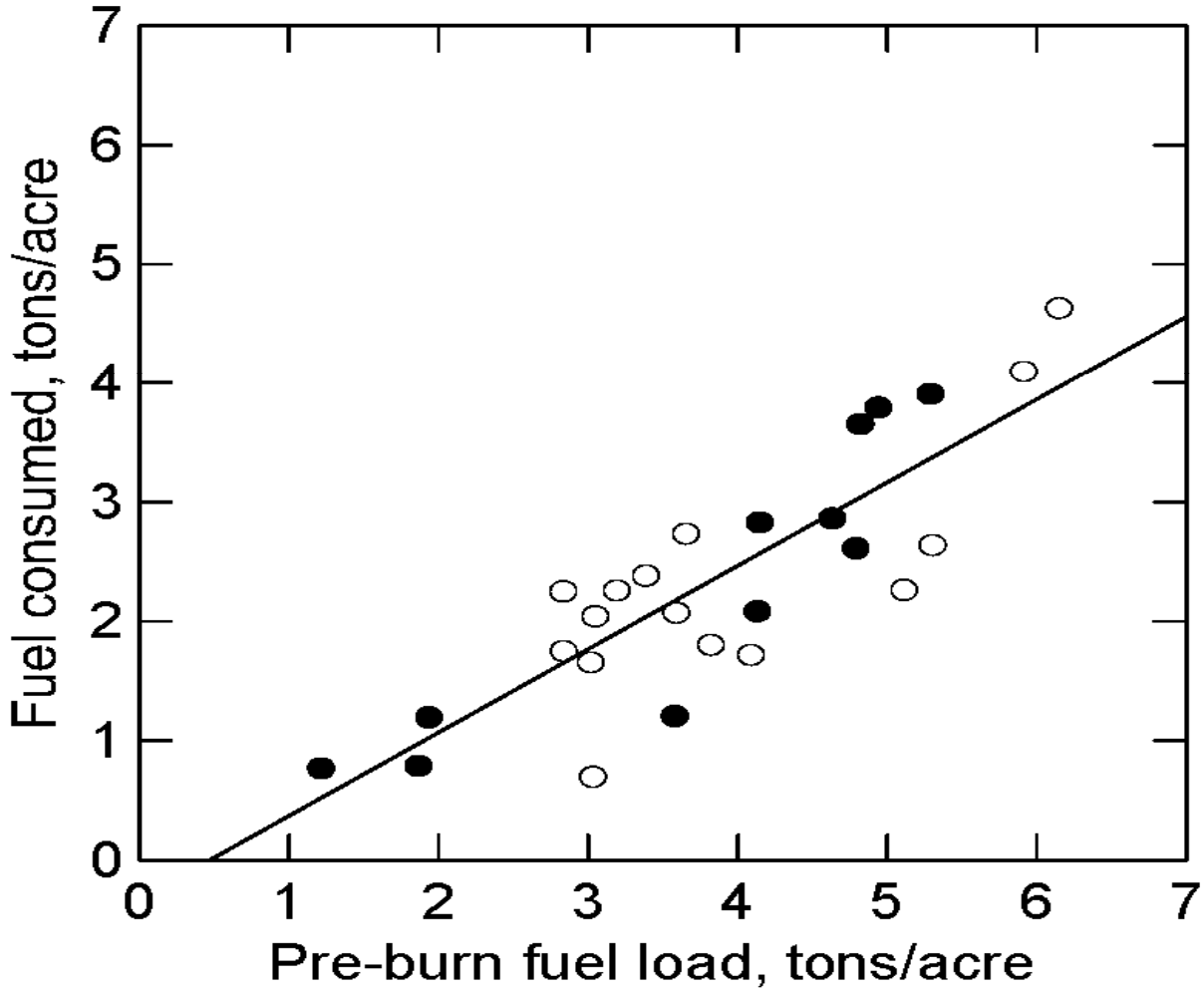
- Negative impacts on overall soil organic matter levels
- Loss of nutrients (e.g. N, P and S)
- Increased hazard of soil erosion if burning is combined with too much tillage

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)

Figure 3.2. Absolute Fuel Consumption as a Function of Pre-Burn Residue Loading for Spring (Open Circles) and Fall Season (Closed Circles)

The relationship can be described as follows: Fuel consumption = -0.417 + (0.713 x Pre-Burn Residue Loading), R^2=0.71, $F_{1,24}$=60.85, P<0.001).



AIR SCIENCES INC.

FINAL REPORT:

CEREAL-GRAIN RESIDUE OPEN-FIELD BURNING EMISSIONS STUDY

Prepared for and funded by:

WASHINGTON DEPARTMENT OF ECOLOGY

WASHINGTON ASSOCIATION OF WHEAT GROWERS

U.S. ENVIRONMENTAL PROTECTION AGENCY, REGION 10

Prepared by:

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PROJECT NO. 152-02
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N O R T H E R N
G R E A T P L A I N S

Up in Smoke—- Nutrient Loss with Straw Burning

By John Heard, Curtis Cavers, and Greg Adrian

Burning spring wheat, oat, and flax straw resulted in 98 to 100% loss of nitrogen (N), 70 to 90% loss of sulfur (S), and 20 to 40% loss of phosphorus (P) and potassium (K).

Better Crops/Vol. 90 (2006, No. 3)

Effects of burn/low-till on erosion and soil quality
D.K. McCool, C.D. Pannkuk, A.C. Kennedy, P.S. Fletcher--Soil & Tillage Research 101 (2008)

PURDUE UNIVERSITY

PURDUE EXTENSION

Factors Shaping Price and Availability in This Year's Fertilizer Market

by Bruce Erickson and Alan Miller

Unsettled fertilizer markets adjusting to the new realities following the world financial crisis are causing angst for fertilizer companies, agricultural retailers, and farmers who are trying to line up supplies and determine prices. With the spring planting season now just a few weeks away, a brief look at some of the fundamentals of fertilizer markets should be helpful for both growers and agricultural retailers as they develop their plans for spring.

Dramatic Price Swings More Common For many years there was little interest or excitement in discussing or analyzing fertilizer markets, as somewhat predictable and incremental price changes were the rule. This all changed in 2001 with nitrogen fertilizers, and became especially acute in 2008 for a variety of nutrient sources (Figures 1 & 2). Unfortunately few financial tools allow a retailer or a farmer to manage their fertilizer price risk.

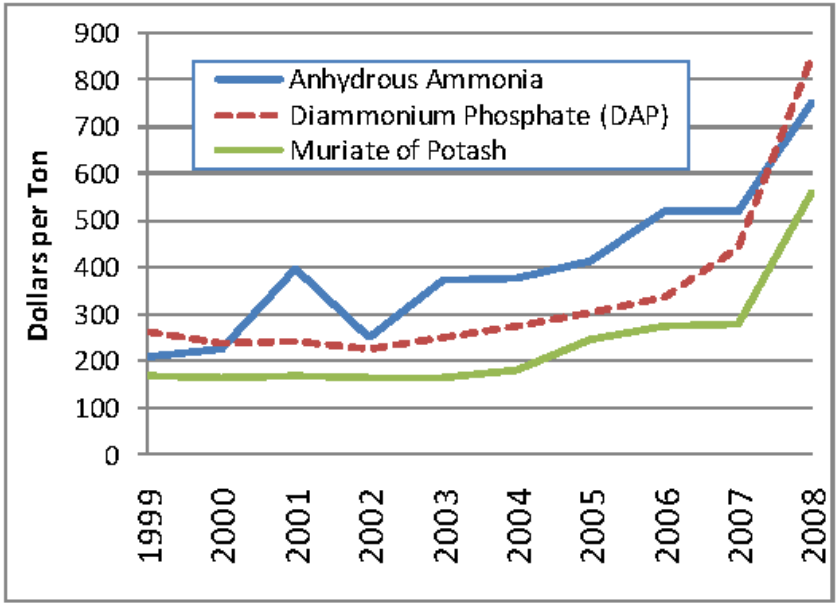


Figure 1. Ten-year summary of April U.S. prices paid of some commonly-used fertilizers. Source: NASS, USDA.

Fertilizer Pricing is Complex Fertilizer contracts are not traded on a common exchange like stocks, currencies, or grains, so it can be much more

Overall Project Goals

- Build on past research conducted on crop rotation and residue management alternatives to burning (Huggins et al., 2005)
- Strengthen scientific knowledge surrounding actual field burning effects on residue C and nutrient losses, nutrient supplies, soil-borne disease, crop performance and associated economics

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

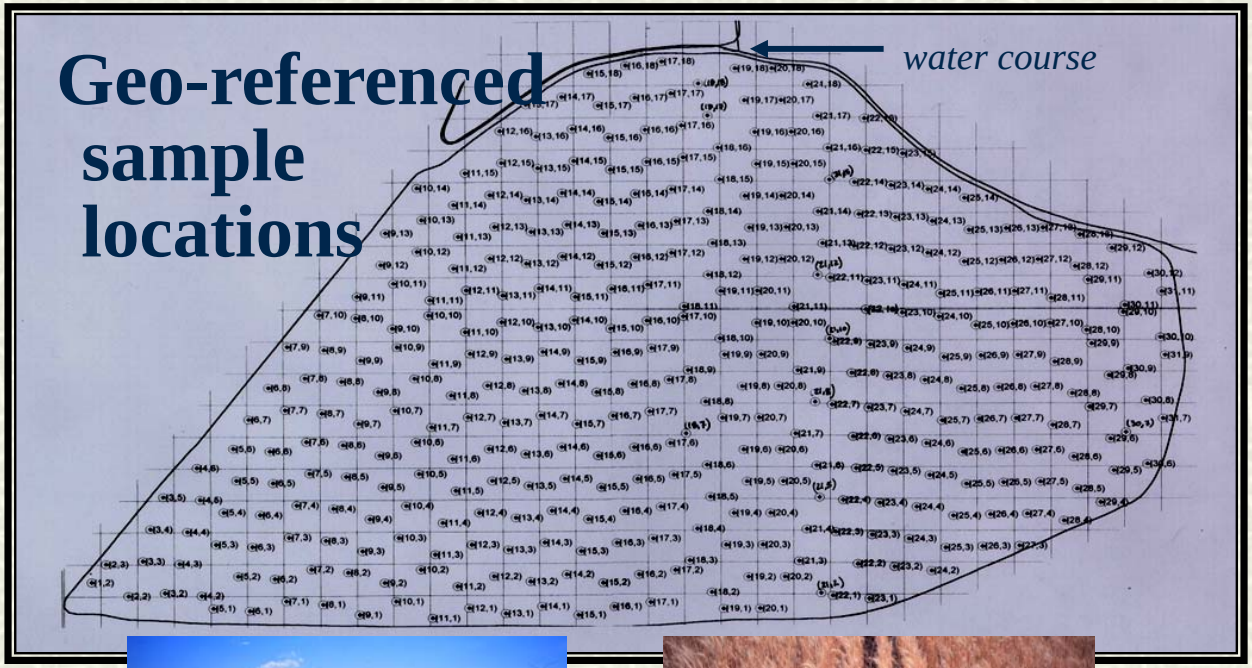
Cook Agronomy Farm

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



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

Methods (Objective 1)

- All residue samples will be analyzed for total C, N, S and P using standard laboratory methods (Leco C/N/S analyzer, and ICP for P)
- Statistical analyses will use regression techniques to find relationships between pre- and post-burn wheat residue loads and associated C, N, P and S

Methods (Objective 1)

- Soil samples from each of the three treatments and 15 sites will be collected at 0-4, 4-8 and 8-12 inch increments and analyzed for soil pH (1:1 with water) total C, N and S (Leco analyzer), particulate organic C, N and S (a measure of labile components), potentially mineralizable N and bulk density
- Yield of the subsequent spring wheat crop will be assessed for each treatment at the 15 field locations

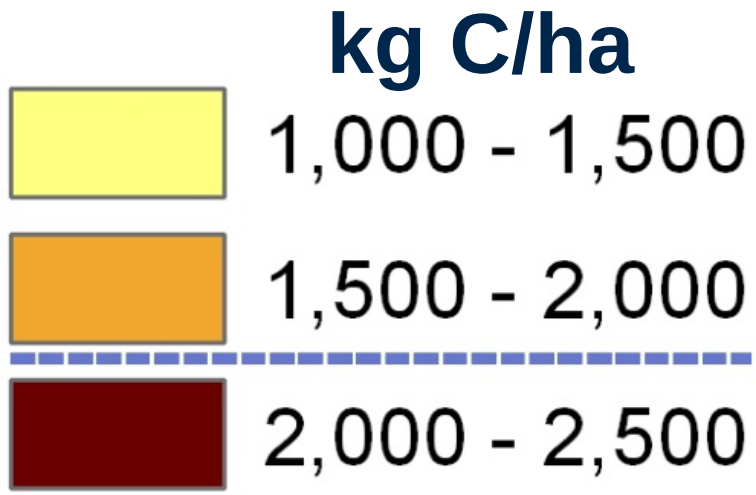
Methods (Objective 1)

- **Economic analyses will evaluate:**
  - **The loss of N, P and S from residues due to burning and the equivalent amount of fertilizer and its dollar value required to replace this loss**
  - **Treatment differences in net N mineralization and the dollar value associated with an equivalent amount of N fertilizer**
  - **Treatment differences in net returns from the spring wheat crop based on partial crop enterprise budgets**

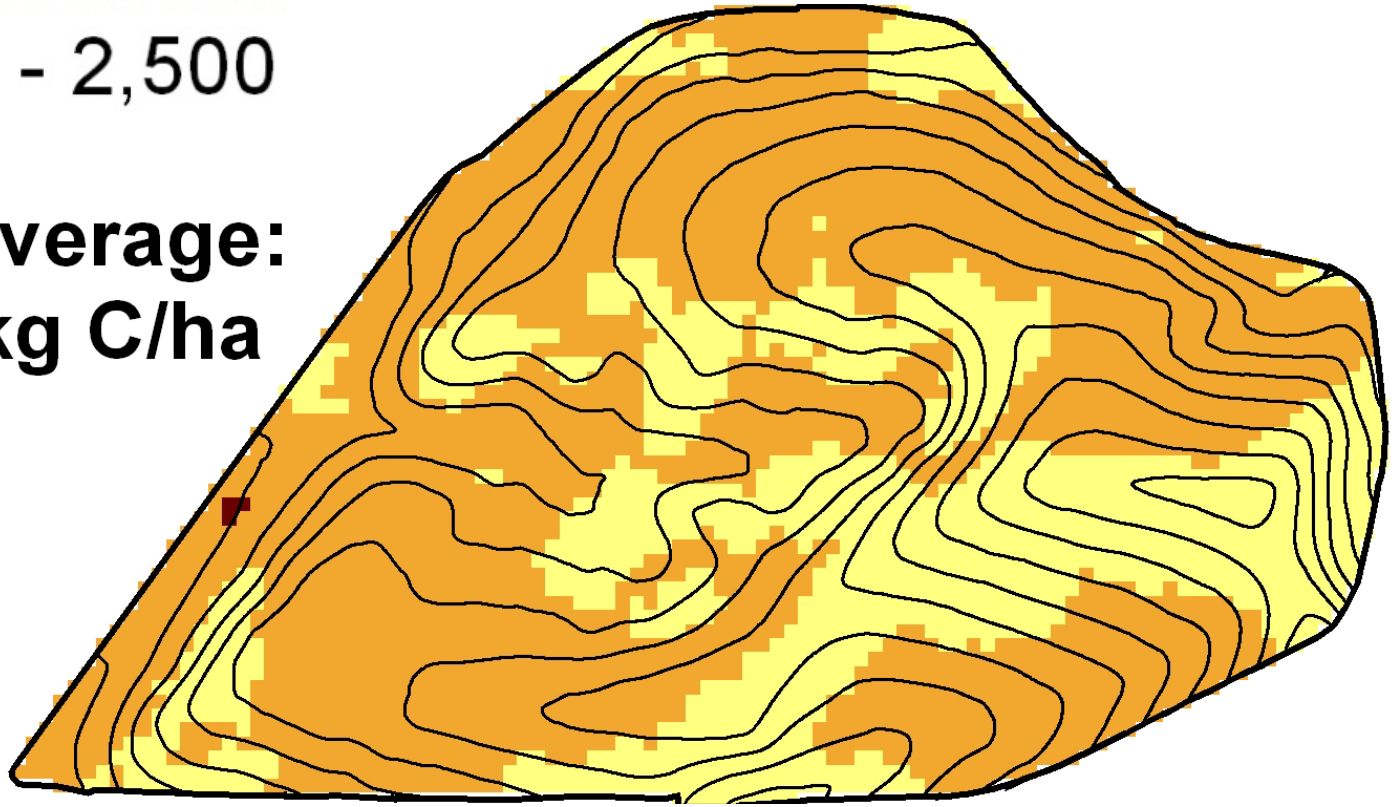
Methods (Objective 1)

- Results of plot studies will be extrapolated to 369 geo-referenced points covering the 92 acre CAF
  - RUSLE
  - SCI
  - Nutrients
  - Residue C returned and soil C
  - Economics

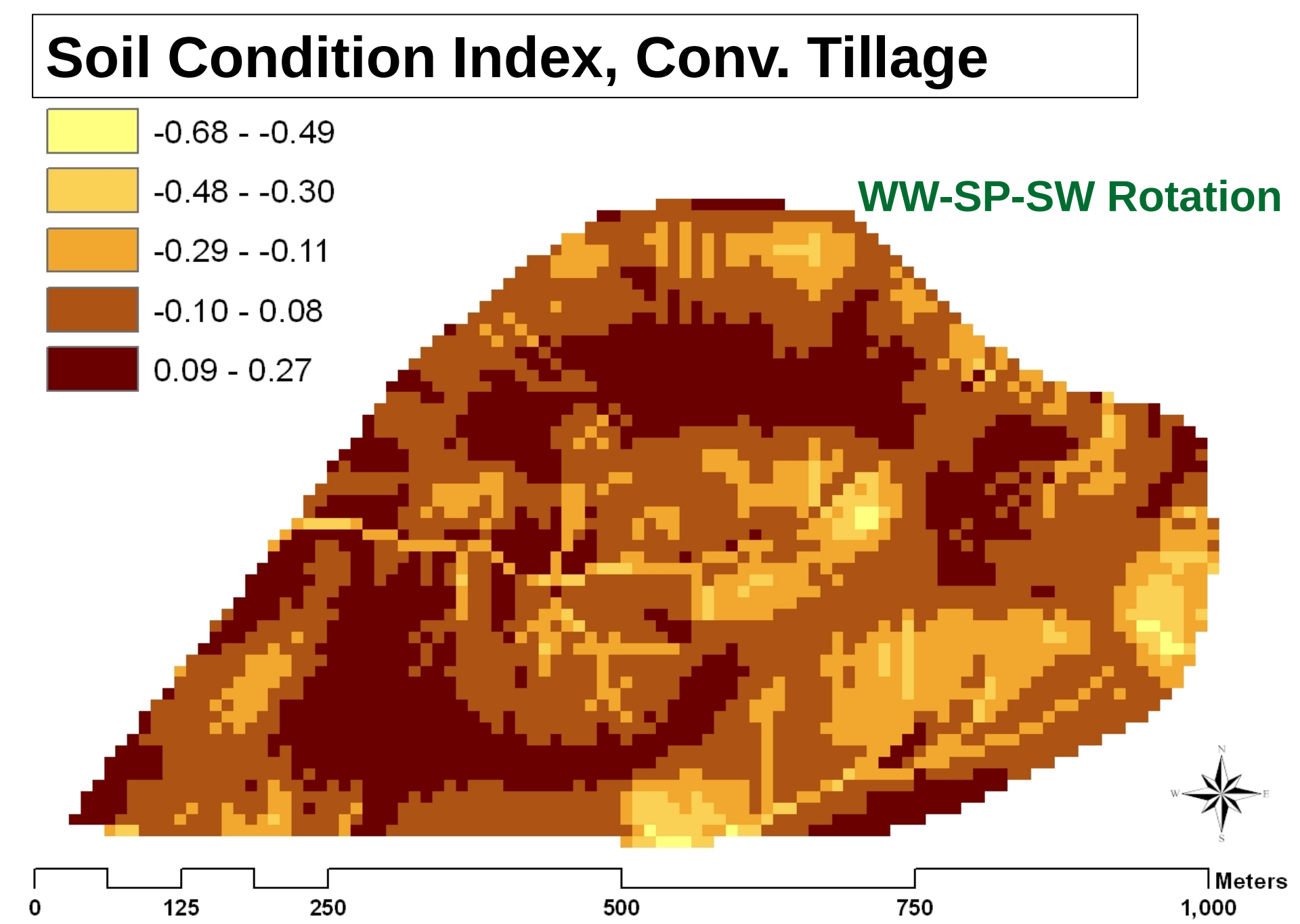
Residue carbon remaining in field after baling



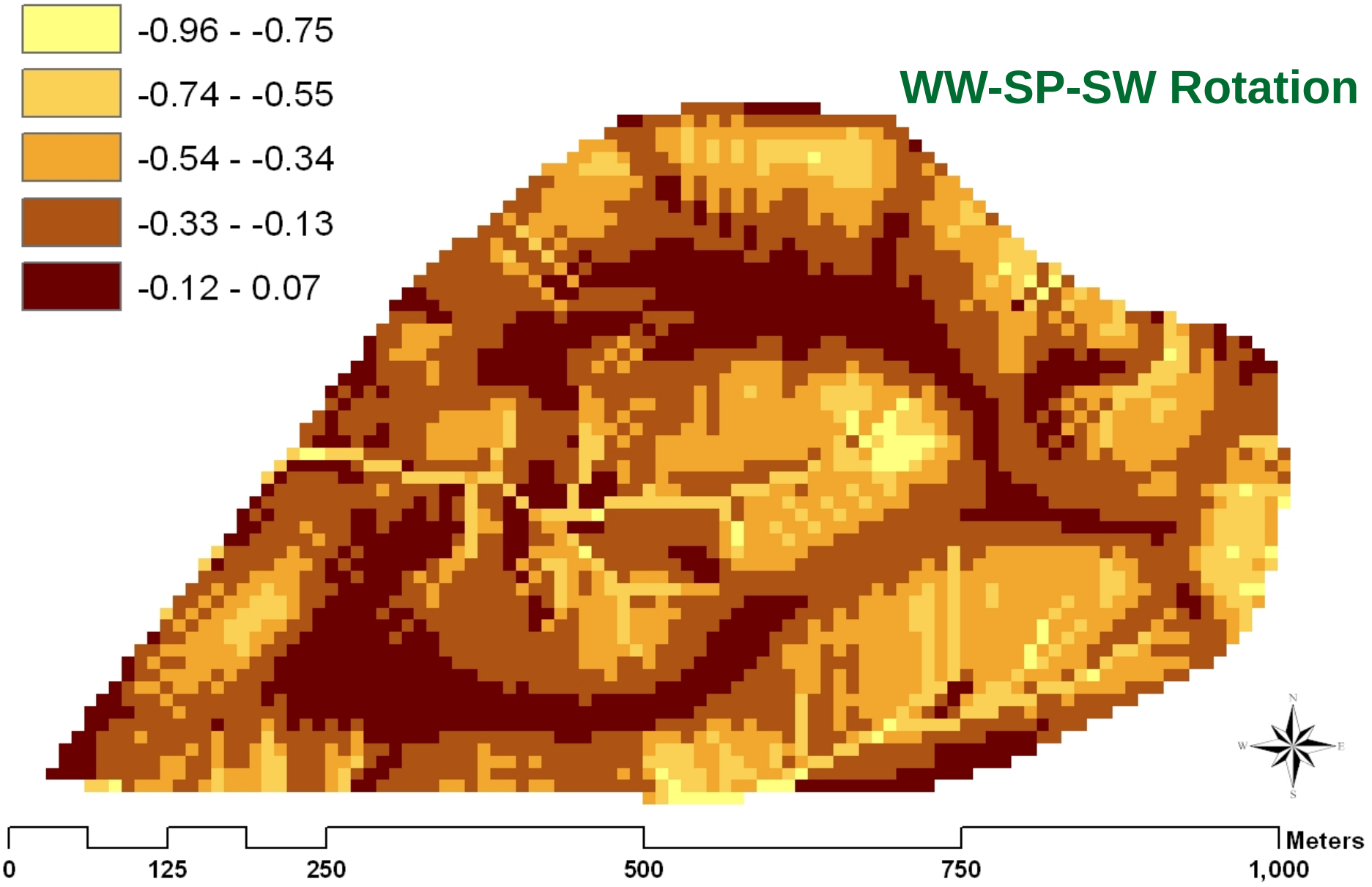
Field average:
1563 kg C/ha



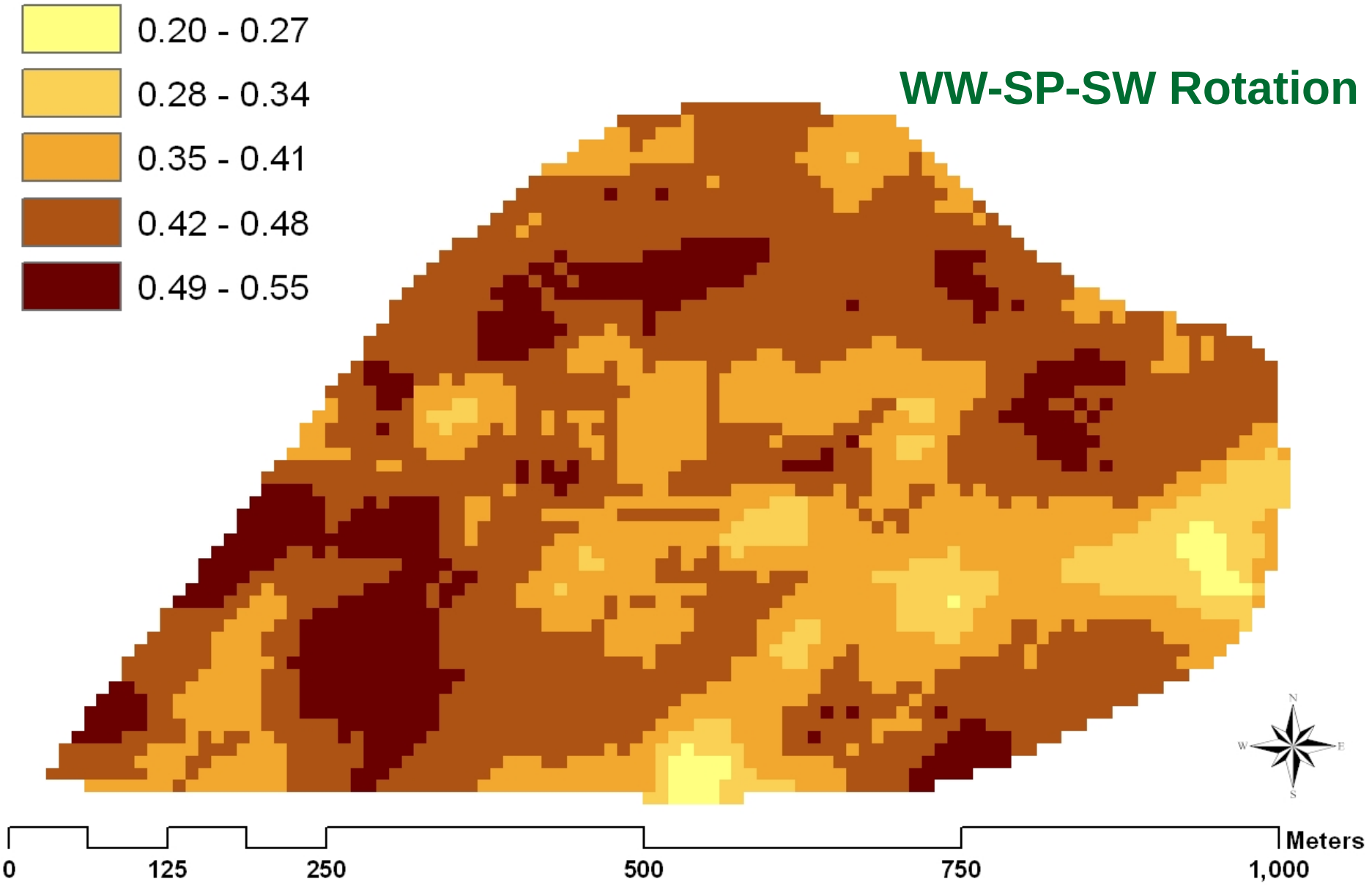
Soil Condition Index, Conv. Tillage



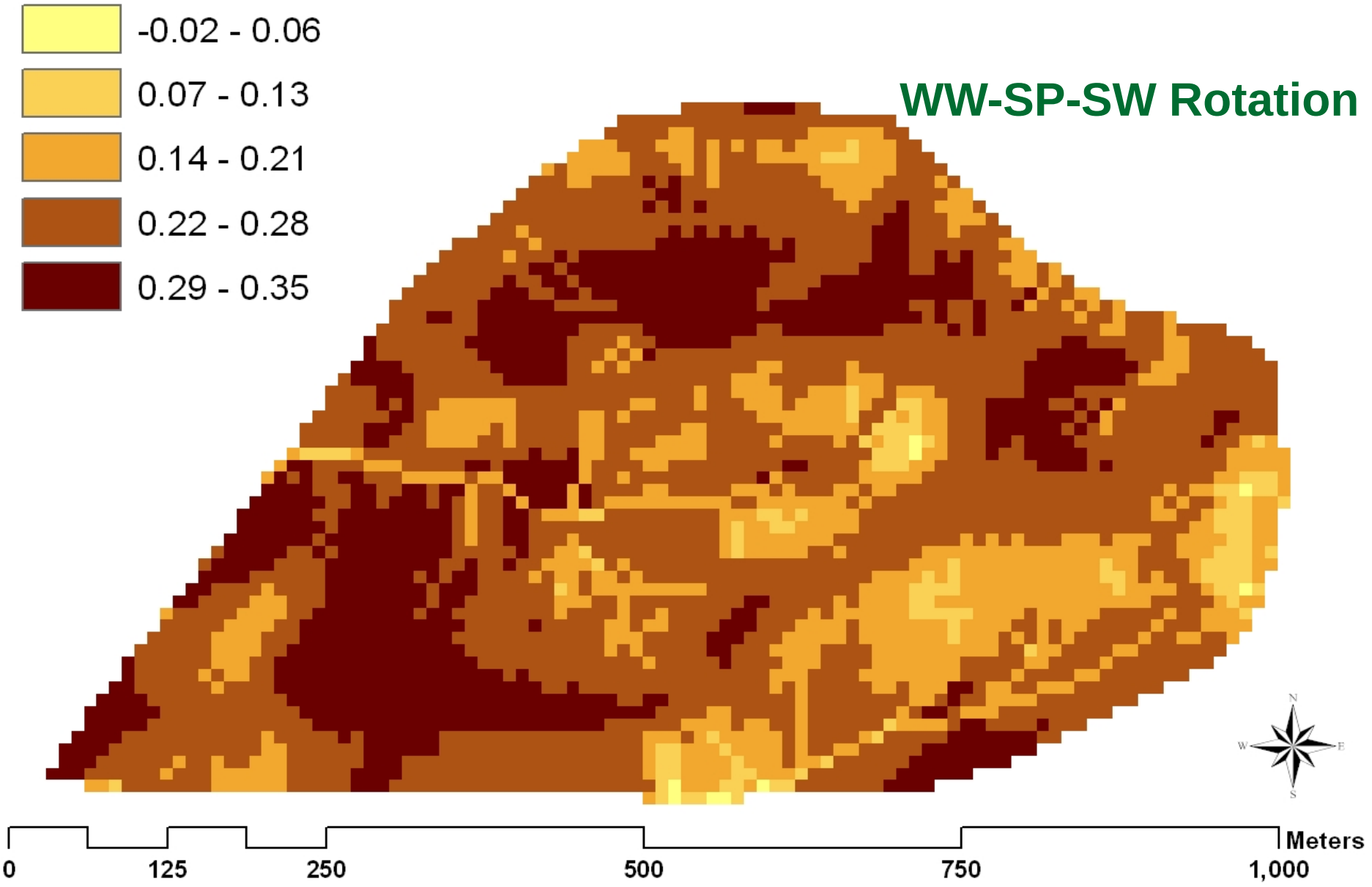
SCI, Conv. Tillage, Baled Straw



Soil Condition Index, No-till



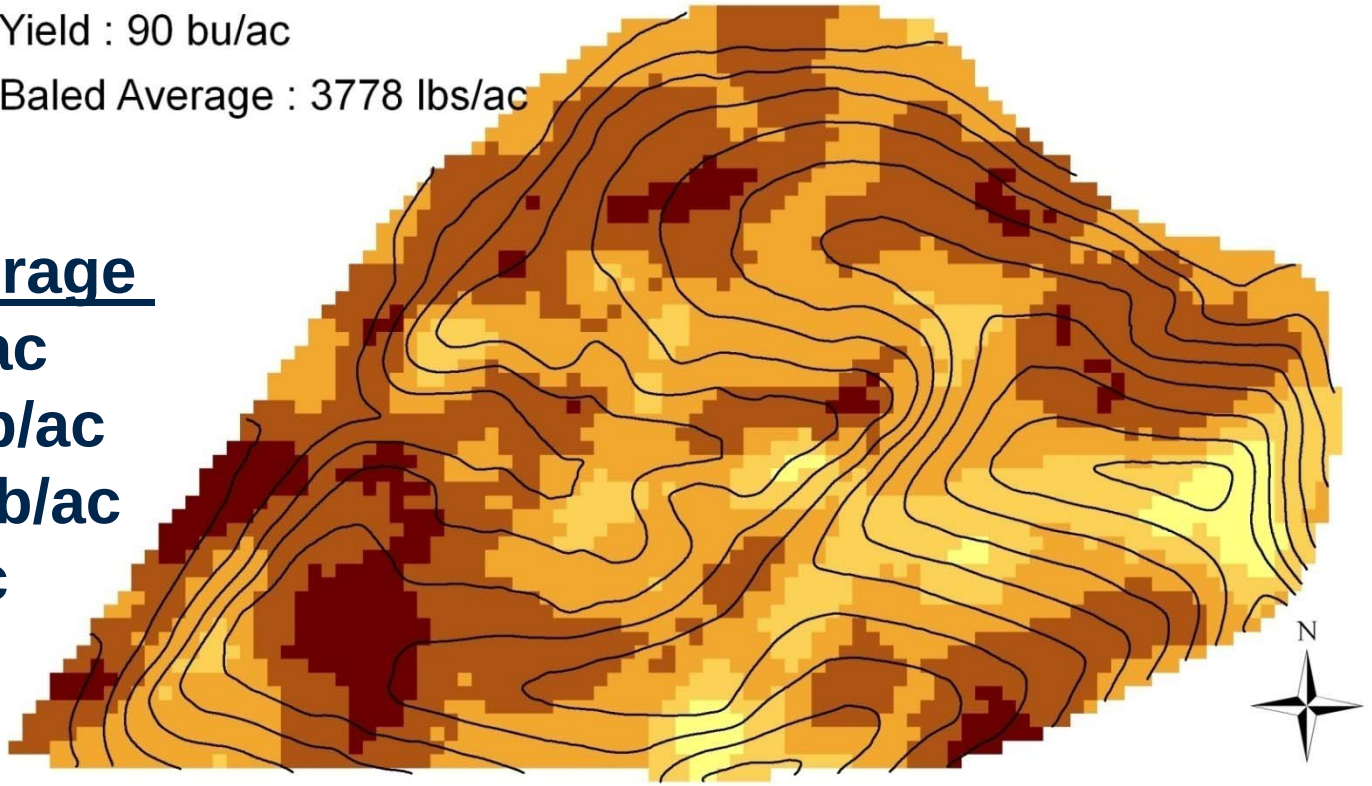
SCI, No-till, Baled Straw



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

Project Objectives (2)

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

Methods (Objective 2)

- Evaluation of spring chickpea performance (yield, net returns) following winter wheat under tillage, burning and direct-seed treatments (sequence study)
- Evaluation of direct-seed crop rotation alternatives following winter wheat with and without burning (rotation study)

Methods (Objective 2)
Crop Sequence Study

- Randomized-block, small-plot study will establish chickpeas following winter wheat
  - Conventional tillage
  - Fall burning and direct seeding with a low disturbance drill (Cross-slot drill)
  - Spring burning and direct seeding with a low disturbance drill (Cross-slot drill)
  - No burning and direct seeding with a low disturbance drill (Cross-slot drill)
  - No burning and direct seeding with a high disturbance drill (Horsch-Anderson drill)

Methods (Objective 2)
Rotation Study

- Treatments will be established following winter wheat harvest in four of the existing three-year crop rotations:
  - (1) winter wheat/spring wheat/spring chickpea
  - (2) winter wheat/spring chickpea/spring wheat
  - (3) winter wheat/spring canola/spring wheat
  - (4) winter wheat/spring barley/spring wheat

Methods (Objective 2) Rotation Study

- Treatments will be established following winter wheat harvest in four of the existing three-year crop rotations
  - Treatments will consist of fall burn and no burn on small plots (15 ft by 30 ft) established in high and low wheat residue field locations with four replications (64 total plots)
  - All field crops will be seeded with a Horsch-Anderson direct-seed drill (hoe-type opener)
  - Crop performance (yield, quality, net returns) will be evaluated for all treatments

Project Objectives (3)

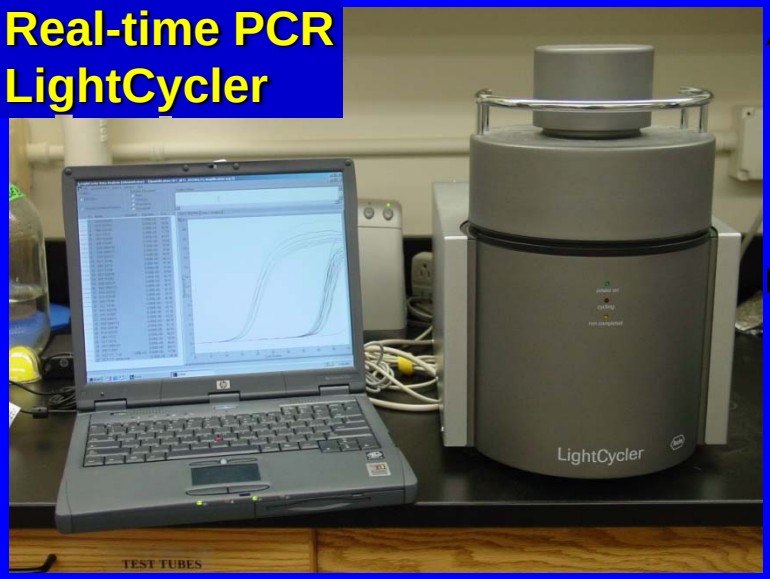
- (3) Document effects of wheat straw management and rotation alternatives on root pathogens

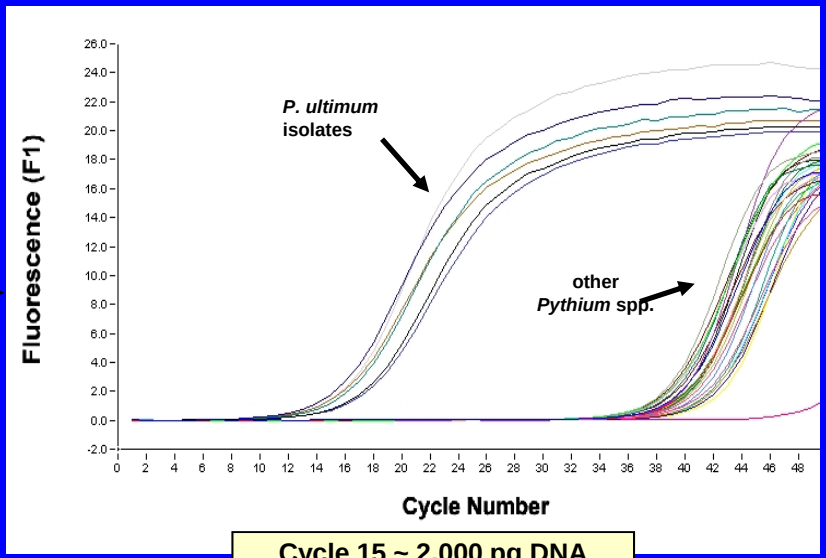
Methods (Objective 3) Root Pathogen Study

- This objective will rely on the crop sequence and rotation studies described under objective 2
- We will use real-time quantitative PCR methods to quantify the levels of soil-borne pathogens in these treatments to determine if the populations of fungal pathogens are affected by residue management or rotations
- We can now readily quantify levels of Rhizoctonia, Fusarium, and Pythium
- Specific diseases will be quantified on spring wheat, barley, chickpea and canola

Extract DNA from soil using kits and bead beater- Need to break DNA out of fungal cells and separate from other inhibitors

Real-time PCR LightCycler





Cycle 15 ~ 2,000 pg DNA
Cycle 39 < 0.005 pg DNA

Project Objectives (4)

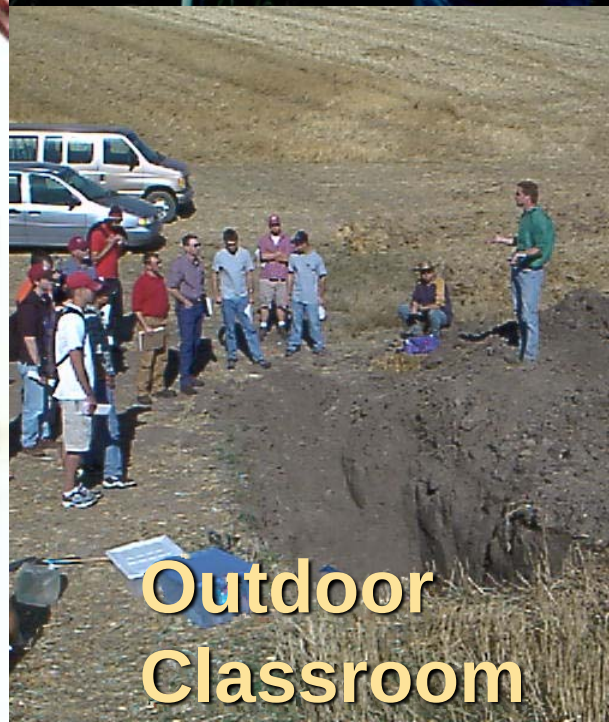
- (4) Convey project findings through electronic and print media, field days, conferences and research site tours

Outreach

Large-scale field studies
‘Seeing is believing’

People: creative force behind global solutions

Field Days



Outdoor Classroom

Deliverables

- Quantification and economic analysis of residue C, N, P and S losses from field burning of winter wheat. Initial data for evaluating impacts of field burning on labile constituents of soil C and N pools
- Agronomic and economic evaluation of benefits, if any, of direct-seed winter wheat-spring chickpea crop sequence as an alternative to field burning including evaluation of low and high disturbance direct-seed drills (one year results)

Deliverables

- Agronomic and economic evaluation of benefits, if any, of direct-seed rotations of: (1) winter wheat/spring wheat/spring chickpea; (2) winter wheat/spring chickpea/spring wheat; (3) winter wheat/spring canola/spring wheat; and (4) winter wheat/spring barley/spring wheat as alternatives to field burning. (one year results)
- Documented effects of wheat straw management and rotation alternatives on root pathogens of spring wheat, barley, canola and chickpea. (one year results)

Deliverables

- Geo-referenced maps of treatment effects over the 92 acre CAF including field burning effects on biomass C and nutrient losses, erosion estimates (RUSLE), and soil condition index (SCI), crop performance (yield, net return) and pathogen distributions. Site-specific effects of field burning under different crop management scenarios
- Presentation of results during at least one field tour of the research site and at least one conference/presentation by each of the co-principle investigators

Budget

Budget (September 1, 2009 through October 31, 2010)

Salaries (0.50 FTE Associate in Research)	$22,020
Benefits @ 38%	8,368
Timeslip $9/hr, 10 hrs/week	1,080
Benefits @ 2.1%	23
Total salaries, wages, and benefits	$31,491
Supplies and Services for lab analyses	$10,176
Total Direct Costs	$41,667
Total F and A @ 8.00%	3,333
Total Costs	$45,000