Crop Residue – What's It Worth?

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Presentation Outline

Responding to the bioenergy challenge

- Formation of the REAP Team

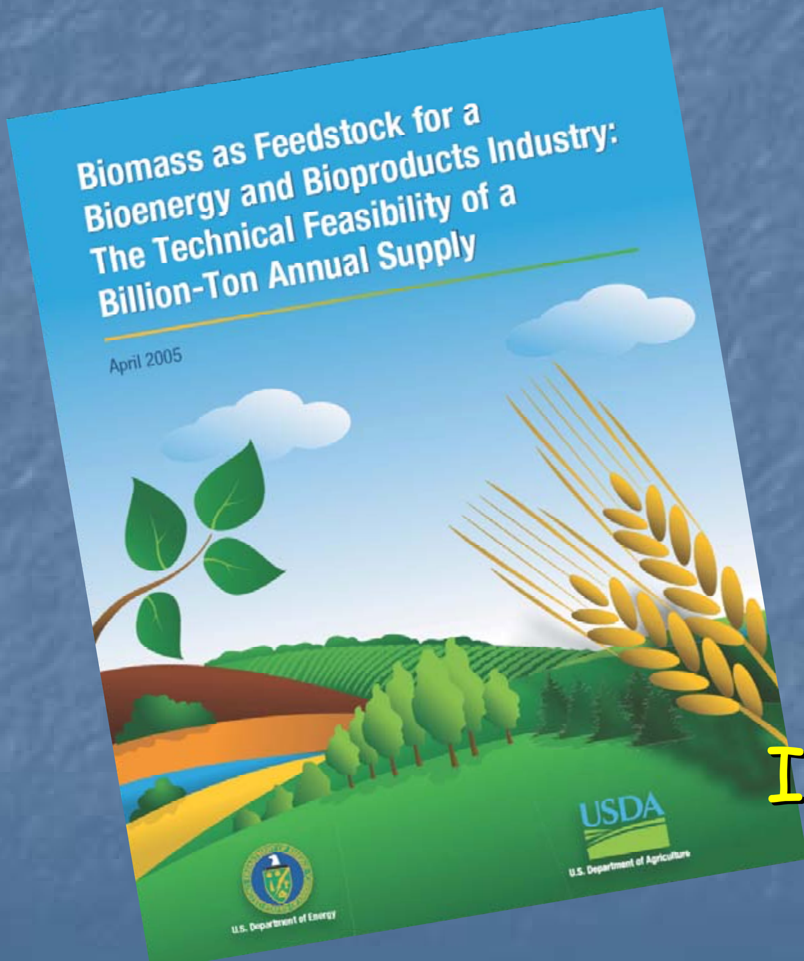
Why are crop residues important?

What have we learned at Ames?

- Stover harvest strategies
- Yield response & stover quality
- Nutrient removal & value

What's needed for sustainable bioenergy production?

Comprehending the Challenge

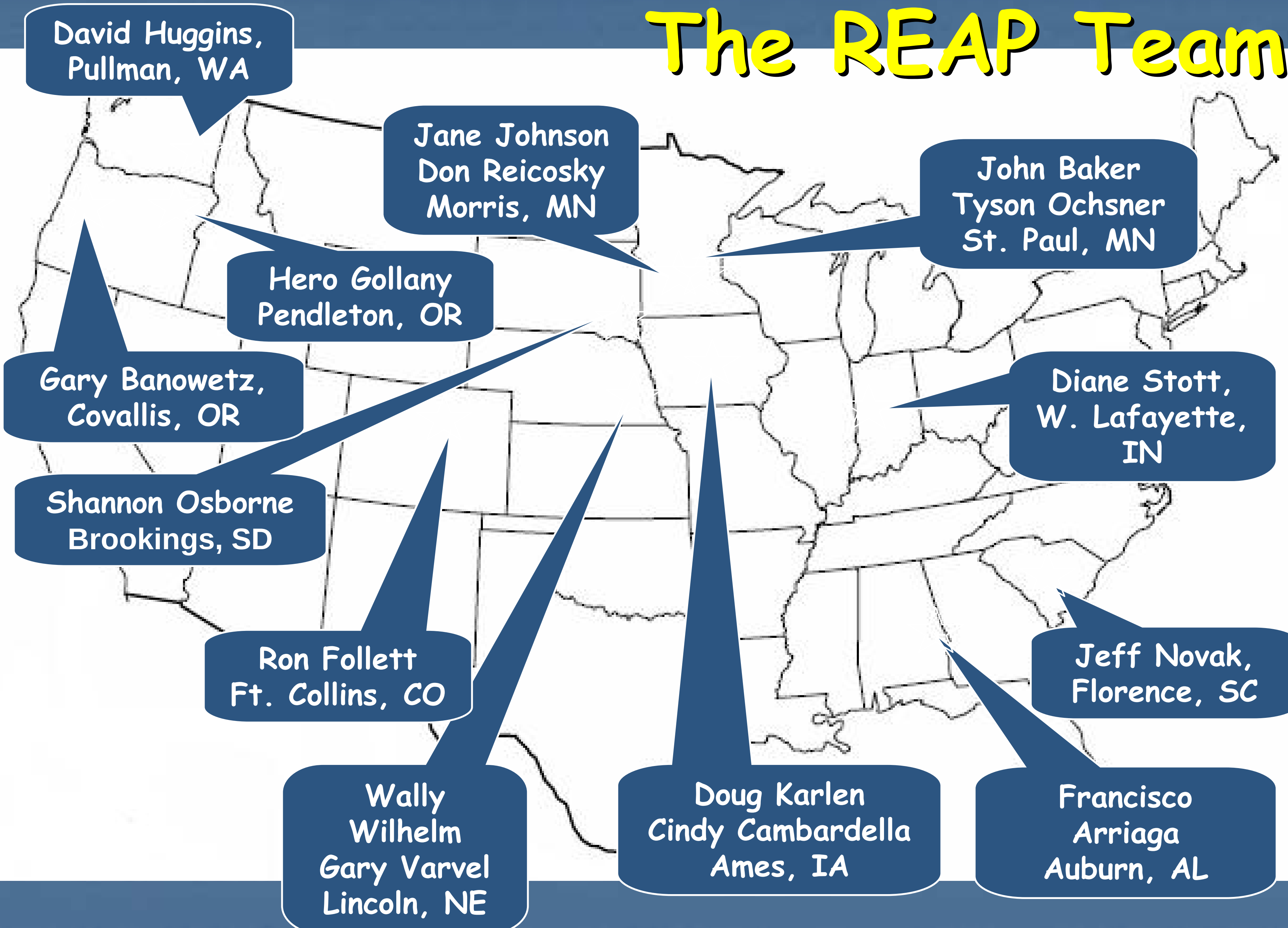


Row of 1000 lb round bales, 5 ft long, placed end-to-end; = 1.89 million miles or (75 times around the earth)

If one ton = 1 sq in

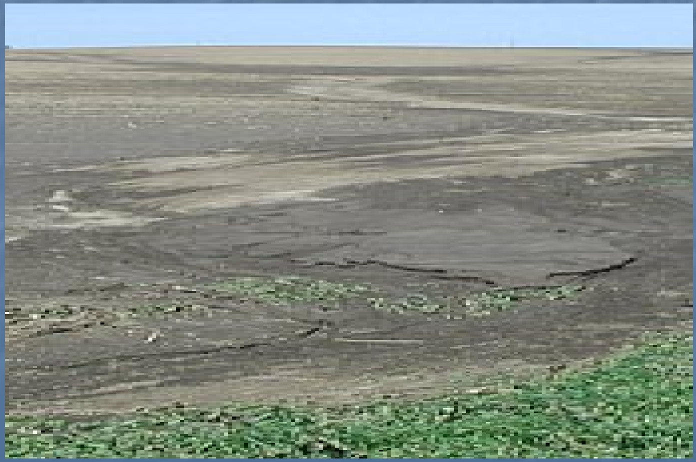
1 billion tons = 145 football fields

The REAP Team



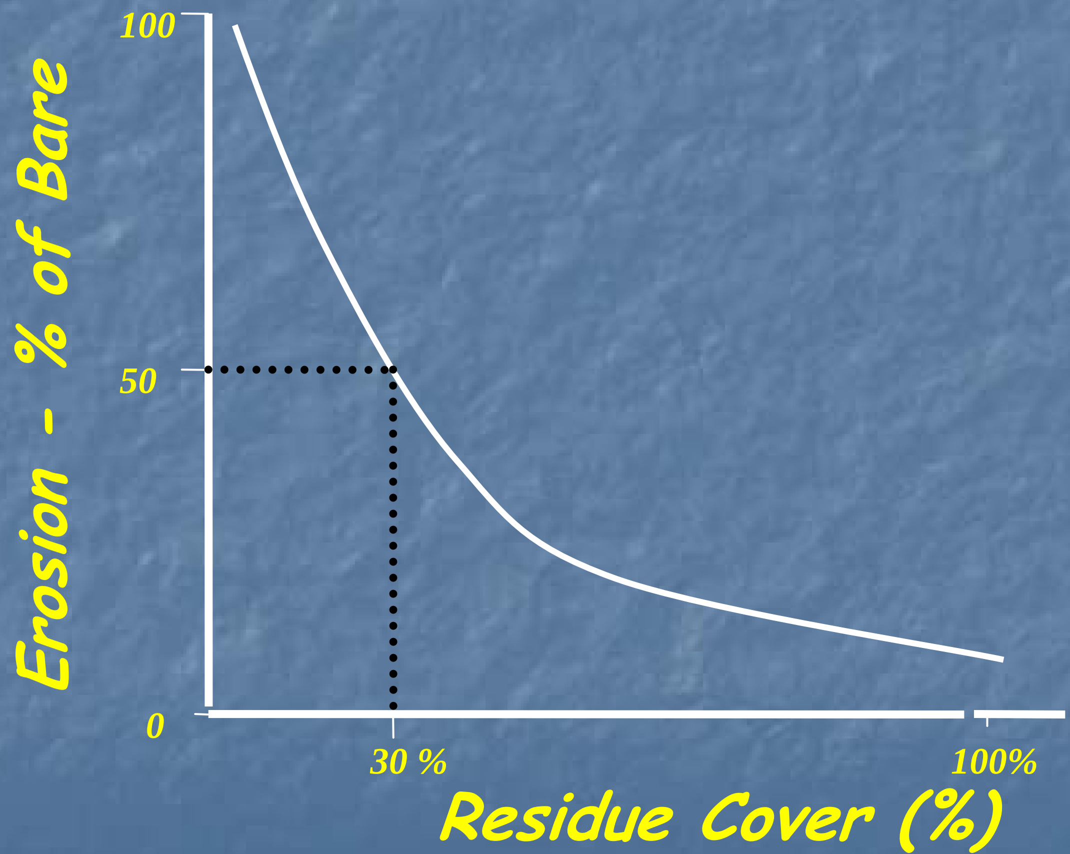
Crop Residues

- Are NOT TRASH
- They're critical for:
  - Water & wind erosion protection
  - Carbon sequestration
  - Nutrient cycling
  - Food for soil fauna
  - Improved physical properties



Crop Residues Reduce Erosion

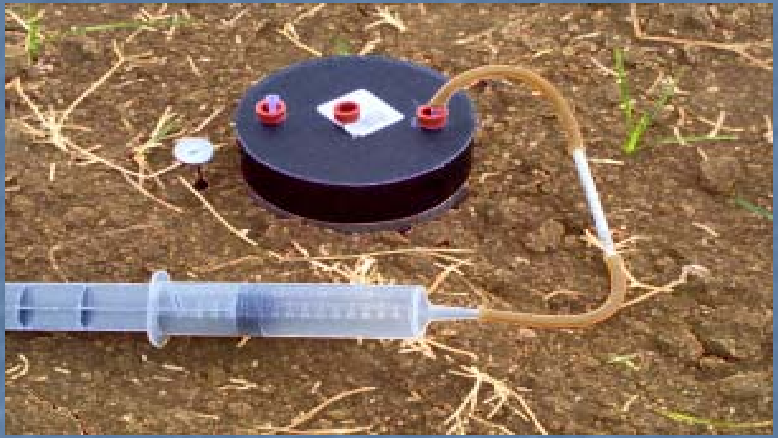
Effect of Residue on Soil Erosion



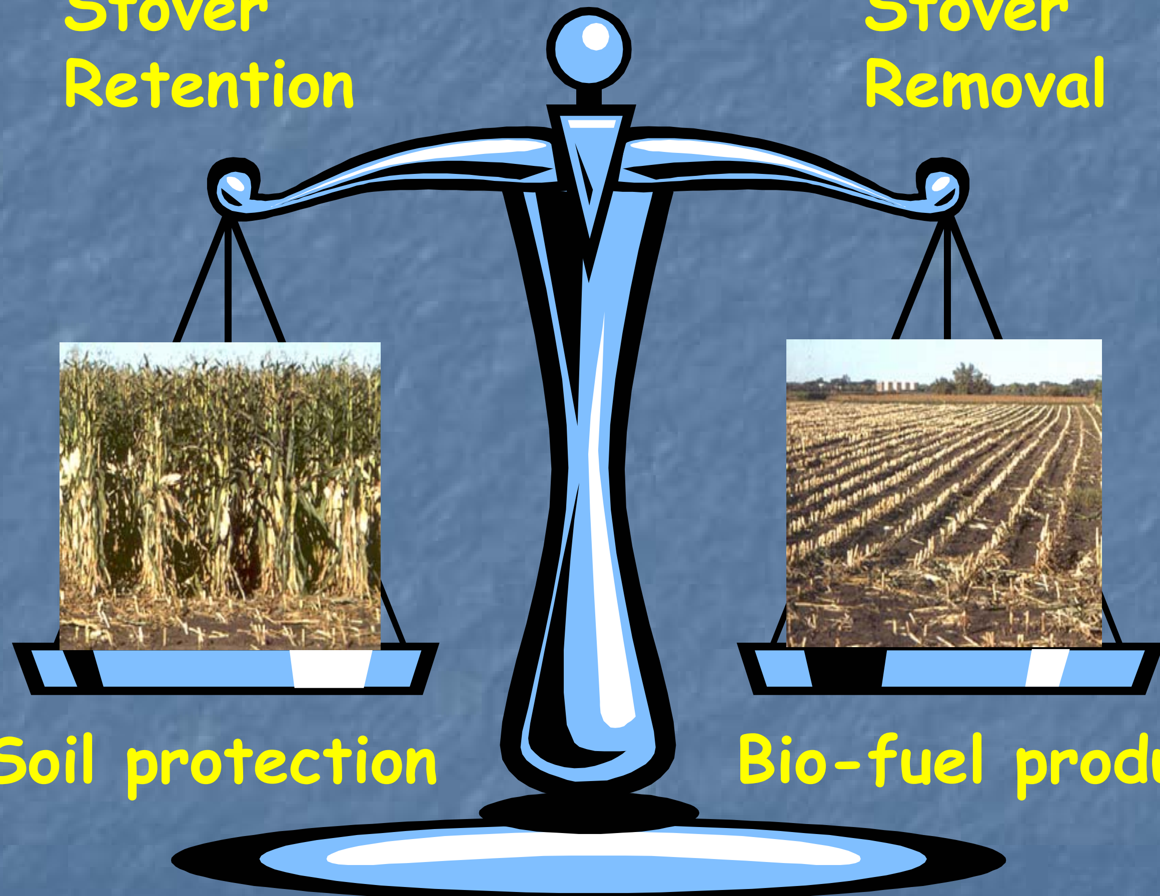
Laflen, J. M., and T. S. Colvin. Effect of crop residue on soil loss from continuous row cropping. Trans. Am. Soc. Agric. Eng. 24(3):605-609. 1981.

Soil C & Physical Properties

Crop Residue as a Food Source



Soil Conservation - Bioenergy Balance



A challenging balancing act!

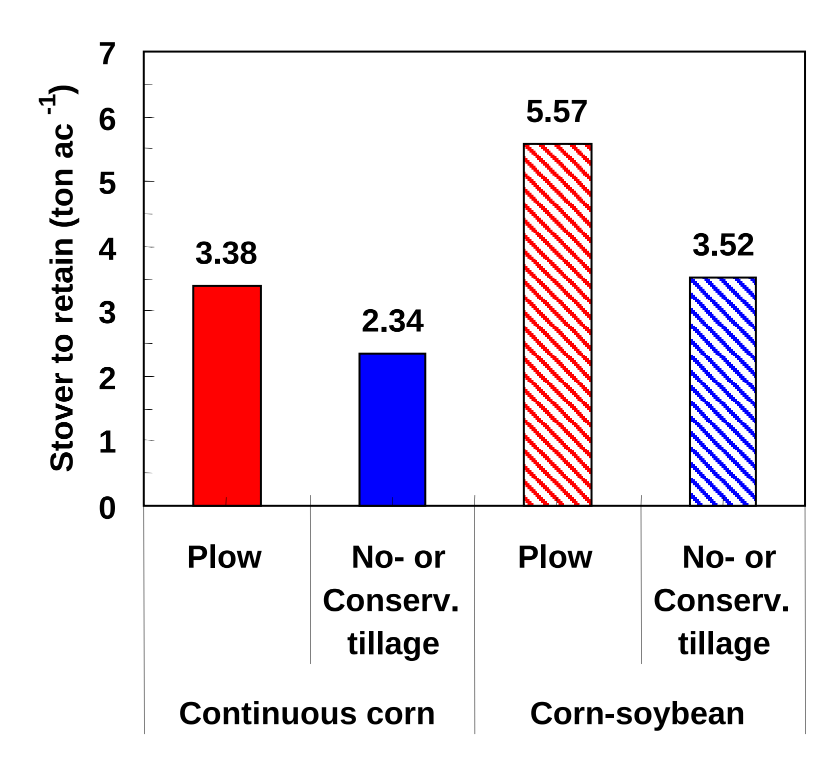
How Much Residue Do I Have?

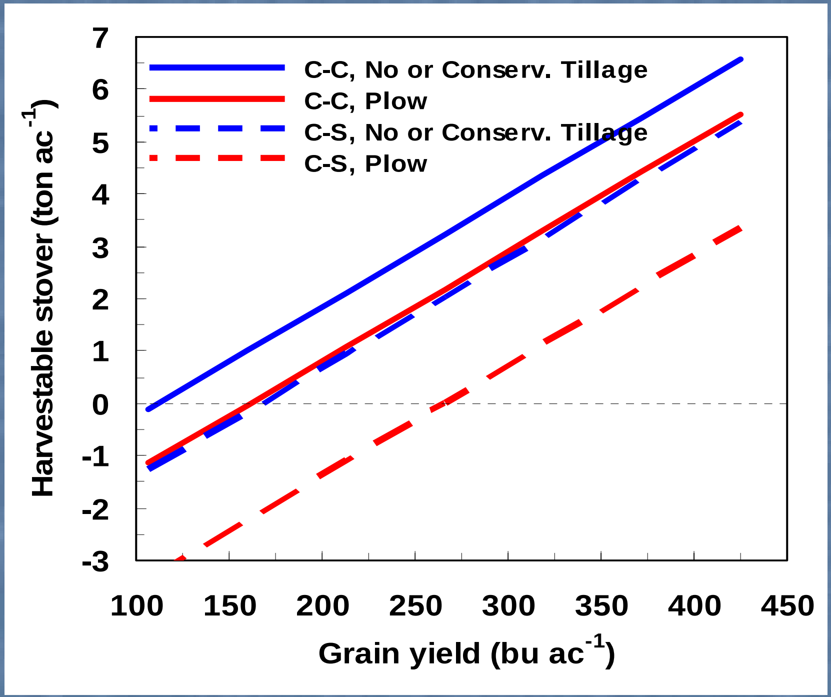
- Assumptions
  - Stalk density = 0.5 g cm^{-3}
  - Stalk cutting height = 20 cm (8 inches)
  - Stalk diameter = 2.5 cm (1 inch)
  - Plant population = 74 K ha^{-1} (30 K ac^{-1})

- Crop residue remaining in the field =
  - 3.6 Mg ha^{-1} (1.6 tons ac^{-1})

R. M. Cruse, personal communication

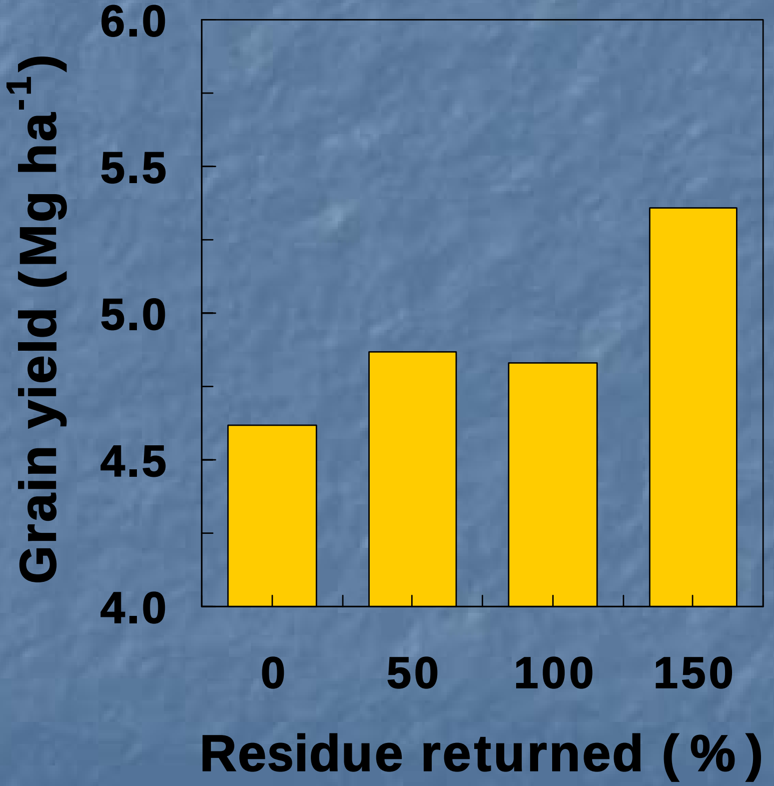
How Much Stover Do I Need?

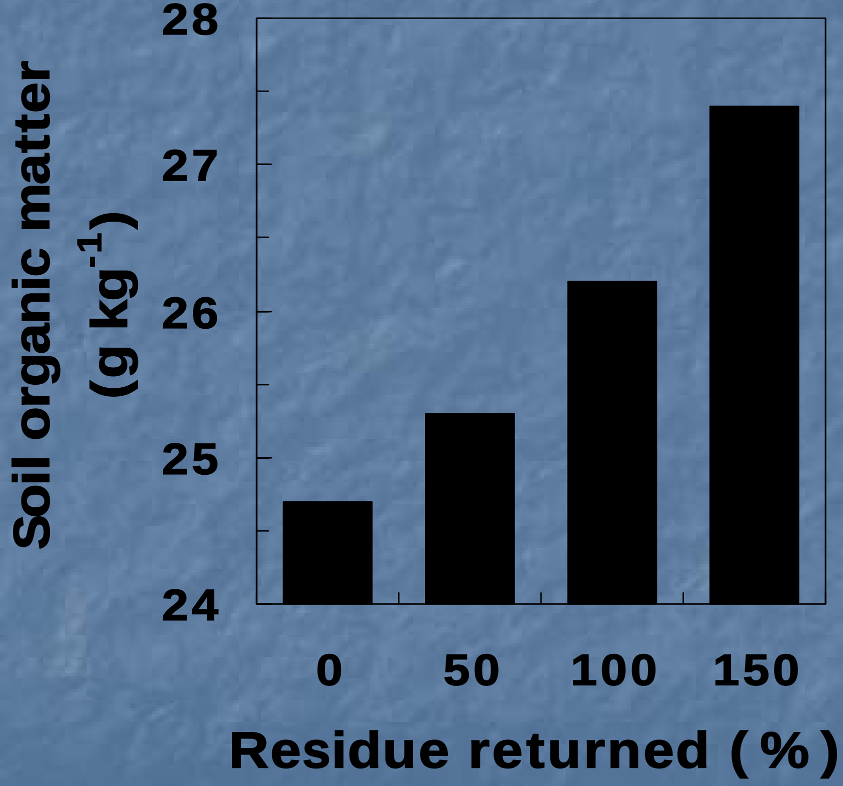




Johnson et al. 2006. Agron. J. 98:622-636.

What Effects Do Residues Have?





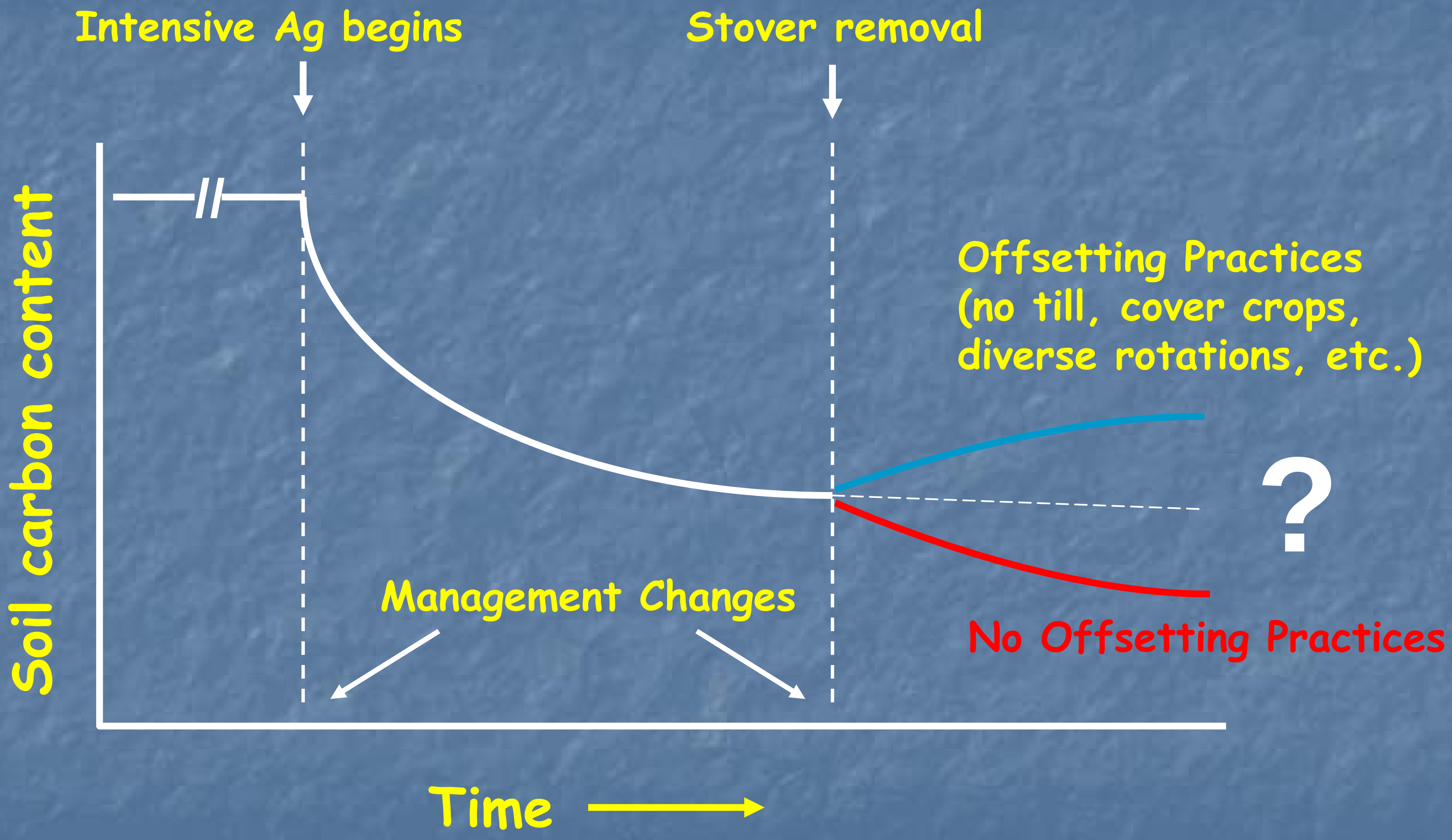
Adapted from Maskina et al., 1993. SSSAJ 57:1555-1560

Residual Crop Residue Effects

10-year Crop Residue Management History	Corn Yield 4-Years Later	
	$Mg\ ha^{-1}$	$bu\ ac^{-1}$
Crop residue removed	11.7	189
Crop residue retained	12.0	194
Double crop residues	13.0	210

Karlen et al., SSSAJ 61:4-10, 1997

Soil Carbon Response to Management



Initial Biomass Studies at Ames, IA

Participants and Questions

- Collaborative with Drs. S. Birrell (ISU) & C. Radtke, Idaho National Lab (DOE)
- Evaluating continuous corn & corn/soybean rotations
- Residue harvest scenarios
- Nutrient removal
- Feedstock quality
- Soil quality impact

Corn Grain & Stover Yields

Continuous Corn	2005 (DKC-52-45)		2006 (P35Y61)	
Stover Harvest Scenario	Grain	Stover	Grain	Stover
	---------- Mg ha^{-1} ----------			
Whole plant	10.12	4.70	9.67	6.32
Cob & top 50%	10.07	2.91	9.45	5.11
Bottom 50%	10.06	1.26	8.93	1.57
Grain only	10.10	----	8.81	----
LSD $_{(0.1)}$	NS	0.24	0.19	0.17

Corn Grain & Stover Yields

Rotated Corn	'05 Corn (Fontenell 5393)		'06 Soybean (Apache 626RR)	
Stover Harvest Scenario	Grain	Stover	Grain	Stover
	---------- Mg ha^{-1} ----------			
Whole plant	12.35	7.11	2.17	----
Cob & top 50%	12.01	4.58	2.78	----
Bottom 50%	13.85	1.80	2.75	----
Grain only	15.00	----	3.14	----
$LSD_{(0.1)}$	1.62	1.59	0.60	----

Soil Test Status – Fall 2005

Indicator	Units	Management Practice	
		Cont. Corn	Rotated Corn
Total organic C	g kg^{-1}	53.7	19.0
pH		7.72	6.68
Mehlich 3 Ext. P	µg g^{-1}	32 (opt)	22 (low)
Mehlich 3 Ext. K	µg g^{-1}	128 (low)	94 (low)

Macro-Nutrient Removal

Stover Harvest Scenario	Ranges for Three Hybrids		
	N	P	K
	---------- kg ha^{-1} ----------		
Whole plant	19 - 50	2 - 4	33 - 43
Cob & top 50%	14 – 31	2 – 4	26 - 32
Bottom 50%	4 - 13	0.5 - 0.7	6 – 13

Macro-Nutrient Replacement Cost

Stover Harvest Scenario	Average for Three Hybrids	
	$ ha^{-1}	$ Mg^{-1}
Whole plant	$ 56.07	$ 8.79
Cob & top 50%	$ 38.34	$ 8.90
Bottom 50%	$ 14.64	$ 8.98

Secondary & Micro-Nutrients

Stover Harvest Scenario	Average Removal for Three Hybrids					
	Ca	Mg	Cu	Fe	Mn	Zn
	kg ha^{-1}		------ g ha^{-1} ------			
Whole plant	29	21	11	504	151	92
Cob & top 50%	16	11	7	305	85	67
Bottom 50%	8	6	2	214	44	20

Secondary & Micro-Nutrients

Stover Harvest Scenario	Average Replacement Cost	
	$ ha^{-1}	$ Mg^{-1}
Whole plant	$ 12.37	$ 2.05
Cob & top 50%	$ 7.28	$ 1.73
Bottom 50%	$ 3.62	$ 2.34

Total Nutrient Replacement Cost

Stover Harvest Scenario	Average for Three Hybrids	
	\$ ha^{-1}	\$ Mg^{-1}
Whole plant	\$ 68.44	\$ 10.84
Cob & top 50%	\$ 45.62	\$ 10.63
Bottom 50%	\$ 18.26	\$ 11.32

Total Nutrient Replacement Cost

Stover Harvest Scenario	Average for Three Hybrids			
	$ $ ha^{-1}$	$ $ Mg^{-1}$	$ $ ton^{-1}$	$ gal $EtOH^{-1}$
Whole plant	**$ 68.44**	**$ 10.84**	$ 9.67	$0.121†
Cob & top 50%	**$ 45.62**	**$ 10.63**	$9.48	$0.118
Bottom 50%	**$ 18.26**	**$ 11.32**	$10.10	$ 0.126

† Assumes 80 gal EtOH ton^{-1} biomass

Erosion Cost For Grain Bioenergy

- IA NRI shows a soil loss of 4.9 tons ac^{-1} yr^{-1}
- The 2005 & 2006 average corn yield of 170 bu ac^{-1}
- Assume 2.7 gal EtOH bu^{-1}
- Soil loss = 21 lbs gal^{-1}
- Walmart™ topsoil = $0.028 lb^{-1}

Estimate developed by Duane Sand and published by the Iowa Natural Heritage Foundation, 2006

Unanswered Questions

Effects of Climate Change

- As the amount & intensity of precipitation increases, soil erosion increases

Land Tenure Questions

- Short-term focus
  - Increases monoculture and N fertilizer rates
  - Increased N losses and decreased soil C
  - Decreased surface residues – higher erosion

Summary

- Crop residue is **NOT** Trash!!
  - It is an extremely valuable resource

- All bioenergy strategies must be examined for their sustainability

- "Economic growth that destroys ecological support systems is neither sustainable nor truly progress"
  - (Postel & Richter, 2003)

Diversity Can Make Us All Winners

- Ligno-cellulosic technologies can provide viable markets for a wide variety of crops
- Landscape diversity can help solve bioenergy, air quality, water quality, global warming (through C sequestration) & rural economic problems – IF implemented as an entire agricultural system.

Conclusions

By using a systems approach, emphasizing spatial and temporal diversity, American agriculture can provide:

A win for bioenergy

A win for our soil resources

A win for our water resources

A win for producers

A win for consumers & communities