Biomass Colloquies
Outlook for Commercialization

BioEnergy Conference

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OVERVIEW

- Colloquies
- Purpose—Look out 2 to 5 years
  - Issues
  - Increase Awareness
  - Set Priorities
  - Accelerate Commercialization
- Conclusions

Participants

Suppliers

- Seeds
- Growers
- Ag Machinery
- Enzymes
- Process Engineering

Processors

- Ethanol
- Food/Chemicals
- Plastics
- Agri-Pulp

DOE, ORNL, NREL, USDA ARS & NRC, State and National Grower Organizations, Investors

ISSUES

- Sustainable Collection
- Producer Benefits
- Harvest & Storage
- Economic Process
- Process Validation
- Will Market Be There

CORN STOVER
Largest Biomass Feedstock

Corn Stover, dry tons

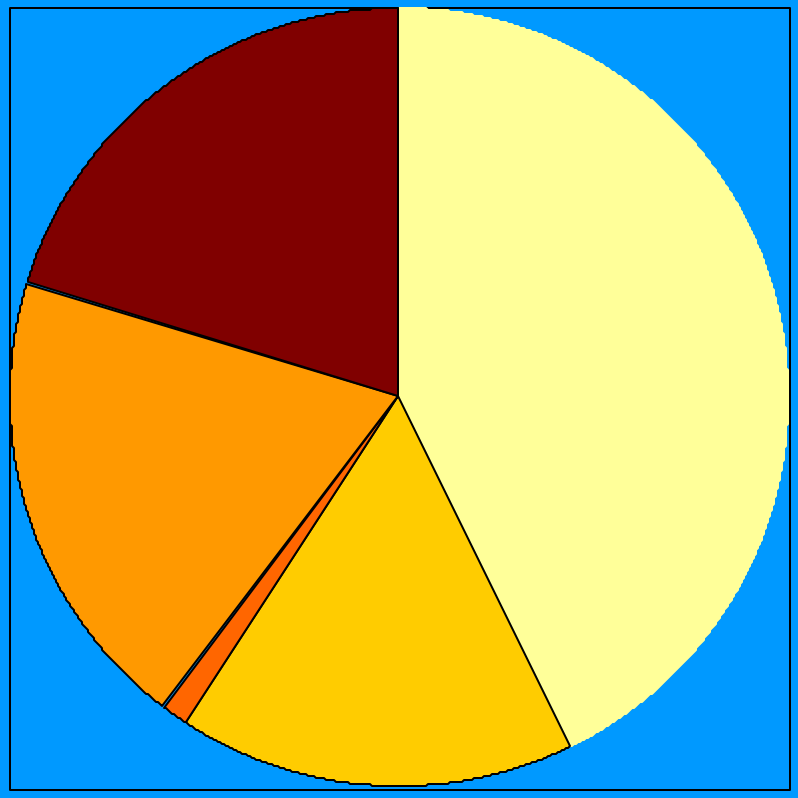
- **255 M tons produced**
- **153 M tons available, 60%**

or 43% of Total Biomass

All less than $50/ton

- **Corn Stover . . . . . 153 M dry tons**
- **Other Ag Stover . . 58**
- **Corn Fiber 4**
- **Energy Crops 70**
- **Wood Co-Products. 72**

TOTAL dry tons . . 357M



SUSTAINABLE COLLECTION
Corn Stover Surface Effect

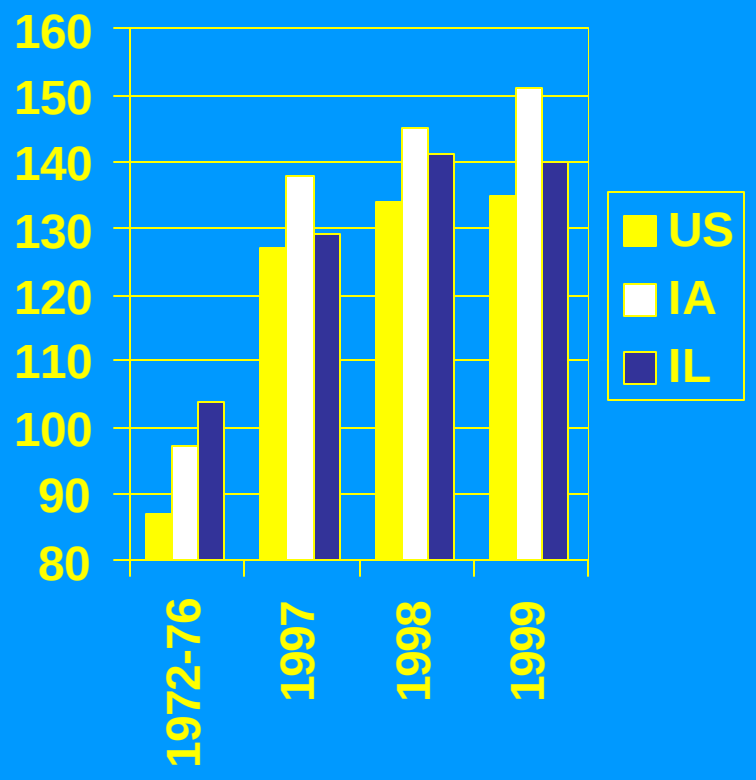
- **PRO**
  - Erosion Protection
  - Nutrients Recycled
  - Retains Soil Moisture
  - Some SOM Added If No-till
  - Diurnal Temperature Cycle Reduced
- **CON**
  - Harbors Weed Seeds and Disease
  - More Pesticide and Herbicide Needed
  - Can Require More N Fertilizer
  - Retains Soil Moisture
  - Low Spring Soil Temperatures

Corn Stover Sustainable Collection

- **Soil cover is important to prevent wind and water erosion**
- **Erosion control depends on soil, crop rotation, tillage practice, slope and other factors**
  - **Extensive USDA study in 1978-1980:**
    - **1972 -1976 yields, ~90 Bushels/acre**
    - **MLRA, USLE, WEE**
  - **Results: 47-- 52 Million tons available**

Major Differences Today
More Stover ! !

- YIELDS INCREASING
- 200 BU/AC COMMON
- MORE TO COME
  - PRECISION FARMING
  - BIOTECHNOLOGY
  - GENETIC POTENTIAL IS 400 TO 600 BU/AC
- WHAT TO DO WITH IT?



Major Differences Today
Where The Stover Goes Now

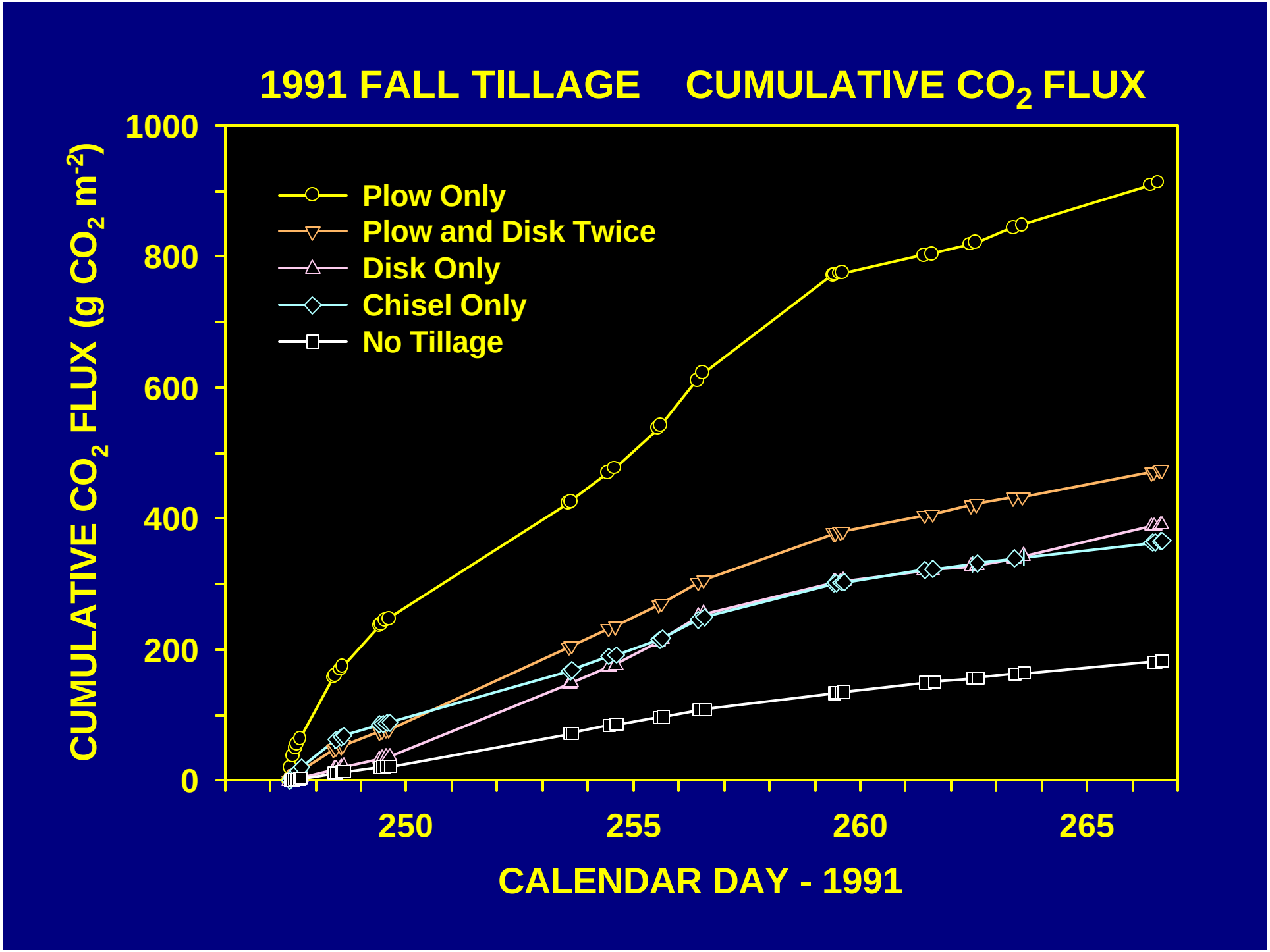
Most surface residue lost as CO_2

- **The USDA National Soil Tilth Lab report:**

  Just *11 to 19%* **of carbon in the surface stover contributes to formation of Soil Organic Material**

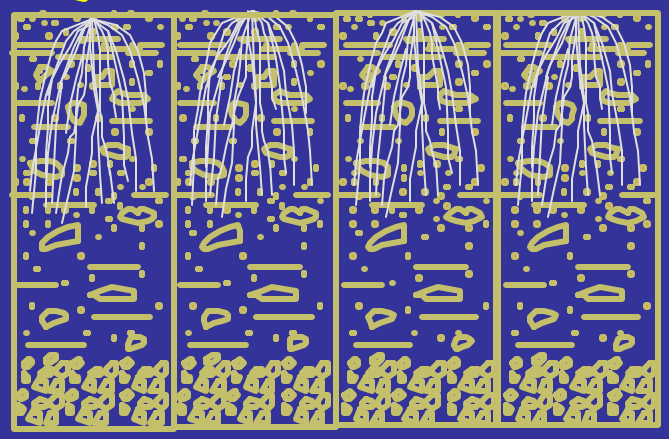
  Roots contribute *44 %* **of their carbon**

- **If plowed below surface, a carbon deficit can occur in the soil**

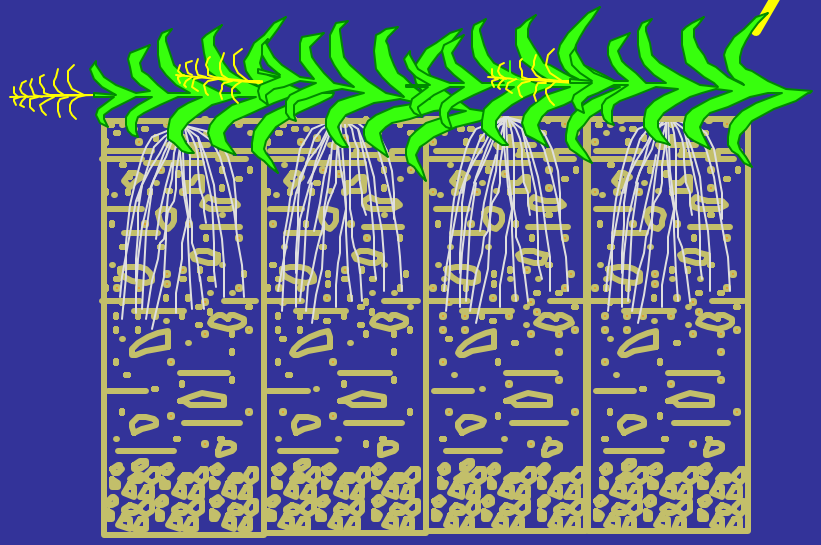

1991 FALL TILLAGE CUMULATIVE CO_2 FLUX
CUMULATIVE CO_2 FLUX (g CO_2 m^{-2})
1000
800
600
400
200
0
Plow Only
Plow and Disk Twice
Disk Only
Chisel Only
No Tillage
250
255
260
265
CALENDAR DAY - 1991

30 Years Continuous Corn + Plow

Silage removed (grain and stover removed)



Grain removed (stover returned)



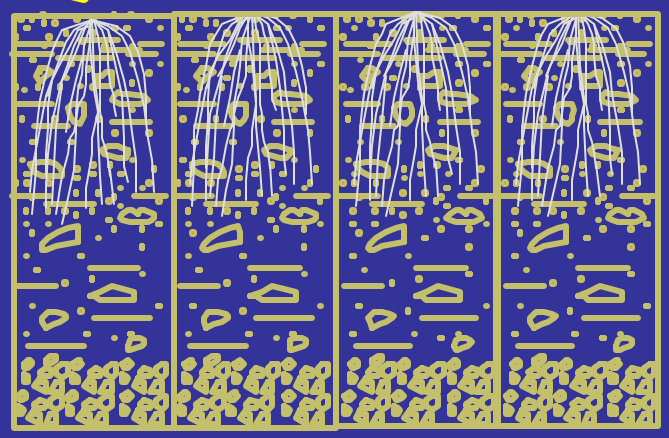
Fertility	low	high	low	high
N	74	148	74	148
P_2O_5	48	96	48	96
K_2O	48	96	48	96
(lb/ac/yr)				

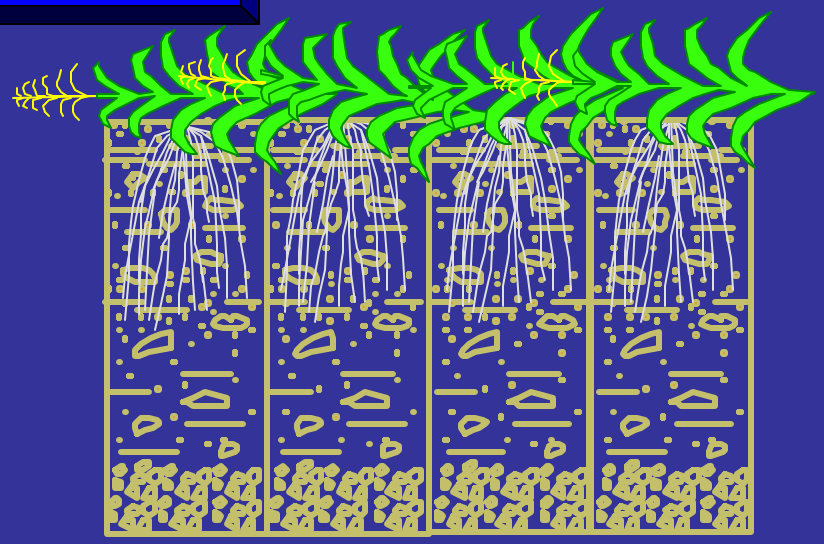
30 Years Continuous Corn + Plow

Total Biomass (ton/ac)

- 163 - 177

+ 90 + 97





Fertility low high

low high

Silage removed (grain and stover removed)

Grain removed (stover returned)

30 Years Continuous Corn + Plow

	Silage removed (grain and stover removed)			Grain removed (stover returned)	
Total Carbon (ton/ac)	- 67	- 72		+ 37	+ 40
Fertility	low	high		low	high
(0-6 in) Soil Carbon (%)	2.13	2.14		2.13	2.17

Results suggest intensive tillage(moldboard plow) common to all treatments overshadowed stover carbon removal or addition.

Producer Benefit with Custom Operator

Basis: 1 ton left per ac, Bu/acre	130	170	200
1:1 ratio, 16% moisture, sell . . .	2 t/ac	3 t	3.8 t
P & K Nutrients ($3.20/dry ton). . .	$(6.40)	(9.60)	(12.16)
Tillage, Cultivating	10.00	10.00	10.00
Stover Sale ($35/ dry ton).	70.00	105.00	133.00
Carbon Credit* ($10/ton carbon)	*18.00*	*24.00*	*31.00*
Total revenue increase/acre . . .	$74	$105	$130
Less custom Baler	(30)	(44)	(57)
Net w/custom Baling	$44	$62	$73

Transport cost from field is additional

*Not Included

Harvest & Storage

- Bio Mass Suppliers
  - Biomass Agri-Products LLC, Harlan, IA
  - Geneva Enterprises, Mendota, IL
  - Kearney Area Ag Producers Assn, NE
  - Century 21 Alliance, KS
- "One Million Tons in 50 Mile Radius Now"
  - Round vs Square vs Stover Silage
  - $25 to $50 per dry ton delivered

BALE STORAGE
60,000+ Bales in Jan '97

Economic Process

Process Validation

- Scale Up Problem
- Green Field—1,000 ton per day
- Add-on, 40 ton per day
  - Iogen—Straw, Switchgrass, Stover
  - Wet Mill—Corn Fiber, *Stover*
  - Dry Mill—DDG, *Stover*
- "Pay as you go"

Dry Mill Co-Production of c5 EtOH from Corn Stover

Process: Remove Germ--Pretreat DDG

- **Add Corn Stover to maintain 26% protein**
- **Demo Supply (40 tons per day) and Process — Pretreatment, rFermentation, Enzymes**

Pretreatment Results, Base Case			
	Lb In	Lb to EtOH	Sugar Yield
DDG	17.3	1.3	25%
Stover	1.6	0.3	29%
Total		1.6	
EtOH Gal		0.16	

MARKETS
Will they be there?

- **Fuel Ethanol**
  - RFG, Displace MTBE . . . . . 2 Billion gal
  - Octane Enhancers . . . 1.5 to 4 Billion gal

    20 to 50 M tons of stover potential
- **3¢ to 4¢ Sugars for Chemicals & Plastics**

    100 M tons of stover
- **Fiber**
  - 30 M tons Hardwood in North America
  - More Limited Particleboard

    60 M tons of stover potential

Agri-Pulp Benefits
Corn Stover Potential

Pulp Prices, $200 to $800/ton

- Market Need
- Economic Driver
- Environmental Driver

Pro Forma Revenue, $M, 1000 DT/day, 350 days/yr			
Component	EtOH $1/Gal	Mech Pulp $200/ton	90 Bright $800/ton
Cellulose	$18	mix	$70
Other Sugars	$12	mix	$18
Total Revenue	$30	$66	$88

Colloquy Conclusions

- Reliable Supply of Feedstock
- Business Model -- Grower & Biomass Supplier Link w/Processor
- Feedstock Price Will Decline
- Process Technology Validation
- Agri-Pulp Emerging – Co-location Likely