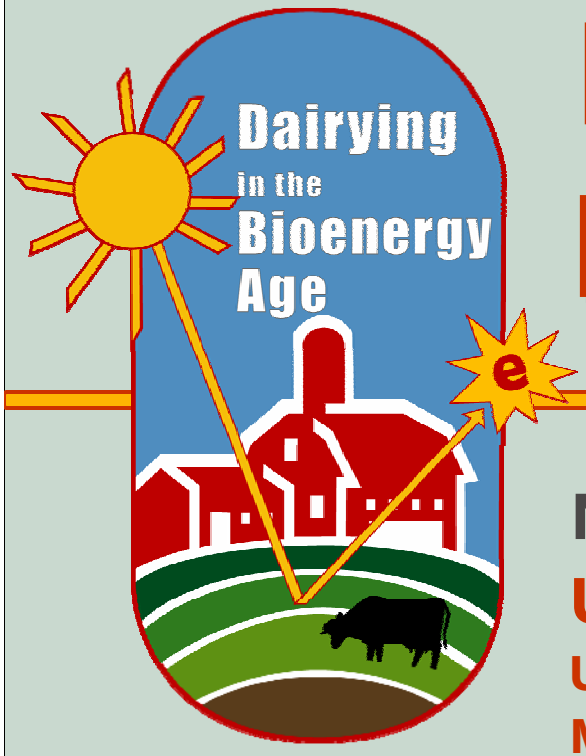


Dairying in the Bioenergy Age

Neal Martin, Director

U.S. Dairy Forage Research Center

USDA-Agricultural Research Service

Madison, WI

at the

World's Forage Analysis Superbowl

World Dairy Expo

Oct. 4, 2007

Dairying in the Bioenergy Age

1. Corn ethanol dominates today.
   - How it impacts dairy
2. Cellulosic ethanol will emerge in the future.
   - Finding and creating opportunities for dairy farms
3. Turning manure into energy.

   (Not covered in this talk)
4. Addressing environmental impact.

Corn Ethanol: Trends

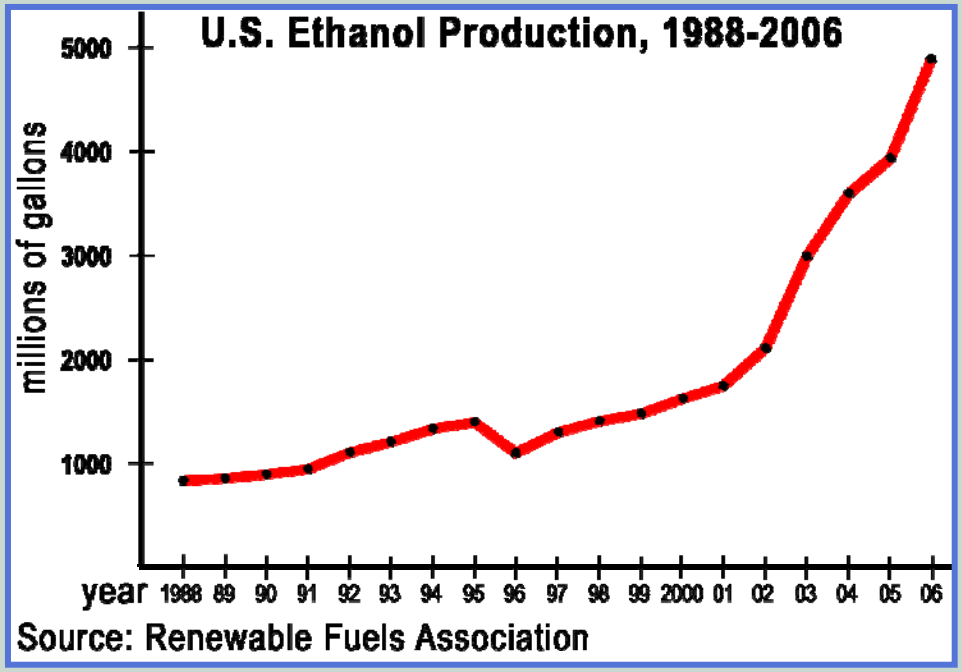
- Need for renewable energy has become national priority, brought on by high fuel prices, environmental concerns and goals of reducing our dependence on foreign oil
- In U. S., ethanol is primary renewable fuel used in gasoline blends. Most ethanol produced from corn.

USDA-ERS. May 2007 – Westcott, Paul

Corn Ethanol: Trends

- **Current expansion in use of corn is unprecedented in speed & magnitude as well as impacts on feed grain market**
- **Ethanol production totaled 5 billion gallons in 2006, up 1 billion from 2005**

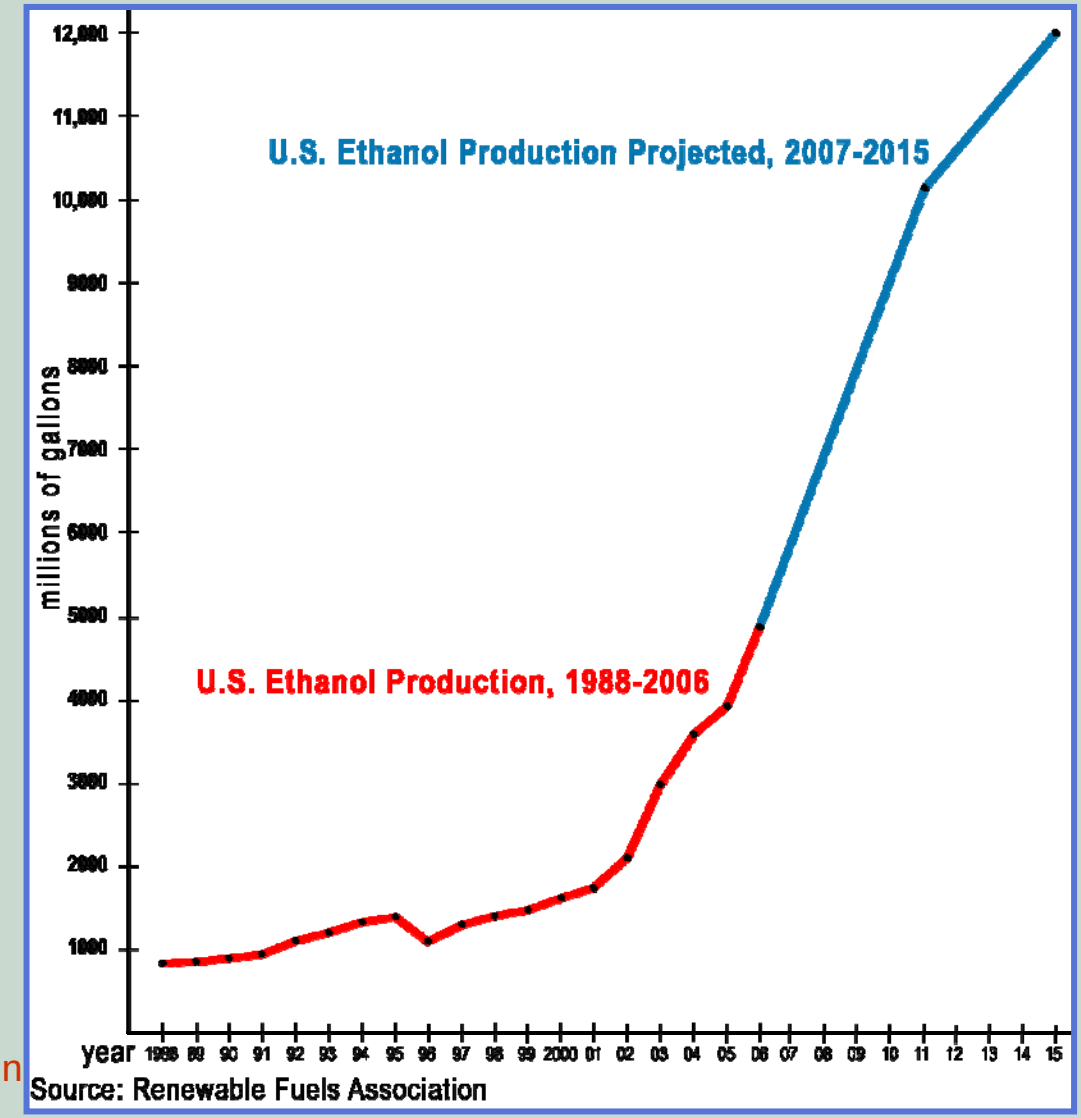
USDA-ERS. May 2007 – Paul Westcott



Corn Ethanol: Trends

- **Ethanol production is expected to exceed 10 billions gallons by 2009 – topping 12 billion gallons by middle of next decade.**

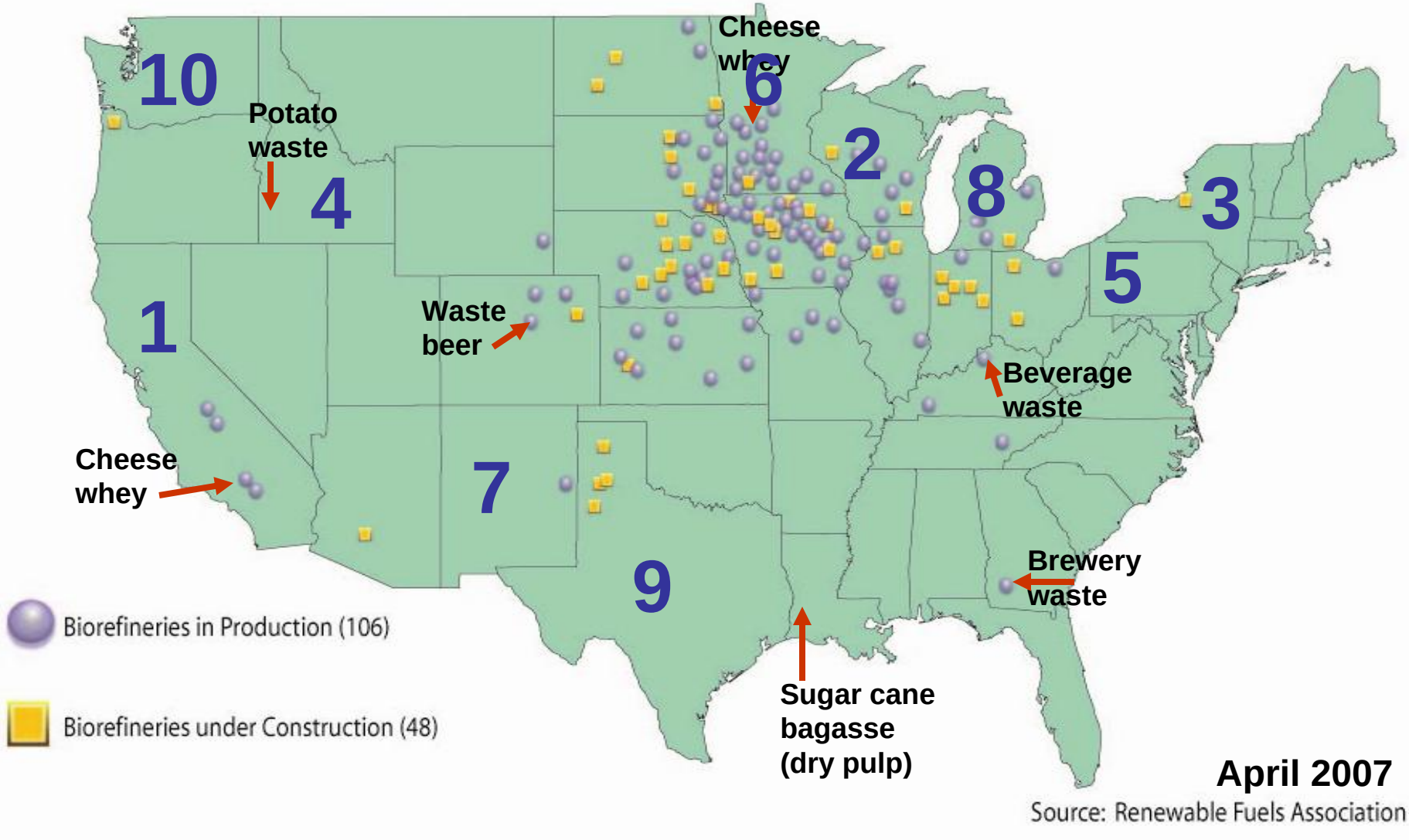
USDA-ERS. May 2007 – Paul Westcott



U.S. Ethanol Biorefinery Locations

All sites use CORN as the major feedstock

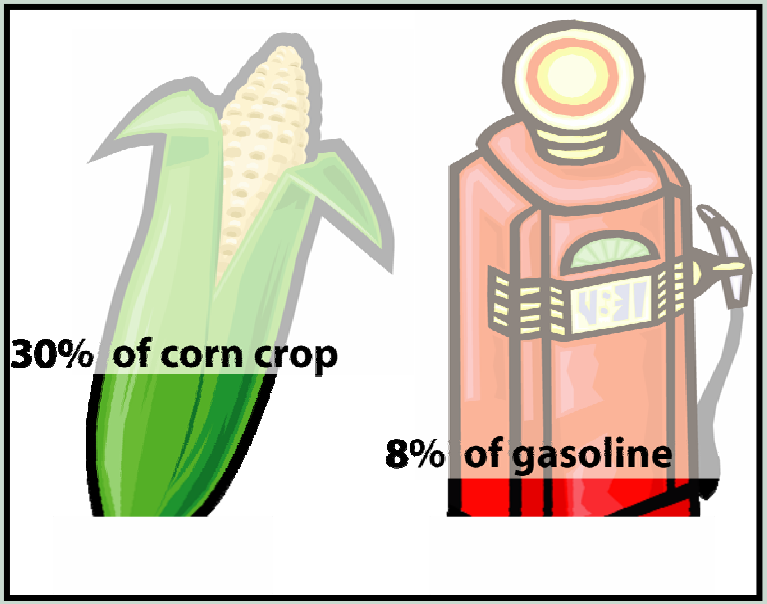
EXCEPT:



Corn Ethanol: Trends

- Ethanol's importance in overall gasoline market still is small, but in corn sector it's big news.
- Within a few years, greater than 30 % of corn crop used for fuel (8 % of gasoline market).

USDA-ERS. May 2007 – Westcott, Paul



Corn Ethanol: Market Adjustments

How does Agricultural Sector Adjust?

- **Higher corn prices leading to incentive to plant more corn**
- **Higher prices lead to a reduction in corn used for livestock feed over next few years and less corn exported**
- **Net effect is lower carryover stocks of corn – market more sensitive to production shortfalls**

USDA-ERS. May 2007 – Westcott, Paul

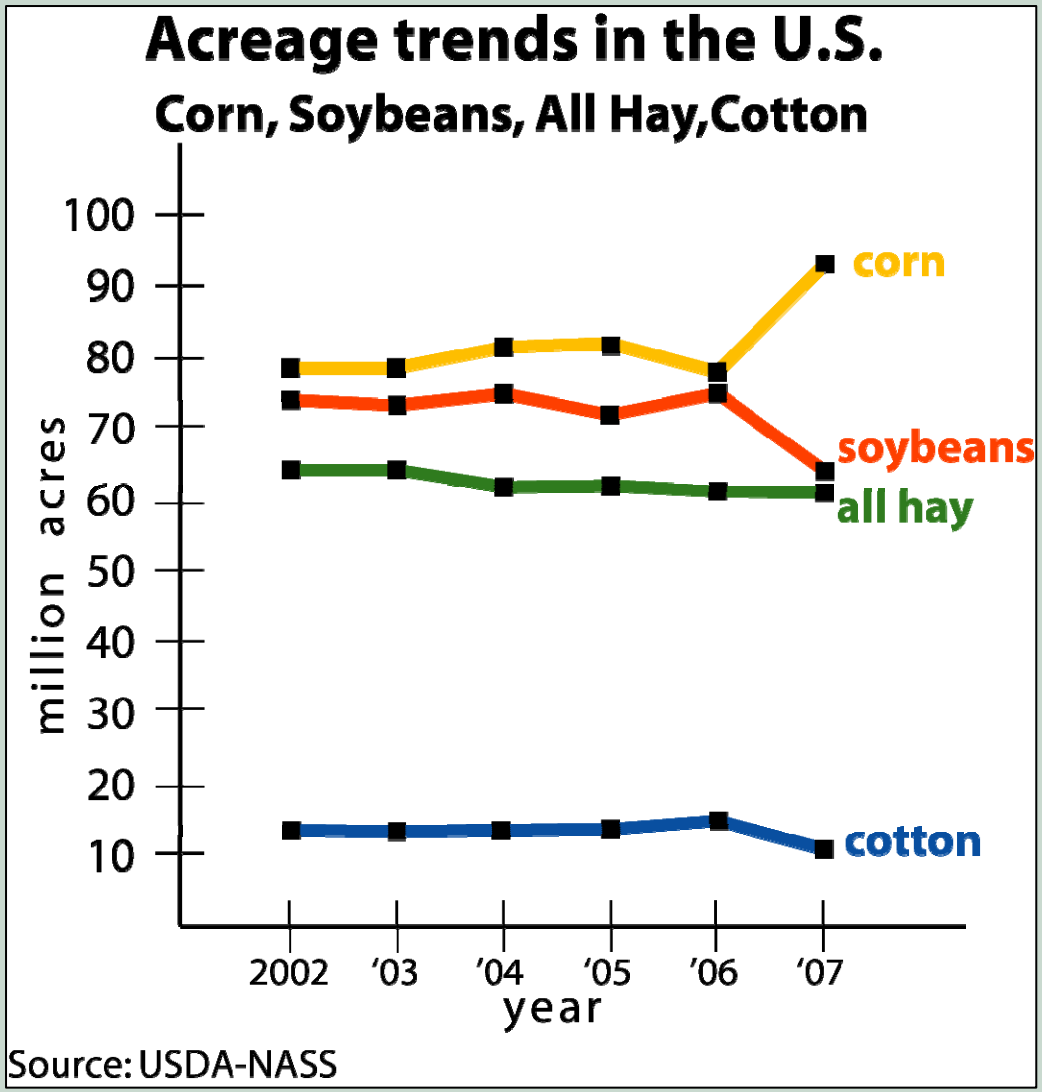
Corn Ethanol: Market Adjustments

How does Agricultural Sector Adjust?

- **Soybeans compete directly with corn for acreage**
- **More corn acreage reduces soybean acreage**
- **Lower soybean production triggers higher prices & exports decline**
- **Planting of other crops compete with corn – cotton declines**

USDA-ERS. May 2007 – Westcott, Paul

Corn Ethanol: Market Adjustments



Corn Ethanol: Market Adjustments

Feedstuffs
THE WEEKLY NEWSPAPER FOR AGRIBUSINESS
July 9, 2007 VOL 79 - NO 28 $4.00 www.Feedstuffs.com

For Feedstuffs FoodLink, See page 9

Study says biofuels to keep ag prices high for next decade

By **IAN ELLIOTT**

THE world's push into biofuels is likely to keep agricultural prices high for the next decade, ensuring that the "food versus fuel" debate continues, according to a new study.

The outlook for agriculture over the next decade, published by the Organization for Economic Cooperation & Development (OECD) and the U.N.'s Food & Agriculture Organization (FAO), however, does not blame the recent

Key Points

- Lower crop surpluses, fewer export subsidies also to blame.
- Corn going into U.S. ethanol production to double by 2016.

the longer term, structural changes are underway that could well maintain relatively high nominal prices for many agricultural products over the coming decade," the OECD-FAO "Agricultural Outlook

to these long-term ch
markets, but more in
is the growing use of
sugar, oilseeds and v
oils to produce fossil
stitutes, ethanol and
sel. This is underpinn
prices and, indirectly
higher animal feed co
the prices for livesto
ucts," the authors ad

The annual study w
public July 4 in Paris.
It is based on econon
els used by both organ
and assumes continu
nomic conditions and

Dairy Profit Weekly
a DairyBusiness Communications Publication www.dairyprofit.com

An **Iowa State Center for Agriculture and Rural Development** study shows the United States may eventually use **75% of its corn production to make ethanol.** If that comes true, the United States will have to import corn to accommodate demand, warned Phil Abbott, Purdue ag economist who specializes in international trade and ag development. With higher corn prices, the U.S. livestock industry will cut production, driving up consumer prices and reducing meat consumption.

Dairying in the Bioenergy Age

Corn Ethanol: Market Adjustments

How does Agricultural Sector Adjust?

- **Higher corn prices affect livestock sector because corn important feed**
- **Partial offset to higher feed costs for livestock producers – distillers grains, co-product of dry mill ethanol production, can replace some corn grain & soybean meal in animal rations**
- **Feed costs rise, red meat production declines and poultry production slows over next several years**

USDA-ERS. May 2007 – Westcott, Paul

Corn Ethanol: Feeding By-Products

High-Fiber

- Beet Pulp
- Brewers Dried grains
- Brewers Wet grains
- Corn gluten feed
- Cottonseeds
- Distillers dried grain
- Distillers dried grain w/ solubles
- Distillers solubles
- Distillers wet grain
- Hominy
- Malt sprouts
- Soy hulls
- Wheat By-products

High-Protein

- Canola Meal
- Corn Gluten Meal
- Cottonseed Meal
- Linseed Meal
- Soybean Meal
- Soybeans (raw, roasted or extrusion)
- Sunflower meal

Animal-Marine

- Blood meal
- Hydrolyzed feather meal
- Fish meal
- Meat and Bone meal
- Poultry by-product meal

SOURCE: By-Product Feedstuffs… Shaver, Randy, UW-Madison

Corn Ethanol: Feeding By-Products

Limitations of feeding distillers grains to dairy cattle

- Low lysine of undegradable protein
- Relatively rich content of free, largely unsaturated oil
- Phosphorus content

New milling processes in ethanol represent new opportunities for feeding distillers grains

- Low fat
- Low protein and low P of corn bran fractions
- Proteins from endosperm residue and germ meal could be blended to better match ruminal degradable protein and lysine
- Corn oil can be priced independently

SOURCE: Corn ethanol byproducts- present and future. Four-State Nutrition Conf. June 2007. Armentano, Lou

Corn Ethanol: Feeding By-Products

Feed Composition

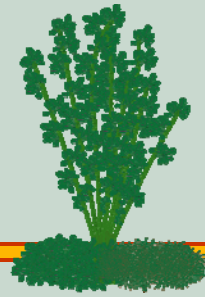
Feed	CP	NDF	Fat	Ca	Phos
	---------- % DM ----------				
ALM*	28	34	2.8	2.47	0.34
DDGS**	30	39	10.0	0.22	0.83
SBM**	50	15	1.6	0.40	0.71
Corn**	9	10	4.2	0.04	0.30

** Dicostanzo et al. 1999. Proc. MN Nutr. Conf.*
*** NRC. 2001.*
SOURCE: August 2007. Jung, Hans-Joachim

Corn Is Ethanol's Present

Cellulose Is Ethanol's Future

Cellulosic Ethanol



- Cellulose is the main component of plant cell walls and is the most common organic compound on earth.
- It is more difficult to break down cellulose to convert it into usable sugars for ethanol production. Yet, making ethanol from cellulose dramatically expands the types and amount of available material for ethanol production.
- This includes many materials now regarded as wastes requiring disposal.

Cellulose: Ethanol's Future

- Producing ethanol from cellulose promises to greatly increase the volume of fuel ethanol that can be produced in the U.S. and abroad.
- Importantly, it offers tremendous opportunities for new jobs and economic growth outside the traditional "grain belt," with production across the country from locally available resources.
- Cellulose ethanol production will also provide additional greenhouse gas emissions reductions.

Cellulose: Ethanol's Future

U.S. DEPARTMENT OF ENERGY

Advanced Energy Initiative

- **Make cellulosic ethanol cost competitive by 2012**

Dairying in the Bioenergy Age

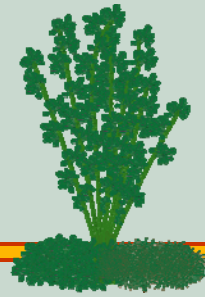
SOURCE: August 2007. Ferrell, John

DOE: Science Bioenergy Centers

- **The DOE BioEnergy Science Center led by the DOE's Oak Ridge National Laboratory in Oak Ridge, Tennessee.**
- **The DOE Great Lakes Bioenergy Research Center will be led by the University of Wisconsin in Madison, Wisconsin, in close collaboration with Michigan State University in East Lansing, Michigan.**
- **The DOE Joint BioEnergy Institute will be led by DOE's Lawrence Berkeley National Laboratory.**

SOURCE: August 2007. Ferrell, John

Cellulosic Ethanol



- Future impact of cellulosic ethanol production on the dairy industry depends on:
  - Where the plants will be located.
  - What feedstocks will be used.
  - What systems opportunities could include dairies.

Cellulosic Ethanol: Location

Major DOE Biofuels Efforts

- **Abengoa Bioenergy Biomass of Kansas, LLC; in Kansas; up to $76 million**
- **ALICO, Inc. in LaBelle, Florida; up to $33 million**
- **BlueFire Ethanol, Inc. in southern California; up to $40 million**

SOURCE: August 2007. Ferrell, John

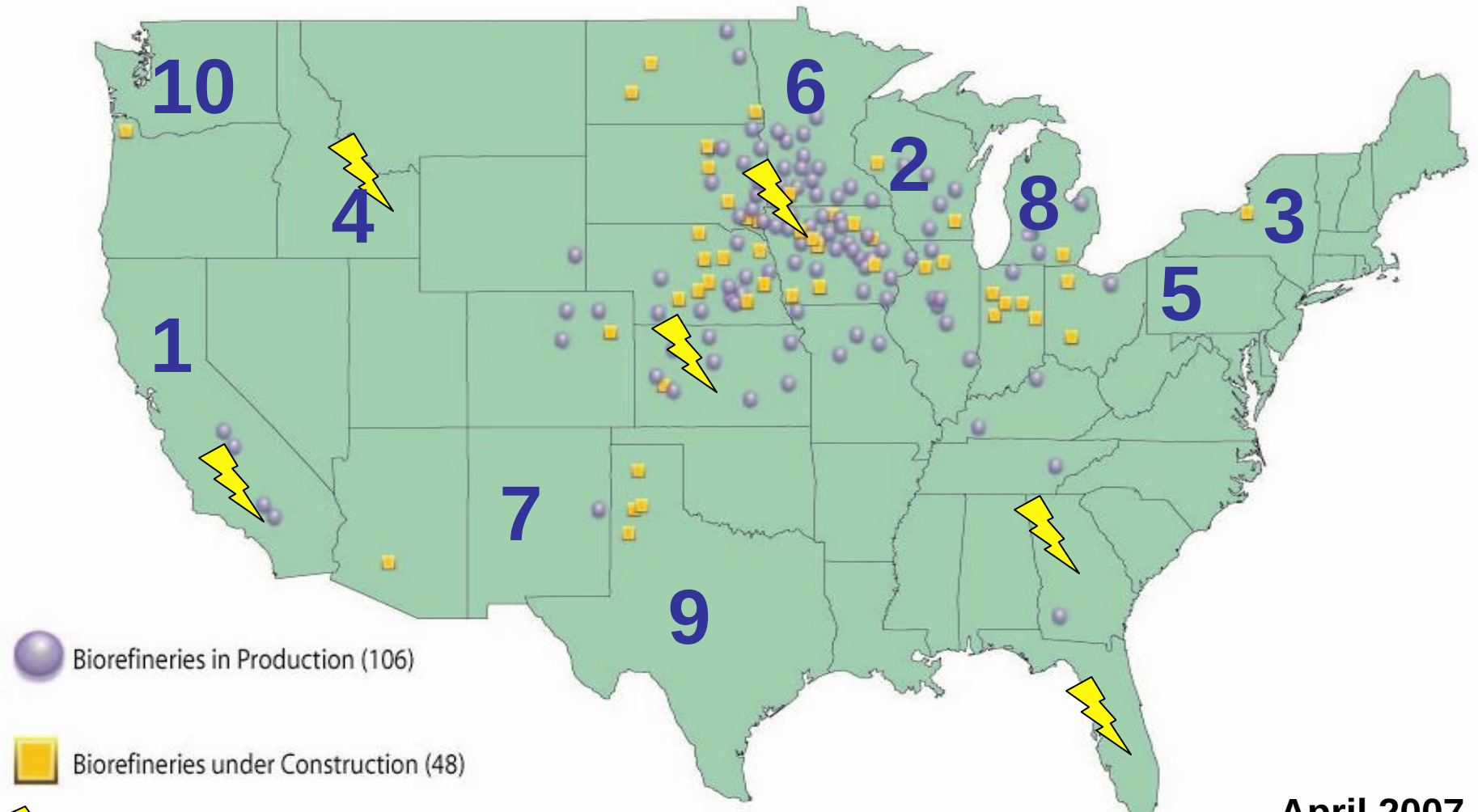
Cellulosic Ethanol: Location

Major DOE Biofuels Efforts

- **Broin Companies in Iowa; up to $80 million**
- **Iogen Biorefinery Partners, LLC, in Idaho; up to $80 million**
- **Range Fuels (formerly Kergy Inc.) in Georgia; up to $76 million**

SOURCE: August 2007. Ferrell, John

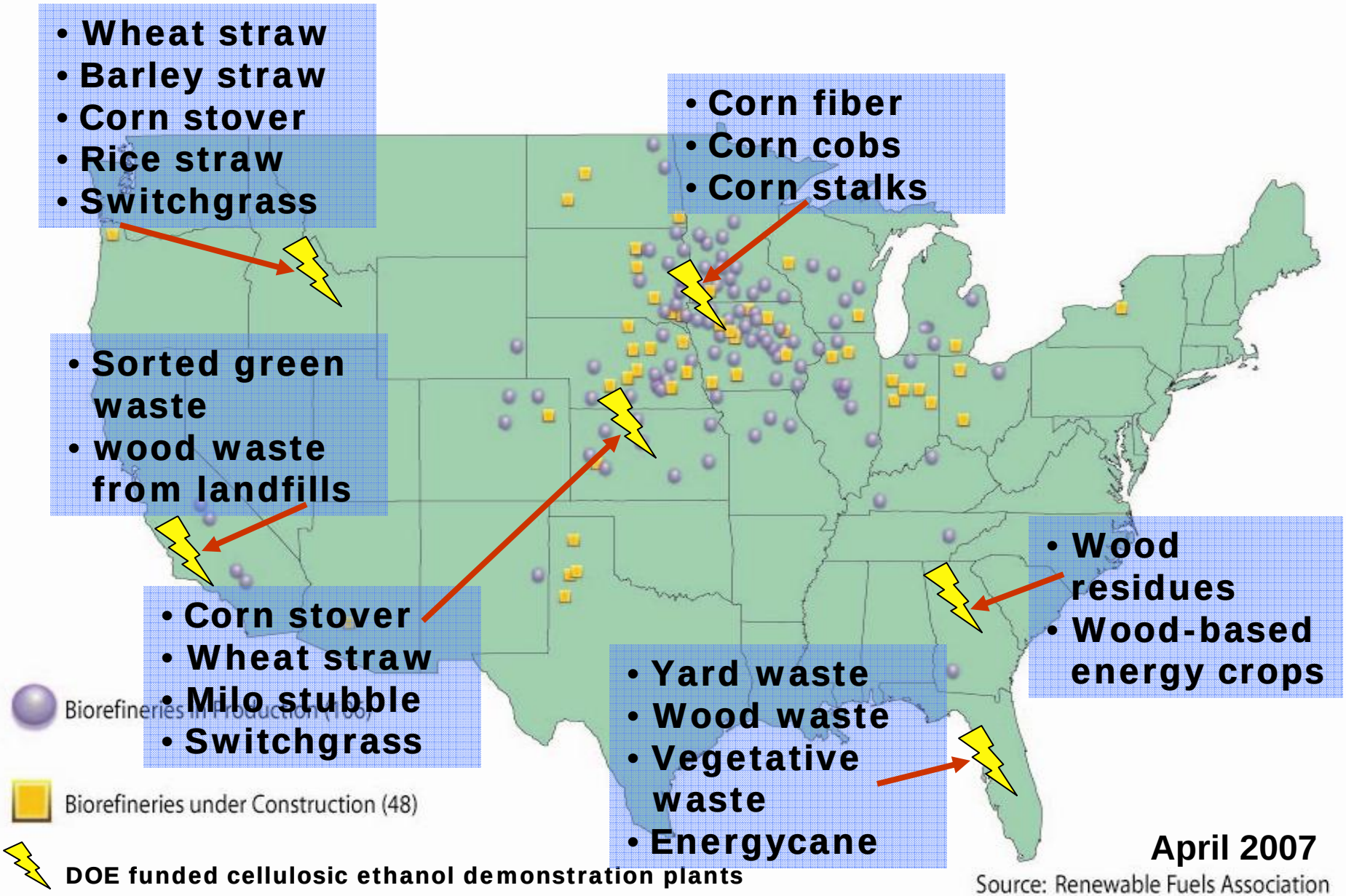
U.S. Ethanol Biorefinery Locations



April 2007

Source: Renewable Fuels Association

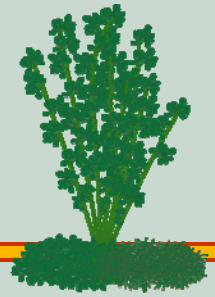
U.S. Ethanol Biorefinery Locations

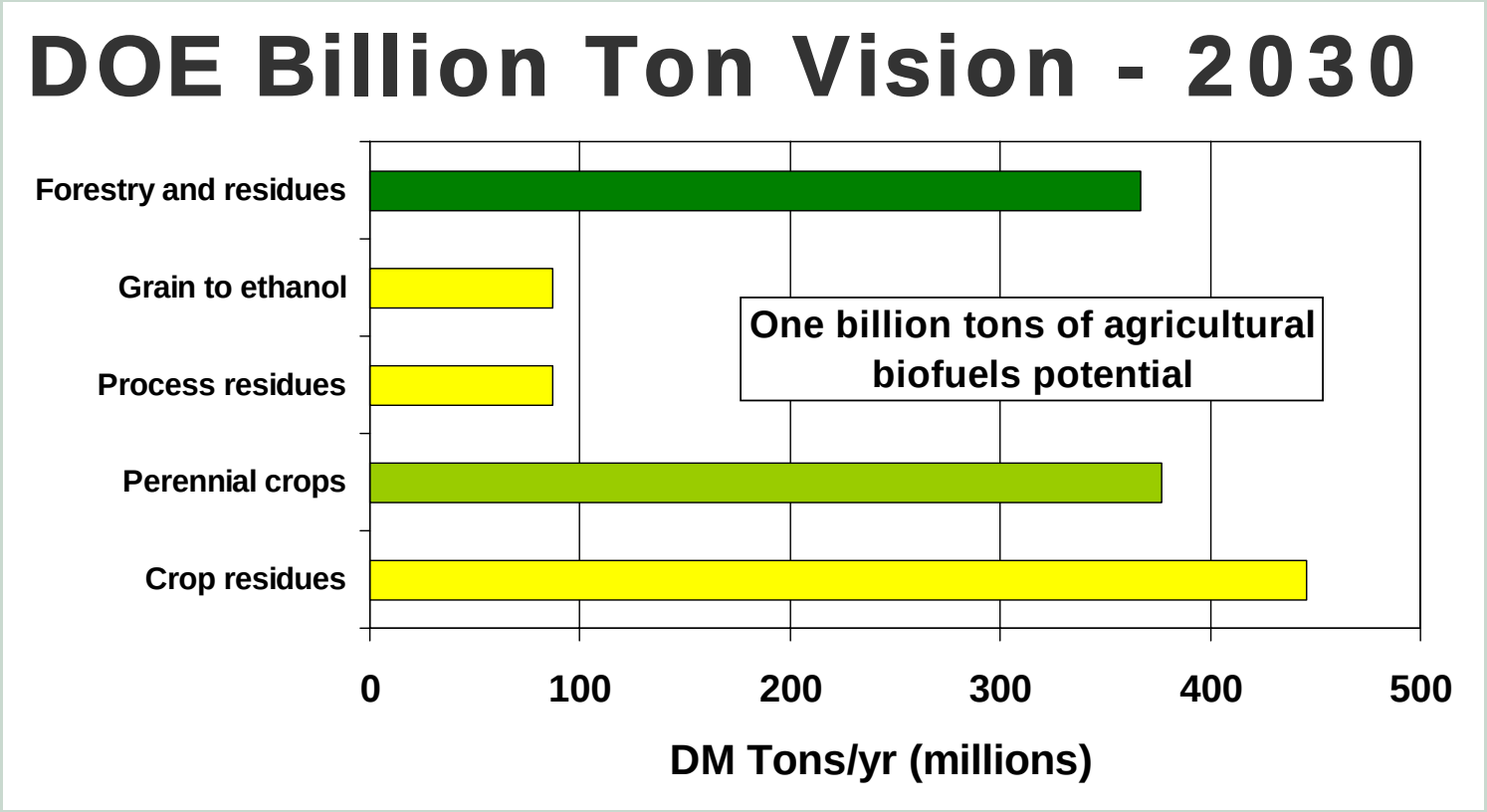


April 2007

Source: Renewable Fuels Association

Cellulosic Ethanol: Feedstocks





Ethanol from corn grain is expected to provide only a portion of a biofuels solution.

Forestry and process residues, perennial crops, crop residues, and other designated energy crops will provide the bulk of a biofuels solution longer term.

Cellulosic Ethanol: Feedstocks-Alfalfa

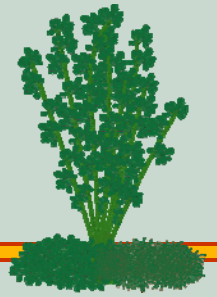
Biomass-Type Alfalfa

Developed by USDA-ARS

Traits Incorporated:

- Large, lodging resistant stems
- Maintenance of leaf yield
- Winter hardiness
- Disease / pest resistance
  - Root rot
  - Leaf hopper

Cellulosic Ethanol: Feedstocks-Alfalfa



Alfalfa Biomass Production Practices

First Production Year Stand

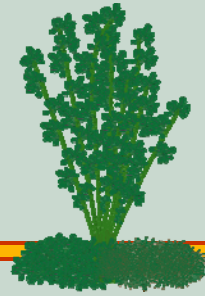
Traditional
42 plants/ft^2

Biomass
17 plants/ft^2

Modify production practices to maximize both leaf and stem yield.

1. **<u>Bigger Plants</u>: Decrease stand density to give plants more room to grow.**

Cellulosic Ethanol: Feedstocks-Alfalfa



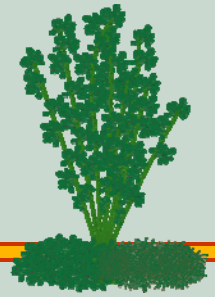
2. More Stem Biomass: Delay harvest from early bud stage to late flower/green pod stage to get longer stems. Lodging increases at later maturities.

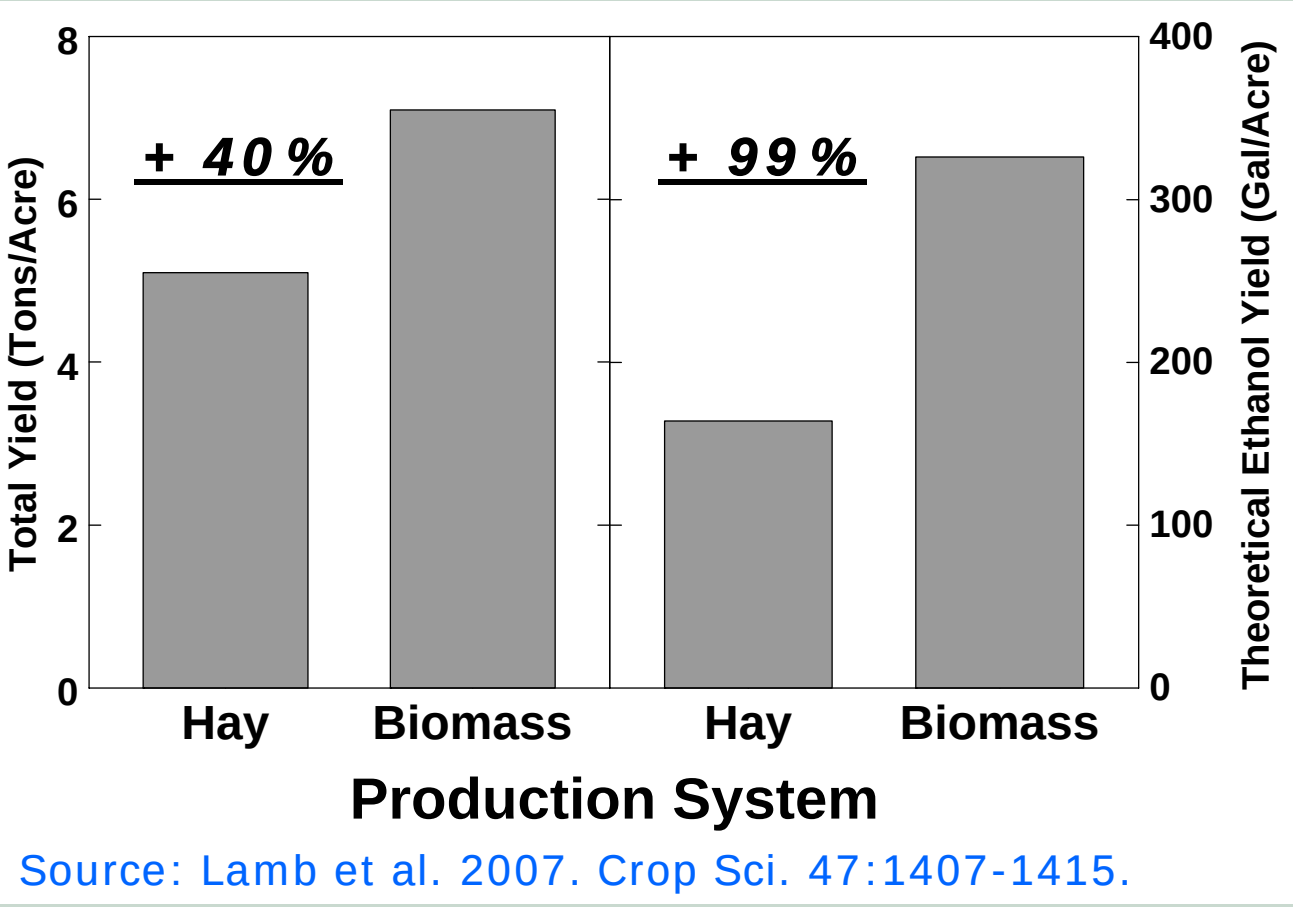
Full Bloom Maturity Stage

Dairy Hay Type

Biomass Type

Cellulosic Ethanol: Feedstocks - Alfalfa





Source: Lamb et al. 2007. Crop Sci. 47:1407-1415.

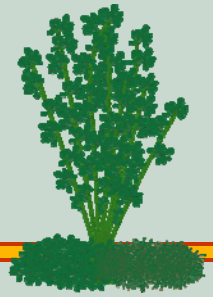
Biomass-Type Alfalfa + Biomass Management Doubles Ethanol Yield

Cellulosic Ethanol: Feedstocks-Alfalfa

Research to design equipment to separate alfalfa leaves and stems in-field; ongoing at the University of Wisconsin

Kevin Shinners and Matt Digman

Cellulosic Ethanol: Feedstocks - Alfalfa



Efficient separation of stem and leaf material is technically feasible

Stripped Leaves

- Leaf Fraction: 60%*
- Purity: 90% leaves
- Protein: 27%
- Fiber: 20%

Remaining Stems

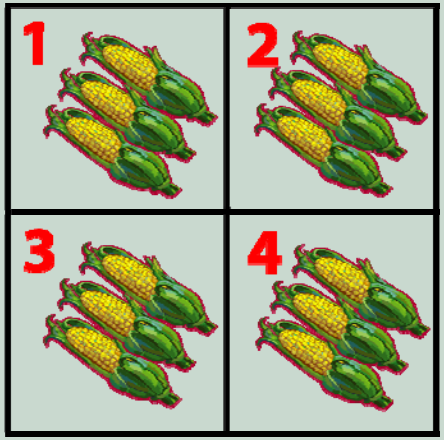
- Stem Fraction: 40%*
- Purity: 90% stems
- Protein: 13%
- Fiber: 50%

**Ratio of leaves to stems can be adjusted by changing rotor speed*

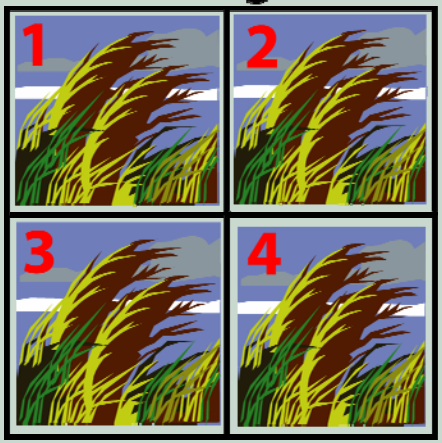
Cellulosic Ethanol: Systems Opportunities

Comparison of three systems

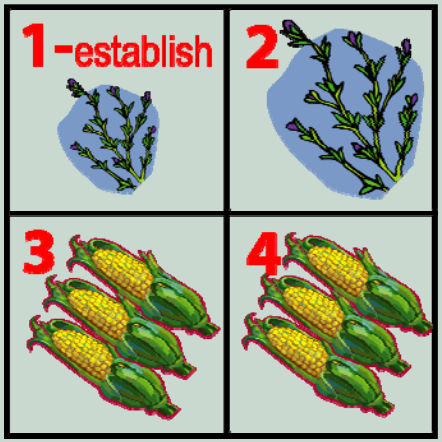
continuous corn



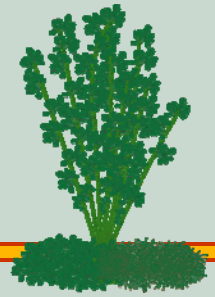
switch grass



alfalfa/corn rotation



Cellulosic Ethanol: Systems Opportunities

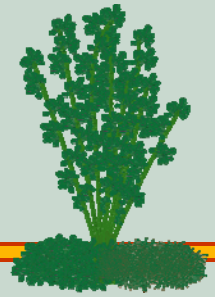


Production costs, profit and energy balances of biofuel crop rotations.

Rotation*	Cost	Profit	Net Energy** Prod	Ethanol	Ratio
	---$/A---		MJ/A	gal/A	O:I
2A-2C	364	741	38,181	615	2.4
Switch	272	288	37,948	542	7.3
Corn	438	942	41,733	962	1.9

*2A: 3 & 6 T/A, seed & production; corn: 188 bu/A & 3.2 T/A
Switchgrass: 5 T/A
Corn: 175 bu/A & 3.0 T/A, grain & stover
**MJ= mega joules
SOURCE: Vadas et al. 2007. In review.

Cellulosic Ethanol: Systems Opportunities

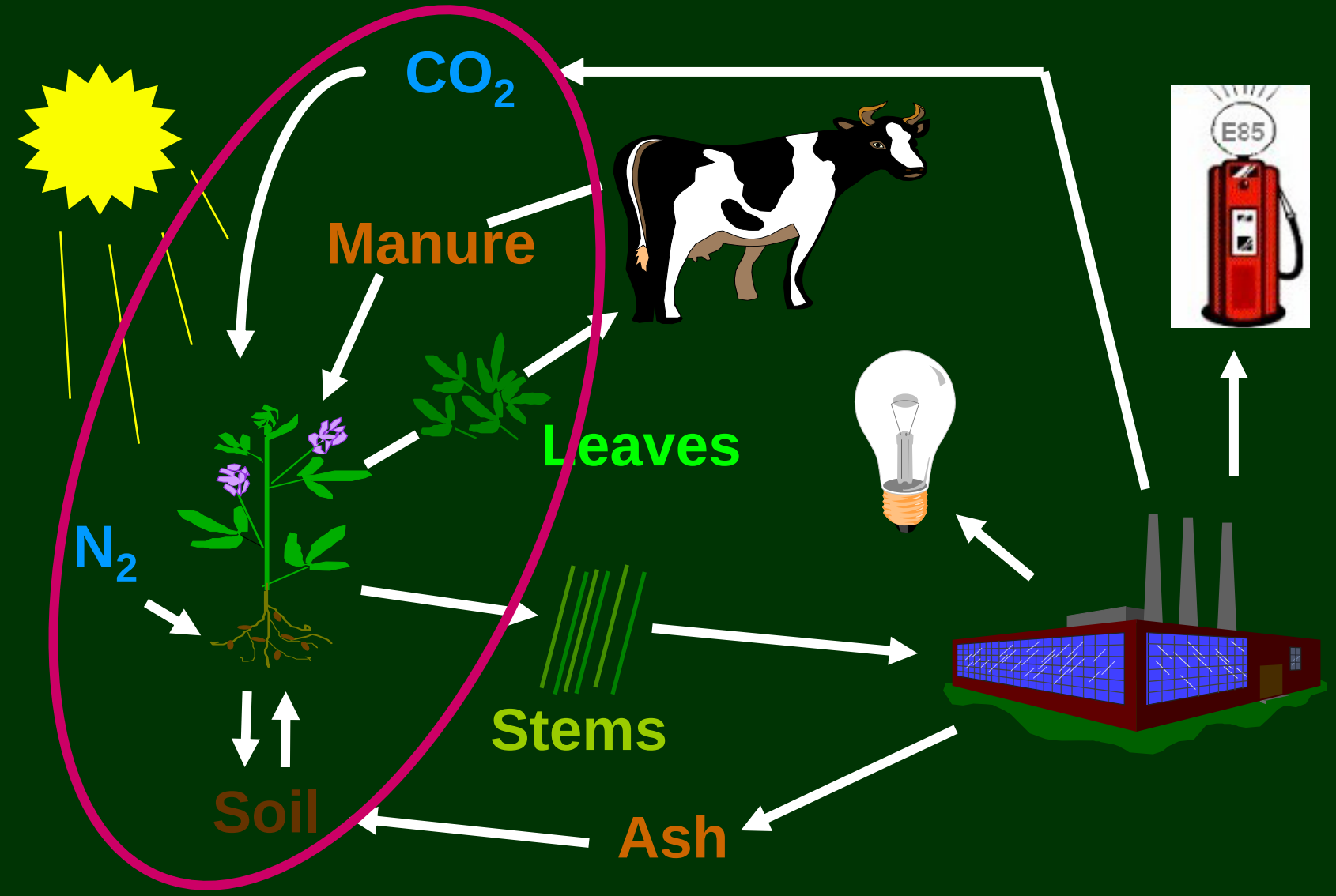


Environmental Impact: Annual N leaching, denitrification and erosion of 3 ethanol cropping systems.

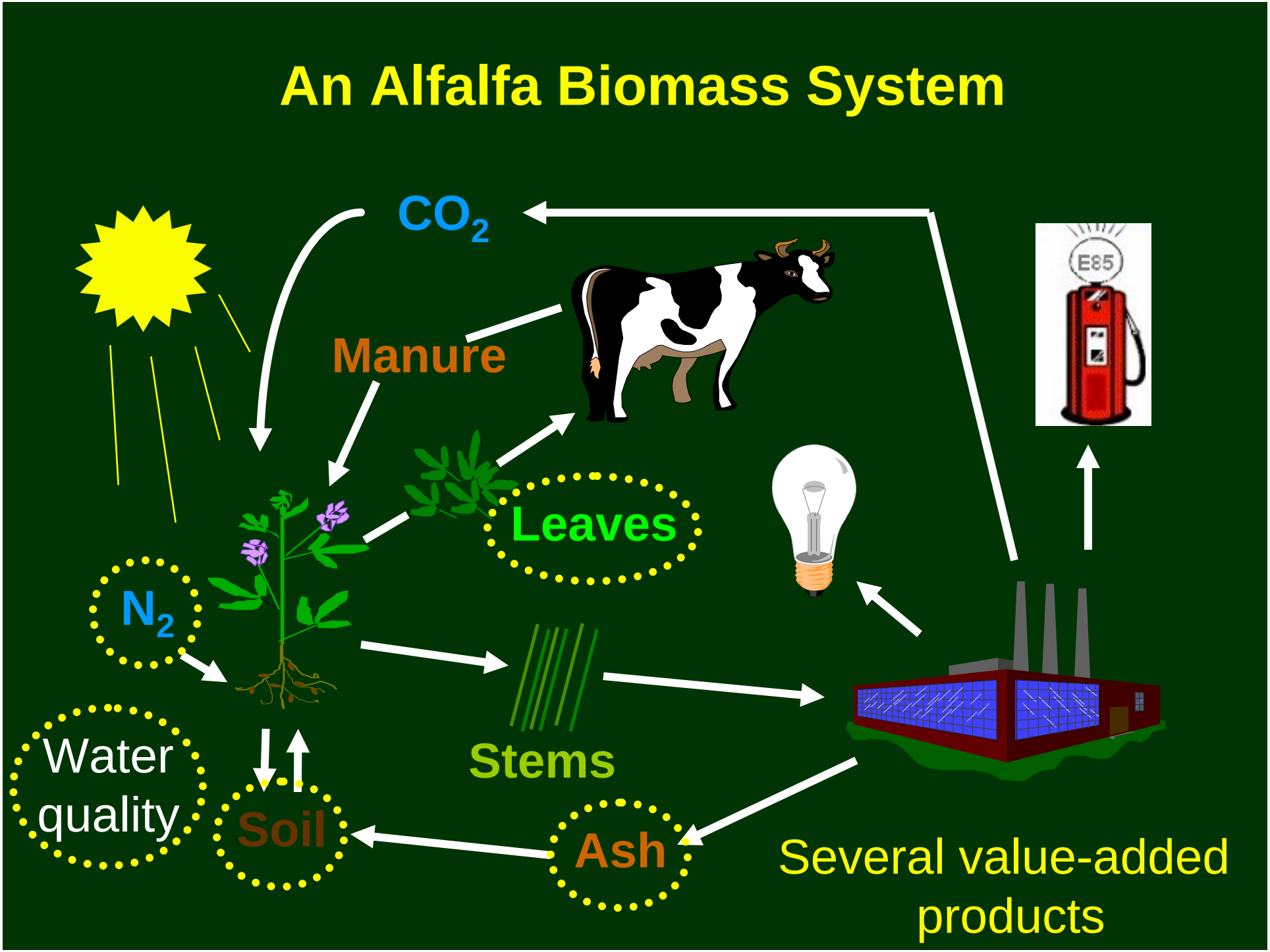
Rotation*	-----N loss, lb/A----- leach	denitrification	Soil loss lb/A
2A-2C	2.4	5.9	1044
Switch	7.6	14.8	62
Corn	11.4	27.7	1636

*2A: 3 & 6 T/A, seed & production; corn: 188 bu/A & 3.2 T/A
Switchgrass: 5 T/A
Corn: 175 bu/A & 3.0 T/A, grain & stover
SOURCE: Vadas et al. 2007. In review.

An Alfalfa Biomass System



An Alfalfa Biomass System



Summary

- Ethanol conversion plants need cheap biomass (No ethanol has been produced from Cellulosic feedstock, yet).
- Most feedstock production is commodity oriented and more directed at 'all out' production rather than sustainable economics and sustainable environment.
- Dairy operations that grow forages and grains may offer an excellent model for nutrient utilization, energy conservation, and environmental sustainability in a bioenergy age.

Research Needs

- Develop crop systems that are economically, environmentally sustainable.
- Feedstock production, harvest and storage of perennials with conversion potential on ethanol platforms in use and in research.
- Utilize dairy farm system to determine bioenergy production, energy conservation, and reduction of greenhouse gas.

Research Benefits to Dairy Producers

- Research on crops utilized by dairy for bioenergy could provide dairy operations:
  - More yield per acre.
  - Reduced harvest costs (less cuts).
  - New compatible method of removing excess nutrients.
  - New feeds with improved nutritional value (NDFD and RUP).
  - Energy conservation & reduced greenhouse gas.

Related Web Sites

Renewable Fuels Association

http://www.ethanolrfa.org

U.S. Dept. of Energy

http://www.doe.gov

National Alfalfa and Forage Alliance

http://www.alfalfa.org

U.S. Dairy Forage Research Center

http://ars.usda.gov/mwa/madison/dfrc

(this presentation will be posted here)