ceres

growing tomorrow's fuel today

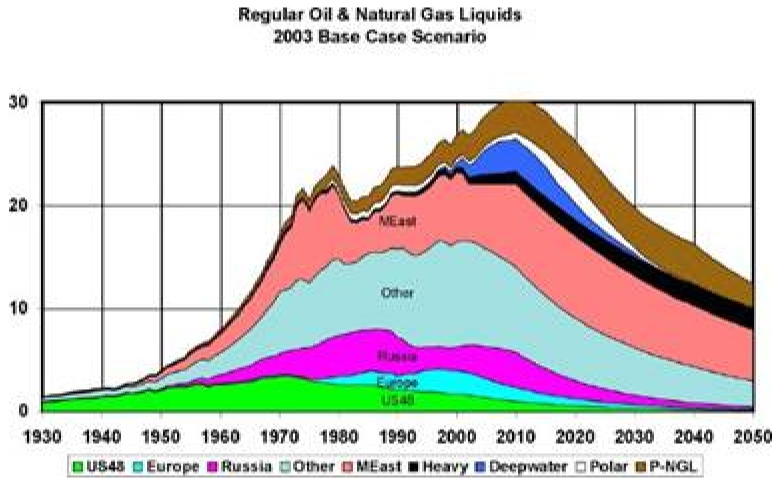
BIOFUELS: GROWING ENERGY

Government-University-Industry Research Roundtable Meeting (GUIRR)

February 19, 2007

"Torn From The Headlines" Issues

growing tomorrow's fuel today



Energy supply

Environmental impact

Energy demand

Energy security

ceres

A Midwest Goldrush?

growing tomorrow's fuel today

U.S. Corn Starch Ethanol Plants

Current installed capacity **5.5 B gallons/yr**
112 facilities

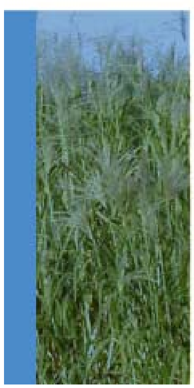
Capacity under construction **6.2 B gallons/yr**
77 new plants; 7 expansions

source: Renewable Fuel Association

ceres

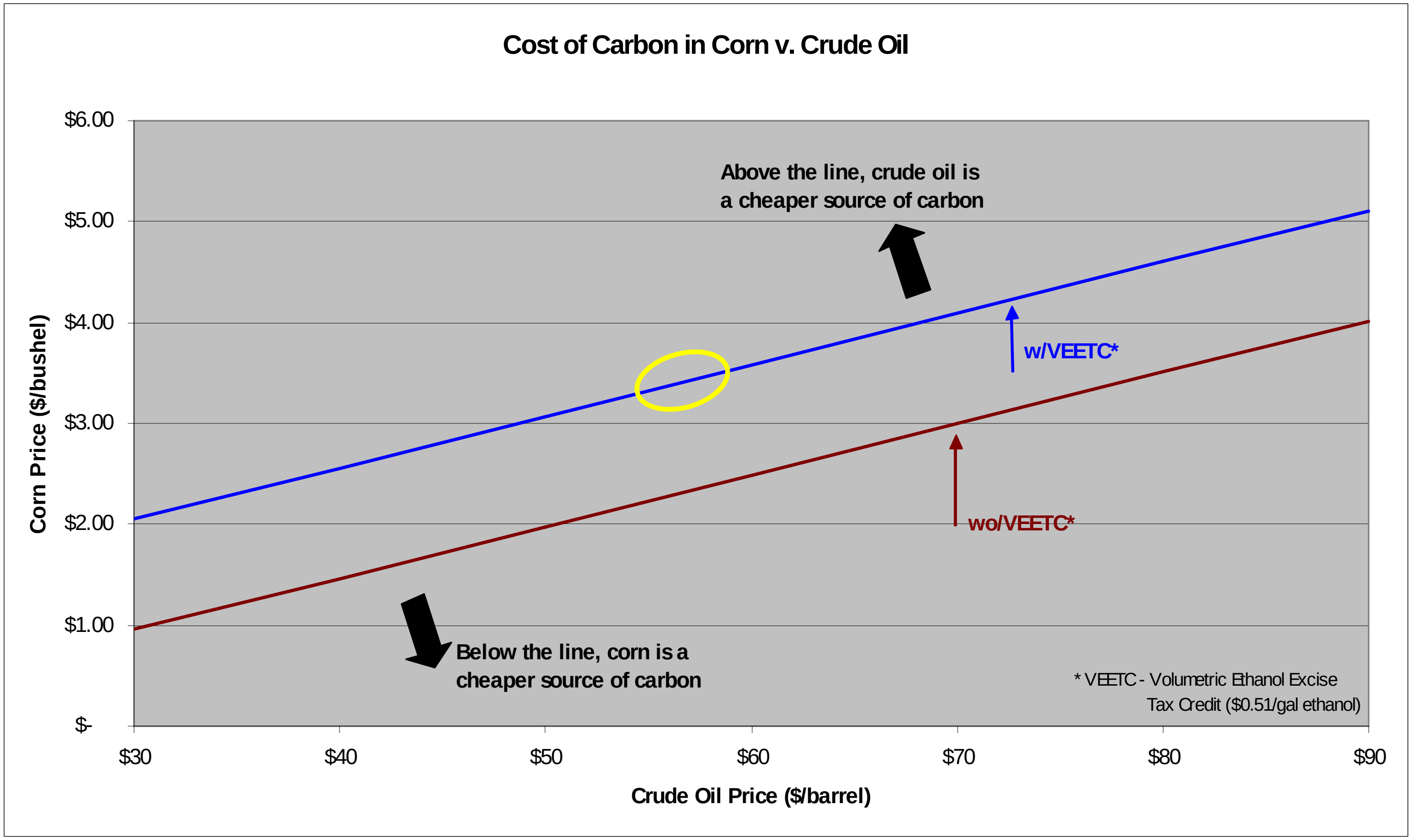
Driving Corn Prices to Historic Highs

growing tomorrow's fuel today



Corn Starch v. Crude Oil

growing tomorrow's fuel today



2007 State Of The Union Address

ceres

growing tomorrow's fuel today

"…we must increase the supply of alternative fuels, by setting a mandatory fuels standard to require 35 billion gallons of renewable and alternative fuels in 2017 -- and that is nearly five times the current target."

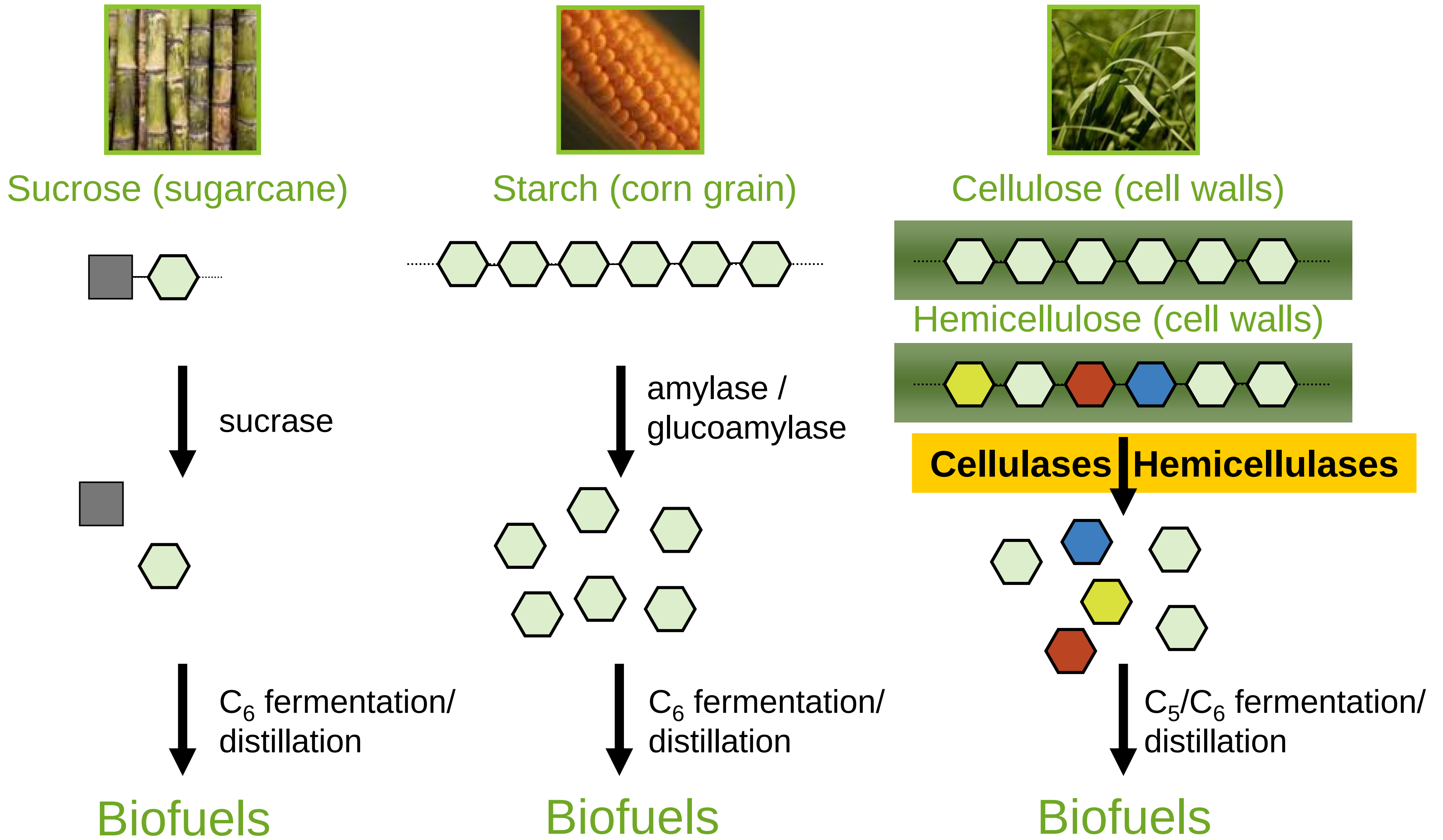
It’s The Cellulose, Stupid

Biofuels produced incidentally to food-crop agriculture are suboptimal in several dimensions, but the *cellulose* from *engineered energy crops*, processed in new ways, offers the prospect of significant improvement and material benefit for transportation fuels.

Steven E. Koonin
Chief Scientist, BP

ceres

Basic Carbohydrate Biochemistry



Plants Did Not Evolve To Serve Man

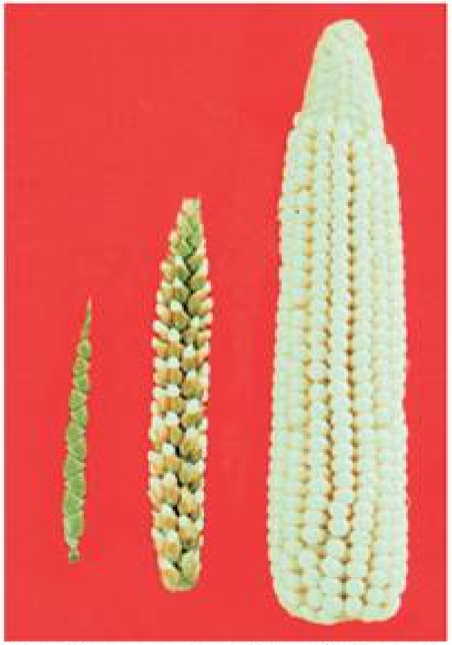


Figure 2. Modern corn hybrid (right), its wild relative teosinte (left), and their hybrid (cob in the center). (Photo kindly provided by John Doebley.)

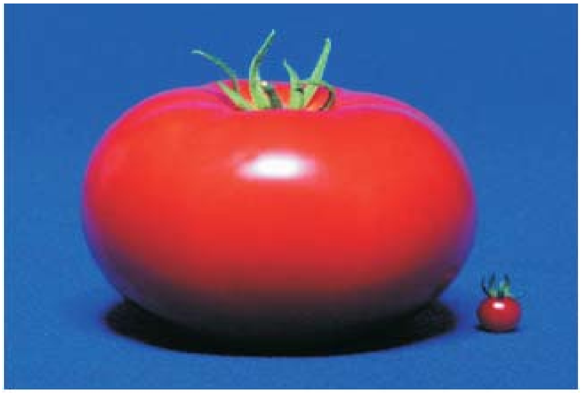


Figure 1. Cultivated tomato (left) and its wild relative *Lycopersicon pimpinellifolium* (right; approximate diameter of smaller tomato = 1 cm). (Photo kindly provided by Steve Tanksley.)

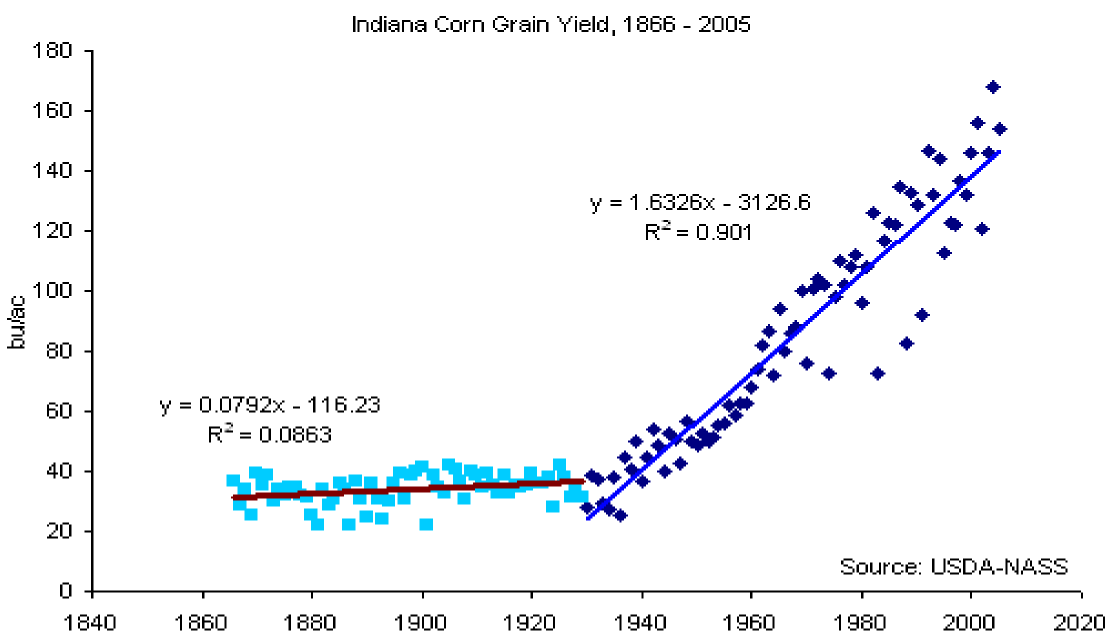
Genetic manipulation or “breeding” has been instrumental

Plant Physiology, May 2001, Vol. 126, pp. 8–15, www.plantphysiol.org © 2001 American Society of Plant Physiologists

What Limits Crop Yields?

- Germplasm
- Biotic stress
  - Weeds
  - Insects
  - Fungi
- Abiotic stress
  - Drought
  - Nitrogen
  - Temperature

Technology Is Game Changing…



Adoption of hybrid genetics has tripled US corn yield since 1940

Biotechnology Has Been Game Changing

- Reduced insecticide use
- Reduced fungal infection
- Lower aflatoxins

- Increased “con-till”
- Reduced soil erosion

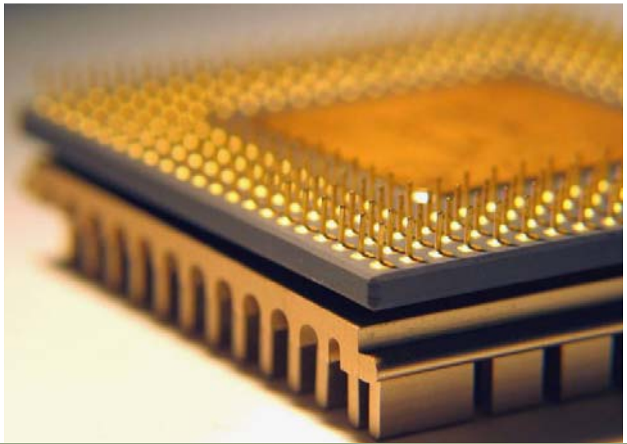
A Third Technological Revolution

"Changes that will have effects comparable to those of the Industrial Revolution and the computer-based revolution are now beginning. The next great era, a genomics revolution, is in an early phase.

Thus far, the pharmacological potentials of genomics have been emphasized, ***but the greatest ultimate global impact of genomics will result from the manipulation of the DNA of plants****.*

Ultimately, the world will obtain most of its food, fuel, fiber, chemical feedstocks, and some of its pharmaceuticals from genetically altered vegetation and trees."

Philip H. Abelson, Editor
Science, March 1998


Who is Ceres?

growing tomorrow's fuel today

- World's leading plant genomics company
  - More plant genes-traits identified than any other entity
- Monsanto's largest external gene technology supplier
  - Technology and IP validated by $137M collaboration
- Developer of dedicated energy crops leveraging technology platforms
  - Genes/traits for drought, biomass, nitrogen, composition, processing etc. already identified
- Exclusive R&D and commercialization partner of the Noble Foundation, foremost forage grass research institute in U.S.
  - Seed multiplication of improved commercial energy crops underway

Plant Genomics is Game Changing

Parts of the Equation	Relevant Traits	Impact
Acres	▪ Stress tolerance (e.g. drought, heat, cold, salt)	▪ Growth on marginal acreage helps enable critical mass
Tons per acre	▪ Increased yield (e.g. photosynthetic efficiency)	▪ Lower production and transport costs and increased carbon sequestration
Dollars per acre	▪ Nutrient requirements (e.g. nitrogen utilization)	▪ Lower fertilizer costs and less N2O emissions
Gallons per ton	▪ Composition & structure (e.g. C5/C6, cell wall structure)	▪ Increase theoretical yield of ethanol per ton of biomass
Capital cost of refinery & variable cost per gallon	▪ Composition, structure & enzyme production (e.g. cellulases)	▪ Eliminate need for acid hydrolysis, reduce need for enzymes and bring actual yield closer to theoretical
Co-products	▪ Metabolic engineering & sequestration	▪ Enhance overall economics

Ceres' High-Throughput Pipeline

Proprietary Genomic Technology Enables Rapid Product Development

Identify cDNA

Various Plant Species

Sequence & characterize

>70,000 genes

>10,000 promoters

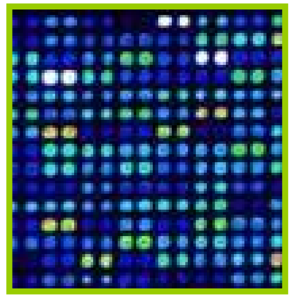
Transform into Model Plant

Arabidopsis

Transform gene-promoter combinations into model plant

(4,000/qtr)

Screen for Traits



Define valuable gene-trait combinations via high-throughput screens

(3,600/qtr)

Transform into Crops

Rice

Move successful gene-promoter combinations into commercial food crops

(150/qtr)

Transform into Energy Crops

Switchgrass Miscanthus

Move valuable gene-promoter combinations into cellulosic energy crops

(Proprietary)

Ceres' Comprehensive Gene Set Enables Systems Approach

Stand Establishment
- Germination rate
- Cold germination
- Cold growth
- Herbicide tolerance

Nitrogen Economy
- Uptake and translocation
- Reduction and partitioning

Stress Tolerance
- Drought tolerance and recovery
- Heat
- Cold
- Salt
- Photoperiod

Improved Processing
- Lignin content
- C6/C5 ratio
- Cell structure
- Organ structure

Hormone biology
- Brassinolides
- Gibberellins
- Auxin

Photosynthesis
- Planting density
- Light harvesting / utilization
- Chloroplast position and number
- PEP carboxylase, SBPase, FBPase

Plant Architecture
- Branching
- Stalk thickness
- Root length
- Stature
- Leaf size / angle

Reproduction
- Heterosis
- Genetic confinement

*Picture of switchgrass growing in Ceres Greenhouse

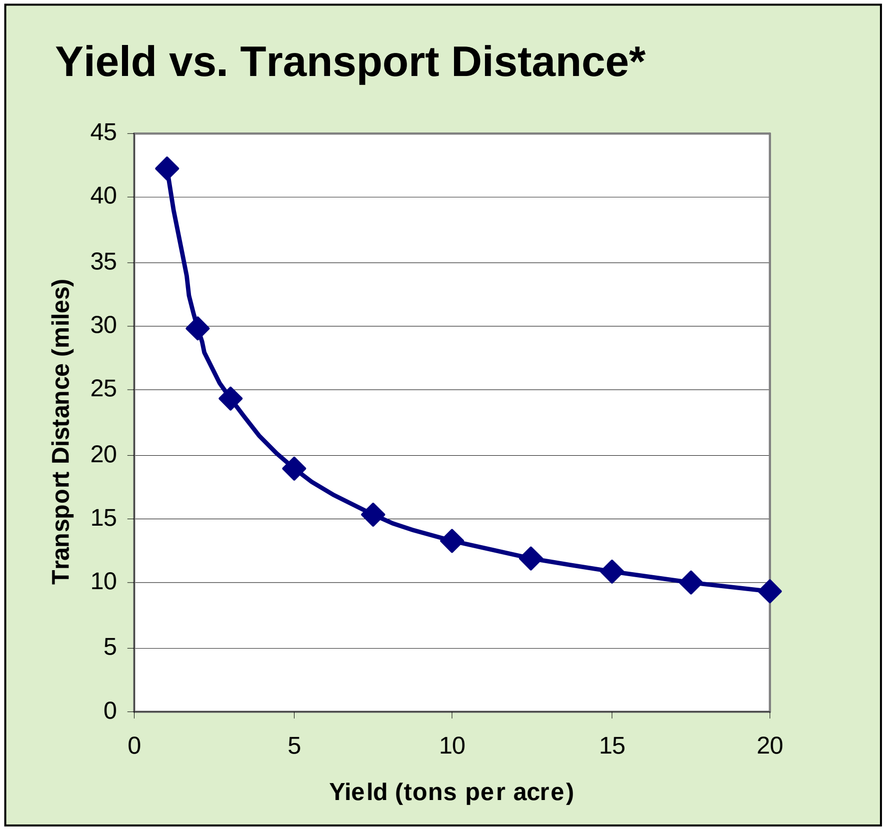
Increasing Tons per Acre…

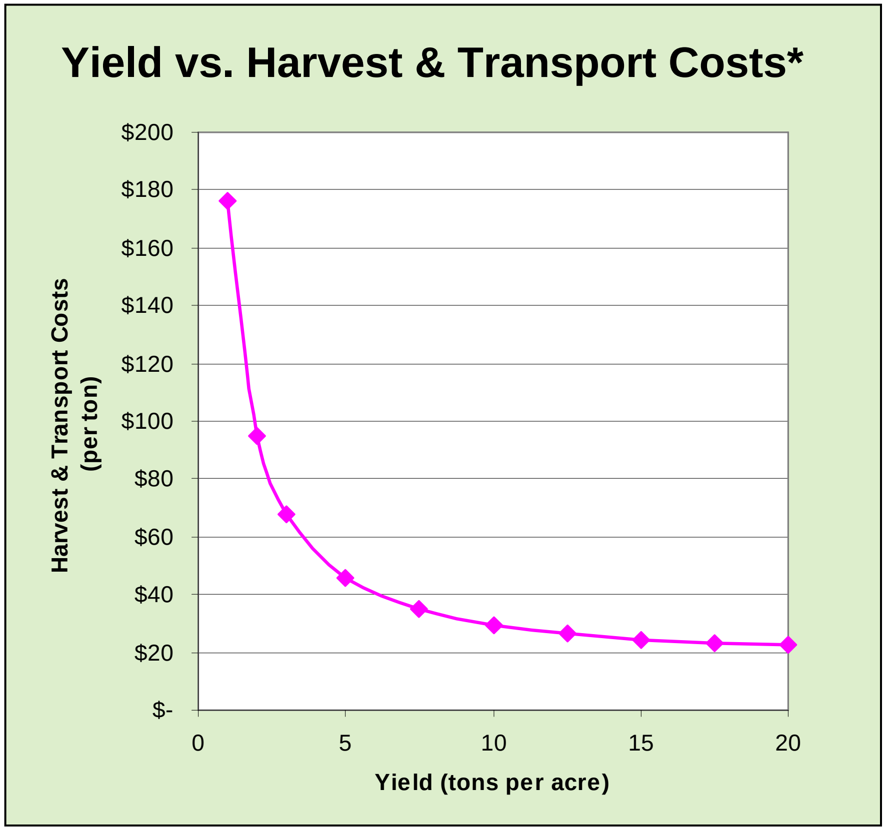
Control Transgenic

Control Transgenic

The Tyranny of Distance

Yield density both reduces transport distance (thereby reducing transport cost) and improves economy of scale for use of harvesting equipment





* Assumes a 10,000 ton/day processing facility with 50% of surrounding land used for biomass

Reduced Agronomic Inputs…

Expanding Usable Acres: Heat Stress

Arab gene Control Corn gene

RICE

Control Arabidopsis gene

TOMATO

Expanding Usable Acres: Drought

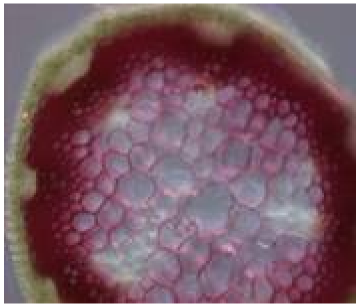
Control

Transgenic

Expanding Usable Acres: Cold Stress

Improving Composition…

Non-transgenic
Wild type



Transgenic line
increased lignin
deposition

Transgenic line
decreased lignin
deposition

- Genes for cell-wall biosynthesis in hand.
- Actively screening plant lines for improved processing and energy content
- Working with processing and enzyme companies to develop tailored solutions

Ceres-Noble Collaboration

Samuel Roberts Noble Foundation

- Located in Ardmore, OK
- World's premier organization for conventional and molecular breeding of switchgrass and other perennial grass crops
- Three divisions – Agriculture, Plant Science, Forage Improvement
- ~300 research, 435,000 sq ft of research space
- 10,000 acres of adjacent farm land

THE SAMUEL ROBERTS NOBLE FOUNDATION

Switchgrass in Oklahoma…

ceres

Miscanthus in Illinois…

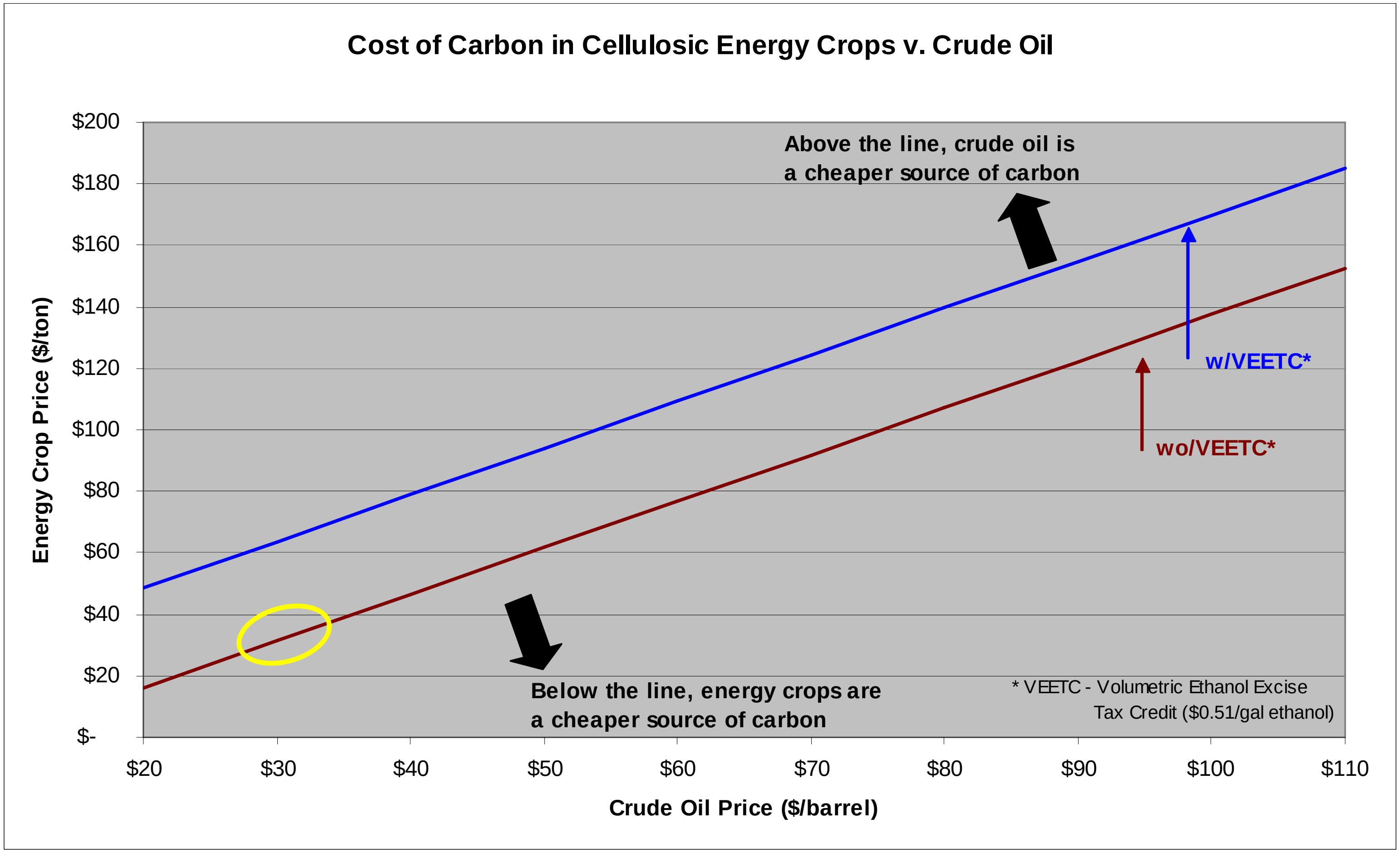
Emily Heaton, Manager of Energy Crop Product Development at Ceres, Inc., stands next to a field of Miscanthus (*Miscanthus* x *giganteus*) being evaluated on the Caveny farm in central Illinois. The biomass shown is one year's growth; scale markings are in feet. Photo courtesy of John Caveny Monticello, Illinois.

Jefferson Would Have Loved Energy Crops!

"The greatest service a citizen can do for his country is to add a new crop for his countrymen."

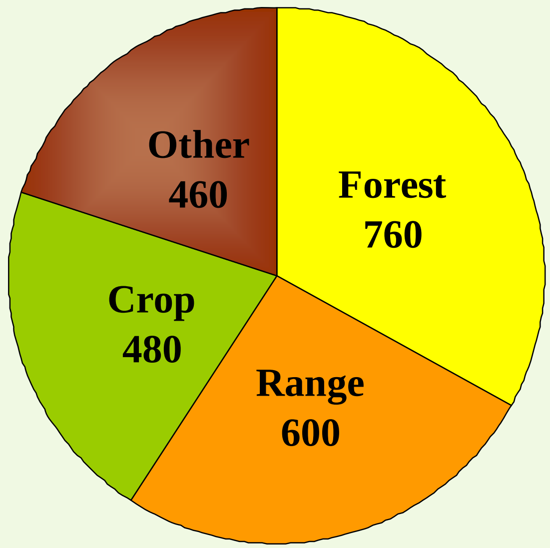
- Thomas Jefferson

Energy Crops vs. Crude Oil

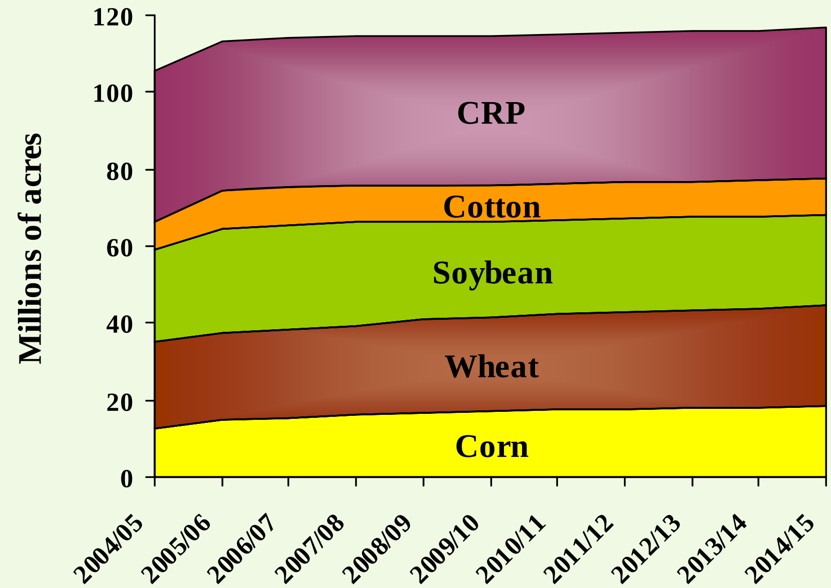


Is There Enough Land?…

Total U.S. Acreage



U.S. Cropland Unused or Used for Export Crops



By 2017, 78M export acres plus 39M CRP acres could produce 384M gallons of ethanol per day or ~75% of current U.S. gasoline demand

Food versus Fuel?

growing tomorrow's fuel today

- Land use choices: cultivate or not cultivate
- Cropping choices: e.g. corn vs. cotton
- Germplasm choices: hybrids and biotech
- Technology choices: US yields vs. ROW
- Food choices: animal protein vs. plant protein

Nearly all these choices are driven by market economics

- Biofuel choices will be the same

Will Markets Choose Wisely?…

ceres

Let Entrepreneurs Innovate…

- Improved pre-treatment technologies
  - Plant composition, ammonia explosion, etc.
- Improved biomass digesting enzymes
  - Reduced cost, enhanced specific activity
- Improved fermentation strains
  - C5 & C6 fermentation pathways
  - Ethanol tolerance
  - Other fuel molecules
  - Consolidated bioprocessing

SunOpta BioProcess Group

novozymes

DIVERSA HARNESSING THE POWER OF ENZYMES

CODEXIS

Celunol

MASCOMA

What Should The Government Do?

- Get 1st generation cellulosic biorefineries built
  - Loan guarantees and other incentives
- Create market demand for cellulosic ethanol
  - Fuel standards, tax credits and other incentives
- Fund *basic* research in biomass conversion
  - Do not compete with private enterprise
- Help farmers grow energy crops
  - Agronomics, stand establishment, crop insurance
- Give energy companies a reason to care
  - Allow SEC to count biomass as proven reserves

Biomass as Reserves

1 acre	=	209 barrels of oil*
100M acres	=	20.9 billion barrels

	Proven Reserves (billion barrels)
Exxon Mobil	22.20
BP	18.50
Royal Dutch Shell	12.98
Chevron	9.95
Conoco Phillips	7.60

* Assumes 10 yr contract
Source: Energy Intelligence (data as of end of 2004)

ceres

“The Stone Age did not end for lack of stone, and the Oil Age will end long before the world runs out of oil.”

Sheikh Zaki Yamani
Former Saudi Arabia Oil Minister

growing tomorrow’s fuel today

ceres

growing tomorrow's fuel today