



GREENWOOD
RESOURCES

A Resource That Lasts Forever™



Agroforestry and Cellulosic Ethanol from Sustainable Poplar Tree Farms

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Short Rotation Crops
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Presentation Outline

- GreenWood Resources (GWR) Profile
- Policy Drivers in the US Renewable Energy Markets
- US Bio-fuels Market
- Current GWR efforts in developing poplar bioenergy feedstock
- Future potential for cellulosic ethanol
 - ZeaChem
- Roadblocks to beginning production today



GreenWood Resources, Inc.

- Founded in 1998, GWR is a global leader in high-yield, short rotation, sustainable tree farms.
- Expertise and value from proprietary plant material and nurseries, the development and management of sustainable tree farms, and capital management.
- Operations in North America, China, South America-Chile.
- In 2007 GWR organized the US\$175 million GreenWood Tree Farm Fund
 - 14,000 hectares (35,000 acres) of poplar in the PNW
 - Saw mill at the Boardman Oregon Tree Farm
 - Managed by Collins Co. and will produce Pacific Albus™ Lumber
- In 2008 GWR organized a US\$200 million dollar investment fund for tree farm development in China.
- Where possible, certifying plantations to the Forest Stewardship Council (FSC) standard.

Pacific Northwest: OR and WA

Columbia River Basin: 11,000 ha (26,000 acres)



- Desert environment
- Drip irrigation
- 20 GT per ac per yr



Pacific Northwest: OR

Lower Columbia River: 2,500 ha (6,500 acres)



- Alluvial sites
- Network of levees and drainage canals
- 15 GT per ac per yr



China: Shandong Province



Poplar Bioenergy in China



South America: Los Angeles, Chile Santa Julia Nursery



One Year Growth from Coppice





Policy Drivers for US Renewable Energy Development

- Goal of Energy Independence
 - US imports 60% of its crude oil
- Global Climate Change
 - Transportation sector accounts for 30% of total US GHG's
- Oil Prices
 - Over \$140 per barrel in July, 2008
 - Gas prices to reach \$4-5 per gallon this summer
- Biofuels and Clean Energy Technologies are a Growth Area in a Slow Economy
 - Solar, wind and cellulosic's



How Has Congress Reacted?

- Energy Independence and Security Act of 2007
 - CAFE standard of 35 mpg by 2020
 - US biofuels production target of 36 billion gallons by 2022
- Food, Conservation, and Energy Act of 2008 – The Farm Bill
 - Strong push to commercialize cellulosic biofuels
 - \$1.01 per gallon tax credit for cellulosic biofuels
 - \$300 million dedicated to research on cellulosic biofuels
- Lieberman-Warner Climate Change Bill
 - Dies in congress

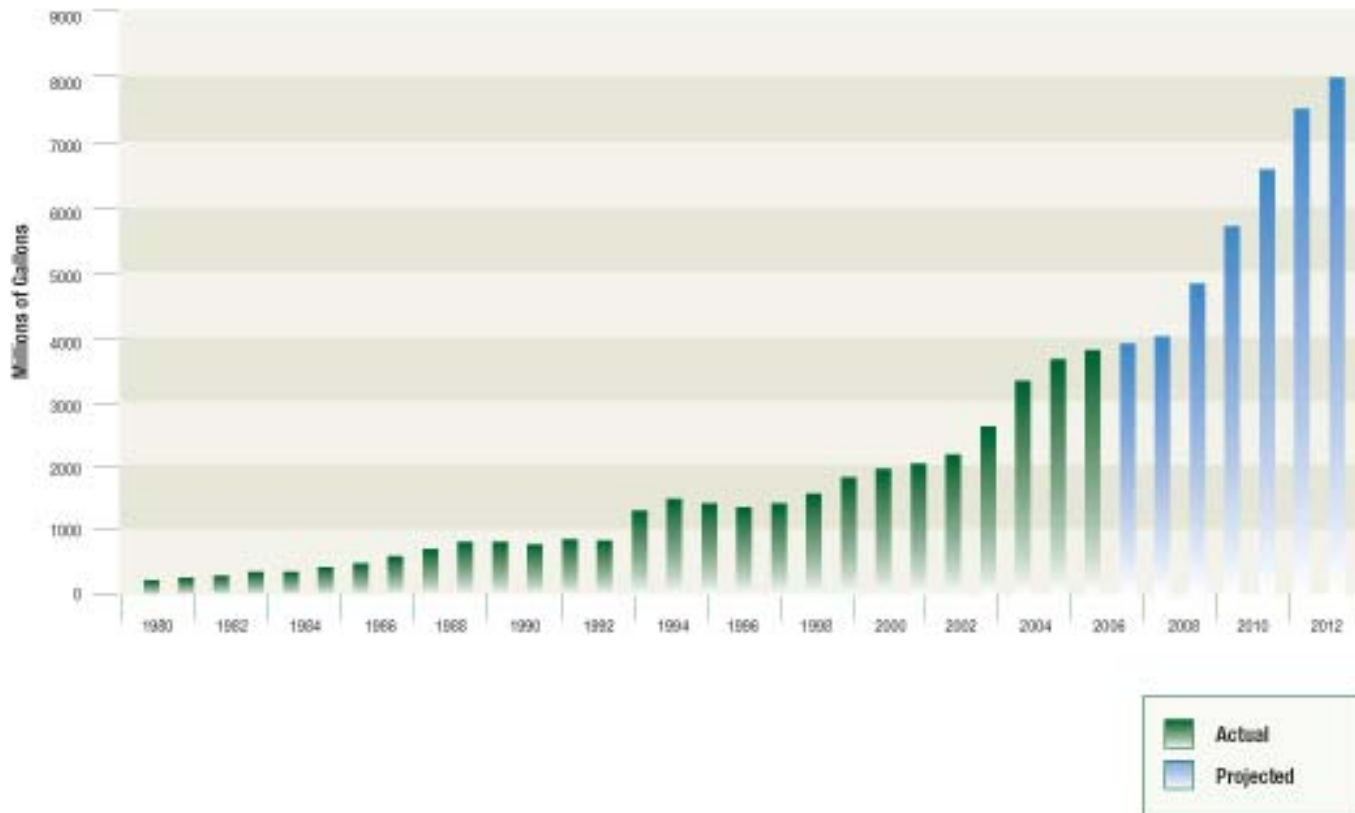


Biomass Markets are Heating Up

- Prices for chip logs and residuals are climbing
 - Up 2-3x in some PNW markets since 2006
 - Up 50% in some SE markets in the last 6 mo
 - Increases are enhanced by saw mill production slowdown
 - Before 2004 GWR returned residuals to the field, couldn't give them away
 - 2008 price for hog fuel is over \$20/GT
- What does the future hold?

The US Bio-fuels Market

- Ethanol Growth






Limitations of Corn Based Ethanol

- Important as a first generation biofuel - BUT
- Requires more herbicide and nitrogen fertilizer than other biofuels crops
- Producing corn ethanol results in a small net energy gain
- Corn ethanol can potentially provide but 5-10% of our transportation fuel needs
- Corn planting is increasing at the expense of other feed crops, resulting in rising commodity prices



Why Cellulosic Feedstock?

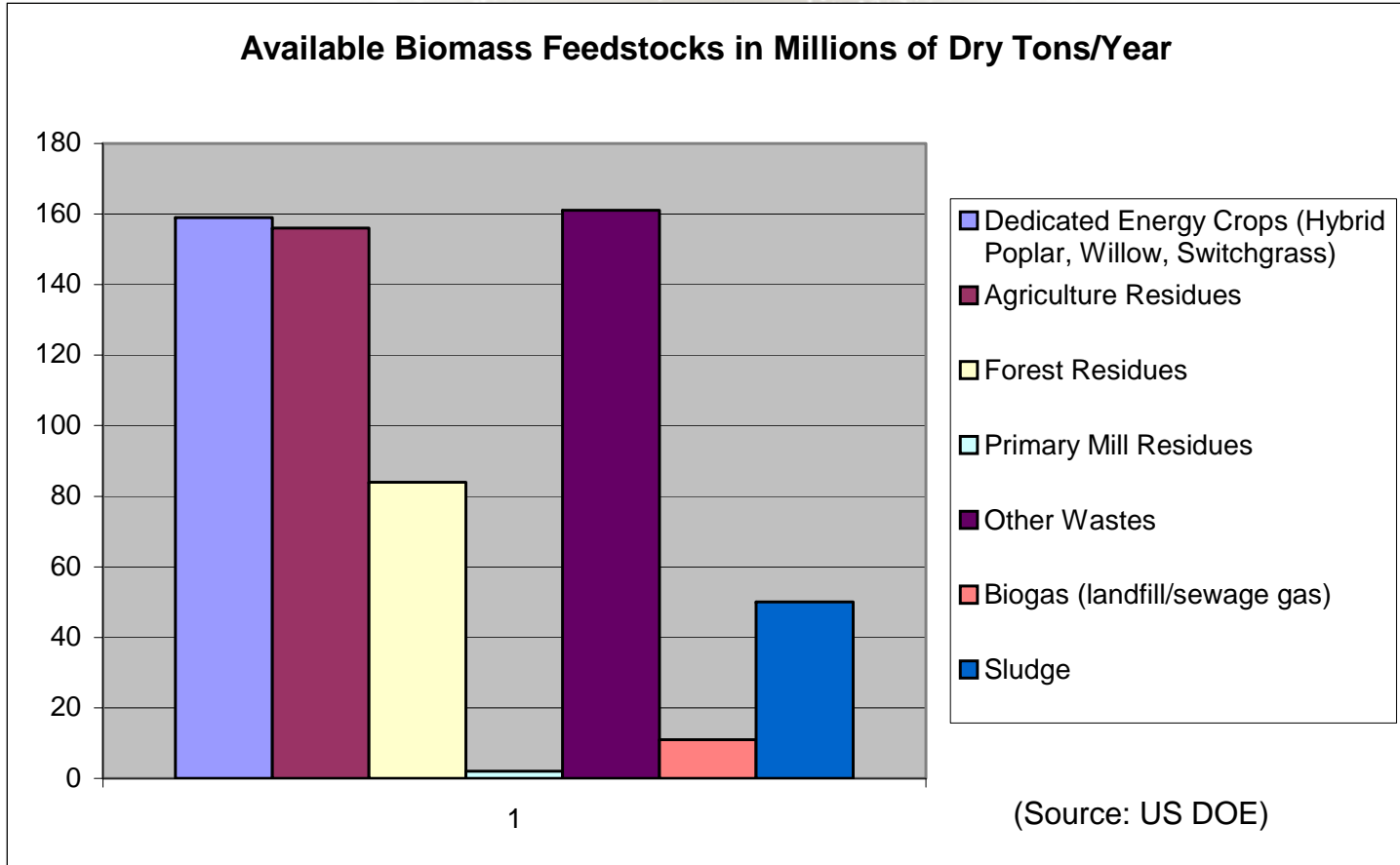
- Grown with less water and fertilizer
- Produce 3 times the biomass per acre
- Less intensive than annual crops
- Can not get to US biofuels goals with corn alone
- Superior energy budget



Bio-Fuels Energy Balance: energy output versus energy input

- Corn Ethanol – 1.3
 - 300-400 gallons of ethanol per acre
- Soybean Biodiesel – 2.5
 - 60 gallons of biodiesel per acre
- Sugar Cane Ethanol – 8.0
 - 600-800 gallons of ethanol per acre
- Poplar Cellulosic Ethanol – 12.0
 - 1500+ gallons of ethanol per acre

Dedicated Crops Drive Growth





GreenWood's Strategy: Two Pathways

- Strategic Objective: Promote poplar from dedicated energy tree farms as the feedstock of choice for cellulosic ethanol
 1. Production systems
 - Adapting Silvicultural techniques to multiple coppice cycle rotations
 - Equipment automation – planting and harvesting
 2. Feedstock Quality
 - Screening for high wood density, favorable wood chemistry for ethanol conversion

Production Systems

- Biomass Yield:
 - GWR has the largest poplar breeding program in North America
- Silvicultural activities to maximize productivity:
 - Sustainable coppice rotation (2-5 years), fertilizer, weed control, pest control, irrigation
- Harvesting and processing energy crops:
 - Cooperating in the development of combine-like harvesters



Improving Production Economics: Farming Strategy



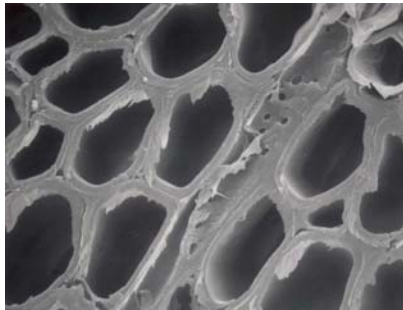
Silviculture - High-density plantings of 2,200 stems per acre managed on 2 to 5-year coppice rotations



Harvesting and Processing - Combine-like harvesters operating to fell, shred, and load feedstock

Feedstock Quality

- Wood Chemistry and Conversion:
 - Gene association studies with UC Davis, DOE/ORNL, and UBC to identify genes controlling cellulose and lignin biosynthesis
 - Use the information to breed a new generation of energy cultivars for high yield and ease of conversion
- Adaptability to Sites of Marginal Agronomic Quality
 - Pest and disease tolerance
 - Drought and salt tolerance



Advantages of Poplar Biomass for Energy & Fuels



FUELS, CHEMICALS, MATERIALS, HEAT AND POWER FROM BIOMASS



BIOMASS FEEDSTOCK

Hybrid poplar trees
Willows
Switchgrass
Agriculture crops
Agriculture residues
Wastes

CONVERSION PROCESS

Combustions & Co-firing
Pyrolysis
Gasification
Enzymatic Fermentation
Acid Hydrolysis

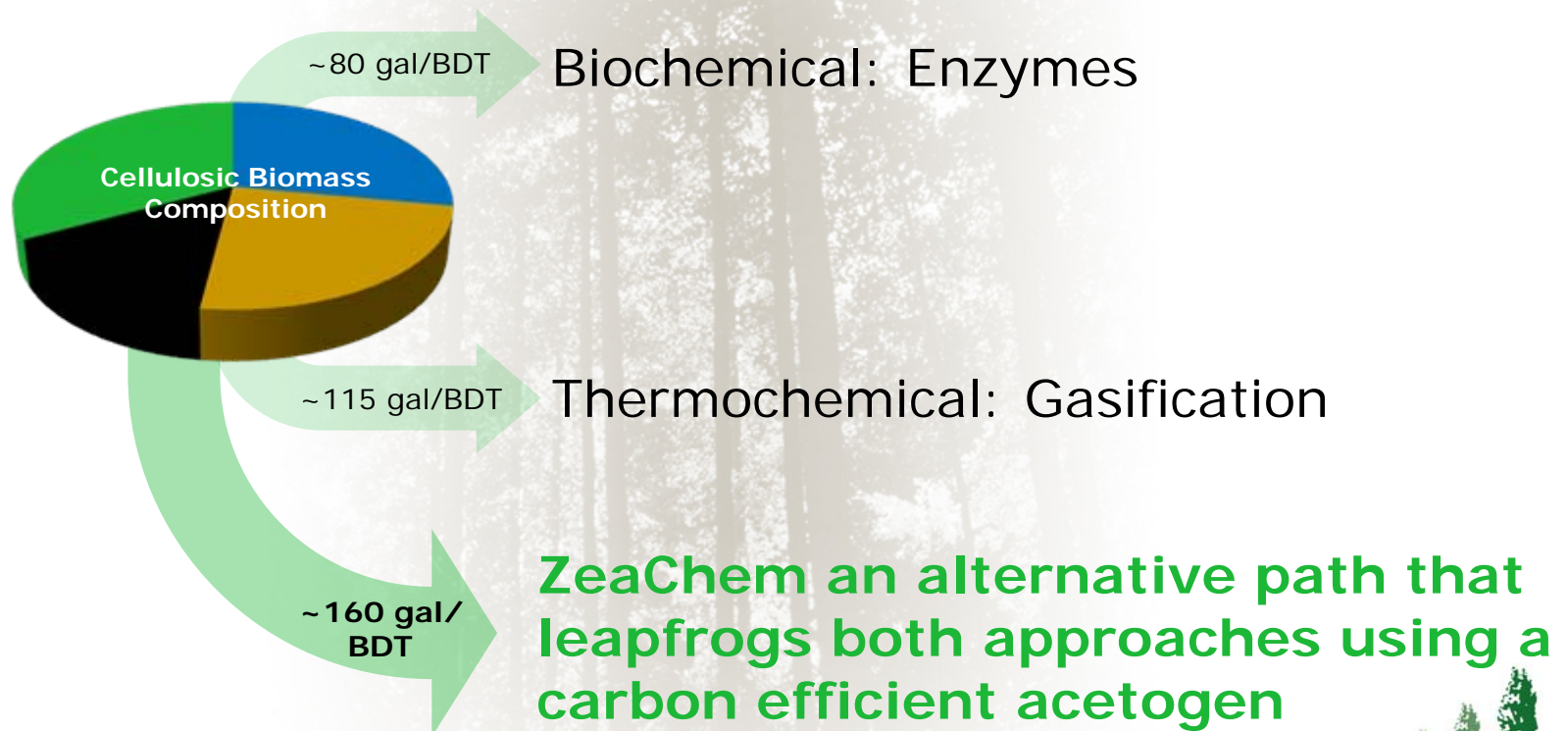
PRODUCTS

Fuels	Chemicals
Ethanol	Plastics
Diesel	Solvents
	Adhesives
Electricity	Acids
Combustion	Paints
Co-firing	Detergents
Gasification	Phenolics
	Chemical Intermediates

1. Rich knowledge base in breeding and Silviculture
2. Known yield, logistics and economics
3. Stored on the stump
4. Superior energy budgets and environmental benefits
5. Wider site adaptability- marginal farmland
6. Perennial crop
7. Integrates well with cellulosic conversion processes

Why ZeaChem? (www.zeachem.com)

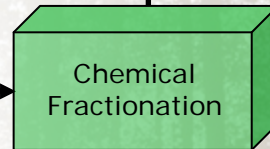
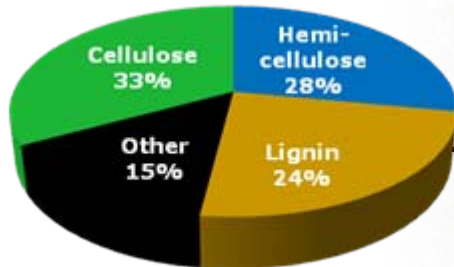
- Market currently views only viable options as either enzyme or gasification based



ZeaChem Process

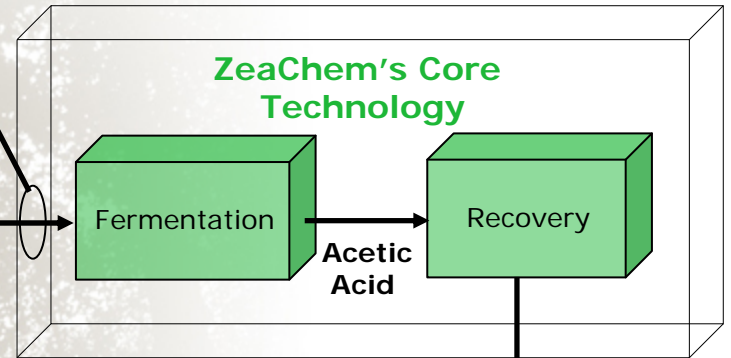
- Use an acetogen rather than yeast for fermentation for C5 & C6 sugars
- Fermentation is nearly 100% carbon efficient & No CO₂
- Produce an acetate intermediate rather than ethanol
- Hydrogen used to hydrogenate the acetate to produce ethanol or other chemicals

Cellulosic Biomass Composition

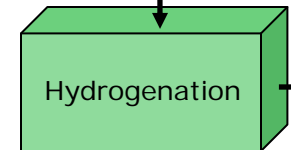


C5 & C6 Sugars

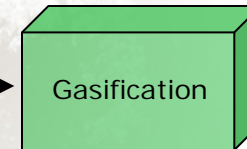
Carbohydrates



Ethyl Acetate



Residue



Hydrogen

Ethanol

NEV = 12

Yield = 155–160 gal/BDT (Highest Theoretical Efficiency)

Process Advantages

- Use a natural organism (Acetogens) found in termites
 - Advantages vs. yeast:
 - Converts all carbohydrates and tolerates all breakdown products of biomass
 - Operates in harsh environments
 - Don't have to engineer “Frankenbug “
 - Produces no CO₂
- Yield advantages directly translate into economics
 - 50% higher fermentation yield (Lower opex/capex)
 - Acetogenic platform produces multiple products
- Proven industrial processes

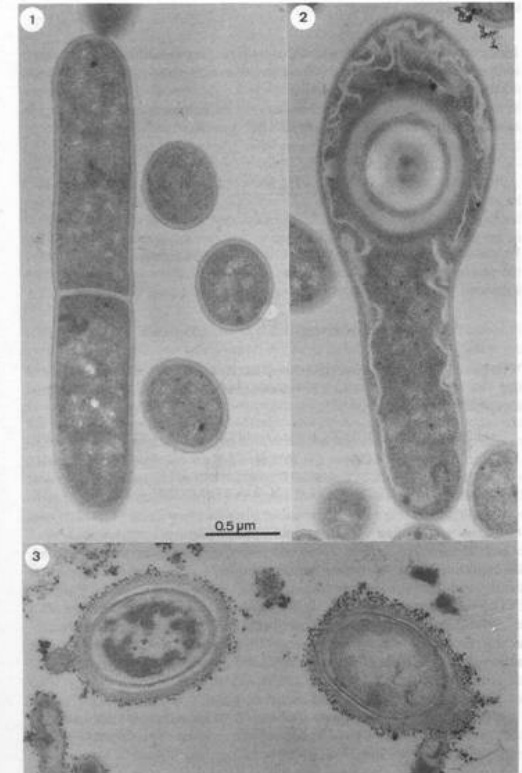


Figure 1.2. Thin sections of chemolithoautotrophically cultivated *Clostridium thermoaceticum*. Panel 1: vegetative cell; panel 2: sporulated cell; panel 3: spore.



Roadblocks to Beginning Production Today

- The winner will be the one that matches the conversion technology to the lowest cost feedstock
 - Conversion technologies for cellulosic's are rapidly catching up to those for starch based ethanol
 - ZeaChem will break ground on a pilot facility at Boardman, OR in 2008 that uses Pacific Albus residuals
- Technology certainty that will attract investment capital
 - Feedstock security issues
 - Dedicated energy crops versus residuals and/or forest thinning biomass
 - Combination of several feedstocks and sources
- Developing specialized equipment that automates the production and harvesting systems
 - Planting, cultivation, harvesting