GREENWOOD RESOURCES

A Resource That Lasts Forever™

Opportunities and Challenges for Poplar Bioenergy Farms

October 9, 2009

"Growing Poplars for Biomass and Energy"

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- Vision and Key Concepts for Biomass Energy
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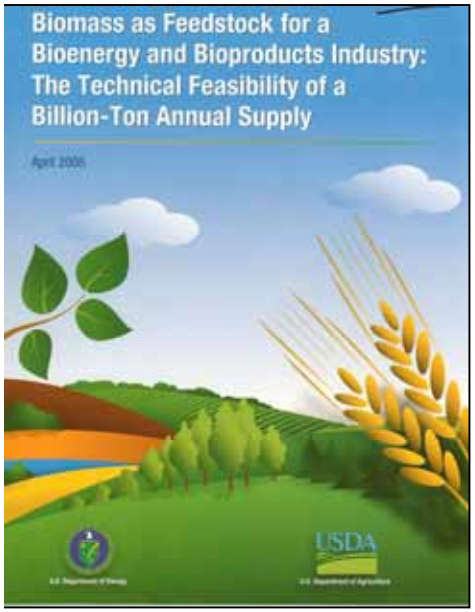
GreenWood Resources, Inc.

- Based out of Portland, Oregon
- Currently manage 38,000 acres of hybrid poplar plantations in the PNW
- Expertise in financial modeling and management, plantation development and management, genetics and clonal development, product development, marketing and sales
- Research and operations in North America, China and Chile
- Currently employ 57 people worldwide

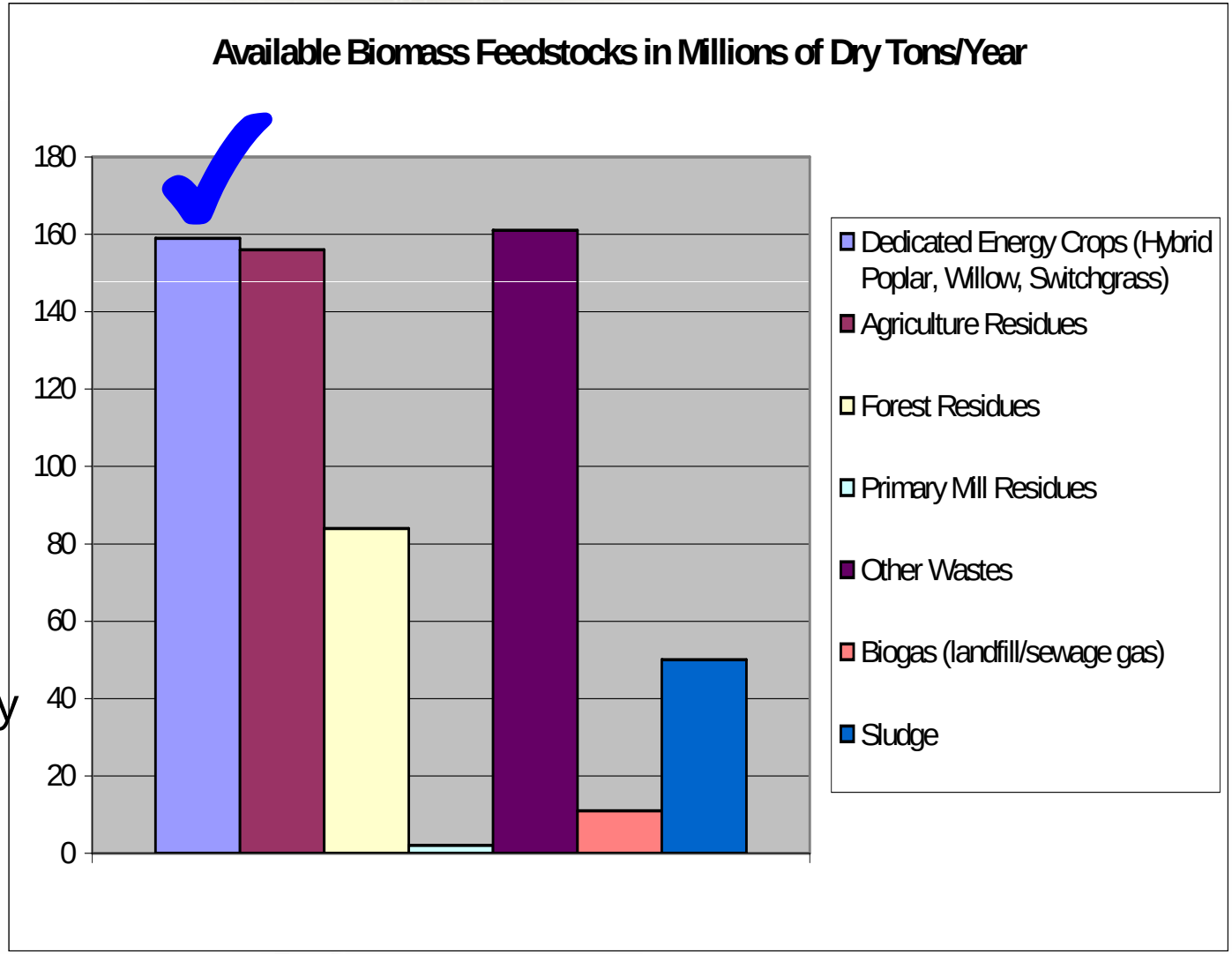
Vision for the Future

- 30 x 30 Vision
  - DOE organized effort - Biofuels could meet up to 30 percent of our present fuel needs by 2030
- Key points
  - Ethanol production and markets exist now and are growing
  - Biomass is the only renewable energy source available that can supplement transportation fuels now
  - Biofuels produced from domestic resources will reduce our dependence on foreign sources of energy
  - Energy supply diversity makes us less vulnerable to price volatilities, and supply disruptions from geopolitical uncertainties and natural disasters



Dedicated Crops Drive Growth

- USDA and DOE have projected 1 billion tons annually could meet annually renewable goals in 25 years
- Two largest sources are dedicated energy crops and agriculture residues



Key Concepts for Bioenergy Plantations

- Land – agricultural sites, reclaimed lands with flat to gently rolling topography
- Management – agronomic techniques and equipment
- Establishment and Harvesting – high levels of mechanization at every stage
- Genetics – Adaptable, pest resistant, high-yield cultivars

Cultivation

- Thorough site preparation
- Chemical and mechanical weed control
- Monoclonal plantings of elite plant materials
- Planting density: up to 2,200 stems per acre

In-Field Processing

- Cutting and chipping in the field to produce whole-tree chips
- Saves transportation costs
- Chips are transported to local or regional processing centers

Ethanol Energy Budgets

	Corn Ethanol	Cane Ethanol	Cellulosic Ethanol	Biodiesel
Largest Producer	USA	Brazil	No large scale producers	Germany
Annual Production	4.86 billion gallons	3.96 billion gallons	---	0.5 billion gallons
Energy Budget	1.3 : 1	8.0 : 1	4.6 : 1 (could be up to 30.0 : 1)	2.5 : 1
Emissions Reduction	22%	56%	91%	68%

Sources: U.S. DOE; U.S. EPA, Worldwatch Institute
From National Geographic, October, 2007, Vol. 212, No. 4

Poplar Biomass for Biochemical Conversion

Crop[1]	Glucan (%)	Xylan (%)	Lignin (%)	Ash (%)
Corn Stover	34.0	19.5	19.7	10
Wheat Straw	32.6	19.2	16.8	10
Switch grass	34.3	22.4	17.4	5
Hybrid poplar	42.1	16.2	23.5	< 1

1/ DOE Biomass Composition data base: http://www.eere.energy.gov/biomass/progs/search1.cgi

“Top Ten” Reasons for Using Poplar Feedstock

10. Fastest growing tree in the temperate zone
9. Not an annual crop
8. Eliminate large holding and storage areas
7. Lower transportation costs
6. Superior energy budgets
5. Excellent chemical conversion properties
4. Wide site adaptability
3. Superior environmental benefits
2. Can clonally propagate
1. Advances in cellulosic conversion technology

Poplar Biomass Production Costs[1]

Region	Farm Cost ($/ton)	Harvest Cost ($/ton)	Total Cost ($/ton)
Pacific Northwest	29	29	58
North Central	27	28	55
Mississippi Valley	22	26	48

1/ Growing costs reported as NPV (6.5% discount rate) per dry ton, inclusive of the cost of land rent, site preparation, planting stock, planting, and crop care through rotation.

Poplar Biomass for Renewable Energy: Direct Combustion

- Historic use of harvest residue in co-firing boilers – 10-20% of total biomass
- Will likely not produce significant biomass for conversion from residuals
- Future: dedicated coppice production systems

Improving Production Economics: Biomass Yield

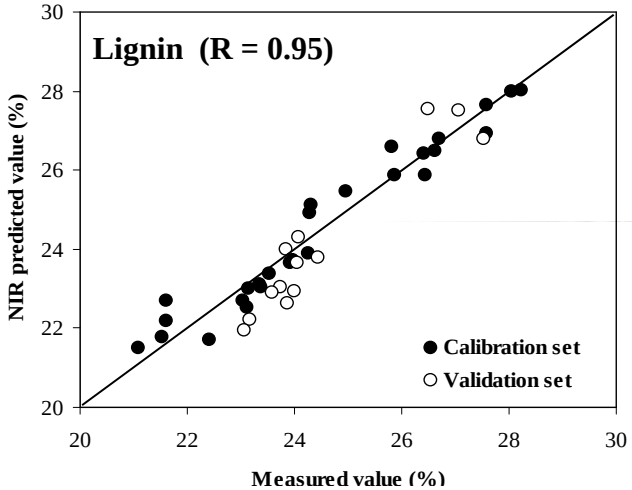
Classical approach of hybridization and selection for:

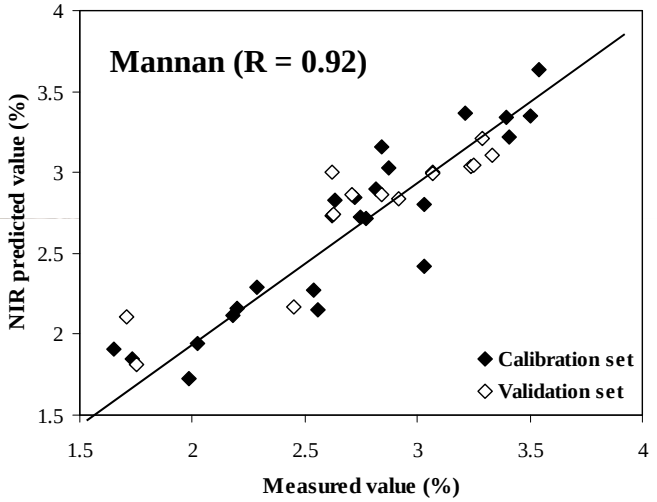
1. Growth rate
2. Wood density
3. Pest resistance
4. Adaptability to marginal sites

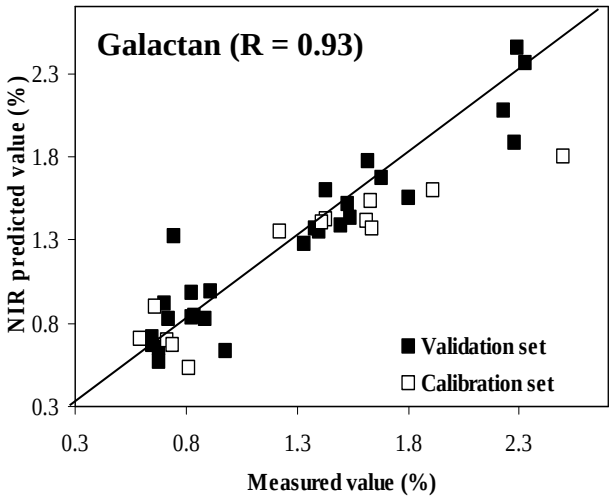
Target growth rates of 7.0 to 8.2 dry tons acre^{-1} yr $^{-1}$

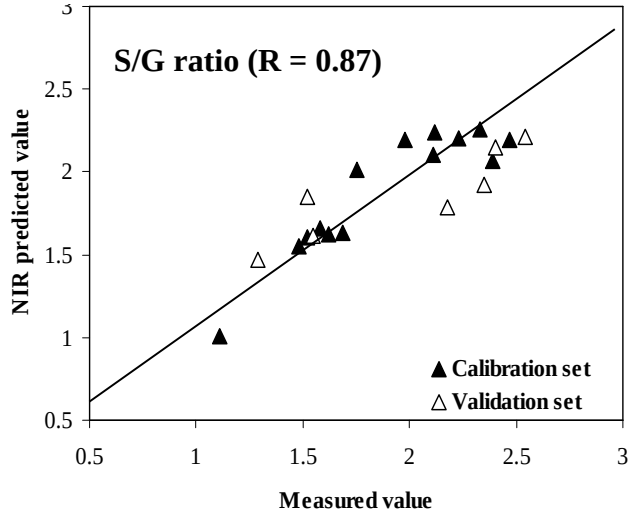
Predicting Chemical Composition With NIR

Relationship between measured/actual value and NIR predicted value using 1st derivative spectra









Populus trichocarpa Proof-of-Concept Population

S/G Lignin Ratio (phenotypic standard deviates) Additive Inheritance Model

			Male				
			GS-039-08	GS-050-08	PS-033-94	GS-155-09	GS-046-11
			Independence, OR	Santa Clara, OR	Albany, OR	Vancouver, WA	Canby, OR
Female			**2.31**	**0.98**	**0.03**	**-1.05**	**-1.52**
GS-006-04	Camas, WA	**1.64**	1.98	1.31	0.84	0.30	0.06
PS-052-90	Scio, OR	**0.99**	1.65	0.99	0.51	-0.03	-0.27
GS-001-03	Carson, WA	**-0.05**	1.13	0.46	-0.01	-0.55	-0.78
GS-018-12	Stella, WA	**-0.83**	0.74	0.08	-0.40	-0.94	-1.17
GS-010-01	Bonneville, WA	**-2.06**	0.13	-0.54	-1.02	-1.55	-1.79

Improving Production Economics: Feedstock Quality

Tuskan, G. A. et al. 2006. The genome of black cottonwood *Populus trichocarpa* (Torr. & Gray). **Science** 313: 1596-1604.

1. "Lignin and polysaccharide biosynthesis in wood formation of *Populus trichocarpa*"

   North Carolina State University

2. "Manipulation of lignin biosynthesis to maximize ethanol production from *Populus* feedstock"

   Purdue University

3. "Cellulose and lignin biosynthetic pathways of *Populus trichocarpa*"

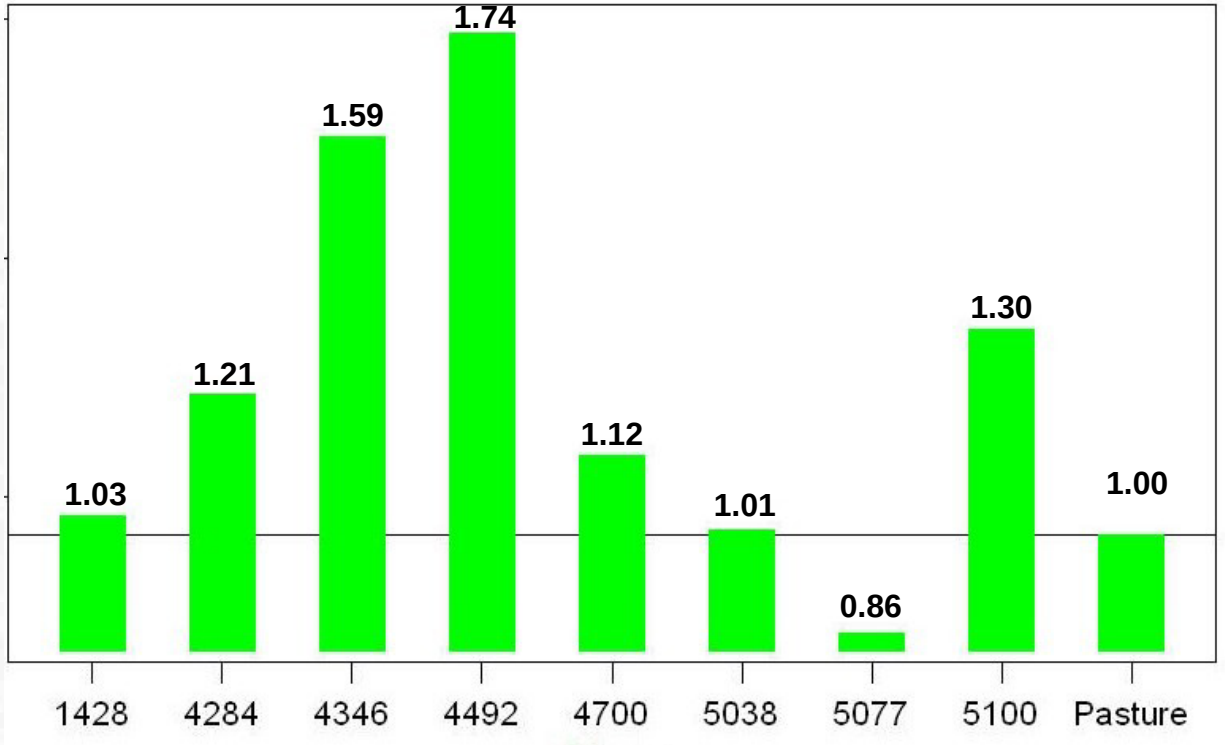
   University of California, Davis, GreenWood Resources, Michigan Tech University, National Renewable Energy Laboratory

Improving Production Economics: Farming Strategy

High-density plantings managed on two- to three-year coppice rotations

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

Improving Production Economics: Soil Carbon Sequestration



***P. x generosa* varieties managed along the lower Columbia River floodplain**

Conclusion: Poplar's Strategic Position

Well developed production system

- Proven varieties and farming techniques
- Established wood handling and storage capabilities
- Need to optimize for bioenergy production

Conclusion: Poplar's Strategic Position

Excellent opportunity to lower farming costs

- Classical and molecular biology tools
- Tailored harvesting technology

Conclusion: Poplar's Strategic Position

Heightened environmental and societal benefits

- Relatively low energy inputs farming a perennial crop
- Elevated rates of soil carbon storage
- Sustainable production to support rural communities


Thank you!
Questions?