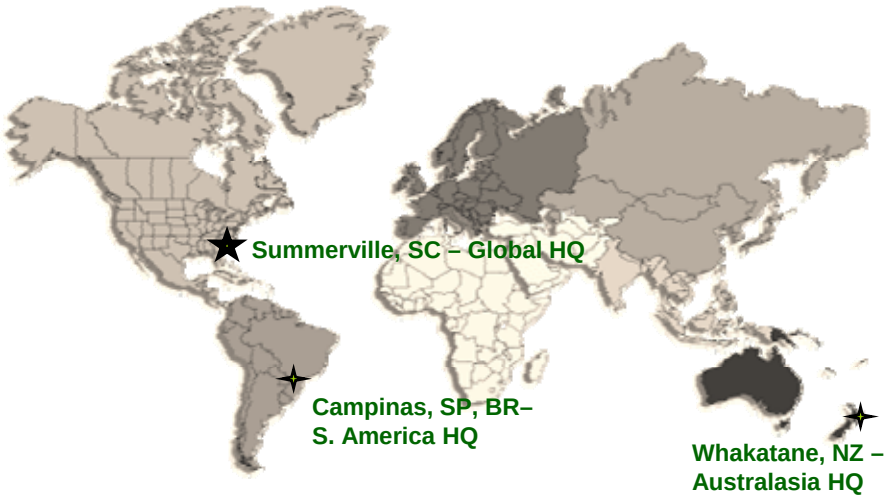
ARBORGEN®

Biotechnology Approaches to Woody Crop Improvement

Hybrid Poplar for Biomass & Bioenergy: A Symposium
Thursday, November 5th, 2009

A Global Leader in Tree Improvement, Production & Sales



Americas
- 250MM Sales
- 33% share of pine market
- 20% share of hardwood market

Australasia
- 23MM Sales
- 45% NZ Radiata market
- 20% Australia softwood market

- The largest producer of trees for planting
  - >275 million trees sold per year
- Technology leader
  - Pipeline of world-class elite germplasm
  - Unique platform is built
  - Most forestry field / regulatory trials
- Global with business operations in:
  - Southeast U.S.
  - New Zealand & Australia
  - Brazil
- A team with experience, skill and credibility for delivering operational, technical and business success

Demand for Woody Biomass is Growing

Demand Drivers

Pulp, Paper & Wood Products

Pellets (Heat & Power)

Electricity (Direct & Co-firing)

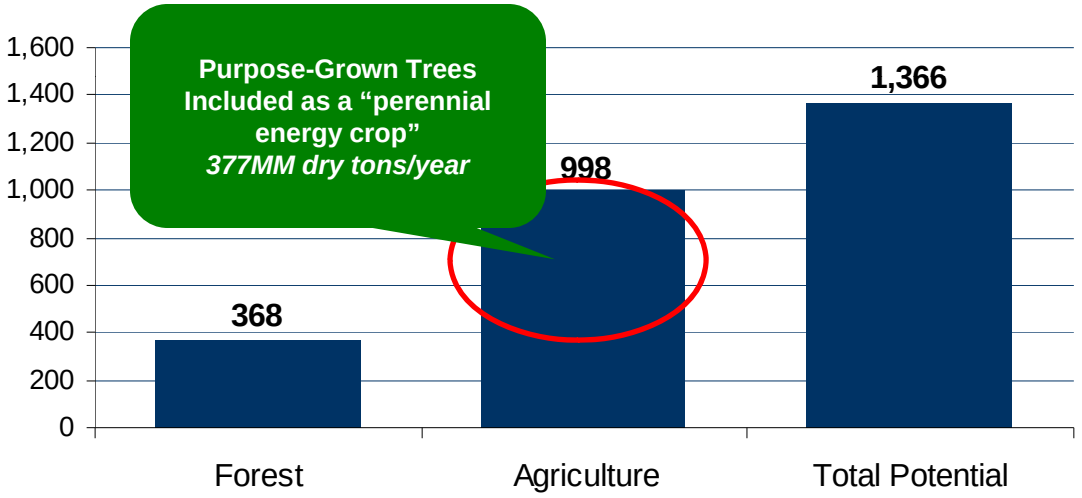
Advanced Biofuels

Trees and Wood Have Been Identified as Part of the Solution

- Trees have been a primary source of energy throughout human history
- Trees have been managed as a "biomass" crop for generations
- Trees have several fundamental advantages
  - "Storage on the Stump"
  - Existing logistical understanding
  - Harvest year-round
  - Lower risk production system
  - Landowner flexibility

Annual Biomass Resource Potential from Forest And Agricultural Resources

Million Dry Tons/Year



"Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion Ton Annual Supply," USDA/DOE 2005

Several Technologies Improve Biomass Supply and Cost

Improved Germplasm

Management Systems

Biotech Improvements

- *Improved growth (biomass yield)*
- *Stress tolerance*
- *Improved wood quality*

Case Study: Hardwood Productivity Improvement Potential through the Application of Knowledge & Technology – Biofuels Applications

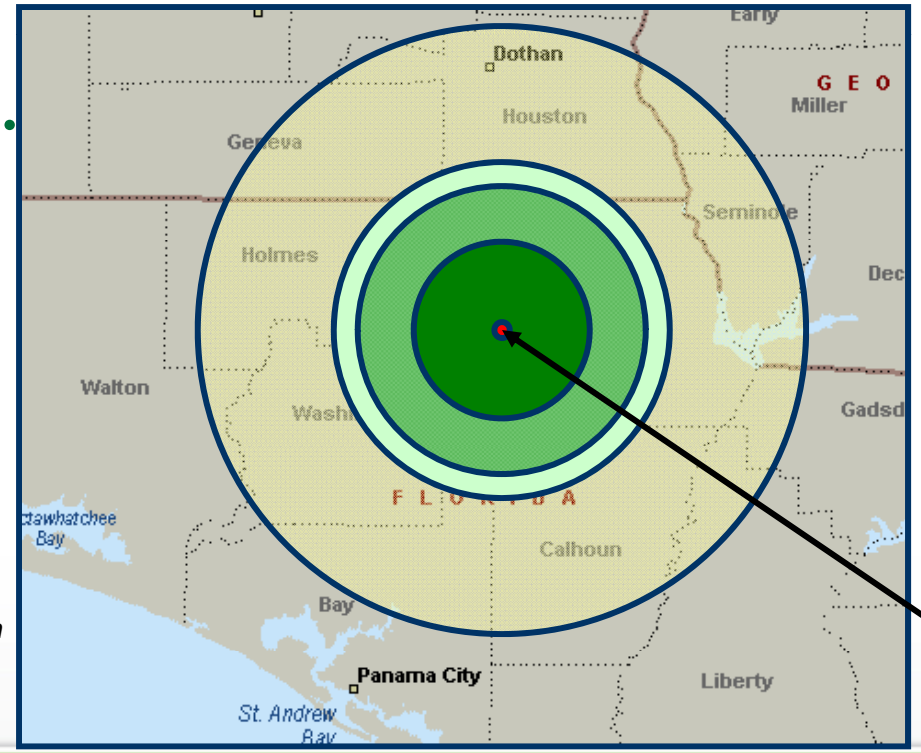
	Baseline			Potential
				
	Naturally Regenerated	Planted Trees	Biomass Management	Biotech Improvements
Biomass Yield	0.5 Dry Ton/Acre/Year	5 to 7	6 to 8	18 to 23
Ethanol Yield[1]	50 Gallons/Acre/Year	500 to 700	600 to 800	1,800 to 2,300
FFVs Fueled[2,3,4]	1 FFV/Acre	10 to 14	12 to 16	35 to 45

[1]100 gallons ethanol/dry ton biomass
[2]Assumes harvest after 1 year's growth
[3]FFVs fueled for 1 month period
[4]Fuel economy = 20 miles/gallon, Travel = 1,000 miles/month

High Productivity Enables Close Proximity

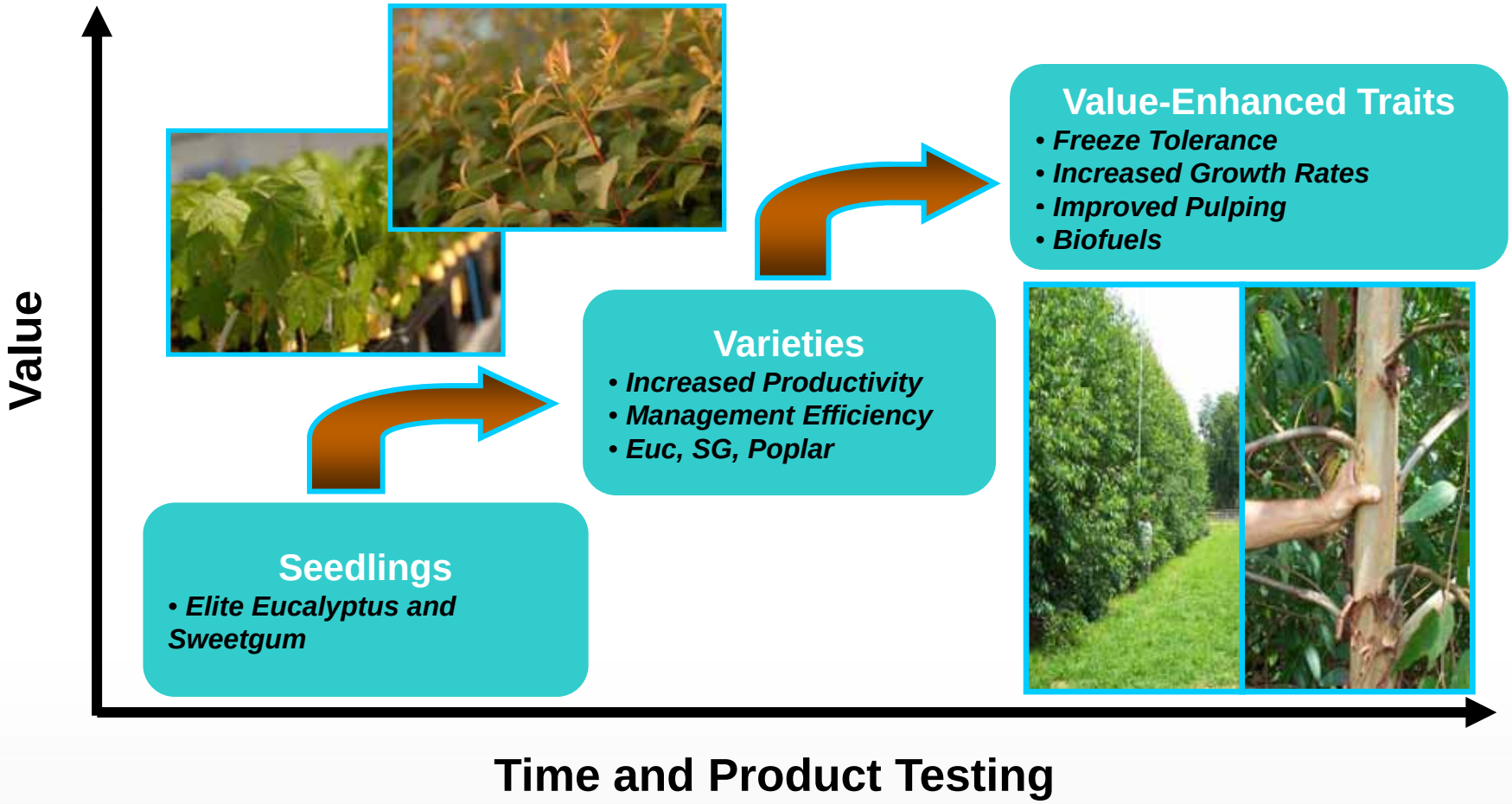
- A processor consuming 1 million dry tons of wood from forest residues would require a radius of over 35 miles to support it.
- Biotechnology can reduce the area needs by over 90%

MORE WOOD.
LESS LAND.®



Assumptions:
- *1 million dry tons/year consumption*
- *20% land utilization*

New Technologies Create Significant Value in Hardwoods



High Productivity in Freeze-Sensitive Tropical Eucalyptus

38 Months Growth – Central Florida

Pulpwood Yield Potential:
7.5 – 12.5 dry tons/ac/yr

Biomass Yield Potential:
12.5 – 17.5 dry tons/ac/yr

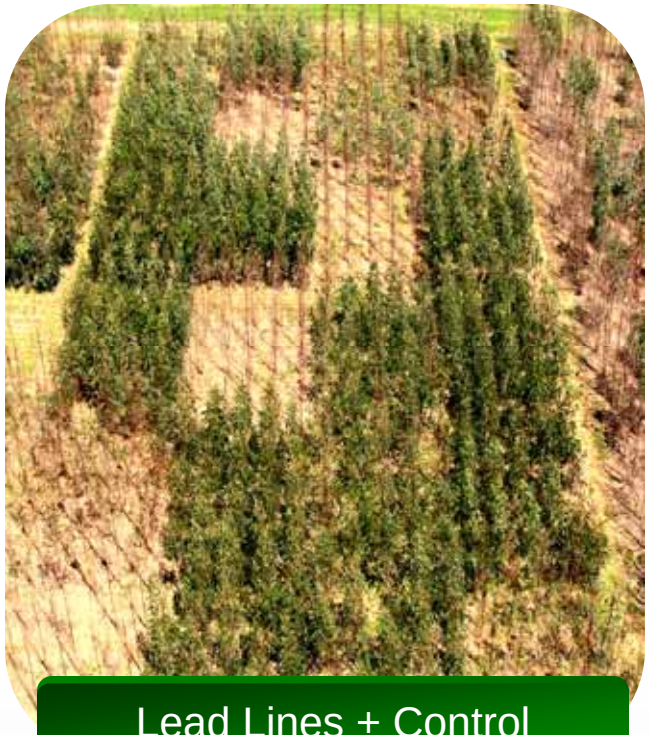
Freeze Tolerance Achieved in Multiple Field Trials

- Results from first winter in South Carolina

Control

Lead Line

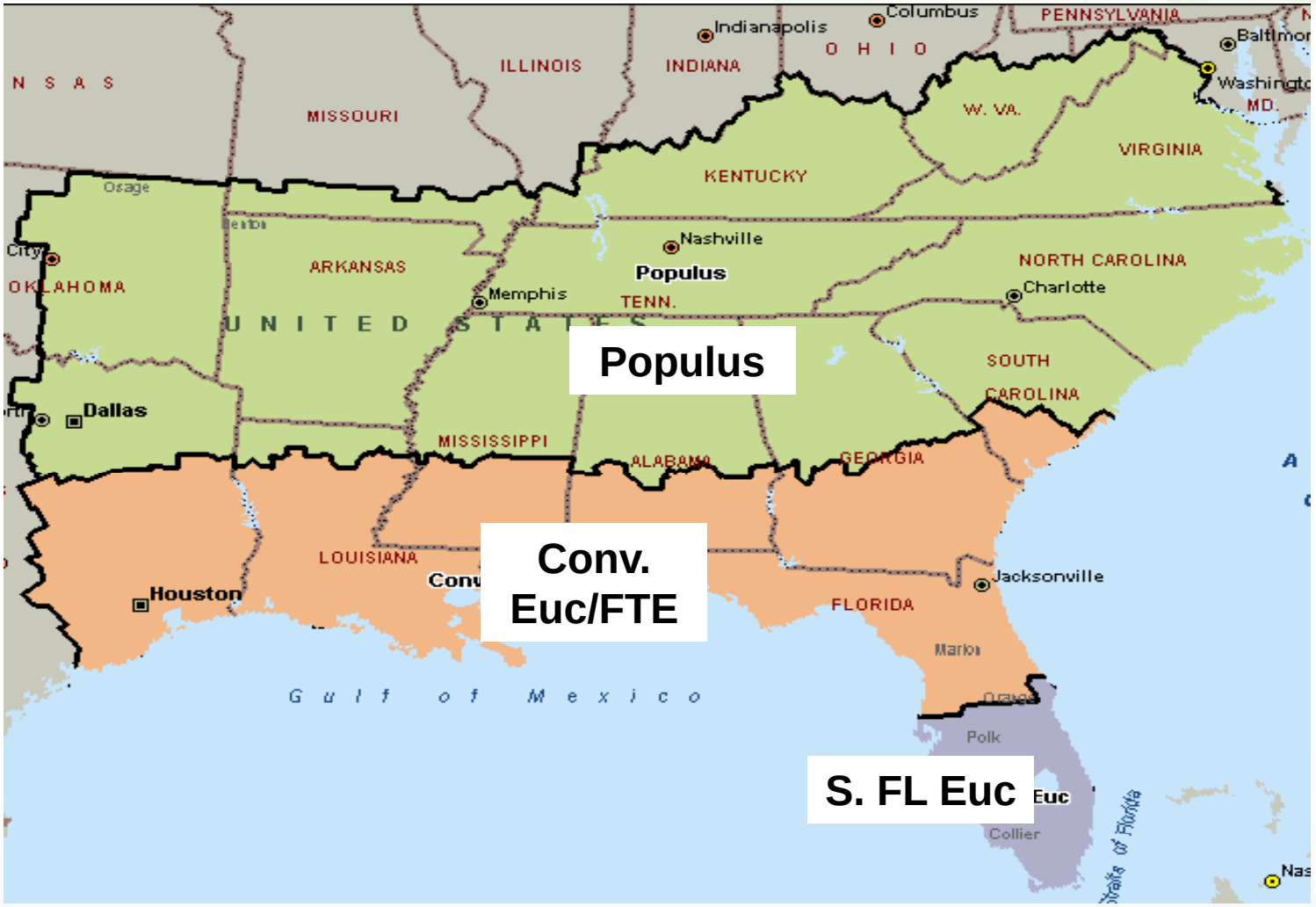
- Results from second winter in Alabama



Lead Lines + Control

Field results indicate freezing tolerance to ~16°F (- 8° to - 9°C)

Hardwood species adapted for each region



Poplar Tree Improvement

12-year-old hybrid poplar planted in NC

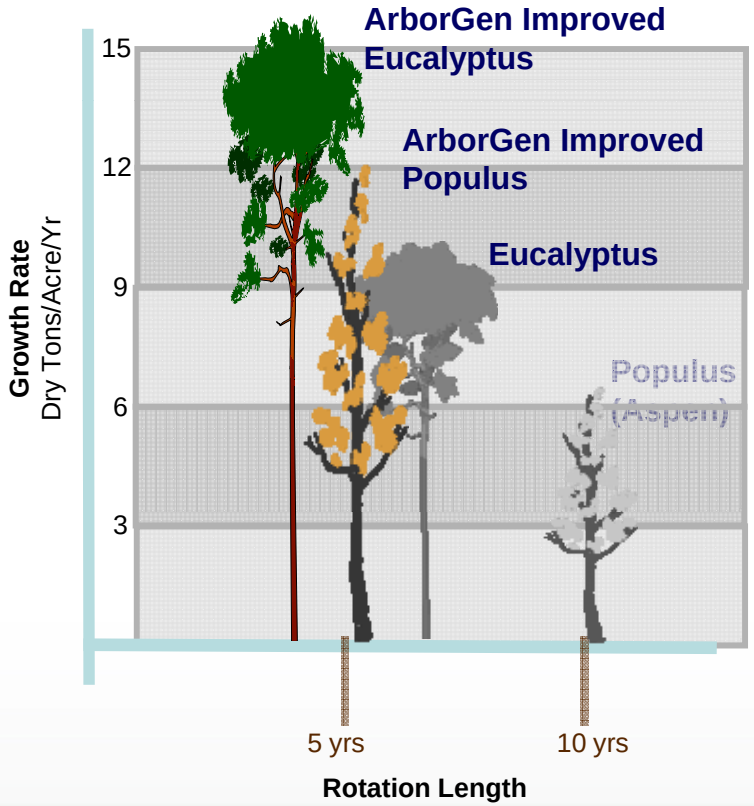
8-yr-old hybrid aspen in KY progeny trial

Populus species have been successfully grown on uplands sites. We are screening a large number of varieties for adaptability

Biotechnology to improve hardwood growth rates

ArborGen is using proven growth genes to enhance hardwood productivity across a range of species

> 100% Volume Gain



ArborGen Short Rotation Populus Testing is underway at multiple locations

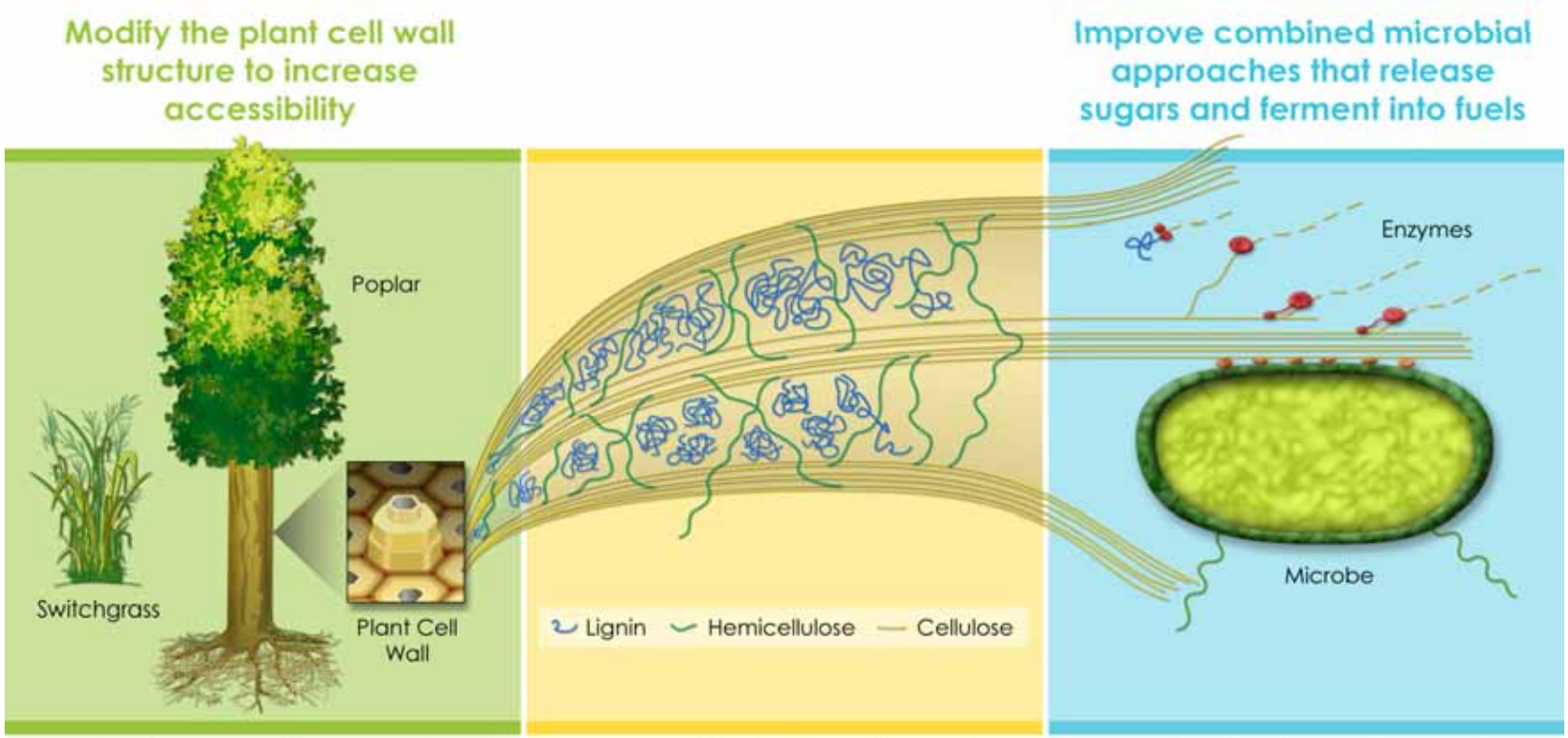
1st year short rotation cottonwood

2nd year short rotation aspen

Additional Processing Efficiency Improvements In Development

- Increased accessibility of cellulose to enzymes (i.e., biofuels)
- More easily extractable lignin
- Increased amount of non-crystalline cellulose
- Increased hemicellulose
- Increased wood density

BESC Objective - Increase the Accessibility of Biomass Sugars by Reducing the Recalcitrance



Both utilize rapid screening for relevant traits followed by detailed analysis of selected samples

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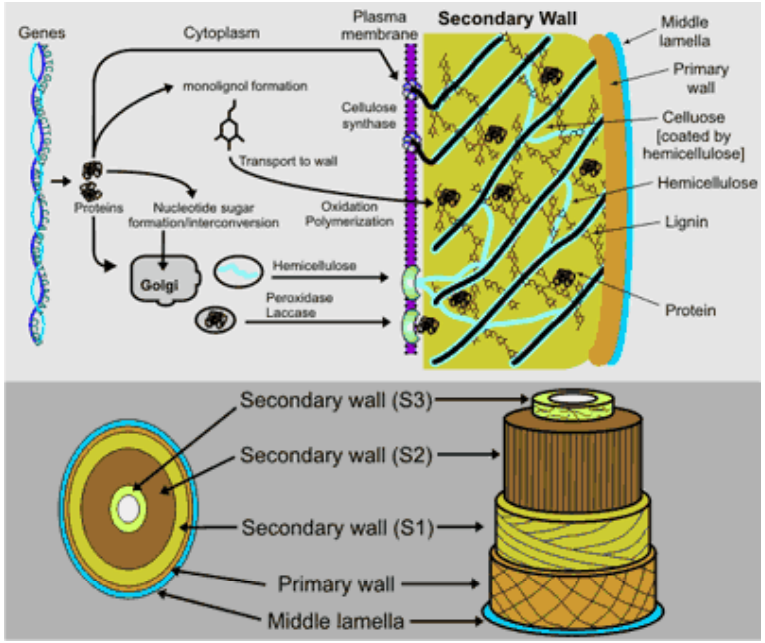
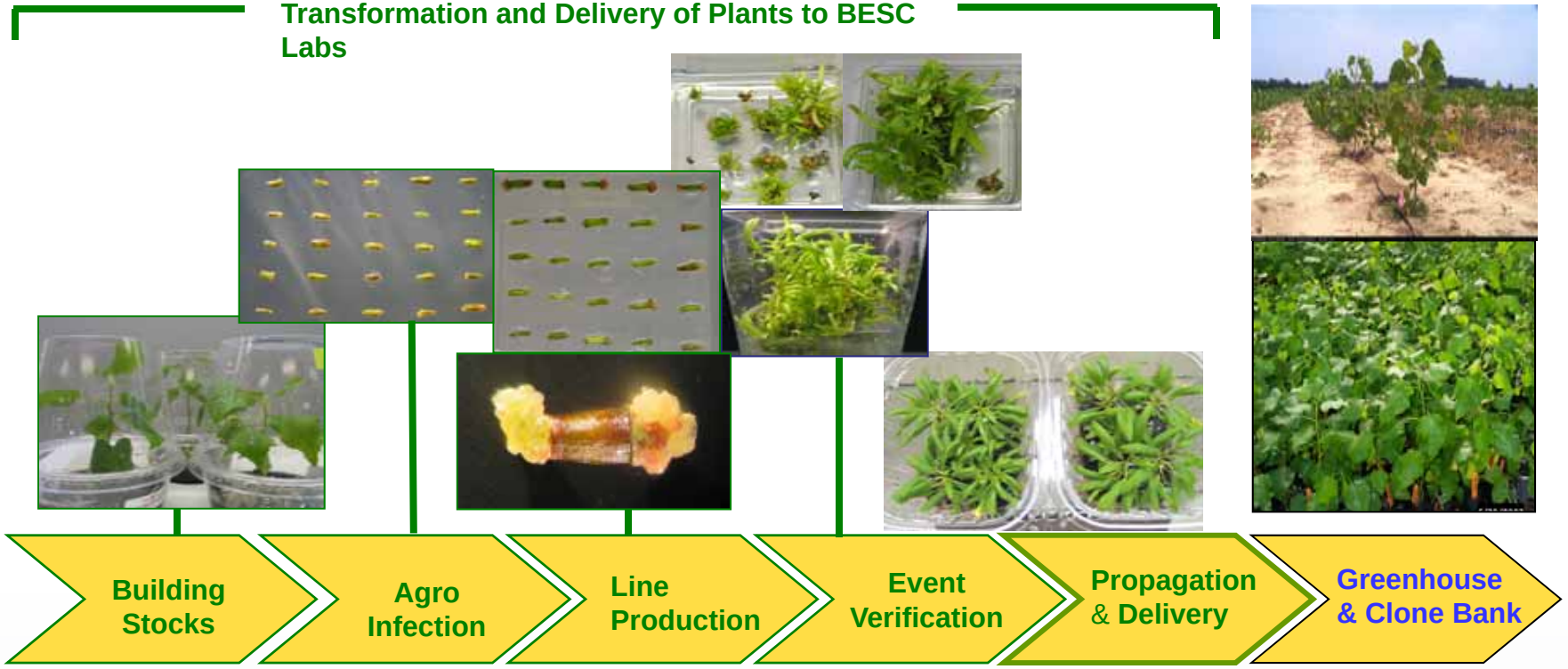


Targets:

800-1000 genes involved in biosynthesis of cell wall

Overexpress and/or knockdown genes to reduce recalcitrance

ArborGen's Populus Transformation Pipeline – BESC Project



Summary

- Demand for woody biomass is on the rise
- Trees have numerous supply chain advantages over alternatives
- Trees are and will be managed to meet sustainability targets
- ArborGen technology and insight is revolutionizing productivity potential
  - Increased yields
  - Shortened rotations
  - Increased environmental adaptability
  - Higher quality wood

For more information contact:

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