



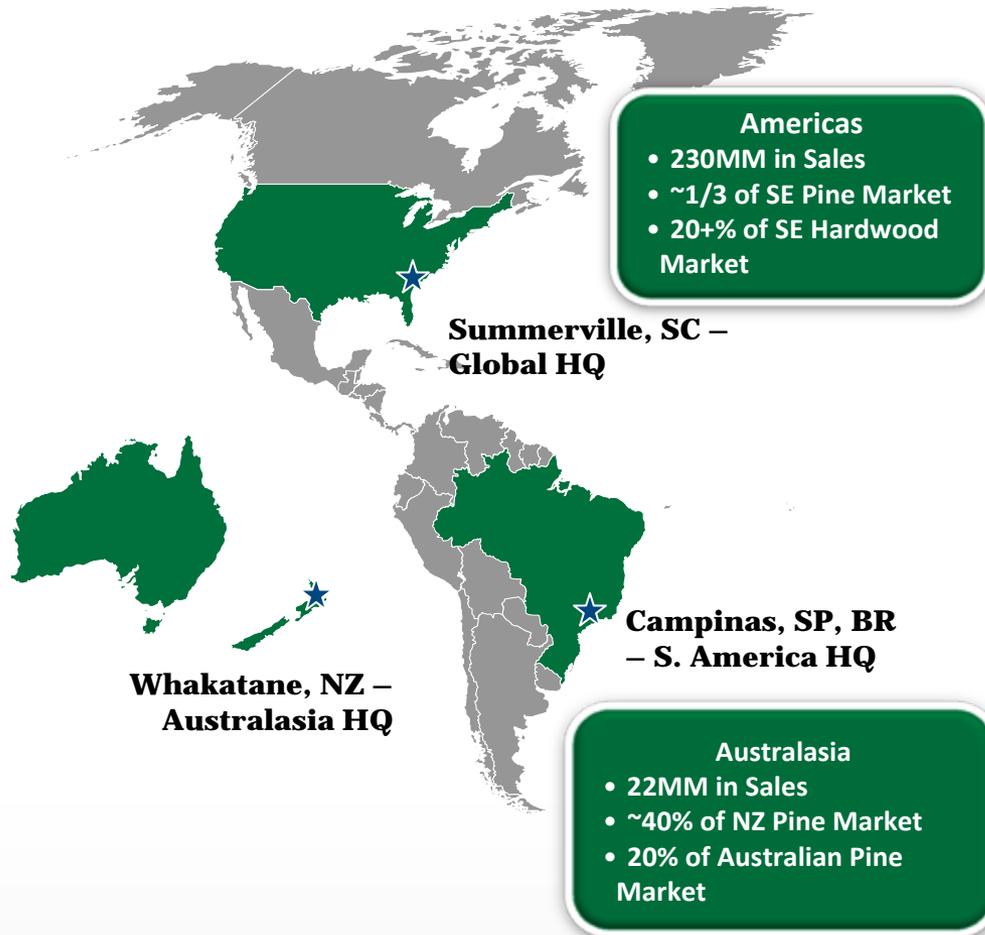
# Purpose Grown Trees as an Economical and Sustainable Biomass Feedstock

Biomass 2010

March 30, 2010



# A Global Leader in Tree Improvement and Production



- Leading producer of trees for planting
  - ~ 250 million trees per year - one for every man, woman and child
- Global operations
  - Southeastern U.S.
  - New Zealand & Australia
  - Brazil
- Providing step-changes in tree productivity
  - Faster growth – shorter rotation
  - Improved wood quality
  - Improved processing efficiency (pulp & bioenergy)
  - Stress tolerance
  - Biomass production
  - Increased carbon up-take

# Commitment to Sustainable Forestry

## More Wood. Less Land.®



- Increasing demand for wood
  - Per capita consumption of wood-based products up 17 times over last century
  - Population ↑ 50% over next 40 years and wood demand will follow
  - Increased environmental demand for wood
    - Recognition of the value of wood fibre as a source of biomass
    - ... and as a means of carbon sequestration
- Delivering technologies that improve productivity, quality and sustainability of purpose grown, working forests
- Providing step-changes in tree productivity through conventional breeding and biotechnology
  - Meet steadily rising demands for wood, fiber and energy from purpose grown trees
  - Mitigate impacts of climate change and urban development that are putting increasing pressure on native forests
- Technology improvements enable more wood and biomass to be produced per acre — protecting native forests

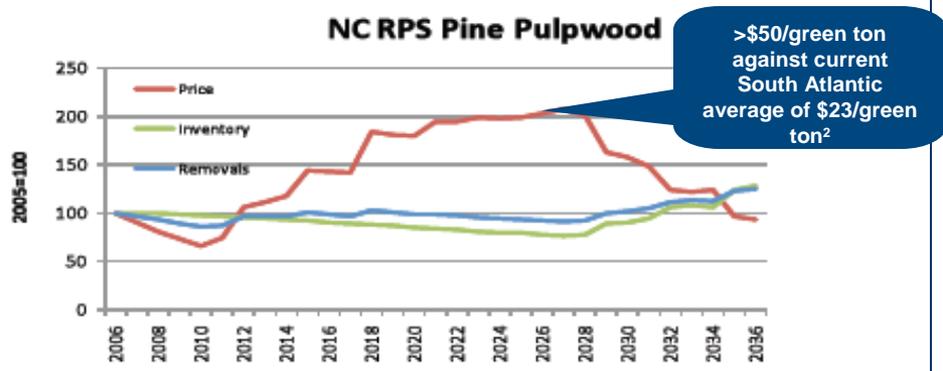


# Purpose Grown Trees are Part of a Sustainable Solution to Meet Biomass Demand



## Forest Residues are not the long term solution

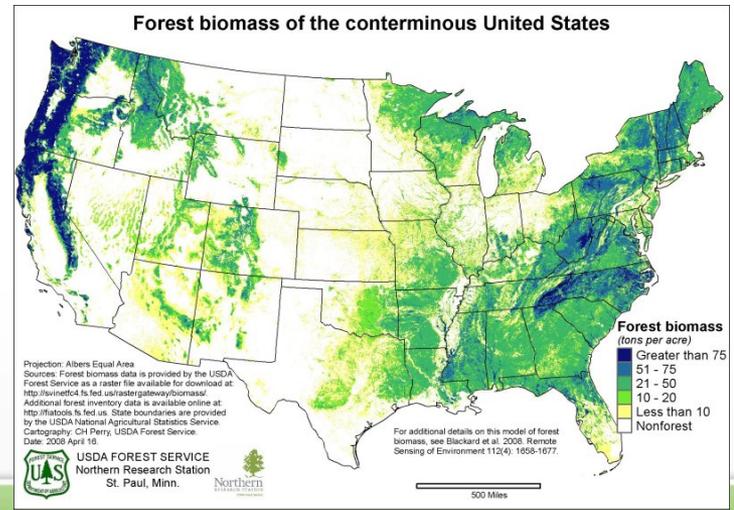
- Multiple regional studies show a dramatic increase in biomass prices with increasing demand when only forest residues are considered



“Residuals could be important but expected demand will quickly exceed residual availability.”<sup>1</sup>

## Trees are the biomass energy solution for the Southeast

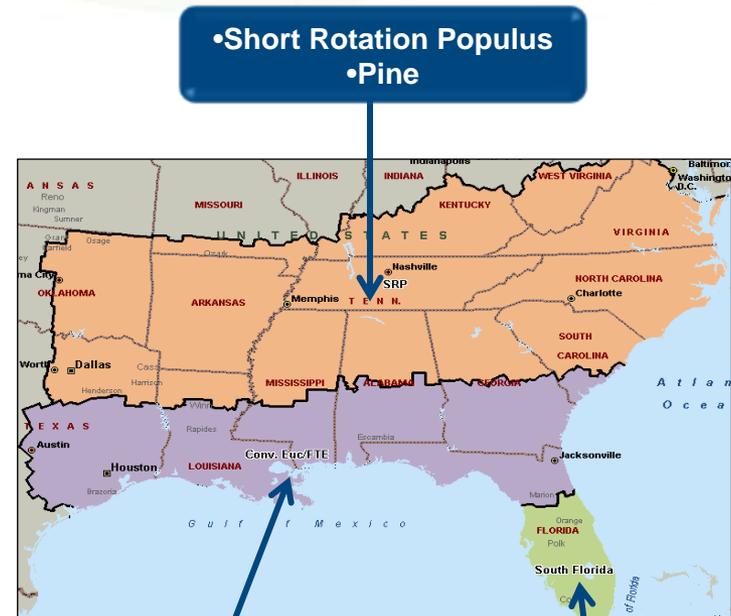
- Trees, along with other purpose-grown energy crops, have great potential to increase biomass supply
- Purpose Grown Trees will be a large part of the solution in the Southeast where plantation forestland is abundant and agricultural alternatives are limited



- Abt, R.C. Cabbage, F.W. Galik, C. Henderson, J.D. Estimating Biomass Supply in the U.S. South. SOFAC Regional Meeting. August, 2009
- RISI Wood Biomass Market Report. May, 2009

# Woody Biomass Products Tailored to Address Biomass Markets in the Southeast

- Demand for biomass for the production of transportation fuels and electricity is expanding
- Woody biomass solutions:
  - High planting density management systems
  - Faster biomass growth with shorter rotations
  - Products tailored for geography



•Freeze Tolerant Tropical Eucalyptus  
•Subtropical Eucalyptus Species  
•Pine

•Tropical Eucalyptus

# Demand for Woody Biomass is Growing

## Demand Drivers

### Pulp, Paper & Wood Products



### Pellets (Heat & Power)



### Electricity (Direct & Co-firing)



### Advanced Biofuels



# Numerous Technologies Improve Tree Productivity

## Improved Germplasm



## Management Systems

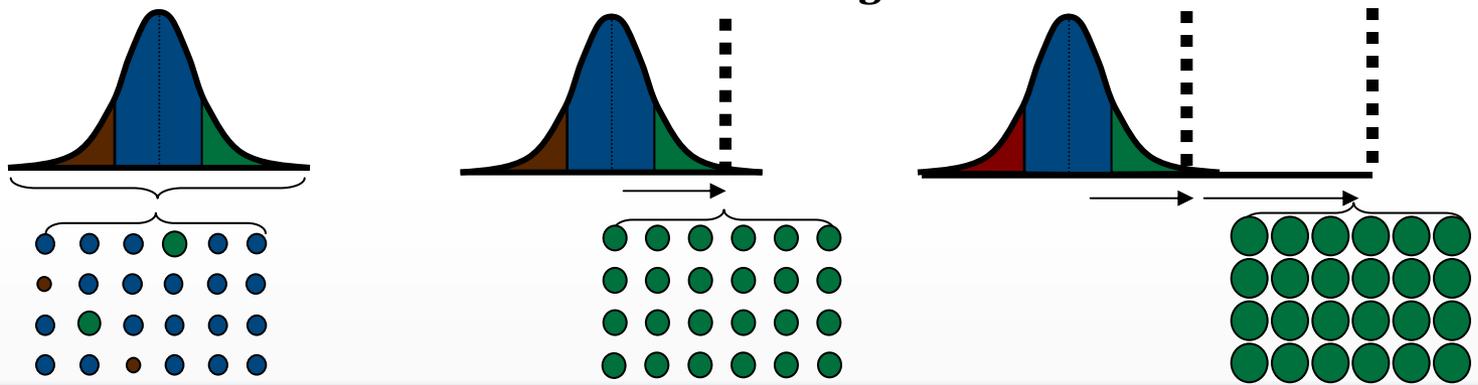
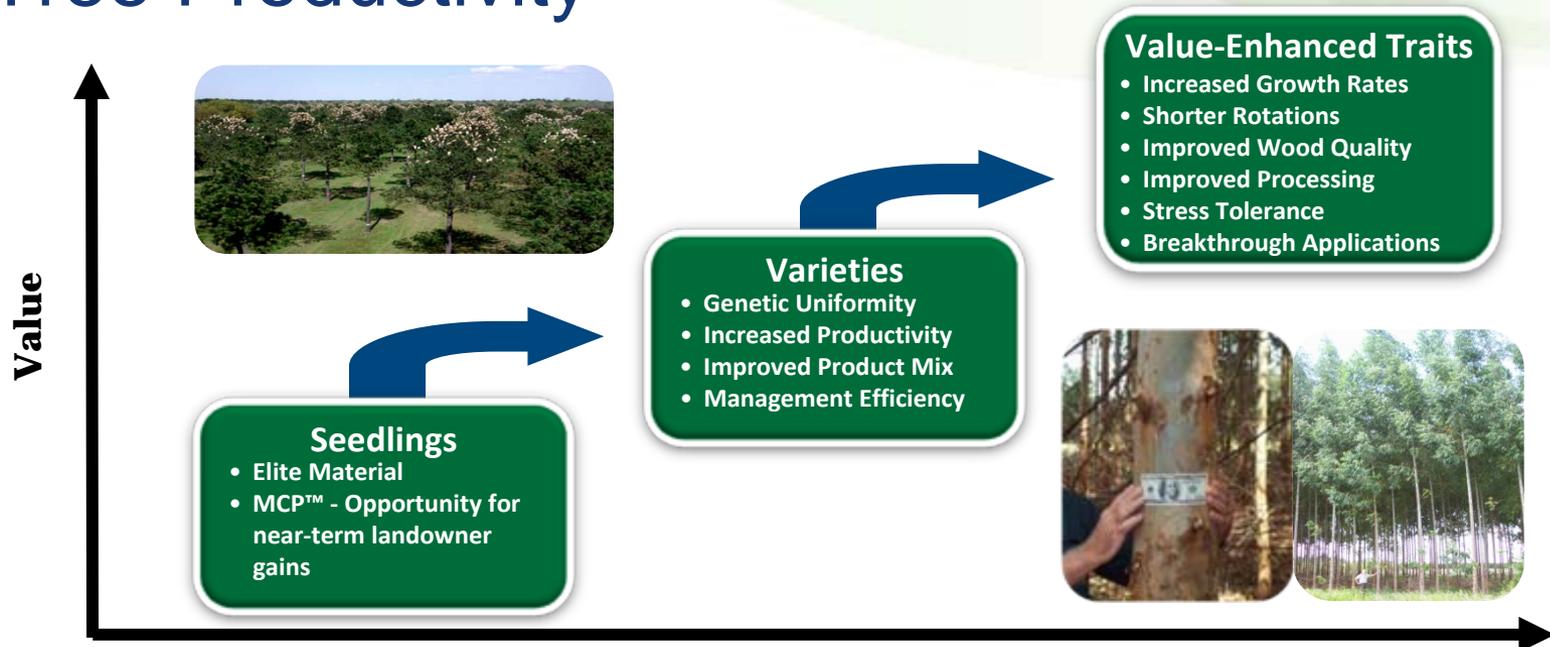


## Biotech Improvements

- Improved Growth
- Shorter Rotation
- Stress Tolerance
- Improved Processing
- Improved Wood Quality



# Biotechnology Brings a Step-Change in Tree Productivity



# Purpose Grown Trees provide Benefits Throughout the Supply Chain



## Feedstock Production

### Productivity

- Equivalent or superior biomass productivity potential as other sources



## Logistics

Harvest    Storage    Transport

### Supply chain

- Year round harvest
  - Match supply with demand
  - No storage challenges
  - Ability to build inventory
- Infrastructure well developed
  - Harvesting and handling
  - Transportation



## Processing

### Conversion

- Matching of physical and chemical tree traits to processes
- Fast growing trees can be utilized in multiple markets

**Increasing productivity is the most influential value driver in determining wood delivered cost**

# Case Study: Hardwood Productivity Potential through the Application of Technology



	Baseline			Potential
	Naturally Regenerated	Planted Trees	Biomass Management	Biotech Improvements
<b>Biomass Yield</b>	1 to 2 Green Tons/Acre/Year	10 to 14	12 to 18	27 to 40
<b>Ethanol Yield<sup>1</sup></b>	50 to 100 Gallons/Acre/Year	500 to 700	600 to 900	1350 to 2000
<b>Biopower Yield<sup>2</sup></b>	750 to 1,500 kWh/Acre/Year	7,500 to 10,500	9,000 to 13,500	20,250 to 30,000

<sup>1</sup>100 gallons of ethanol per dry ton of biomass, assumes 50% moisture content, w.b.  
<sup>2</sup>1.5 MWh per dry ton of biomass, assumes 50% moisture content, w.b.

# Biomass Focused Management of Subtropical Eucalyptus

- Increasing planting densities and shortened rotations along with the ability to utilize whole-tree biomass increases productivity
- Projected to yield 14 to 18 green tons/acre/year, 4 year rotation, 3 harvests
- Ability to coppice generating multiple harvest crops from a single planting

**Subtropical Eucalyptus  
Example**

**8-yr-old Subtropical Eucalyptus in  
South Carolina**

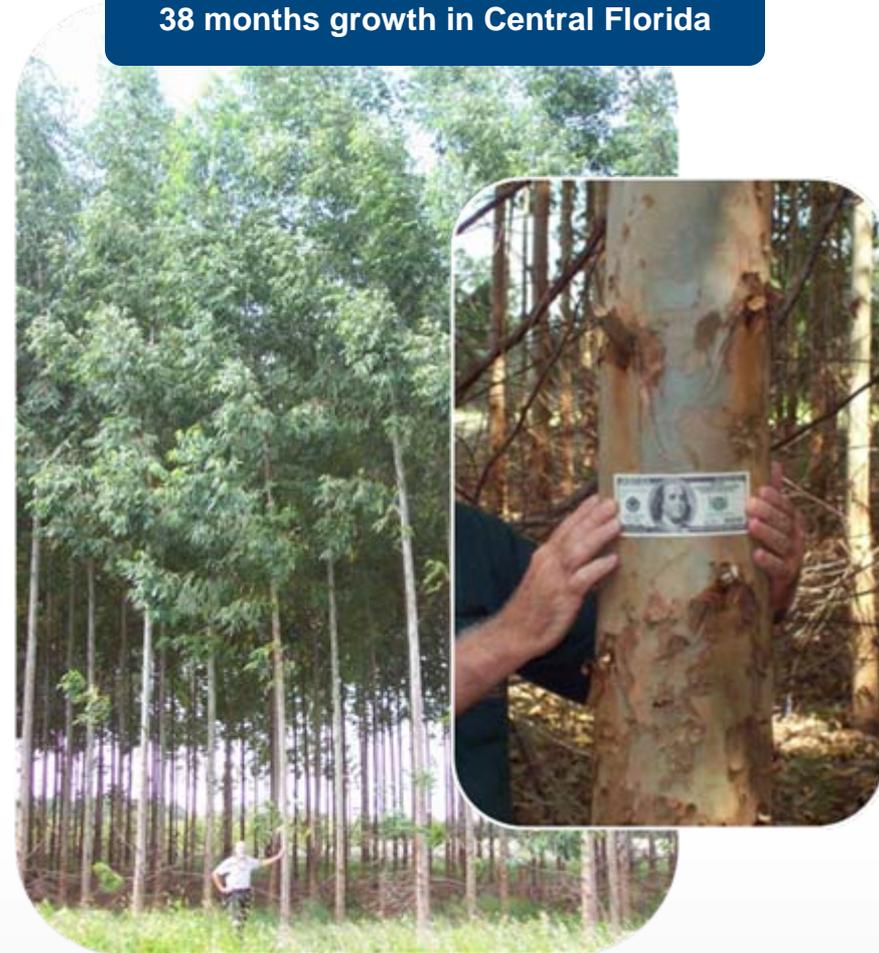


**High Density Eucalyptus Trial in Central  
Florida at Planting**

# Biomass Focused Management of Tropical Eucalyptus

- Increasing planting densities and shortened rotations along with the ability to utilize whole-tree biomass increases productivity
- Projected to yield 27 to 33 green tons/acre/year, 2.5 yr rotation, 3 harvests
- Ability to coppice generating multiple harvest crops from a single planting

38 months growth in Central Florida



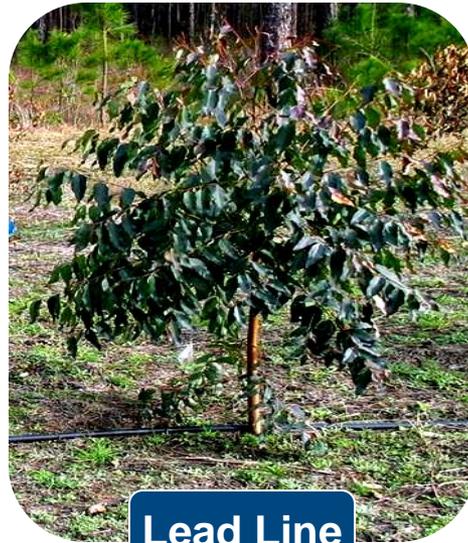
**Tropical Eucalyptus  
Example**

# Freeze Tolerant Eucalyptus Field Performance Demonstrated

Field results indicate freezing tolerance to ~16°F (-8° to -9°C) Height @ 48 months – 56 feet, DBH @ 48 months 6.4 inches Biomass Yield Potential: 27 to 40 green tons/acre/year



Control



Lead Line

Freeze Tolerant  
Eucalyptus Example



Lead Lines + Control

# Biomass Focused Management of Populus

- Increasing planting densities and shortened rotations along with the ability to utilize whole-tree biomass increases productivity
- Projected to yield 12 to 15 green tons/acre/year on a 5 yr rotation
- Ability to coppice generating multiple harvest crops from a single planting



**Populus Example**



**Cottonwood Varietal Screening Trial**

# Case Study: Pine Productivity Potential through the Application of Technology



## Baseline



## Potential



### Currently Planted

### Biomass Management

### Improved Germplasm

### Biotech Improvements

**Biomass Yield**

**4 to 6 Green Tons/Acre/Year**

**8 to 11**

**10 to 12**

**13 to 17**

**Ethanol Yield<sup>1</sup>**

**200 to 300 Gallons/Acre/Year**

**400 to 550**

**500 to 600**

**650 to 850**

**Biopower Yield<sup>2</sup>**

**3,000 to 4,500 kWh/Acre/Year**

**6,000 to 8,250**

**7,500 to 9,000**

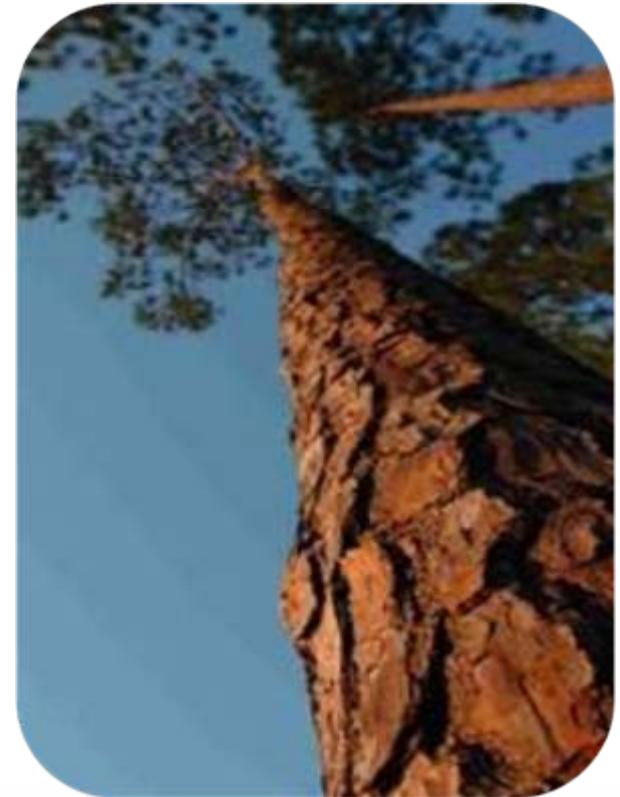
**9,750 to 12,750**

<sup>1</sup>100 gallons of ethanol per dry ton of biomass, assumes 50% moisture content, w.b.

<sup>2</sup>1.5 MWh per dry ton of biomass, assumes 50% moisture content, w.b.

# Purpose Grown Pine has Excellent Potential as a Bioenergy Feedstock

- Southeastern pine plantations represent the largest market for planted trees in the United States
- Landowner management decisions are currently driven by sawtimber production
- Biomass focused management regimes have the potential to improve biomass productivity and provide high returns to landowners



**Purpose Grown  
Example**

# Biomass Focused Management of Loblolly Pine Seedlings

- Increasing planting densities and shortened rotations along with the ability to utilize whole-tree biomass increases productivity
- Projected yield at age 10 at 1,000 trees/acre:
  - 80 to 110 green tons/acre

**High Density Pine Trial  
in Georgia at Age 6  
1,800 trees/acre**



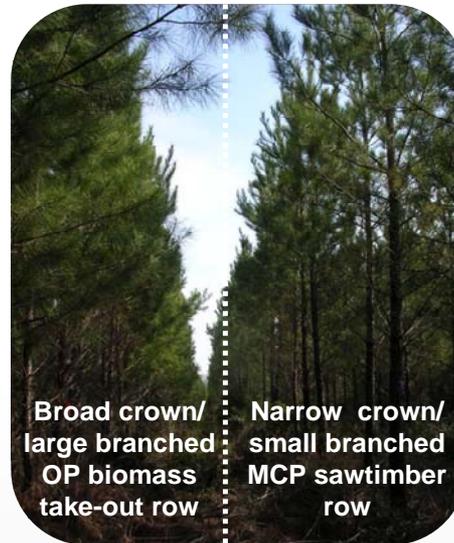
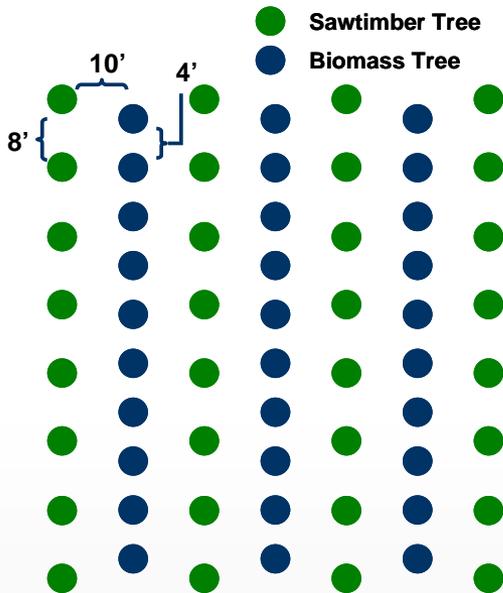
**Loblolly Pine Example**

# FlexStand™ Systems

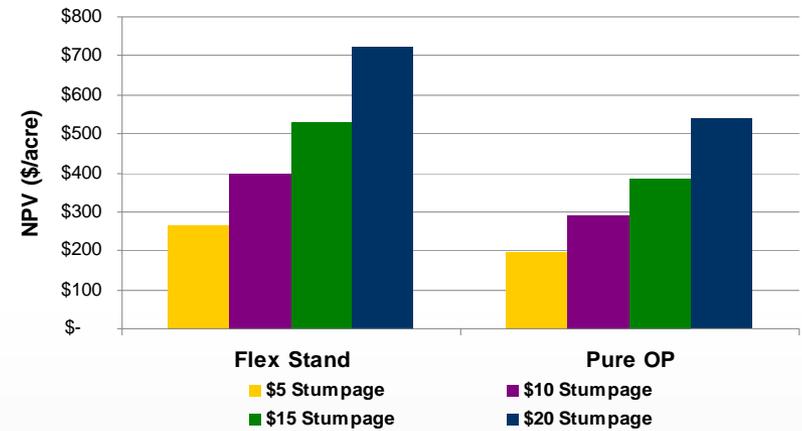


- Stands established to optimize production of multiple timber products for tomorrow's uncertain markets
  - Efficient use of genetic material
  - Focus resources by product value

- FlexStand™ Systems Provide High Biomass Yields and High Returns for Landowners

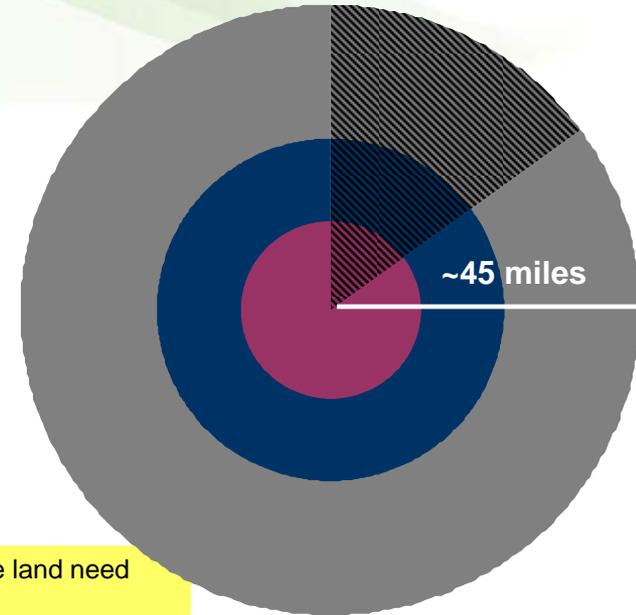


Regime	Thinning		CC-23yr		
	Biomass Row (Gtons/ac)	Crop Row (Gtons/ac)	Pulp (Gtons/ac)	CNS (Gtons/ac)	ST (Gtons/ac)
Flex Stand	56	3	17	73	42
Pure OP	18	21	18	73	33



# High Productivity Enables Close Proximity

- The high productivity of purpose grown trees and biomass regimes can reduce land area needs for biopower or biofuel facilities
- This improves deployment feasibility and reduces transportation costs
- Step-change improvements are being realized with biotechnology



**Example:** A 100 million gallon cellulosic ethanol plant using purpose grown trees is able to reduce land need more than 90% relative to forest residues

## Forest Residues



2 to 4 green tons/acre/year  
1,000,000 acres  
~60 miles<sup>2</sup>

## Pine



8-11 green tons/acre/year<sup>1</sup>  
180,000 to 250,000 acres  
25-30 miles<sup>2</sup>

## Eucalyptus



14-33 green tons/acre/year<sup>1</sup>  
60,000 to 140,000 acres  
14 to 22 miles<sup>2</sup>

1 Includes only currently available products  
2 Assumes access to 15% of the local land base

# Summary

- Demand for woody biomass is on the rise
- Biopower and Biofuels production based on woody biomass is needed to revitalize rural economies in the Southeast
- Purpose grown trees have numerous supply chain advantages over alternatives
- Trees are and will be managed to meet sustainability targets
- ArborGen technology is revolutionizing productivity potential
  - Increased yields
  - Shortened rotations
  - Increased environmental adaptability
  - Improved processing efficiency (pulp & bioenergy)
  - Improved wood quality