Genetics influence on expectations from forest investments: An overview
Agenda

• Review the changes in genetic quality that have taken place

• Discuss the basis for how these changes are influencing expected returns

• Discuss how these changes are impacting silvicultural systems and input cost
Introduction

• **Our expectations from forest investments are strongly driven by our current experiences:**

  • 20 year rotation yields of 80-120 Gt/ac
  • 4-6 Gt/ac/yr mai
  • 20-50% of total rotation yields being sawtimber (ST)
  • Historical costs for establishment and management
Today’s question is; How should we view future forest investments? Where:

- Rotation yields will be 160 – 240 Gt/ac
- Mai will be 8-12 Gt/ac/yr
- 50-90% of rotation yields will be ST (CNS or 13” or>)
- Risk will be lower
- Additional higher valued products will be possible
- Same or reduced establishment and management costs
Enhanced Genetics

Value-$/Ac

Avg. OP

Elite OP

Elite OP / Insight

MCP

MCP / Insight

Early Varietals

Varietals / Insight

Future / Biotechnology
Technology is Creating Significant Value for Our Customers

Value-Enhanced Traits
- Increased Growth Rates
- Shorter Rotations
- Improved Wood Quality
- Breakthrough Applications

Varietals
- Genetic Uniformity
- Increased Productivity
- Improved Product Mix
- Management Efficiency

Seedlings
- Elite Material
- MCP – opportunity for near-term landowner gains

Loblolly Pine

Time and Product Testing
Three types of enhanced genetic quality seedlings are now available:

1. OP/Insight
2. MCP/Insight
3. Varietals
Open Pollinated
Open-Pollinated (OP)

- Seedlings from seed of a mother tree with 50 years of Tree Improvement
- Father (pollen source) unknown

Timeline:
- 1956: Industrial Coop Created (ICTIP) … First selections
- 1969: Began 2nd Gen selections
- 1985: Began elite breeding
- 2000: Began 3rd cycle Breeding
**OP Gains**

\[ \text{OP Gains} = \left( \text{BVfemale} + (\text{BVorchard pollen} - \text{BVwild pollen}) \right) / 2 \]

Because we collect seeds from known mother trees, we are sure to always get BVfemale gains.

**BV orchard pollen** is very good but you have limited control over the actual genetics of the seedling population you will be planting.

**BVwild pollen** has been estimated to contribute from 20 to 80% of the orchard pollen cloud.

**Conclusion:** With OP seedlings, we get a population of seedlings from the best mother tree but with unknown levels of dilution by wild pollen.
<table>
<thead>
<tr>
<th>Material</th>
<th>Height (in)</th>
<th>Exh. SI</th>
<th>Rust%</th>
<th>Yield@23yr P</th>
<th>CNS</th>
<th>ST</th>
<th>GT/ac</th>
<th>Value@9yr</th>
<th>Value @23yr</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elite OP</td>
<td>47.3</td>
<td>92</td>
<td>23%</td>
<td>41</td>
<td>52</td>
<td>108</td>
<td>186</td>
<td>$270</td>
<td>$246, $520, $3024</td>
<td>$4060</td>
</tr>
<tr>
<td>Selected</td>
<td>51.7</td>
<td>97.5</td>
<td>1%</td>
<td>30</td>
<td>22</td>
<td>185</td>
<td>220</td>
<td>$228</td>
<td>$180, $220, $5180</td>
<td>$5808</td>
</tr>
</tbody>
</table>
Mass Controlled Pollination
MCP
Mass Control Pollinated (MCP)

- Genetic potential of the pollen parent is added to the genetic potential of the mother
- Mass production of MCP began in 2005 at MeadWestvaco.
Full Sib, Controlled Crossing

Male Flowers

Pollen Collection

Bagged Female Flowers

Pollination

First Year Conelet
Mass Controlled Pollination
Seed Orchards

MCP (Mass Control Pollination) pine seedlings
MCP Gains:

MCP Gains = (BVfemale + BVmale)/2

Both the BVfemale and BVmale is controlled with MCP
- No longer work with orchard average
- No (or only minor) outside pollen gain dilution
- It enables complimentary breeding

Complimentary breeding permits **Insight** on traits such as branch size, branch angle and internode lengths to be fully capitalized on to produce a population of seedlings that will have high growth potential & high percent sawtimber
Why MCP?

- Gains are substantial in many traits.
  - Growth
  - Disease resistance
  - Straightness

Results from 2nd Gen Coastal Loblolly Orchard Test

Source: MeadWestvaco
Varietals
Varietals

- The best individual from the best mother & father crosses.

Select varieties provide a uniform stand of the highest quality trees.
Components of a Varietal Program

- Define Ideotype(s)
- Focus Breeding
- Varietal Testing
- Selection
- Efficient SE Production
- Variety Characterization & Valuation
- Full Deployment
- Phase II Testing

ArborGen Confidential
Variatetal Summary

- Immature seed tissue
- Cryostored embryonic tissue
- Embryonic tissue for embryo production
- SE Seedling production from embryos
- Varietal forest

Variatetal Technology Summary

- Uses the best individual with regard to many traits
- Permits deploying of the best individual at every planting spot—100% deployable
- Improves traits that are not easy to improve through conventional breeding programs
- Permits using crown architecture differences to minimize risk to wind and ice
- Makes further silvicultural adjustments possible
4-year-old Varietals on a poorly drained soil.
Exhibited SI is > than 100’ at age 25
Percent potential ST is > than 90%
Expected pole production would be high
The total gains from enhanced genetics comes through:

- Growth gains
- Increased % Sawtimber
- Silvicultural adjustments
- Full rotation sawtimber emphasis
- Moving towards non-conventional growth regimes
Integrating the impacts of improved yields and percent sawtimber
Planted: 1994
Trees per acre: 535
Single control-cross of first generation loblolly pine parents
120 varieties from rooting cuttings
Simulations:

<table>
<thead>
<tr>
<th>Stand</th>
<th>SI</th>
<th>ITPA</th>
<th>Thin Age (Years)</th>
<th>Thin (Gtons/ac)</th>
<th>Total CC (Clearcut Gtons/acre)</th>
<th>Pulp$</th>
<th>CNS $</th>
<th>ST $</th>
<th>Red.</th>
<th>Thin$/ac</th>
<th>CC-$/ac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Previous</td>
<td>75</td>
<td>726</td>
<td>13</td>
<td>25</td>
<td>138</td>
<td>42</td>
<td>84</td>
<td>7</td>
<td>40%</td>
<td>150</td>
<td>1,438</td>
</tr>
<tr>
<td>Old CC</td>
<td>90</td>
<td>535</td>
<td>9</td>
<td>25</td>
<td>235</td>
<td>49</td>
<td>65</td>
<td>122</td>
<td>15%</td>
<td>150</td>
<td>4,510</td>
</tr>
<tr>
<td>Variety</td>
<td>95</td>
<td>420</td>
<td>9</td>
<td>26</td>
<td>274</td>
<td>29</td>
<td>42</td>
<td>204</td>
<td>0%</td>
<td>156</td>
<td>6,462</td>
</tr>
<tr>
<td>Variety</td>
<td>95</td>
<td>250</td>
<td>--</td>
<td>--</td>
<td>299</td>
<td>29</td>
<td>15</td>
<td>256</td>
<td>0%</td>
<td>---</td>
<td>7,422</td>
</tr>
</tbody>
</table>

- Assumptions
  - Price: PW=$6/Gton, CNS=$10/Gton, ST=$28/Gton
  - Products: ST>13”, CNS>10” <13”, PW >6” to 2” top
  - Product Adjustments based on expected defects after thin: OP 40%, MCP 15%, Add volume to PW
  - Thin to 250 tpa when average height is 45 feet.
  - Clearcut at age 25 years
Silvicultural Adjustments
Examples of Impacts of enhanced genetics on pine silviculture

- Strategic removal vs for selection considerations
- Row oriented—Mechanical minimization regimes
- High valued products –Total sawtimber, Poles
- Pruning Considerations
- Mixed Sawtimber—Biomass regimes
- Wet weather thinning restriction sites
- Disease/Insect risk sites
- Forestry –Wildlife enhancement regimes
- Total Asset Enhancement considerations
Impacts of enhanced genetics on pine silviculture

- Strategic removal vs for selection considerations
- Row oriented—Mechanical minimization regimes

Reduced Inputs
- $20-$30/Site Prep Pass
- Reduced planting cost--$10/acre
- Reduce herbicide treatment costs with row or spot treatments--$8-$10/ac per treatment
Impacts of enhanced genetics on silviculture cont.

- High valued products – Total sawtimber, Poles
- Pruning Considerations
Impacts of enhanced genetics on pine silviculture cont.

- **Non conventional Regimes-Mixed Sawtimber-Biomass regimes**

  Broad crown-large branched OP planted as biomass take-out rows

  Narrow crown –small branched MCP planted as crop trees

**SI-88**

4, x20’= 545 tpa

Thin @ Age-8 = 46 Gt/ac

Age-8 Cash = $276.00

**Establishment Cost**

- Mechanical---------- $240
- OP&MCP Seedlings-$70
- Herbaceous-2trt------ $90
- Fert@ 9yr------------ $150
- Total------------------- $550

**SI-92**

10’x20’= 218 tpa

Thin to 180 at 8yr

CC @ 25yr

CC Total Gt/ac= 207

CC revenue= $4282

P = $6, CNS = $10, ST = $28. ST vol at CC reduced by 15%
## Non conventional Regimes

### Sawtimber x Biofuels plots

#### Plot layout

<table>
<thead>
<tr>
<th>Regime 1</th>
<th>Regime 2</th>
<th>Regime 3</th>
<th>Regime 4</th>
<th>Regime 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>MCP 217tpa 10’ x 20’</td>
<td>MCP 217tpa 10’ x 20’</td>
<td>MCP 217tpa 10’ x 20’</td>
<td>MCP 217tpa 10’ x 20’</td>
<td>MCP 430 tpa 5’ x 20’</td>
</tr>
<tr>
<td>OP 430 tpa 5’ x 20’</td>
<td>OP 430 tpa 5’ x 20’</td>
<td>OP 430 tpa 5’ x 20’</td>
<td>OP 430 tpa 5’ x 20’</td>
<td>Evaluate BF row impact on ST yields and value</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Narrow MCP</th>
<th>Moderate MCP</th>
<th>Broad MCP</th>
<th>Moderate MCP</th>
<th>Resource Focused</th>
</tr>
</thead>
<tbody>
<tr>
<td>Narrow OP</td>
<td>Broad OP</td>
<td>Broad OP</td>
<td>Broad OP</td>
<td></td>
</tr>
</tbody>
</table>

**ArborGen Confidential**
Introduction Continued:
How are we doing in applying the technology now available?

- [Enhanced Genetic Material]
  Loblolly Pine Market Share

  Mass Control Pollinated (MCP) 3%
  Varietals 2%
  Open Pollinated (OP) 95%

95%+ of plantations being planted today in the SE USA are from OP orchards; i.e. we know we are capturing the mother tree genes.

Source: ArborGen Estimates
ArborGen Confidential
Has genetic contributions to improve forest investments peaked out? ---Not even close!

- Enhanced Genetics

Intensive testing & selection
Development of silviculture regimes that are “Gene-abled”
Use of varieties in breeding program