Harvest scheduling: case study of Eucalyptus amplifolia in Florida

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SRWCOWG, October 18\textsuperscript{th}, 2010
Outline:

1. Eucalyptus yields and economic analysis.
2. Initial results from new field trials.
3. Potential eucalyptus production in the US South.
Site Locations

FORCE

Kent

Orlando
**FORCE**

FORCE: MSW compost + irrigation

Kent: Clay Settling Area

*Total above-ground biomass
Max MAI: 13 dry tons/ac/yr (29 Mg/ha/yr)*

SRWCOWG, October 18th, 2010
Model Explanation: Optimization of Coppice Plantations

Faustman (1850):

\[
LEV(t) = \frac{V(t) \cdot e^{(-r \cdot t)} - C}{1 - e^{(-r \cdot t)}}
\]

\[
V'(t) = r \cdot V(t) + r \cdot LEV
\]
Model Explanation: Optimization of Coppice Plantations

Faustman (1850):

\[
LEV(t) = \frac{V(t) \times e^{-r*t} - C}{1 - e^{-r*t}}
\]

Medema and Lyon (1985):

\[
LEV(t) = \frac{\sum_{s=1}^{n} \left[ V(t_s) \times e^{-r \times \sum_{j=1}^{s} t_j} - C_s \times e^{-r \times \sum_{j=1}^{s} t_{j-1}} \right]}{1 - e^{-r \times \sum_{j=1}^{n} t_j}}
\]

Smart and Burgess (2000):

\[
LEV(t) = \frac{\sum_{s=1}^{n} \left[ V(t_s) \times e^{-r \times \sum_{j=1}^{s} t_j} + NTB_s \times e^{-r \times \sum_{j=1}^{s} t_j} - C_s \times e^{-r \times \sum_{j=1}^{s} t_{j-1}} \right]}{1 - e^{-r \times \sum_{j=1}^{n} t_j}}
\]
## Model Explanation: Optimization of Coppice Plantations

### Dual Optimization

LEV per hectare: (Interest= 6%, wood value=20$ dry Mg⁻¹, value of N removal= $1.00 kg⁻¹):

<table>
<thead>
<tr>
<th>Number of stages/cycle</th>
<th>Optimum stage length (years)</th>
<th>LEV ($/ha)</th>
<th>Marginal LEV ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.4</td>
<td>$ -1,072.00</td>
<td>-</td>
</tr>
<tr>
<td>1</td>
<td>2.3</td>
<td>$ +26.00</td>
<td>$ 1,098.00</td>
</tr>
<tr>
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<td>2.3</td>
<td>$ +26.00</td>
<td>$ 1,098.00</td>
</tr>
<tr>
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<td>2.3</td>
<td>$ +72.00</td>
<td>$ 46.00</td>
</tr>
<tr>
<td>2</td>
<td>2.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2.4</td>
<td>$ -369.00</td>
<td>$ -44.00</td>
</tr>
<tr>
<td>2</td>
<td>2.3</td>
<td>$ -369.00</td>
<td>$ -44.00</td>
</tr>
<tr>
<td>3</td>
<td>2.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>2.0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**FORCE**

**FORCE: MSW compost + irrigation**

*Total above-ground biomass
Max MAI: 13 dry tons/ac/yr
Assume 20% yield declines each stage.*
Comparisons

\[ V_S'(t) = r \cdot V_S(t) + r \cdot LEV(t) \]

<table>
<thead>
<tr>
<th></th>
<th>$5/gt @ 3%</th>
<th>$10/gt @ 7%</th>
<th>$15/gt @ 10%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Optimum stage ages:</td>
<td>8.1, 7.8, 7.3</td>
<td>6.9, 6.6</td>
<td>6.4, 5.9</td>
</tr>
<tr>
<td>Land Expectation Value:</td>
<td>$1,600/ac</td>
<td>$1,546/ac</td>
<td>$1,633/ac</td>
</tr>
<tr>
<td>Equal Annual Equivalent:</td>
<td>$48/ac</td>
<td>$267/ac</td>
<td>$163/ac</td>
</tr>
<tr>
<td>Internal Rate of Return:</td>
<td>9.2%</td>
<td>16.2%</td>
<td>21.9%</td>
</tr>
</tbody>
</table>
### SRWC Decision Support System:

**Land Expectation Value (LEV), Equal Annual Equivalent (EAE), Internal Rate of Return (IRR), and Net Present Value (NPV) Calculator**

#### Inputs

- **Stumpage Price, Incentives, Capital Cost**
  - Stumpage price ($/green ton)
  - Revertable Energy Portfolio Incentive ($/green ton)
  - Other Incentives ($/green ton)
  - Total stumpage value ($/green ton)
  - Capital cost (annual interest rate)

- **Start-up Costs**
  - Herbicide ($/acre)
  - Site Prep ($/acre)
  - Debt ($/acre)
  - Bed ($/acre)
  - Total

- **Costs at the Beginning of Each Rotation**
  - Fertilize ($/acre)
  - Propagule price (per tree)
  - Trees per acre (1,200-1,400)
  - Cost of Trees ($/acre)
  - Planting cost ($/acre)
  - Total

- **Costs at the Beginning of Each Coppice**
  - Weed control ($/acre)

- **Annual Costs**
  - Annual maintenance/administration ($/year)

- **General Parameters**
  - Inside bark or total above-ground biomass
  - Total above-ground biomass
  - Expansion factor for branches and leaves
  - Number of coppices per rotation
  - Age of first harvest
  - Harvest age of first coppice
  - Harvest age of second coppice
  - Harvest age of third coppice
  - Total Rotation Length
  - Initial harvest yield (as % of first harvest)
  - First coppice yield (as % of first harvest)
  - Second coppice yield (as % of first harvest)
  - Third harvest yield (as % of first harvest)

#### Outputs

- **LEV ($/acre)**
- **EAE ($/acre)**
- **IRR**
- **NPV benefits ($/acre)**
- **NPV costs ($/acre)**
- **Benefit/cost ratio**
- **HPV after 1st Rotation ($/acre)**
- **HPV after 2nd Rotation ($/acre)**
- **HPV after 3rd Rotation ($/acre)**
- **HPV after 4th Rotation ($/acre)**
- **HPV after 5th Rotation ($/acre)**

### Estimated Yield Within a Rotation:

- Initial
- 1st Coppic
- 2nd Coppic
- 3rd Coppic

### Yields (green tons/acre)

<table>
<thead>
<tr>
<th>Age (years)</th>
<th>Initial harvest at 3 years of age</th>
<th>First coppice at 3 years of age</th>
<th>Second coppice at 3 years of age</th>
<th>Third coppice at 3 years of age</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>90.1</td>
<td>69.1</td>
<td>69.1</td>
<td>51.1</td>
</tr>
<tr>
<td>1</td>
<td>70%</td>
<td>70%</td>
<td>70%</td>
<td>68%</td>
</tr>
<tr>
<td>2</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
<td>60%</td>
</tr>
<tr>
<td>3</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
<td>50%</td>
</tr>
<tr>
<td>4</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
<td>40%</td>
</tr>
<tr>
<td>5</td>
<td>30%</td>
<td>30%</td>
<td>30%</td>
<td>30%</td>
</tr>
<tr>
<td>6</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
<td>20%</td>
</tr>
<tr>
<td>7</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
<td>10%</td>
</tr>
</tbody>
</table>

*Figure 1. The SRWC Decision Support System spreadsheet.*
Site Locations: 2009 additions

- FORCE
- Kent
- Mosaic
- Fort Meade
- Evans
- Okeechobee
- Orlando
# Planting Date in 2009, Site/Soil Types, Treatments, and Genotypes of Two 2009 Tests

<table>
<thead>
<tr>
<th>Test</th>
<th>Planting Date</th>
<th>Site/Soil</th>
<th>Treatments</th>
<th>Genotypes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mosaic</td>
<td>September</td>
<td>Bedded CSA/Heavy clay</td>
<td>3 densities: 1,025; 2,050; and 3,416 tpa</td>
<td>G1,G2,G3,5408</td>
</tr>
<tr>
<td>Evans</td>
<td>July</td>
<td>Bedded/Poorly drained sand</td>
<td>5 densities: 581; 869; 1,162; 1,452; and 1,742 tpa</td>
<td>G1,G2,G3,G5</td>
</tr>
</tbody>
</table>
Mosaic 2009 E. grandis Cultivar Test on with 3 Planting Densities
Mosaic 2009 E. grandis Cultivar Test at 15 Months
Evans 2009 E. grandis Cultivar Test on 4 Citrus Beds with 2, 3, 4, 5, and 6 Rows of Trees
Evans 2009 E. grandis Cultivar Test at 15 months:

2 Row Cultivar Plot
Evans 2009 E. grandis Cultivar Test at 15 months:

6 Row Cultivar Plot
*Total above-ground biomass
Max MAI: 13 dry tons/ac/yr
Update

*Total above-ground biomass
Update

*Total above-ground biomass
Update

*Total above-ground biomass

1,452 TPA fit
1700 TPA fit
3,399 TPA fit
M-G3-2050 observed
M-G3-2050 fit
M-G1-3416 observed
M-G1-3416 fit
E-G5-1742 observed
E-G5-1742 fit
E-G1-581 observed
E-G1-581 fit

11 dt/a/yr
25 Mg/ha/yr
10 dt/a/yr
22 Mg/ha/yr
4 dt/a/yr
9 Mg/ha/yr

Update
21 SRWCOWG, October 18th, 2010
ENVIRONMENTAL AND SOCIOECONOMIC INDICATORS FOR BIOENERGY SUSTAINABILITY AS APPLIED TO EUCALYPTUS

Virginia H. Dale and Matthew Langholtz
Oak Ridge National Laboratory

Short rotation woody crop (SRWC) potential in the Gulf South

- The Billion Ton Update (DOE 2011) projected potential quantities of feedstocks nationally at a range of prices.
- One potential feedstock identified is SRWCs, likely to include *Eucalyptus* spp. in the Gulf South.
Eucalyptus range

192 Counties in range

Legend

- Eucalyptus range*

SRWC Production in 192 counties

- 1.0 and 1.5 billion dry Mg year\(^{-1}\) nationally (base case and high-yield scenarios) by 2030 at $66 dry Mg\(^{-1}\) ($60 dry ton\(^{-1}\)).
- Includes 114 to 285 million dry Mg year\(^{-1}\) of SRWC in US.
- 27 to 41 million dry Mg year\(^{-1}\) in the 192 counties.
- 1.7 million ha (4.3 m ac)
- 19% of the ag. land and 4.5% of total land in these 192 counties.
Production from forest lands

- Timberland forestland could also be brought into Eucalyptus production.
- 200,900 Mg (220,000 dt) of softwood pulpwood in 2030 from the 192 selected counties.
- Assuming a mean annual increment of 11 Mg ha\(^{-1}\) yr\(^{-1}\), this material could be drawn from about 18 thousand hectares of forestland (5 dt/ac/year, 44 thousand acres).
- Combined Ag+Forest= 1.8 million ha. =4.7% of land of 192 counties.
Conclusions

- Potential profitability under right market conditions.
  - Market
  - Yields
  - Operational costs

- Right economic conditions could incent conversion of up to 2 million ha (5 million acres) in Eucalyptus range to SRWC, up to ~5% land area.

- Calls for application of sustainability indicators.
Thank you