Harvest scheduling: case study of <u>Eucalyptus amplifolia</u> in Florida

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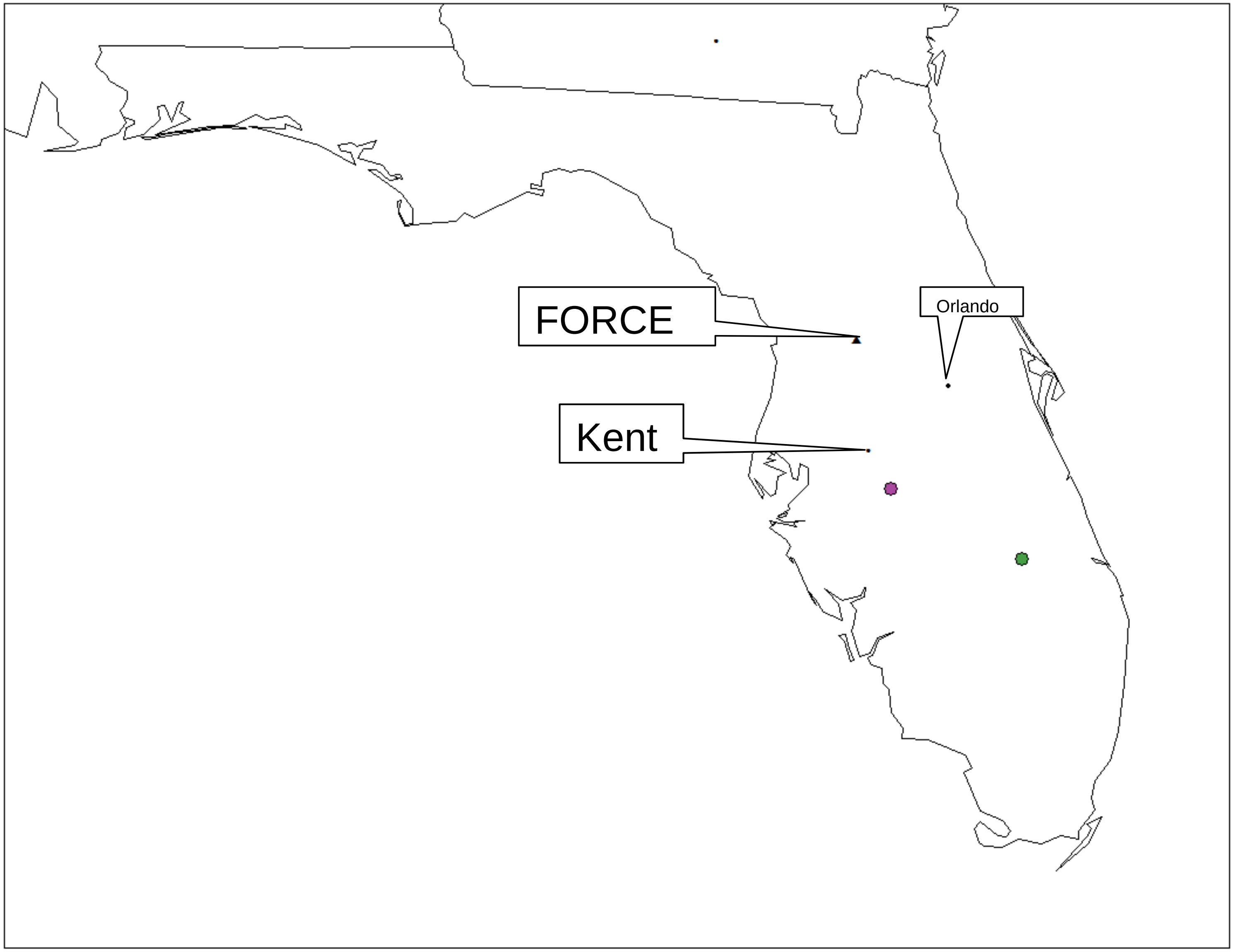
Outline:

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

Site Locations



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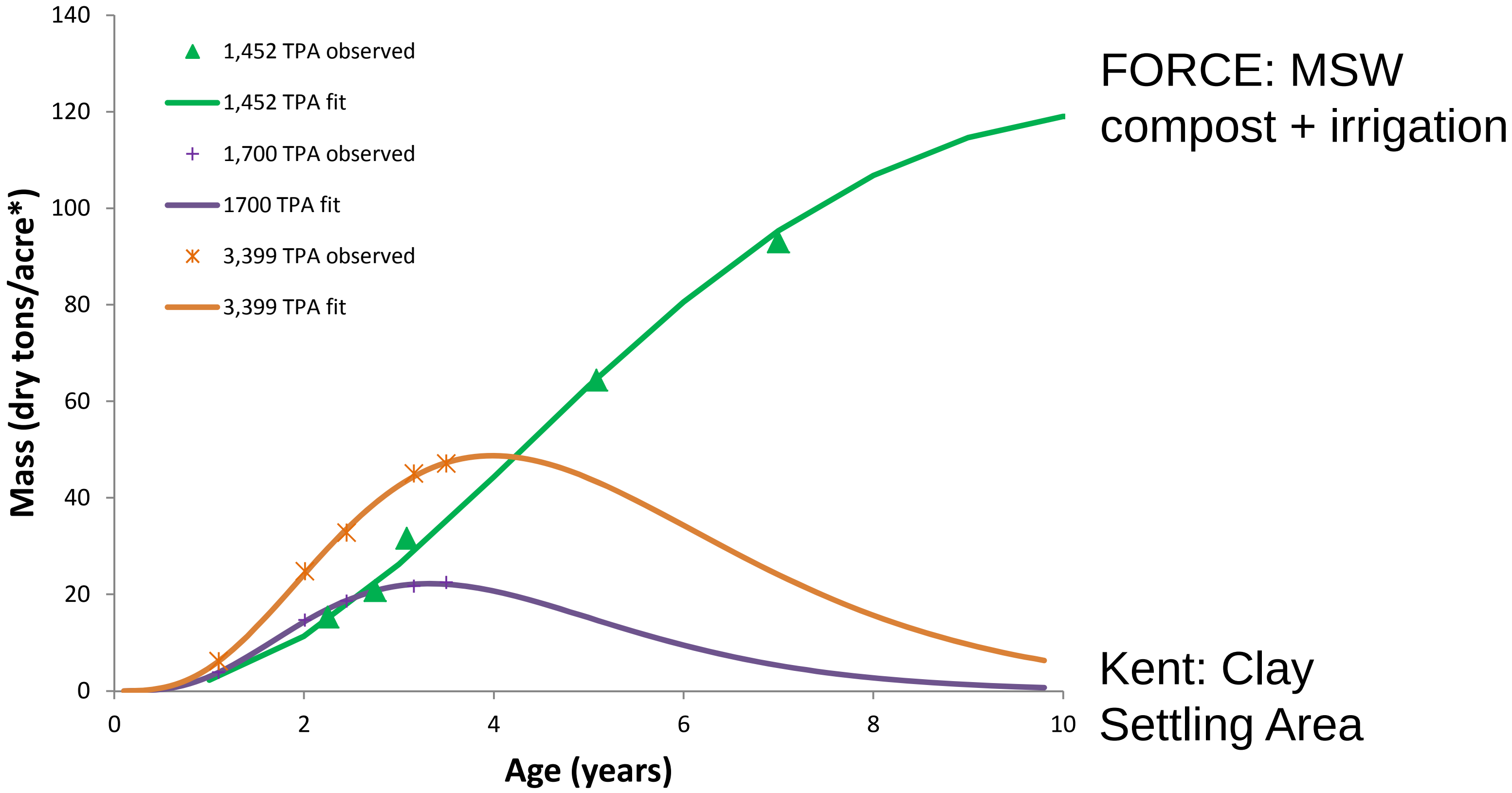

*Total above-ground biomass
Max MAI: 13 dry tons/ac/yr (29 Mg/ha/yr)

Model Explanation: Optimization of Coppice Plantations

Faustman (1850):

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

$$V'(t) = r * V(t) + r * LEV$$

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Faustman (1850):

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

Medema and Lyon (1985):

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

Smart and Burgess (2000):

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

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}):

Number of stages/cycle	*Optimum stage length (years)*	*LEV ($/ha)*	*Marginal LEV ($/ha)*
1	2.4	$ -1,072.00	-
1 2	2.3 2.3	$ +26.00	$ 1,098.00
1 2 3	2.3 2.3 2.2	$ +72.00	$ 46.00
1 2 3 4	2.4 2.3 2.3 2.0	$ -369.00	$ -44.00

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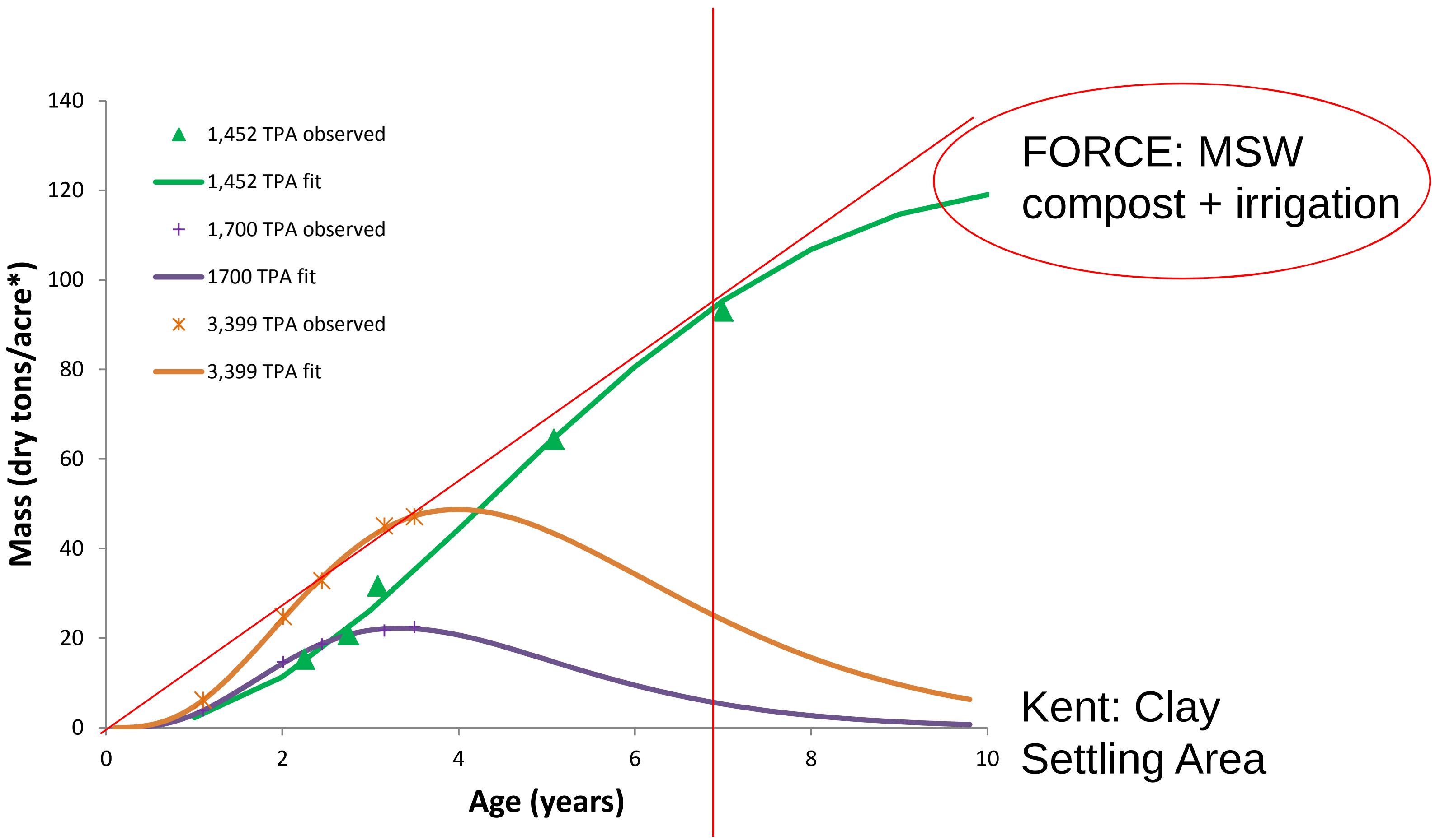
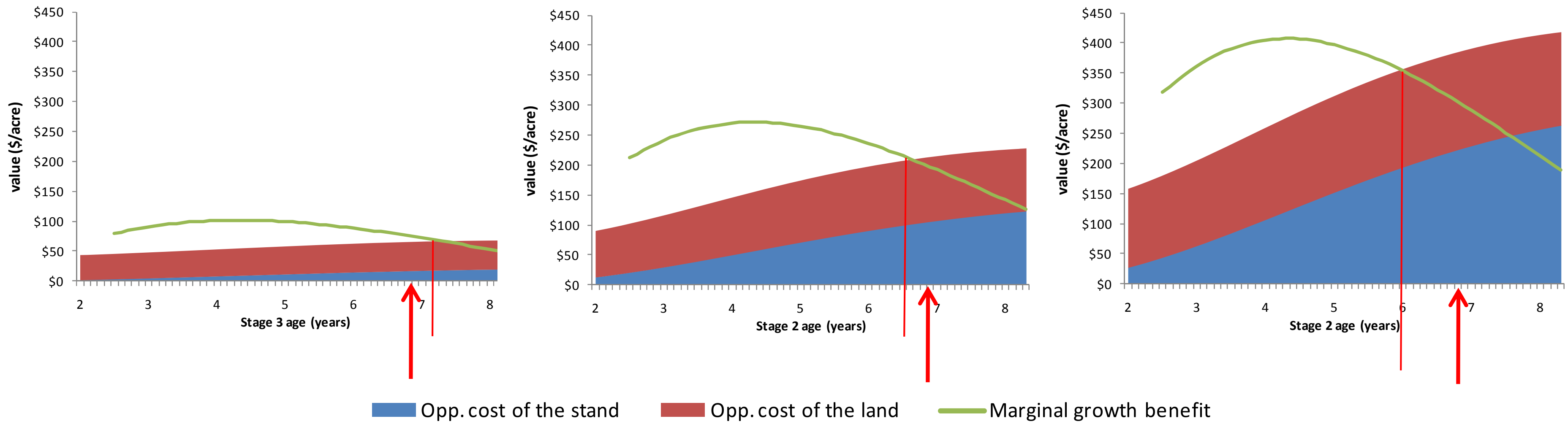


*Total above-ground biomass
Max MAI: 13 dry tons/ac/yr
Assume 20% yield declines each stage.

Comparisons

$$V_S'(t) = r * V_S(t) + r * LEV(t)$$

$5/gt @ 3% | $10/gt @ 7% | $15/gt @10%



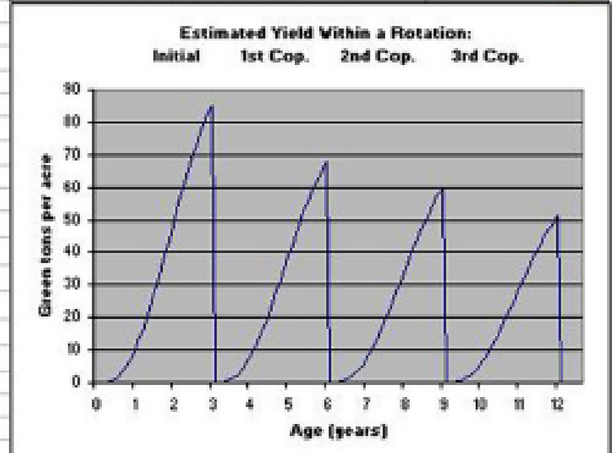
	$5/gt @ 3%	$10/gt @ 7%	$15/gt @ 10%
Optimum stage ages:	8.1, 7.8, 7.3	6.9, 6.6	6.4, 5.9
Land Expectation Value:	$1,600/ac	$1,546/ac	$1,633/ac
Equal Annual Equivalent:	$48/ac	$267/ac	$163/ac
Internal Rate of Return:	9.2%	16.2%	21.9%

SRWC DSS

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^{-1})	$10
Renwweable Energy Porfolio Incentive ($ green ton^{-1})	
Other Incentives ($ green ton^{-1})	
Total stumpage value ($ green ton^{-1})	$10
Capital cost (annual interest rate)	5.0%
Start-up Costs	
Herbicide ($ acre^{-1})	$200
Site Prep ($ acre^{-1})	$50
Disk ($ acre^{-1})	$90
Bed ($ acre^{-1})	$200
Total:	$540
Costs at the Beginning of Each Rotation	
Fertilize ($ acre^{-1})	$40
Propagule price (per tree)	$0.11
Trees per acre (1,700-3,400)	3,400
Cost of Trees ($ acre^{-1})	$374
Planting cost ($ acre^{-1})	$150
Total	$564
Costs at the Beginning of Each Coppice	
Weed control ($ acre^{-1})	$40
Annual Costs	
Annual maintenance/administration ($ acre^{-1})	$10
General Parameters	
Inside bark or total above-ground biomass	Total above-ground biomass
Expansion factor for branches and leaves	1.7
Number of coppices per rotation	4
Age of first harvest	3.0
Harvest age of first coppice	3.0
Harvest age of second coppice	3.0
Harvest age of third coppice	3.0
Total Rotation Length	12.0
Initial harvest yield (as % of first harvest)	100%
First coppice yield (as % of first harvest)	80%
Second coppice yield (as % of first harvest)	70%
Third harvest yield (as % of first harvest)	60%

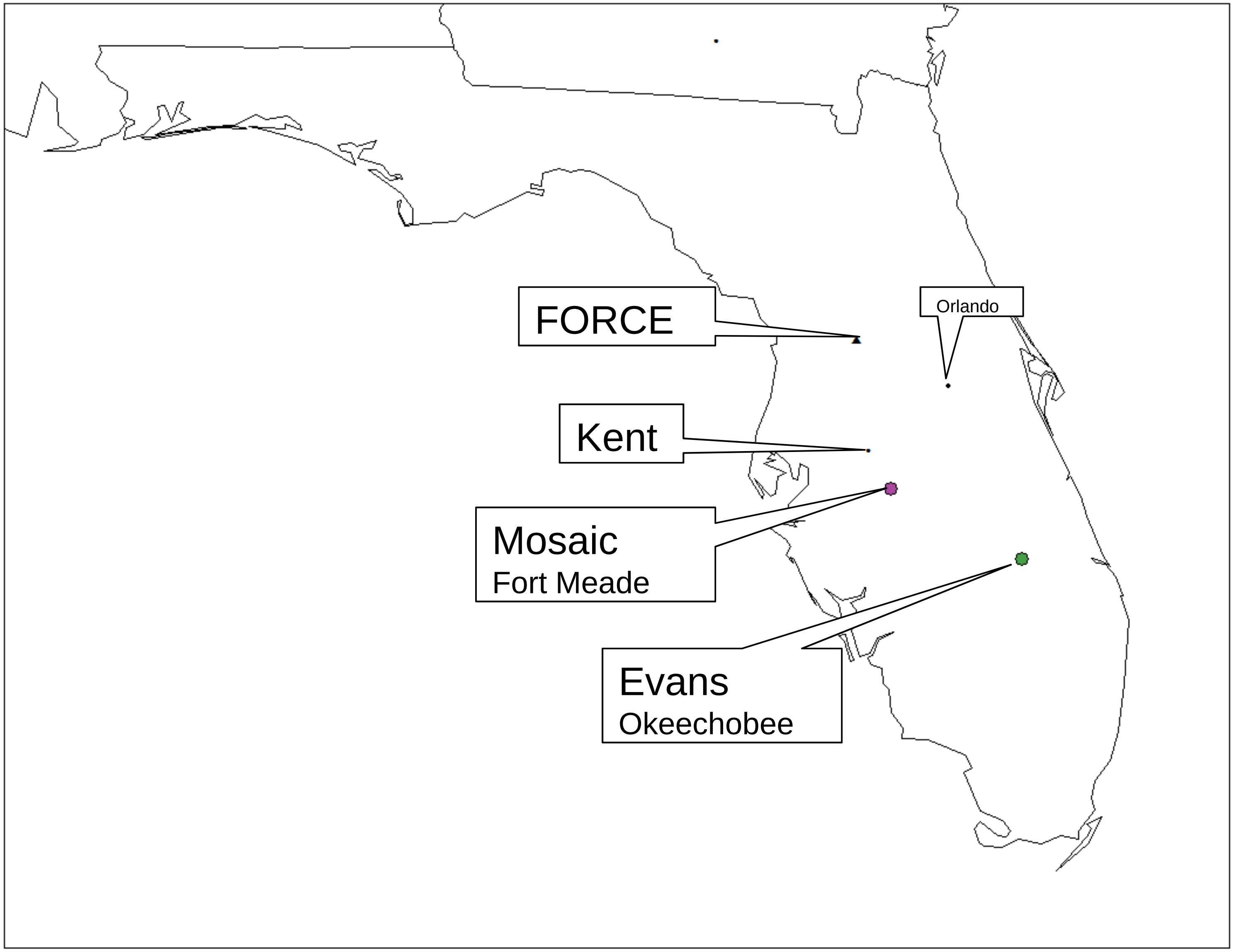
OUTPUTS	
LEV ($ acre^{-1})	**$2,011**
EAE ($ acre^{-1})	**$101**
IRR	**14.0%**
NPV benefits ($ acre^{-1})	$4,205
NPV costs ($ acre^{-1})	$2,194
Benefit/cost ratio	**1.92**
NPV after 1st Rotation ($ acre^{-1})	**$615**
NPV after 2nd Rotation ($ acre^{-1})	**$1,271**
NPV after 3rd Rotation ($ acre^{-1})	**$1,631**
NPV after 4th Rotation ($ acre^{-1})	**$1,828**
NPV after 5th Rotation ($ acre^{-1})	**$1,936**



Yields (green tons acre^{-1}) by harvest age within a rotation	
Initial harvest at 3 years of age	85.1
First coppice at 3 years of age	68.1
Second coppice at 3 years of age	59.6
Third coppice at 3 years of age	51.1

Figure 1. The SRWC Decision Support System spreadsheet.

Site Locations: 2009 additions



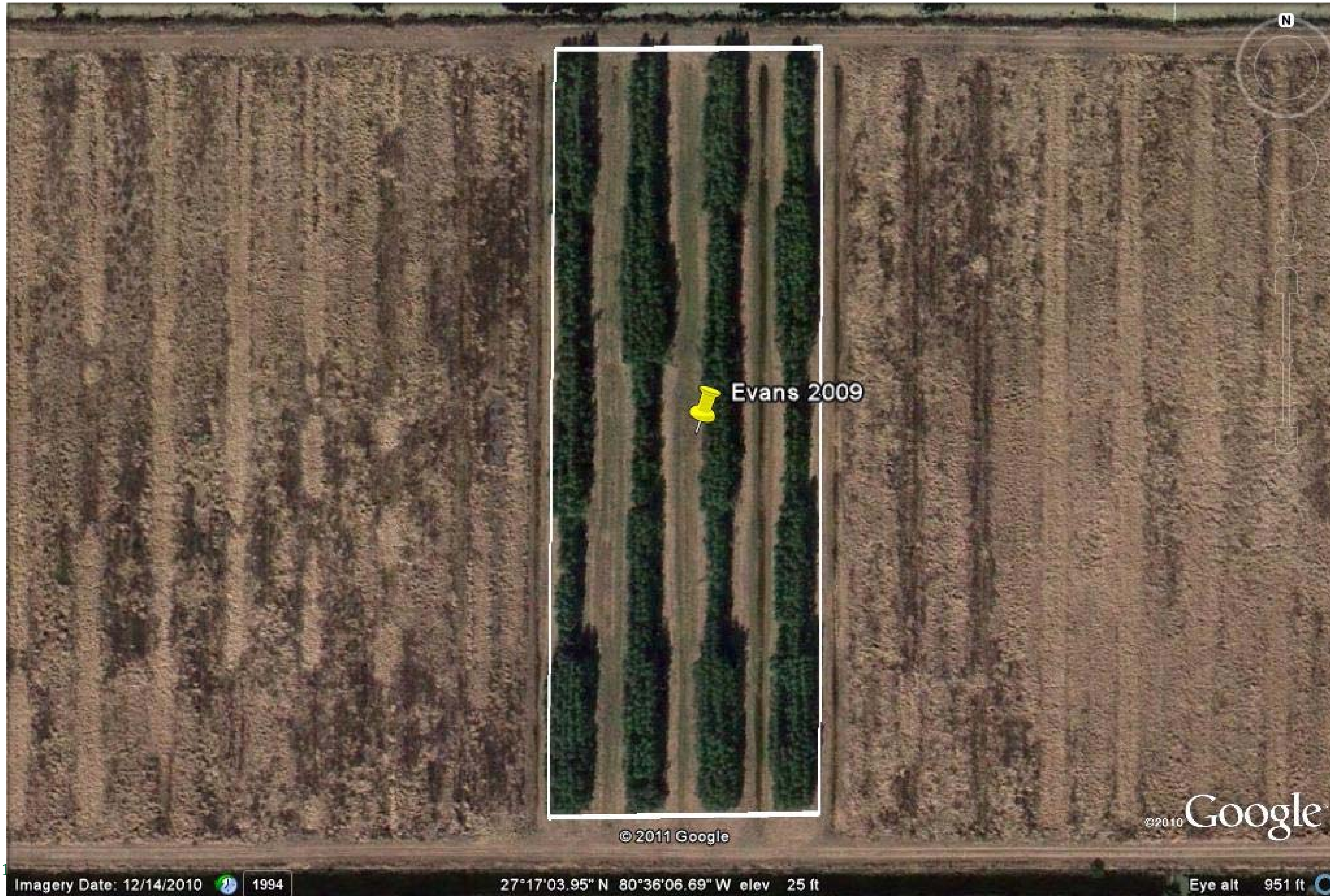
Planting Date in 2009, Site/Soil Types, Treatments, and Genotypes of Two 2009 Tests

Test	Planting Date	Site/Soil	Treatments	Genotypes
Mosaic	September	Bedded CSA/Heavy clay	3 densities: 1,025; 2,050; and 3,416 tpa	G1,G2,G3,5408
Evans	July	Bedded/Poorly drained sand	5 densities: 581; 869; 1,162; 1,452; and 1,742 tpa	G1,G2,G3,G5

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



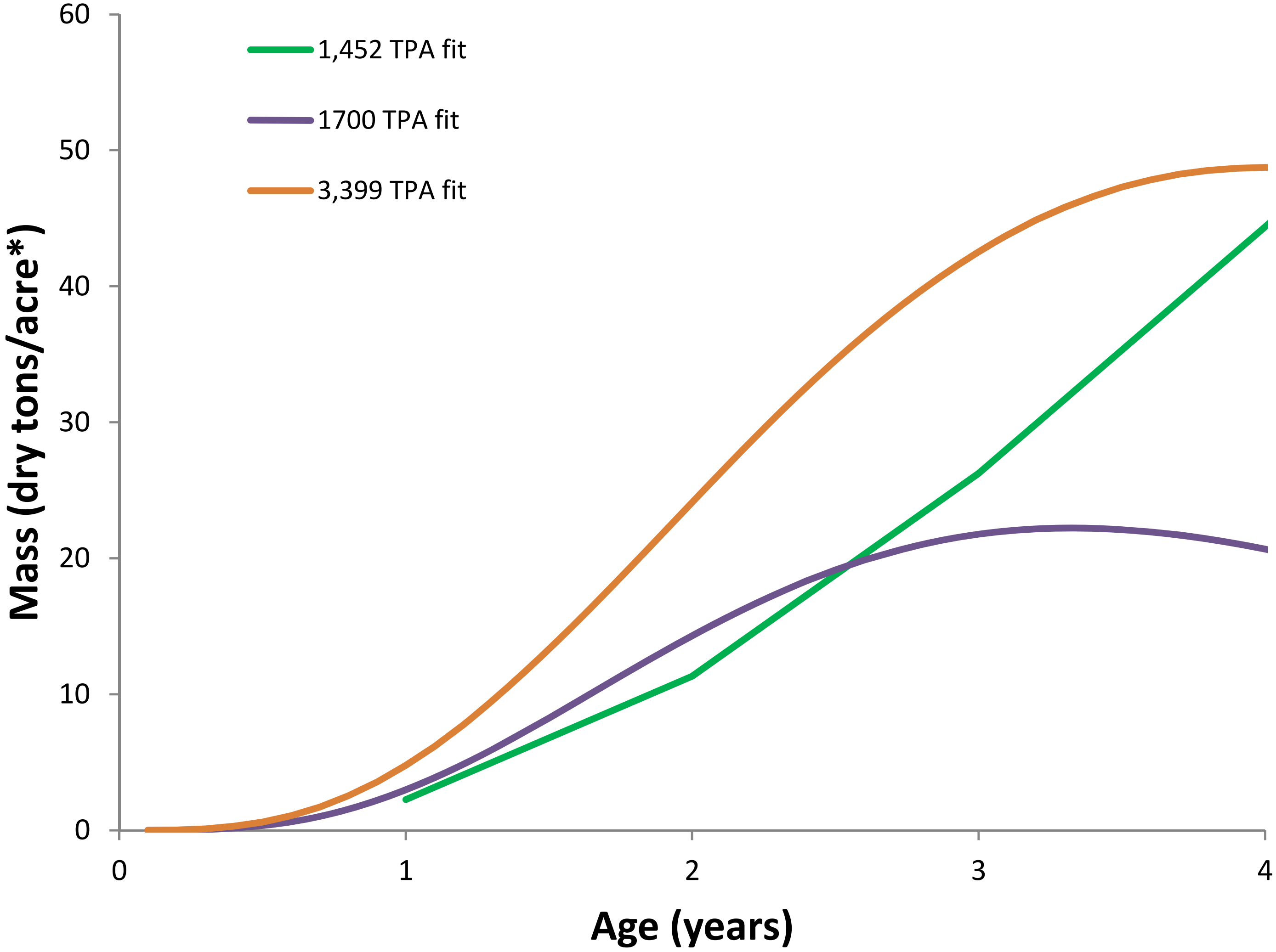
Evans 2009 E. grandis Cultivar Test at 15 months:

2 Row Cultivar Plot

Evans 2009 E. grandis Cultivar Test at 15 months:

6 Row Cultivar Plot

Update



*Total above-ground biomass
Max MAI: 13 dry tons/ac/yr

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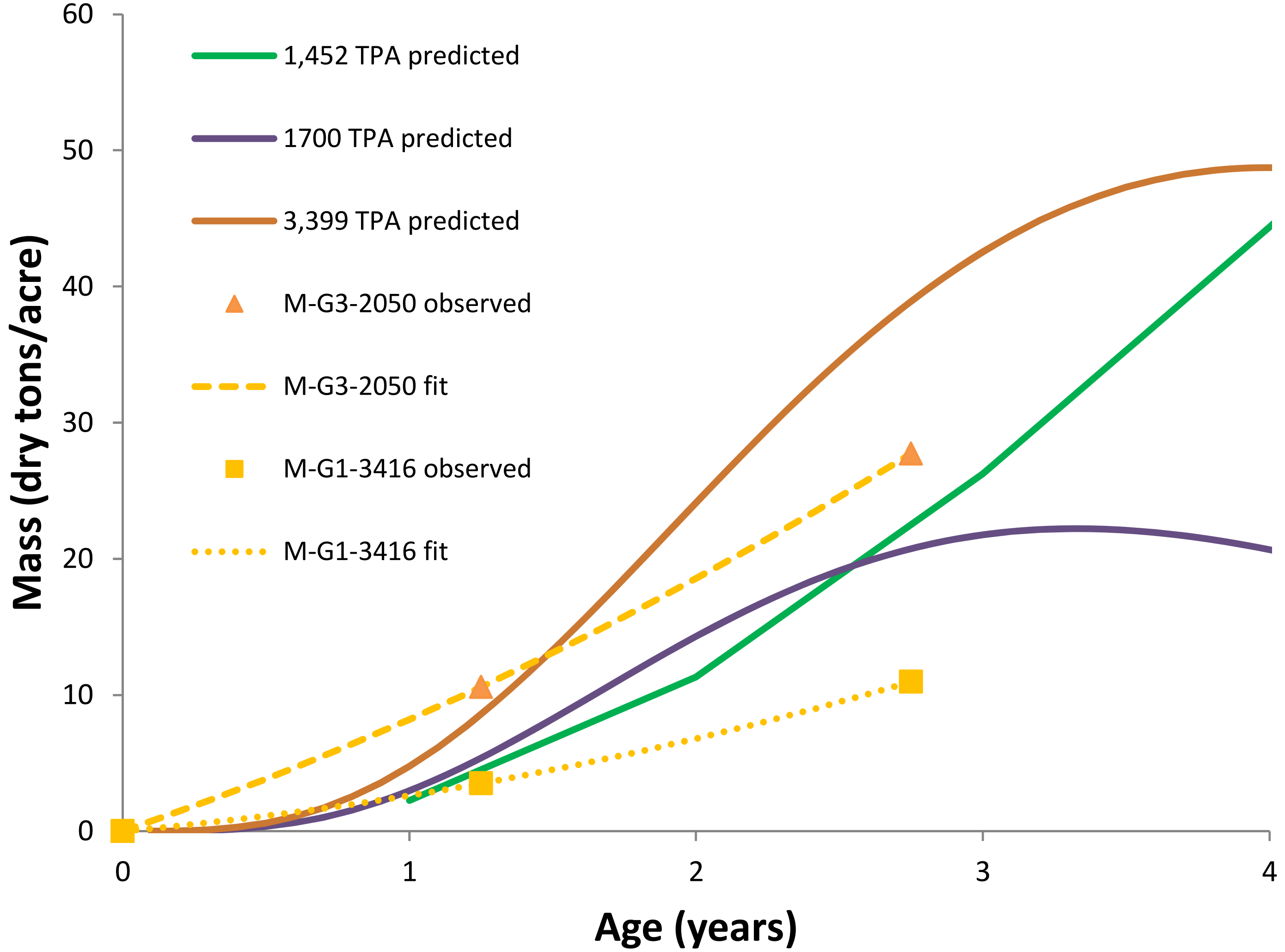

*Total above-ground biomass

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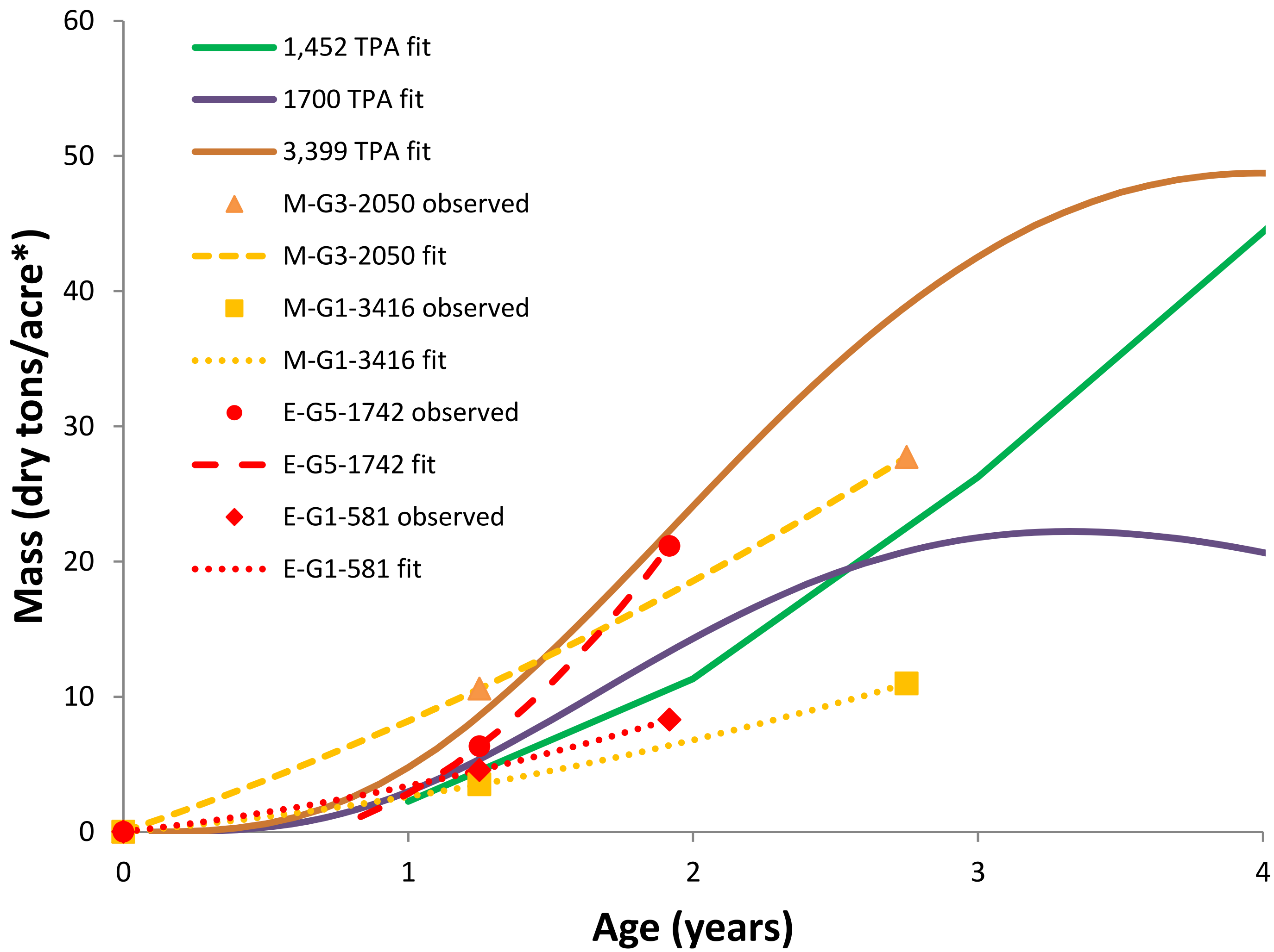

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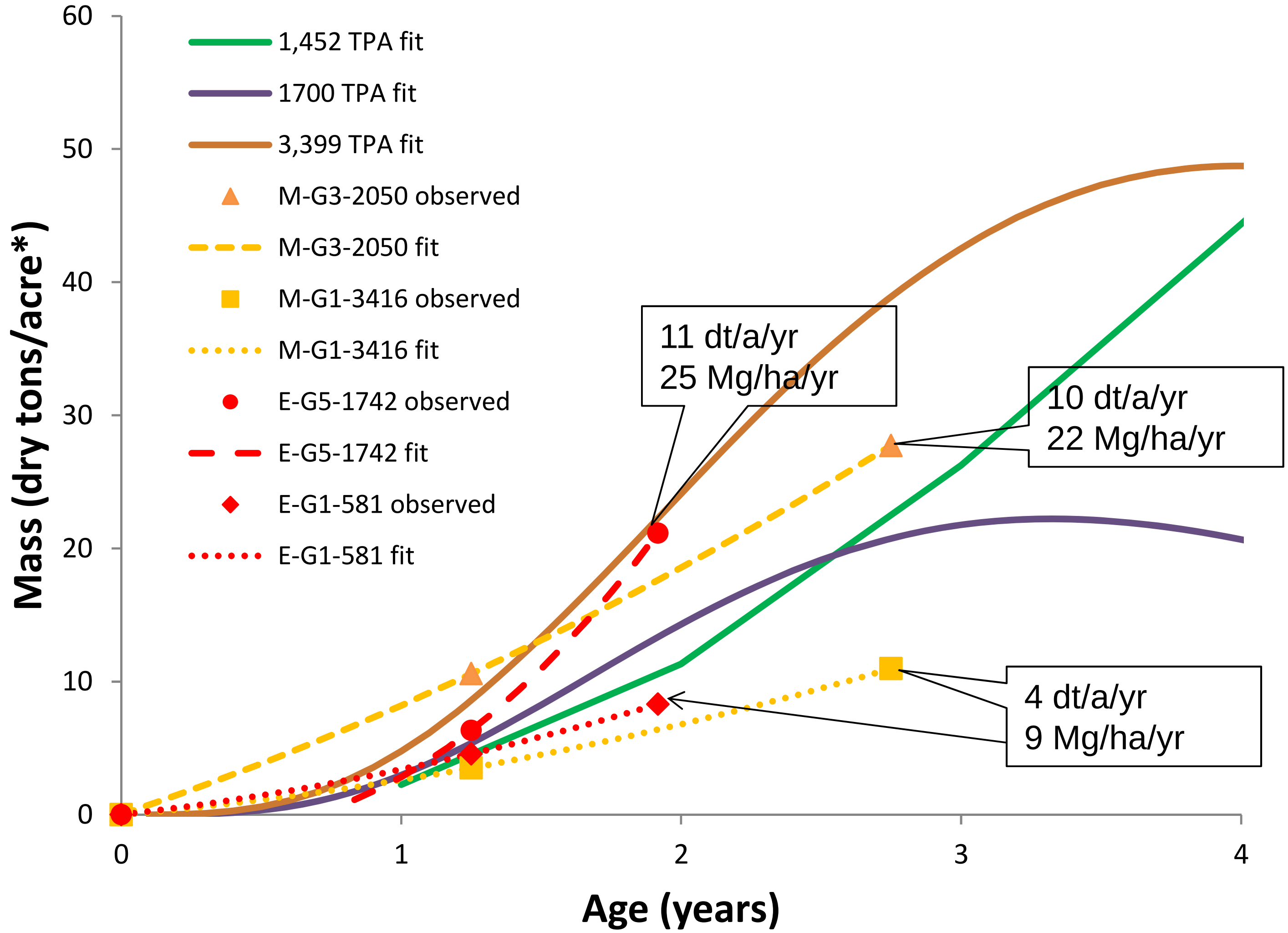

*Total above-ground biomass

ENVIRONMENTAL AND SOCIOECONOMIC INDICATORS FOR BIOENERGY SUSTAINABILITY AS APPLIED TO EUCALYPTUS

Virginia H. Dale and Matthew Langholtz
Oak Ridge National Laboratory

Based on collaborations with LM Baskaran, S Beyeler, MR Davis, ME Downing, LM Eaton, RA Efroymson, C Garten, RL Graham, NA Griffiths, M Hilliard, H Jager, K Kline, PN Leiby, R Lowrance, A McBride, R Middleton, PJ Mulholland, GA Oladosu, ES Parish, RD Perlack, P Robertson, D Rockwood, P Schweizer, A Sorokine, J Storey, NA Thomas, LL Wright

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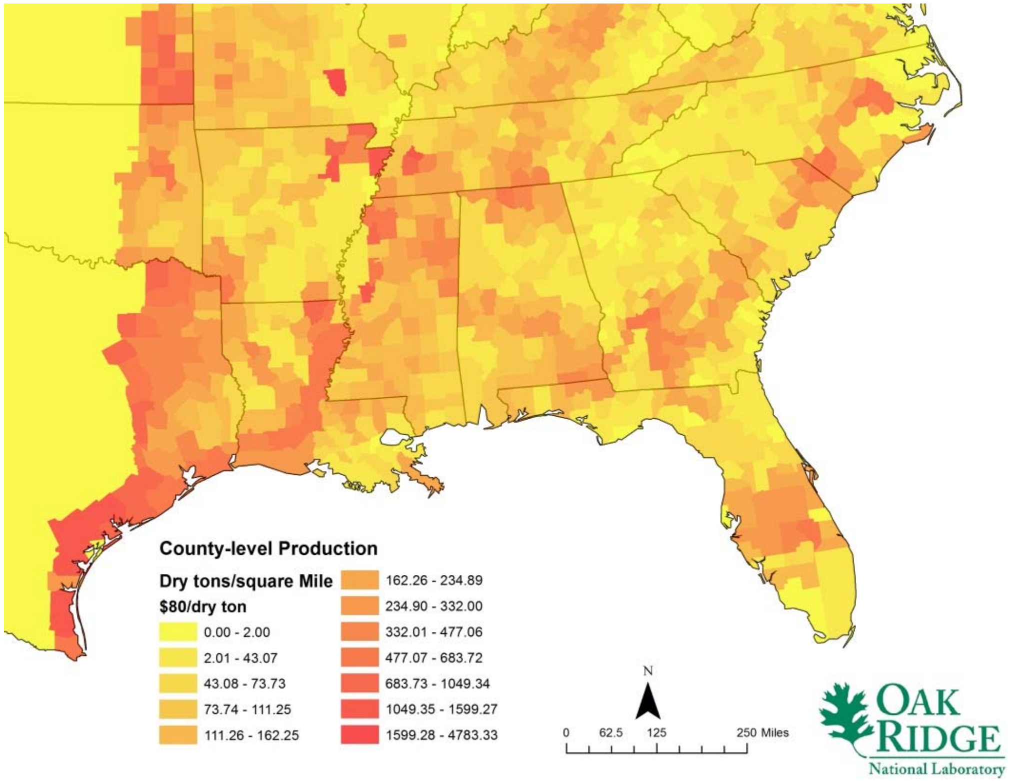
Short rotation woody crop (SRWC) potential in the Gulf South

- 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.



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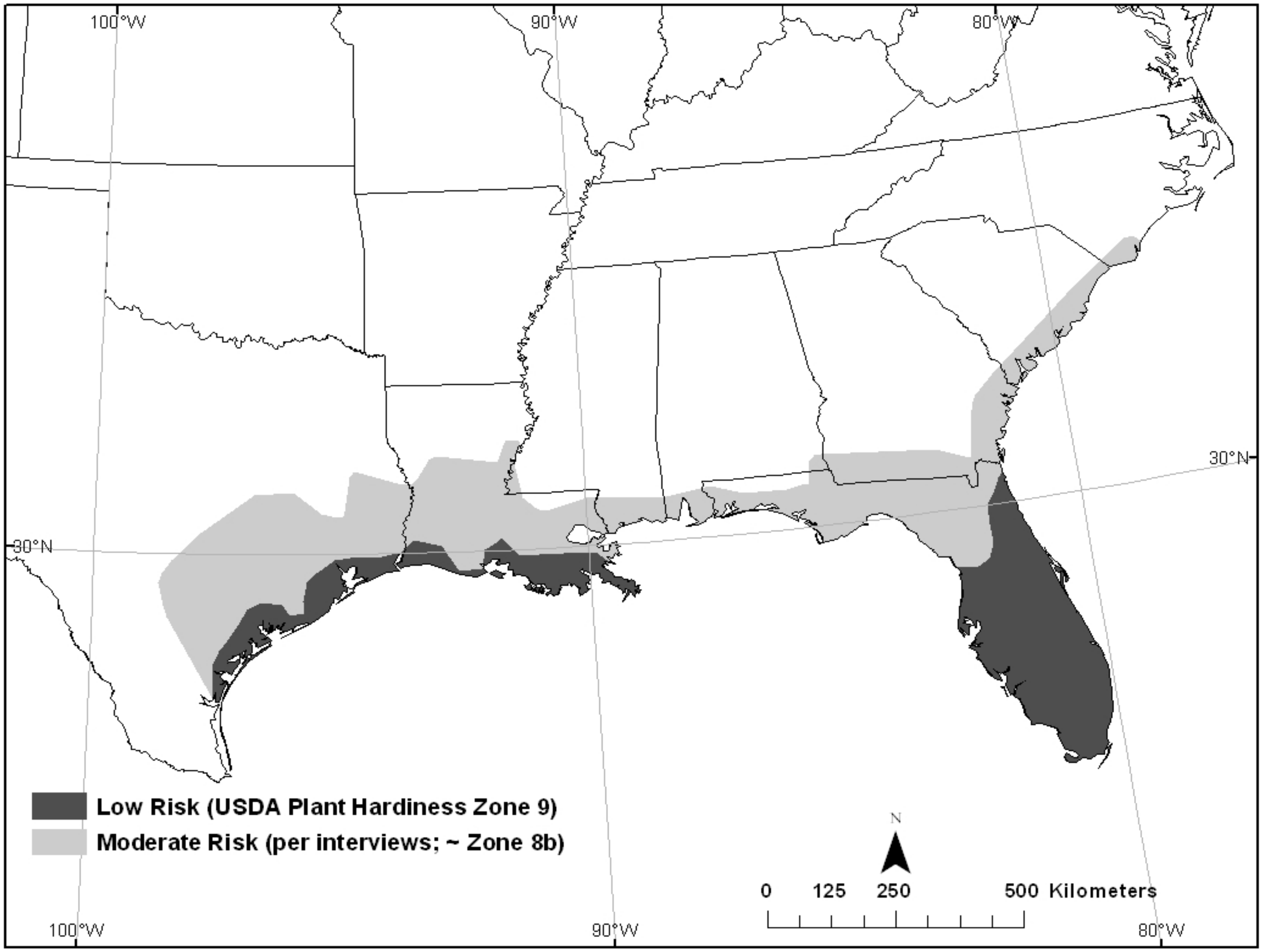
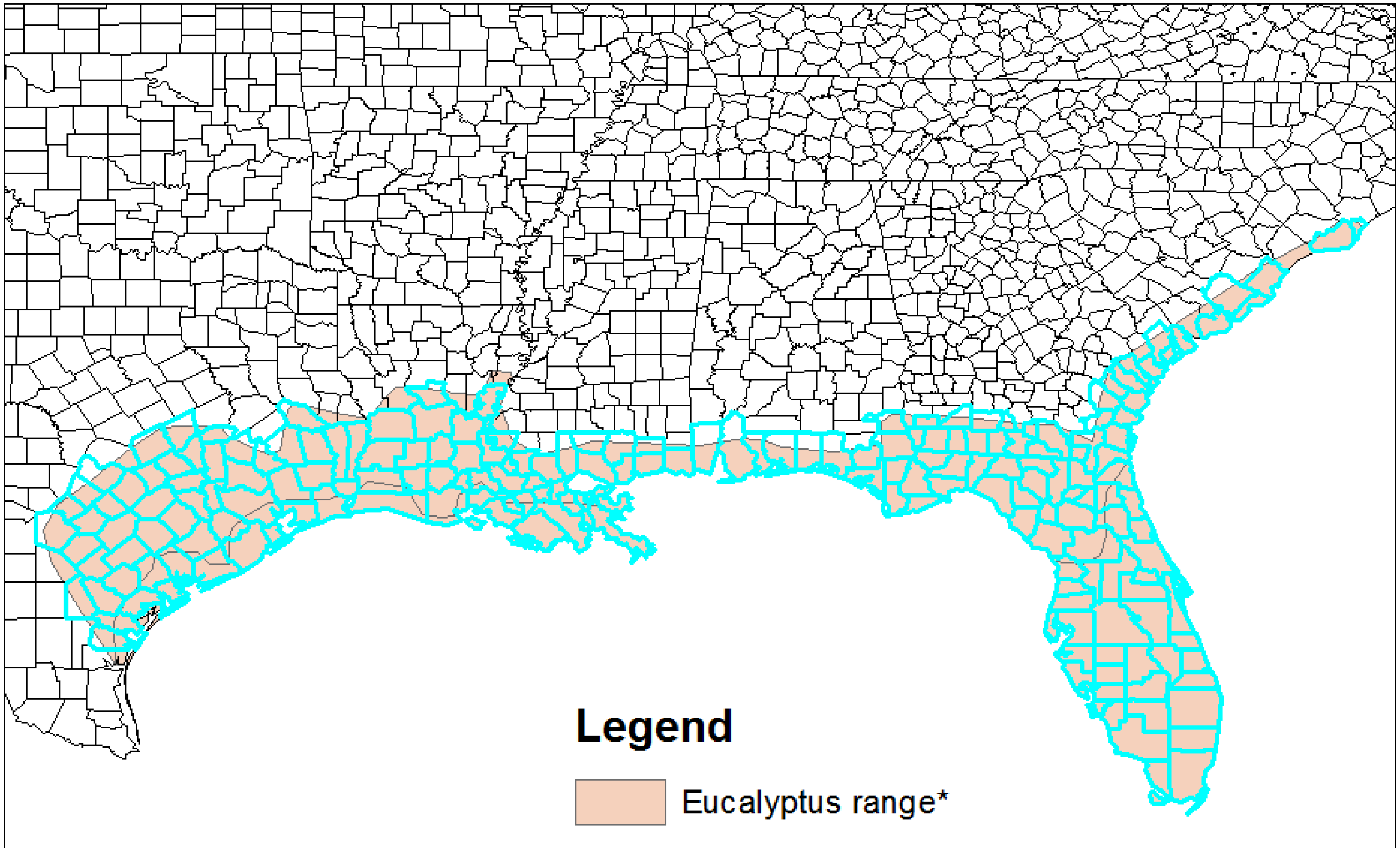
Eucalyptus range



Source: Kline KL, MD Coleman. 2010. Wood energy crops in the southeastern United States: Two centuries of practitioners experience. *Biomass and Bioenergy* 34:1655-1666.

192 Counties in range

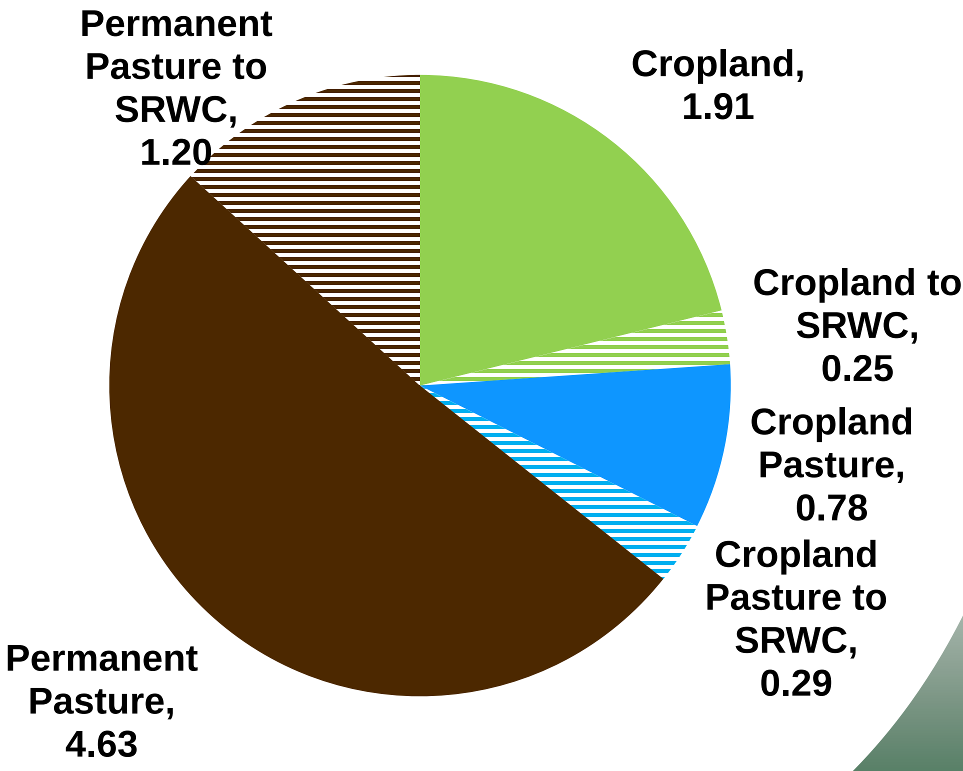


*Source: Kline KL, MD Coleman. 2010. Wood energy crops in the southeastern United States: Two centuries of practitioners experience. *Biomass and Bioenergy* 34:1655-1666.

SRWC Production in 192 counties

- **1.0 and1.5 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.**

Million hectares in 2030, SRWC in 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