Continuing Project

The effects of dominant tree height definition on loblolly pine growth and yield model outputs in the southeast U.S.

CAFS.22.99

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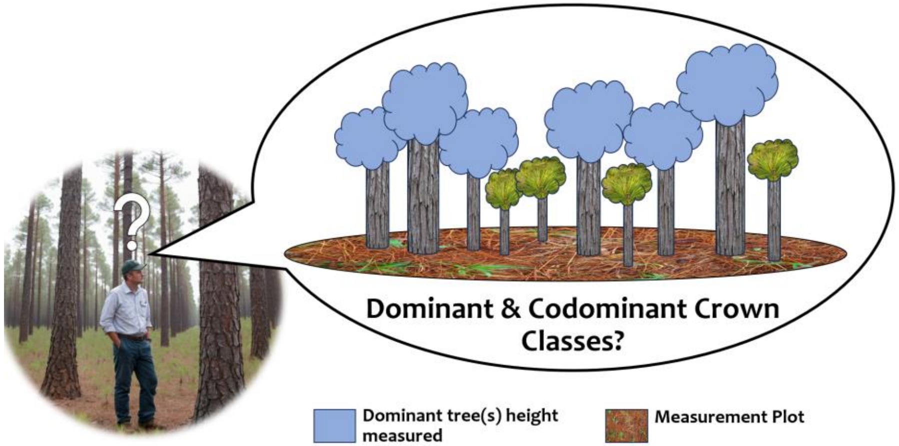
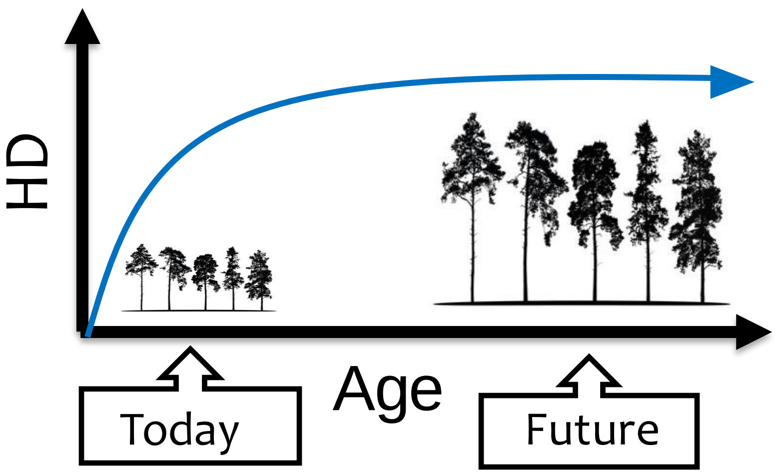
Justification



Which tree(s) to select?



- ❑ **PROBLEM:** No single consensus definition of what constitutes a dominant tree
- ❑ **IMPORTANCE:** Avg. dominant heights & SI are used in G&Y Models
- ❑ **IMPLICATIONS:** G&Y model outputs guide silvicultural & timber invest decisions

Objectives

1. Test for differences in average dominant tree height estimations and distributions at post-treatment based on how dominant trees are selected

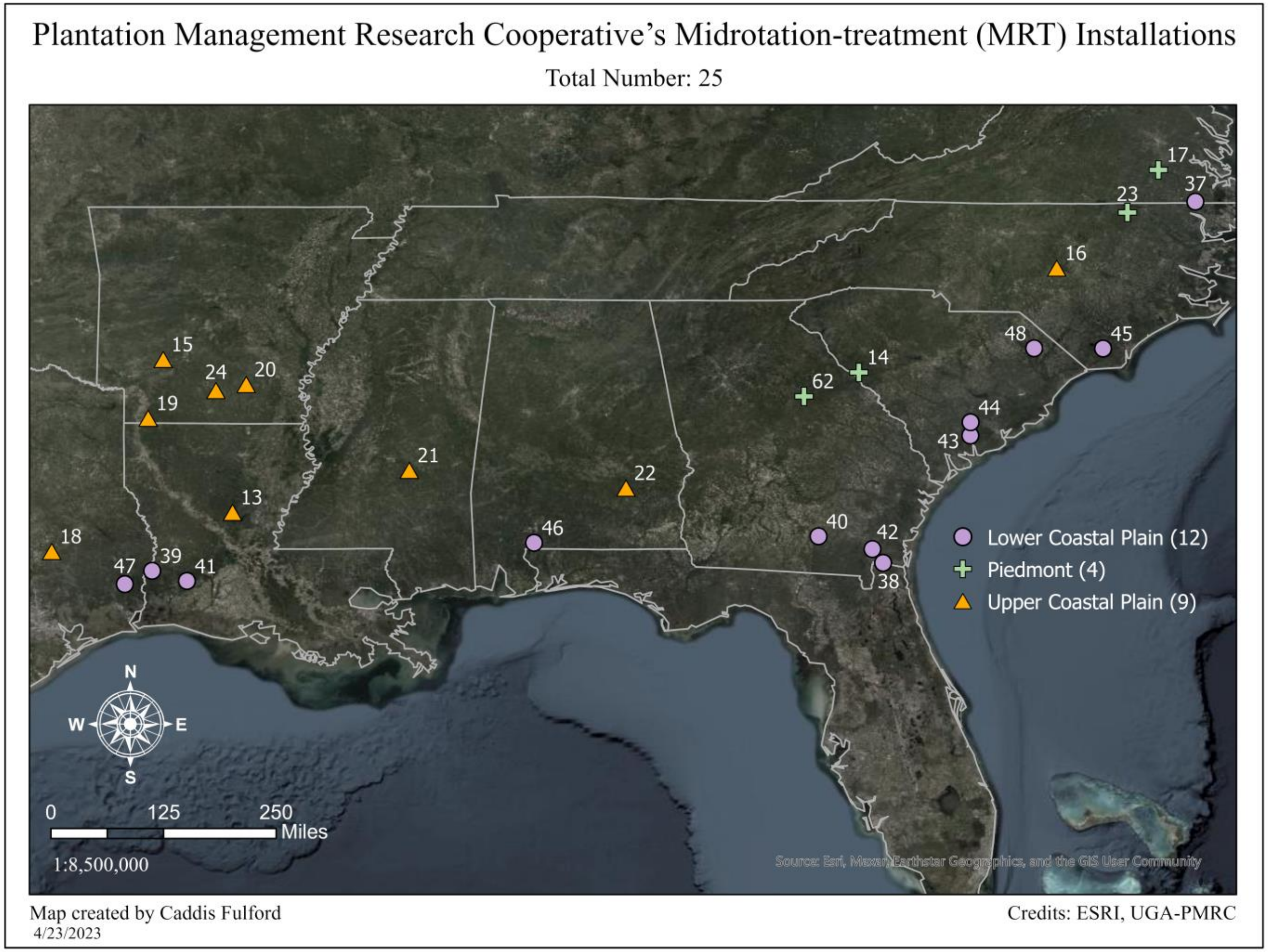
2. Investigate the relationship between silvicultural treatments and dominant tree height definitions

3. Determine if dominant tree height definitions influence a region-level SI model's performance differently

4. Examine how different dominant tree height definitions impact PMRC 1996 whole-stand G&Y model's outputs, predictability, and, subsequently, rotation age decisions for maximizing economic returns

Study Sites

25 Southeast Research Installations



Methods

Species:
Pinus taeda L.

5 Treatments
- Control
- Thin-Only
- T+Fertilization
- T+Release
- T+F+R

Treatment Plots
- 0.75 ac in size
- 125 in total

Measurement Plots
- 0.5 ac in size
- Remeasured every 2 yrs

19 Definitions Evaluated

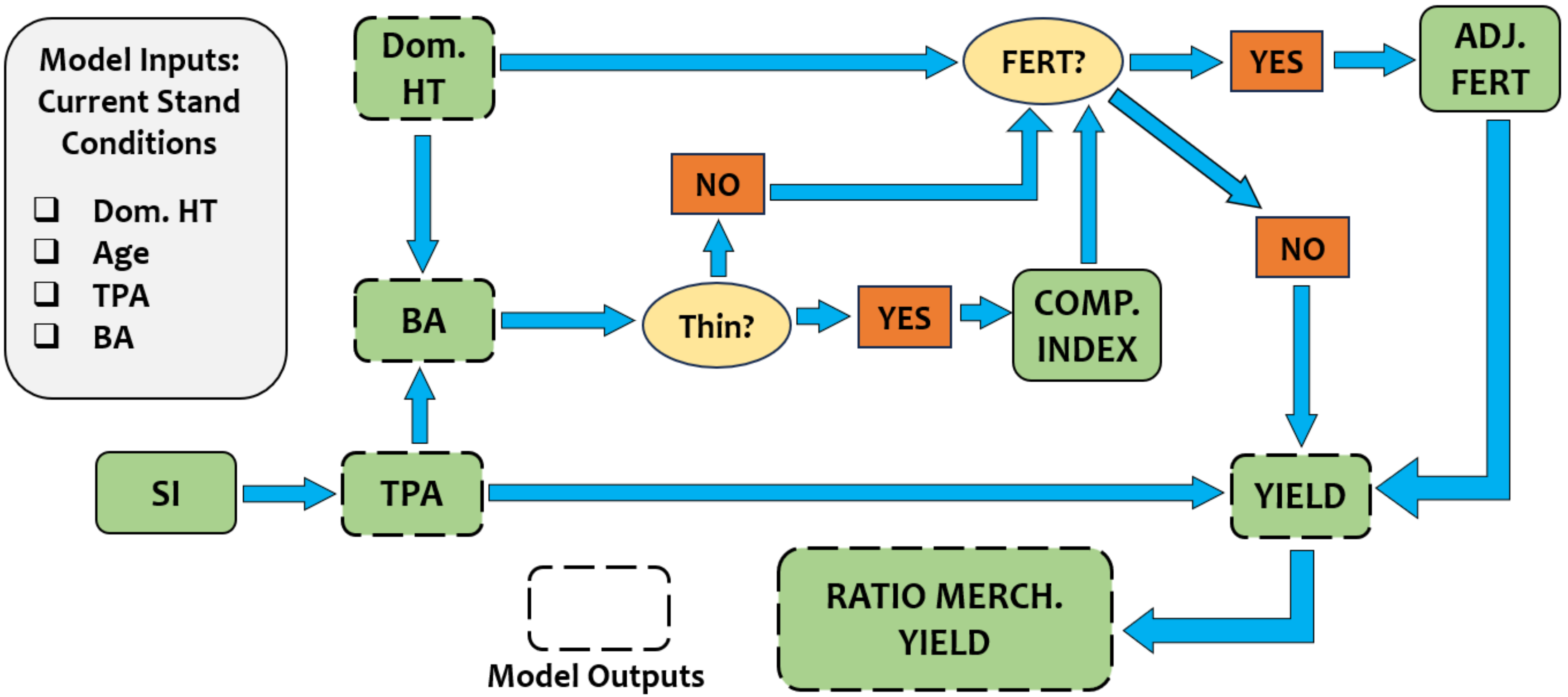
Methods

Average height of trees…

- (**DC**) in the **dominant** and **codominant crown classes**
- (**MD**) with a DBH > **mean diameter**
- (**QMD**) with a DBH > **quadratic mean diameter**
- (**ST**) in the **sawtimber potential** class 0 (i.e., no defects)
- (**LD**P**) of the **10**, **20**, **30**, **40**, & **50% largest DBH trees**
- (**LD****) of the **20**, **30**, **40**, **50**, & **60 largest DBH** **TPA**
- (**TT****) of the **20**, **30**, **40**, **50**, and **60 tallest** TPA

Whole-Stand G&Y Model Used (PMRC 1996)

Methods



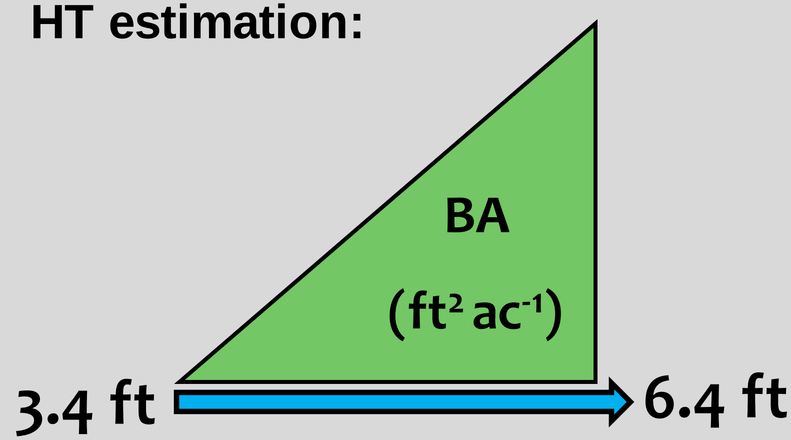
532 different scenarios simulated (Objective 4)

Objectives 1 & 2

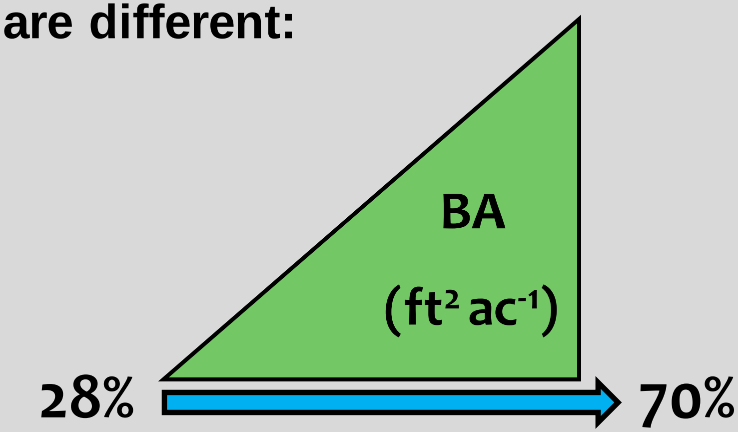
Major Findings

- Significant differences in avg. Dom HT estimations
- Dom HT distributions were significantly different at post-treatment
- Significance pattern between silvicultural treatment and Dom HT depends on definition

Avg. largest difference in Dom HT estimation:



How often Dom HT distributions are different:



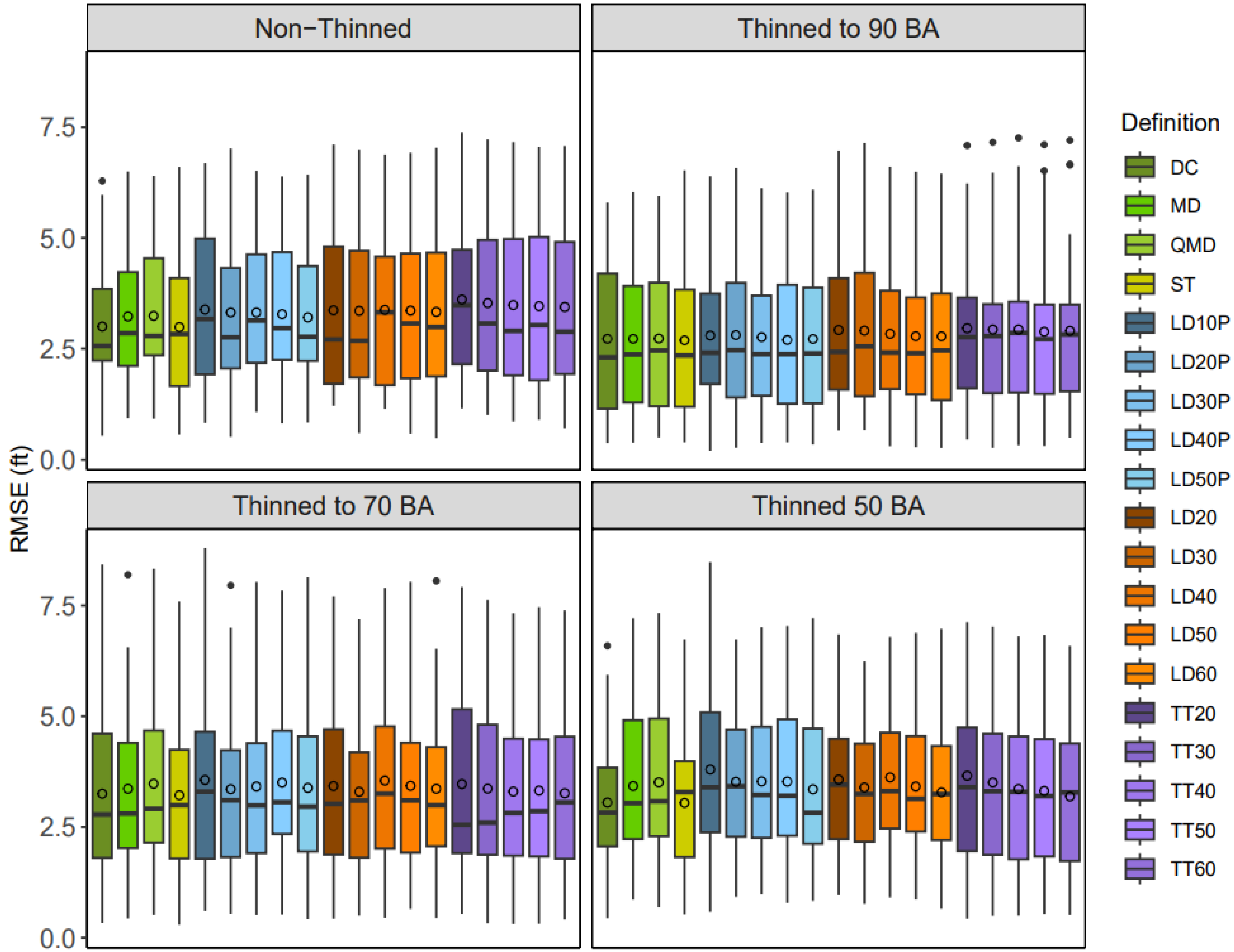
Objectives 3

Major Findings

Region-level SI Model

$$HD = \chi_{i-n_i}\left(1 - e^{-\beta_2 A}\right)^{\beta_3} + \varepsilon \Rightarrow AvgDHT_2 = AvgDHT_1\left(\frac{1 - e^{\beta_2 A_2}}{1 - e^{\beta_2 A_1}}\right)^{\beta_3}$$

Models were fitted across all plots with maximum log-likelihood approach



Kruskal-Wallis Test

Chi-squared: 6.638

df: 18

P-value: 0.9928

Objectives 4

Major Findings

$$AvgDHT_2 = AvgDHT_1\left(\frac{1-e^{\beta_2 A_2}}{1-e^{\beta_2 A_1}}\right)^{\beta_3}$$

Dominant Height Function

Projection:

15 ➡ 25 years

Largest Difference (ft):

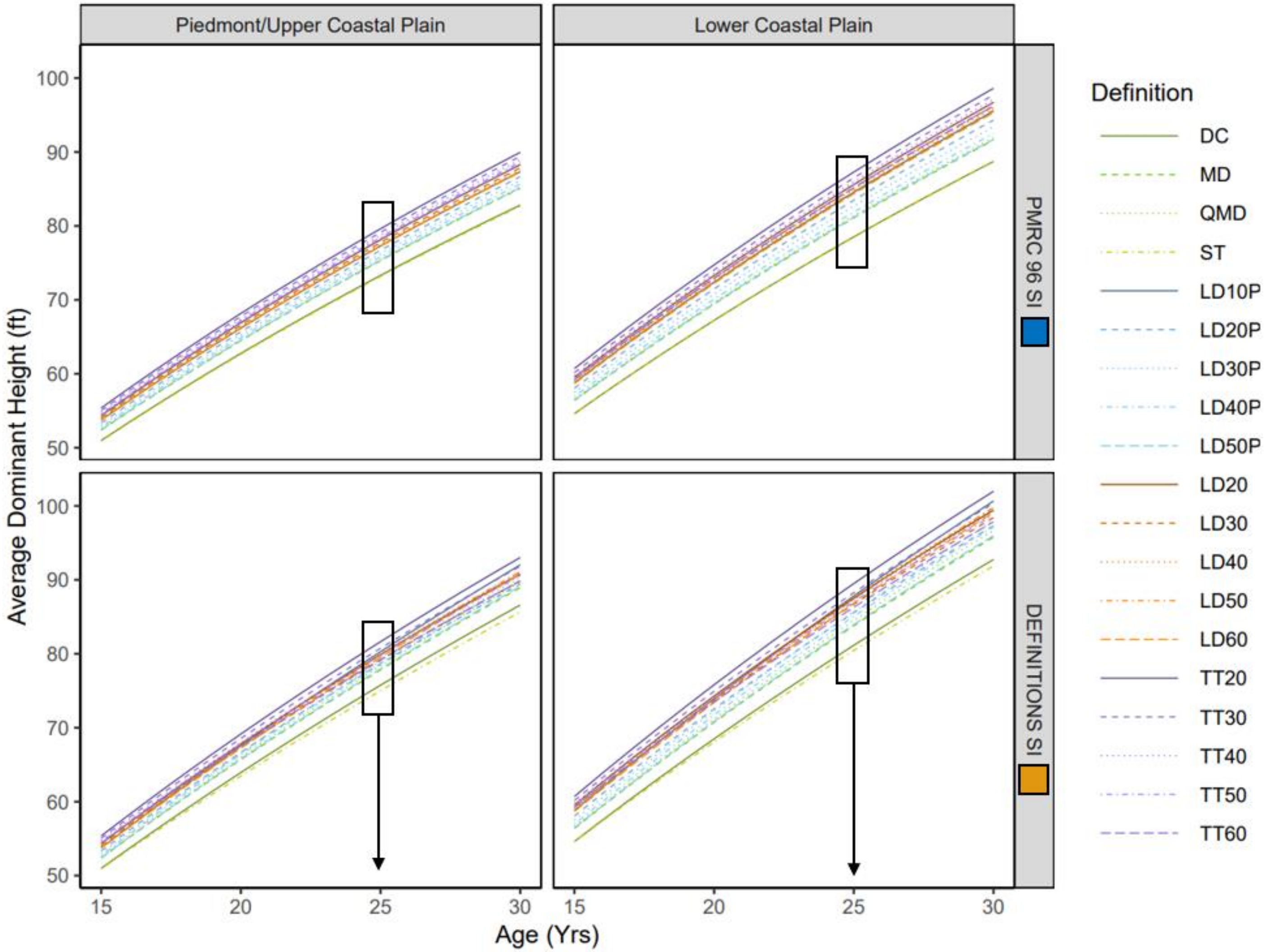
Non-Thinned

PIE/UCP: 6.4 | 6.6

LCP: 8.8 | 9.1

Difference Range

8.4 to 10.7%



Objectives 4

Major Findings

$$TPA_2 = 100 + \left[(TPA_1 - 100)^{B_1} + B_2 SI_{25}({A_2}^{B_3} - {A_1}^{B_3})\right]^{-\frac{1}{B_1}}$$

Mortality Function

Projection:

15 → 25 years

Largest Difference (TPA):

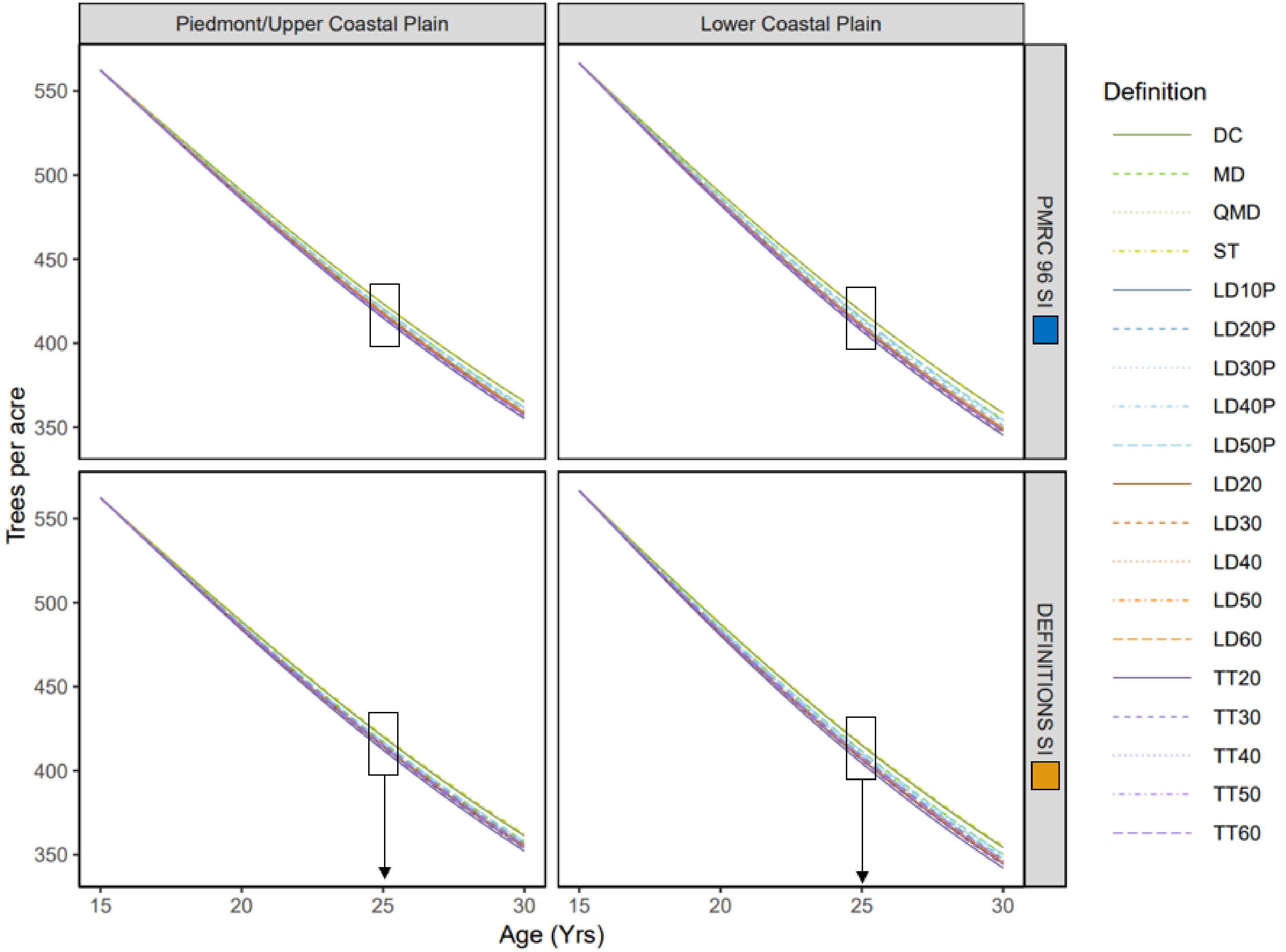
Non-Thinned

PIE/UCP: 8.7 | 8.8

LCP: 11.5 | 11.6

Difference Range

2.1 to 2.9%



Objectives 4

Major Findings

$$\ln(BA_2) = \ln(BA_1) - B_1\left[\frac{1}{A_1} - \frac{1}{A_2}\right] + B_2[\ln(TPA_2) - \ln(TPA_1)] + B_3[\ln(HD_2) - \ln(HD_1)] + B_4\left[\frac{\ln(TPA_2)}{A_2} - \frac{\ln(TPA_1)}{A_1}\right] + B_5\left[\frac{\ln(HD_2)}{A_2} - \frac{\ln(HD_1)}{A_1}\right]$$

Basal Area Function

Projection:

15 → 25 years

Largest Difference (ft^2ac^{-1}):

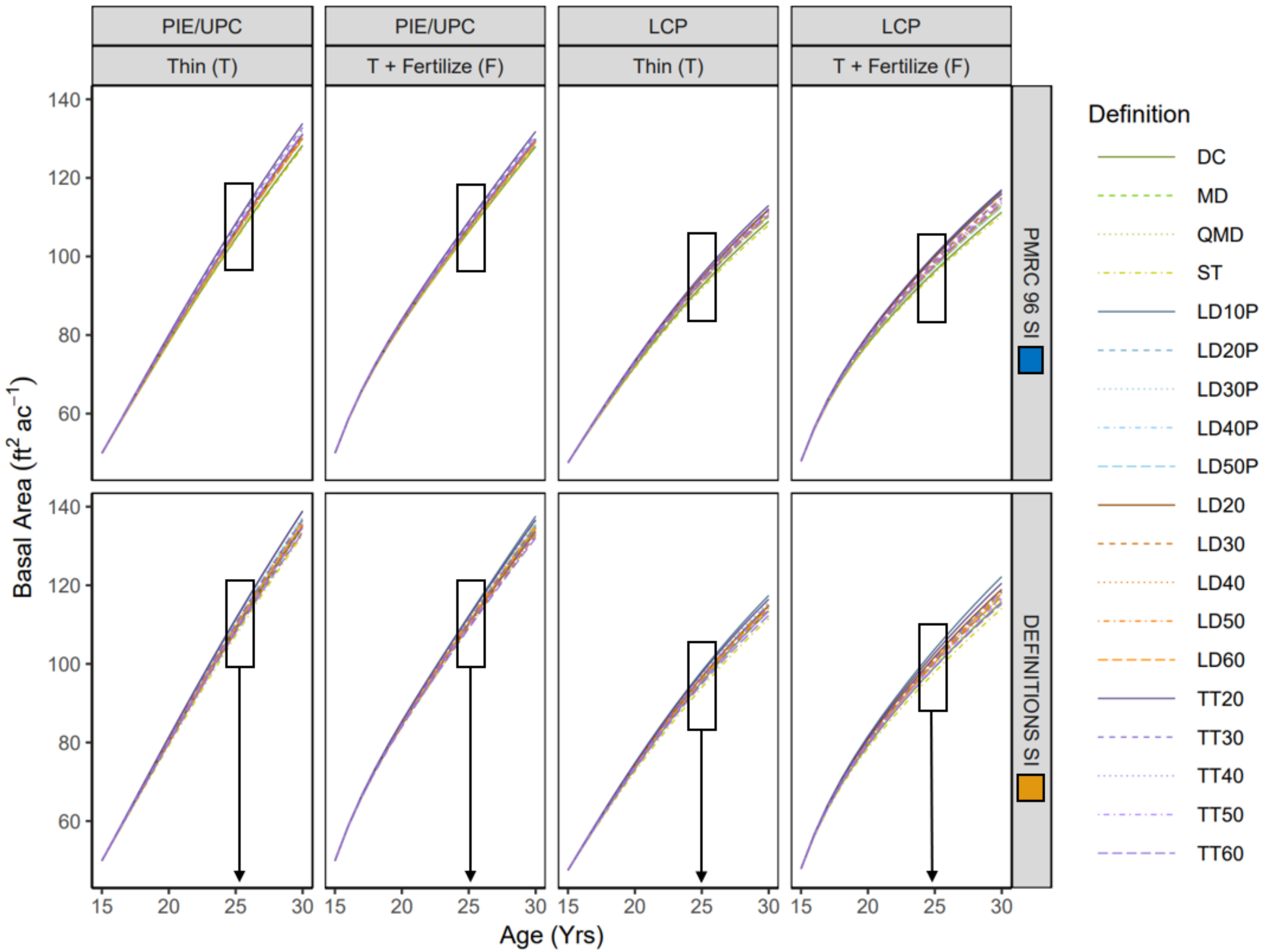
Thinned to 50 BA

PIE/UCP: 4.8 | 5.4

LCP: 4.2 | 4.8

Difference Range

2.5 to 5.9%



Objectives 4

Major Findings

$$ln(Y) = \beta_0 + \beta_1 ln(HD) + \beta_2 (BA) + \beta_3 \frac{\ln(TPA)}{A} + \beta_4 \frac{\ln(HD)}{A} + \beta_5 \frac{\ln(BA)}{A}$$

Total Green Weight Yield Function

Projection:

15 → 25 years

Largest Difference (tons ac-1):

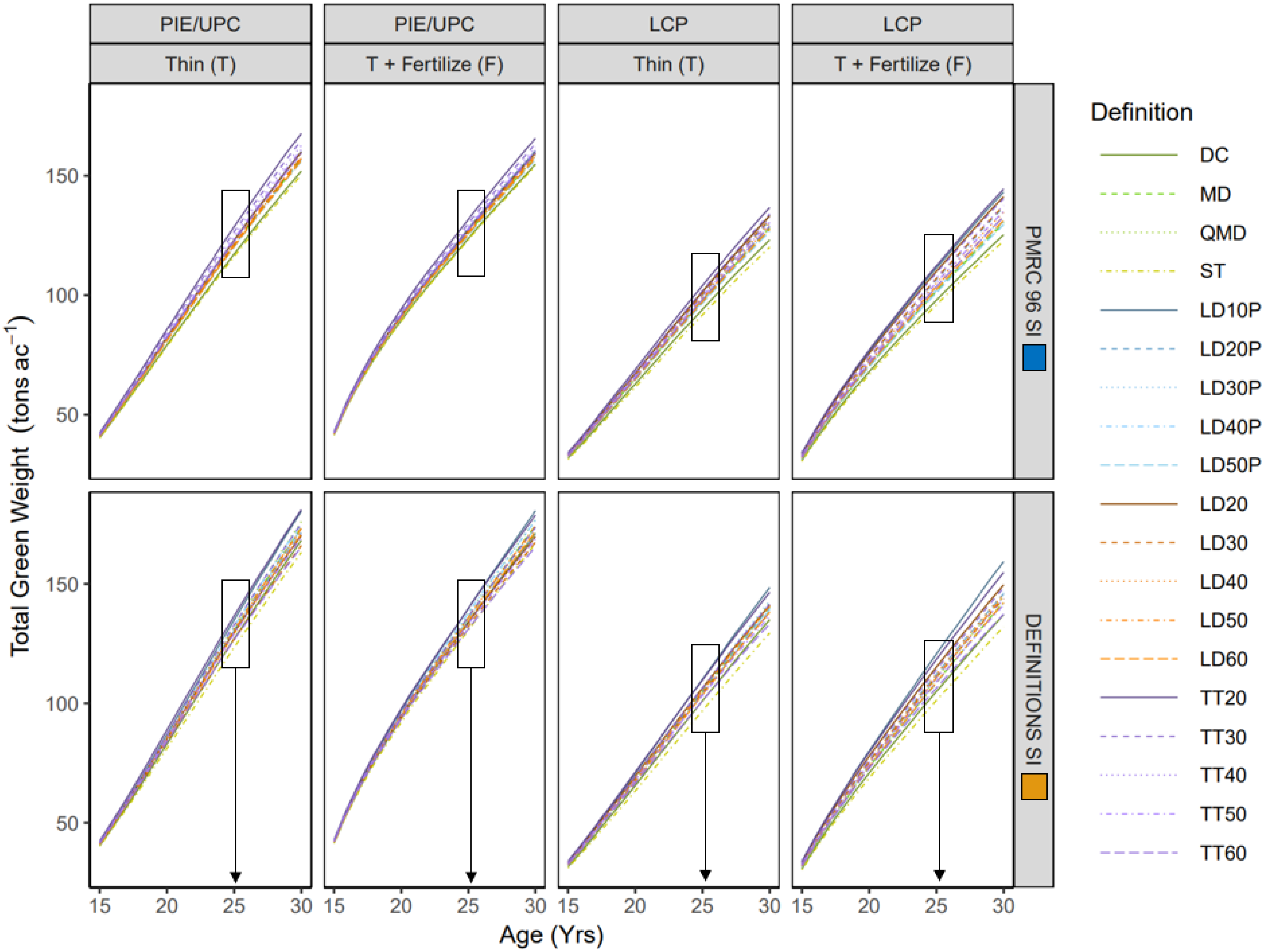
Thinned to 50 BA

PIE/UCP: 12.4 | 13.3

LCP: 16.3 | 19.5

Difference Range

6.7 to 17.6%

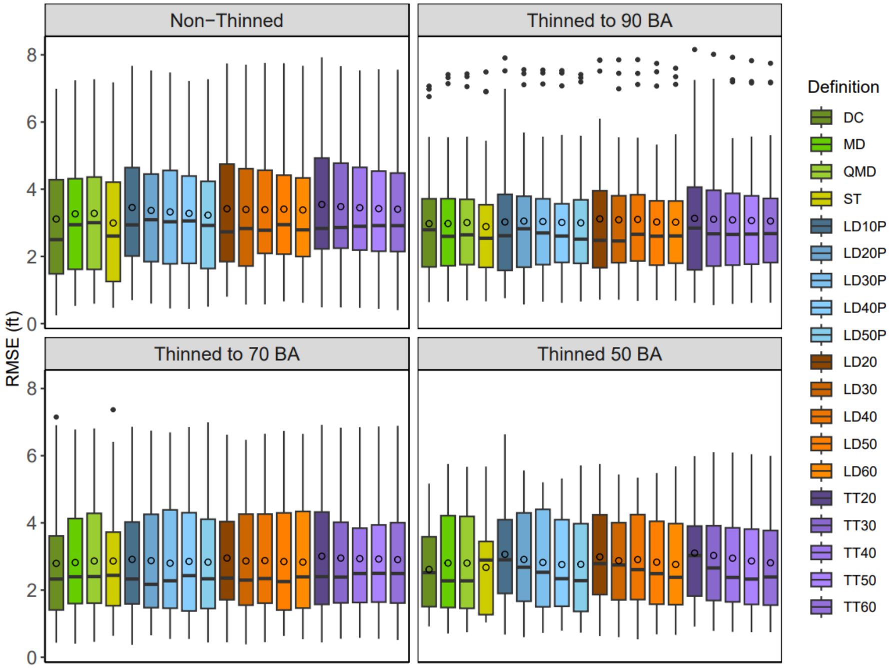


Objectives 4

Major Findings

PMRC 1996 Growth & Yield Function Predictability

Avg. Dominant Height

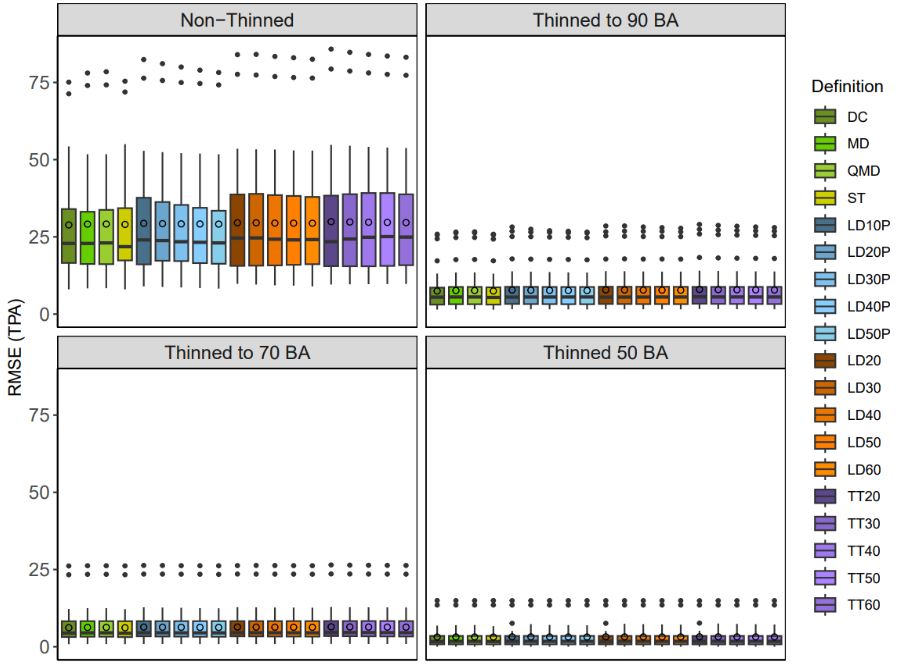


Kruskal-Wallis Test

Chi-squared: 3.280

P-value: 0.9999

Mortality(TPA)



Kruskal-Wallis Test

Chi-squared: 0.416

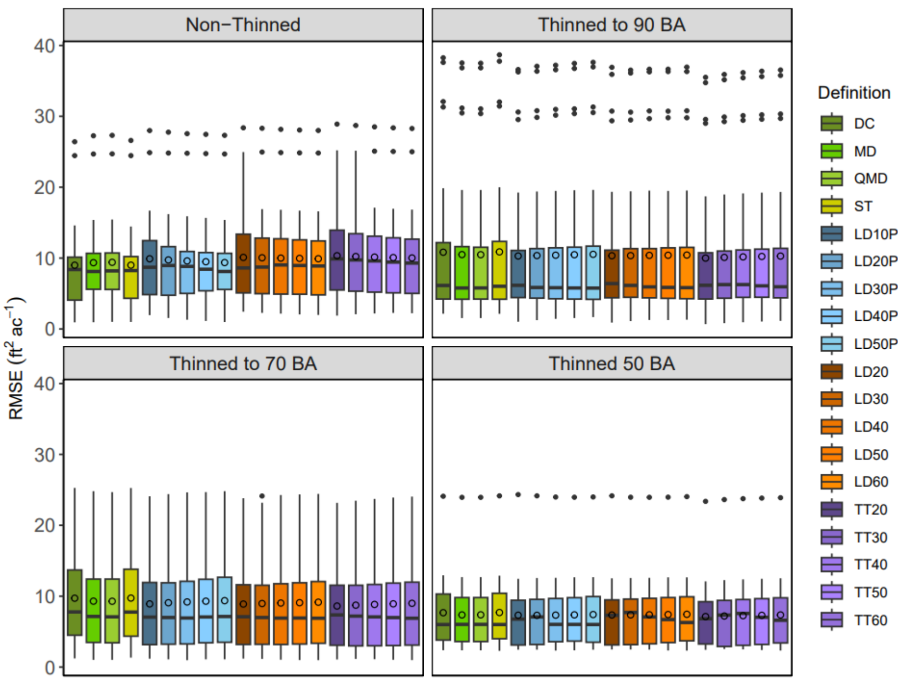
P-value: 1.000

Objectives 4

Major Findings

PMRC 1996 Growth & Yield Function Predictability

Basal Area

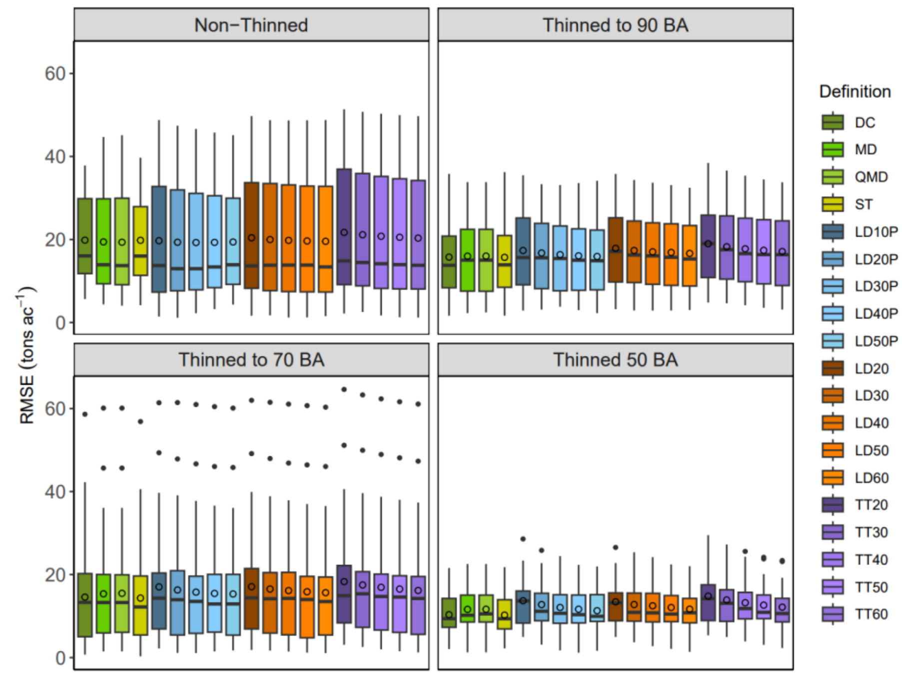


Kruskal-Wallis Test

Chi-squared: 0.457

P-value: 1.000

Total Green Weight Yield



Kruskal-Wallis Test

Chi-squared: 12.020

P-value: 0.8462

Objectives 4

Major Findings

Marginal Revenue & Cost Analyses

Piedmont/Upper Coastal Plain Regions

Inst	Def	Age (yrs)	Pulpwood (Tons ac^{-1})	Chip-n-Saw (Tons ac^{-1})	Sawtimber (Tons ac^{-1})	MR (\$ ac^{-1})	MC (\$ ac^{-1})	Age (yrs)	Pulpwood (Tons ac^{-1})	Chip-n-Saw (Tons ac^{-1})	Sawtimber (Tons ac^{-1})	MR (\$ ac^{-1})	MC (\$ ac^{-1})
		Non-Thinned						Thinned-only to 90 ft^2 ac^{-1}					
	DC	26	47.4	108.9	115.1	218.9	213.1	26	20.5	52.9	96.8	154.3	143.4
	MD	26	48.4	111.4	118.5	219.6	218.9	27	19.7	52.2	114.5	161.2	160.2
13	LD20P	25	52.4	115.7	105.0	229.3	210.0	27	19.7	52.6	120.8	170.0	166.8
	LD40	25	52.8	116.7	106.1	229.6	212.1	27	19.7	52.7	121.8	171.4	167.8
	TT20	25	53.3	117.9	107.4	230.0	214.4	27	19.7	53.1	128.6	180.7	174.9
		Non-Thinned						Thinned-only to 70 ft^2 ac^{-1}					
	DC	27	50.3	111.1	101.4	208.8	202.2	26	19.8	48.4	66.3	112.2	109.3
	MD	27	50.4	111.4	101.7	208.8	202.8	26	19.8	48.8	69.1	116.3	112.5
20	LD20P	27	50.6	111.9	102.2	208.7	203.8	26	19.8	49.0	70.3	118.0	113.8
	LD40	27	50.7	112.3	102.6	208.7	204.4	26	19.8	49.0	70.3	118.0	113.8
	TT20	27	51.1	113.2	103.6	208.7	206.4	26	19.9	49.8	76.5	126.7	120.6
		Non-Thinned						Thinned-only to 50 ft^2 ac^{-1}					
	DC	27	55.3	117.5	92.6	213.0	200.2	28	14.2	37.4	76.0	115.3	108.8
	MD	27	55.9	118.8	94.0	213.0	202.7	28	14.2	37.5	78.7	118.5	111.5
16	LD20P	27	56.2	119.5	94.8	212.9	204.1	28	14.2	37.6	79.5	119.5	112.4
	LD40	27	56.3	119.9	95.2	212.9	204.9	28	14.2	37.5	78.7	118.6	111.6
	TT20	27	56.8	121.1	96.6	212.8	207.4	28	14.2	37.9	84.8	125.9	117.9

Objectives 4

Major Findings

Marginal Revenue & Cost Analyses

Lower Coastal Plain Regions

Inst	Def	Age (yrs)	Pulpwood (Tons ac^{-1})	Chip-n-Saw (Tons ac^{-1})	Sawtimber (Tons ac^{-1})	MR (\$ ac^{-1})	MC (\$ ac^{-1})	Age (yrs)	Pulpwood (Tons ac^{-1})	Chip-n-Saw (Tons ac^{-1})	Sawtimber (Tons ac^{-1})	MR (\$ ac^{-1})	MC (\$ ac^{-1})
		Non-Thinned						Thinned-only to 90 ft^2 ac^{-1}					
48	DC	20	71.5	127.7	40.8	290.8	267.1	22	28.7	60.7	34.1	149.1	145.6
	MD	20	72.5	129.3	41.4	291.6	270.7	22	29.0	62.0	36.1	157.3	150.4
	LD20P	20	73.2	130.3	41.8	292.1	273.0	22	29.2	62.9	37.4	162.8	153.7
	LD40	20	73.2	130.3	41.8	292.1	273.0	22	29.2	62.9	37.5	163.0	153.8
	TT20	20	74.9	132.8	42.8	293.1	278.7	22	29.5	63.9	39.0	169.3	157.5
		Non-Thinned						Thinned-only to 70 ft^2 ac^{-1}					
38	DC	21	93.1	100.7	10.1	210.8	202.9	24	32.2	74.2	57.1	202.7	199.4
	MD	20	99.7	93.5	6.5	218.0	193.4	24	32.5	76.7	64.9	219.9	214.5
	LD20P	20	102.0	94.0	6.2	211.3	195.1	24	32.7	78.5	71.5	233.8	227.0
	LD40	20	103.4	94.3	6.1	207.1	196.2	24	32.8	79.2	74.1	239.1	231.7
	TT20	20	104.9	94.5	5.9	202.6	197.3	24	33.0	81.1	81.8	254.4	245.8
		Non-Thinned						Thinned-only to 50 ft^2 ac^{-1}					
45	DC	21	75.3	113.0	26.8	251.3	230.6	23	16.3	45.0	70.0	178.6	172.4
	MD	21	76.5	113.8	26.3	246.7	231.7	23	16.3	45.2	71.6	181.9	175.1
	LD20P	21	77.4	114.3	25.9	243.4	232.5	23	16.3	45.2	71.4	181.5	174.8
	LD40	21	78.1	114.7	25.7	241.0	233.0	23	16.3	45.2	71.7	182.1	175.3
	TT20	20	84.3	111.1	18.6	249.4	222.3	23	16.4	45.6	74.0	186.8	179.2

Deliverables

- [x] Poster and oral presentation on the project's progress at several regional professional meetings
- [x] Graduate student thesis on the topic
- [ ] Publication(s) in peer-reviewed literature (IN-PROGRESS)

Company Benefits

- Help forest managers make more informed decisions on which definitions to employ
- Highlight potential influence on forest management and/or financial investment decisions as a result of the variability between different dominant tree height definitions
- Suggest new research directions that may include the examination of other important commercial tree species and growth & yield models

Future Research?

- ❑ Whole-stand model vs. Individual-tree model
- ❑ 0.5-acre plot size vs. 0.1-acre plot size
- ❑ Pine species vs. hardwood species
- ❑ Even-aged stand vs. uneven-aged stand (e.g., mixed species)

Summary

- Significant differences in Avg. Dom HT estimations and distributions.
- Relational pattern between Avg. Dom HT and silvicultural treatment varied based on definition usage
- Ten-year projections (15-25 years) avg. differences in growth functions:

0.7% (**TPA**) < 3.5% (**BA**) < 7.3% (**SI**) < 10.8% (**YIELD**)

- No significant differences in PMRC 1996 growth & yield system's performance (i.e., Avg. Dom. HT, TPA, BA per acre, and Yield Per Acre)
- Economic rotation age extended or reduced by a maximum one year based on definition usage