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OBSERVED GROWTH AND YIELD OF LOBLOLLY PINE PLANTATIONS IN EAST TEXAS

BY

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AND

DEAN W. COBLE

REPORT 68

FROM

THE

EAST TEXAS PINE PLANTATION RESEARCH PROJECT

ARTHUR TEMPLE COLLEGE OF FORESTRY

STEPHEN F. AUSTIN STATE UNIVERSITY

NACOGDOCHES, TX 75962

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INTRODUCTION

Forestland in east Texas occupies about 12.1 million acres with 2.9 million acres (24%) classified as pine plantations on private land. Pine plantations are typically managed to produce timber, so information is needed to make informed management decisions. Growth is one piece of information that managers often rely upon in their decision-making process.

The purpose of this paper is to report observed growth in loblolly pine (*Pinus Taeda*) plantations in East Texas. The following annual growth rates are reported by various, site index (25-year index age), and trees per acre, and age classes:

- Quadratic Mean Diameter (inches)
- Average Stand Height (feet)
- Basal Area per Acre (square feet)
- Cubic Foot Volume per Acre (wood and bark, ob).

The yield (cubic foot volume per acre) is also be reported by various site index, trees per acre, and age classes.

PLANTATION MEASUREMENTS

Data for this study were collected from permanent research plots maintained by the East Texas Pine Plantation Research Project (ETPPRP). The ETPPRP is a long-term comprehensive research program that has investigated the factors affecting the management of loblolly and slash pine plantations in East Texas since 1982¹. At this time, 124 plots are intact and available for analysis. The plots are measured on a three-year cycle, with 1/3 of the plots being measured each year. As of summer 2013, the plots have completed two to four measurement cycles.

Each plot is located in a different plantation and is 100 by 100 foot (10,000 ft² or 0.23 acres) in size. There is no buffer surrounding the plot, as the plots are operational in nature. This means that each plot receives the same treatment as the entire plantation, unlike the original ETPPRP plots which were insulated from all subsequent management activities. Treatment history and UTM Nad83 coordinates are known for each plot. Every planted pine tree is individually tagged and measured for diameter, total height, height to live crown, crown position, and disease and damage status. All recruits and hardwoods greater than 4-inches dbh are also individually tagged and measured. Non-planted competing vegetation will be tallied on four nested subplots (1/40th acre circular

¹ The support of the following organizations is much appreciated: Rayonier, Campbell Group, Hancock Forest Resources, and Resource Management Services, Arthur Temple College of Forestry and Agriculture at Stephen F. Austin State University.

plots for large woody competition and 1/200th acre circular plots for small herbaceous and woody competition) located within each plot

From these remeasured plots, 387 loblolly pine observations are available for analysis. Each observation provides the following variables:

- Plantation age at the time of measurement (AGE, years)
- Average total height of the dominant and codominant trees on the plot (HT, feet)
- Site Index (SI, feet, base age 25 years)
- Trees per acre (TPA)
- Basal area per acre (BA, square feet)
- Cubic foot volume wood and bark per acre (CFVWB, total tree).

Each of these variables was summarized into combinations of the following classes:

- Site Index (25-year index age) – four classes: 50, 60, 70, and 80 feet
- Trees per Acre – six classes: 300, 400, 500, 600, 700, 800
- Age – four classes: 5, 10, 15, 20 years.

ANNUAL GROWTH RATES

The following mean annual growth rates (MAI) were calculated for each observation:

- $MAI_{QMD} = \frac{\text{Observed QMD}}{\text{AGE}}$
- $MAI_{HT} = \frac{\text{Observed HT}}{\text{AGE}}$
- $MAI_{BA} = \frac{\text{Observed BA}}{\text{AGE}}$
- $MAI_{CFVWB} = \frac{\text{Observed CFVWB}}{\text{AGE}}$

The following periodic annual growth rates (PAI) were calculated for each observation:

- $PAI_{QMD} = \frac{\text{Observed QMD}}{3}$
- $PAI_{HT} = \frac{\text{Observed HT}}{3}$
- $PAI_{BA} = \frac{\text{Observed BA}}{3}$
- $PAI_{CFVWB} = \frac{\text{Observed CFVWB}}{3}$

Note that the period or cycle length = 3 years.

TABULATED RESULTS

Annual growth rates (MAI and PAI) along with yield were tabulated by the various site index (25-year index age), trees per acre, and age classes for both loblolly pine:

- Overall Annual Growth Rates:
 - Table 1 – MAI and yield
 - Table 2 – PAI

- By Site Index, Trees per Acre, and Age:
 - Table 3 – MAI and yield
 - Table 4 – PAI

- By Age and Site Index Classes:
 - Table 5 – MAI and yield
 - Table 6 – PAI

- By Site Index and Trees per Acre Classes:
 - Table 7 – MAI and yield
 - Table 8 – PAI

- By Age and Trees per Acre Classes:
 - Table 9 – MAI and yield
 - Table 10 – PAI

Note: caution should also be exercised when using values for which sample sizes are small.

GRAPHICAL RESULTS

Annual growth rates (MAI and PAI) along with yield were plotted by site index (25-year index age), trees per acre, and age classes for loblolly pine:

- Yield
 - Figure 1: by Age and Site Index Classes
 - Figure 4: by Age and Trees per Acre Classes

- MAI
 - Figure 2: by Age and Site Index Classes
 - Figure 5: by Age and Trees per Acre Classes

- PAI
 - Figure 3: by Age and Site Index Classes
 - Figure 6: by Age and Trees Per Acre Classes

Table 1. Overall mean annual quadratic mean diameter, average dominant and codominant height, basal area, and cubic foot growth (MAI) and yield for loblolly pine plantations in East Texas.

Measure	Average Annual Growth
Diameter (SE)	0.7 (0.008)
Height (SE)	4.1 (0.04)
Basal area (SE)	8.7 (0.2)
Cubic foot volume wood and bark (SE)	118.2 (3.7)
Yield (cubic foot volume) (SE)	1026.3 (42.7)

Diameter = quadratic mean diameter in inches

Height = average height of dominant and codominant trees

Basal area = square feet per acre

Cubic foot volume wood and bark = total stem cubic feet wood and bark per acre

Yield = cubic foot volume per acre

(SE) = standard error

Average annual growth values based on 387 observations

Table 2. Overall periodic annual quadratic mean diameter, average dominant and codominant height, basal area, and cubic foot volume growth (PAI) for loblolly pine plantations in East Texas.

Measure	Average Annual Growth
Quadratic mean diameter (SE)	1.6 (0.03)
Height of dominant and codominant trees (SE)	9.7 (0.21)
Basal area (SE)	22.7 (0.70)
Cubic foot volume wood and bark (SE)	342.1 (14.22)

Diameter = quadratic mean diameter in inches

Height = average height of dominant and codominant trees

Basal area = square feet per acre

Cubic foot volume wood and bark = total stem cubic feet wood and bark per acre

(SE) = standard error

Average periodic annual growth values based on 387 observations

Table 3. Mean annual quadratic mean diameter, average dominant and codominant height, basal area, and cubic foot volume growth (MAI) and yield by site index (25-year index age), age, and trees per acre classes for loblolly pine plantations in East Texas.

	Average Annual Growth					Observations
	Quadratic Mean Diameter (inches)	Height (feet)	Basal Area (feet ²)	Cubic Foot Volume (wood and bark)	Yield (cubic foot volume per acre wood and bark)	
Site Index (feet)						
50	0.7	4.3	8.6	109.0	880.6	31
60	0.6	4.0	8.4	118.0	1076.7	206
70	0.7	4.3	9.2	120.4	957.9	130
80	0.6	4.3	8.4	120.8	1177.3	20
Total Age Class (years)						
5	0.7	4.4	7.4	74.5	414.2	207
10	0.6	4.0	10.7	170.8	1637.9	152
15	0.5	3.4	7.5	152.8	2208.1	25
20	0.4	2.8	5.4	123.8	2423.9	3
Trees per Acre						
300	0.6	3.6	5.2	105.7	1519.2	17
400	0.7	4.2	7.9	107.2	908.1	91
500	0.7	4.2	8.7	117.9	992.5	142
600	0.7	4.2	9.2	118.0	945.6	94
700	0.6	3.8	10.1	146.0	1443.4	31
800	0.6	4.4	11.3	152.8	1178.3	12

Table 4. Periodic annual quadratic mean diameter, average dominant and codominant height, basal area, and cubic foot volume growth (PAI) by site index (25-year index age), trees per acre, and age classes for loblolly pine plantations in East Texas.

	Average Annual Growth				Observations
	Quadratic Mean Diameter (inches)	Height (feet)	Basal Area (feet ²)	Cubic Foot Volume (wood and bark)	
Site Index (feet)					
50	1.5	9.2	21.2	293.5	31
60	1.6	10.2	23.2	358.9	206
70	1.5	9.0	22.1	319.3	130
80	1.6	10.5	23.7	392.4	20
Total Age Class (years)					
5	1.1	6.8	12.9	138.1	207
10	2.0	12.5	33.7	546.0	152
15	2.4	16.2	35.8	736.0	25
20	2.6	18.4	35.2	808.0	3
Trees per Acre					
300	2.5	15.9	23.7	506.4	17
400	1.6	9.4	20.4	302.7	91
500	1.5	9.5	22.3	330.8	142
600	1.4	8.8	22.2	315.2	94
700	1.6	11.0	30.8	481.1	31
800	1.4	9.8	27.2	392.8	12

Table 5. Mean annual quadratic mean diameter, average dominant and codominant height, basal area, and cubic foot volume growth (MAI) and yield by age and site index classes for loblolly pine plantations in East Texas.

Measure	Site index (feet)	Age (years)			
		5	10	15	20
Diameter (inches)	50	0.7	0.6	0.4	-
	60	0.7	0.6	0.5	0.4
	70	0.7	0.7	0.5	-
	80	0.7	0.6	0.4	0.4
Height (feet)	50	4.6	4.0	3.0	-
	60	4.3	3.9	3.4	2.7
	70	4.4	4.0	3.5	-
	80	4.8	4.1	3.4	3.1
Basal Area (feet ²)	50	7.2	10.4	8.2	-
	60	7.1	10.2	7.2	6.2
	70	7.6	11.4	9.9	-
	80	7.5	11.4	8.4	3.9
Cubic foot volume (wood and bark)	50	69.8	157.8	141.4	-
	60	73.4	164.2	147.0	134.3
	70	76.4	183.6	204.7	-
	80	78.3	183.4	178.2	102.7
Cubic foot yield	50	378.1	1453.3	1979.1	-
	60	420.7	1586.9	2118.9	2609.0
	70	409.5	1759.3	2865.2	-
	80	444.1	1725.3	2660.2	2053.7
Observations	50	17	13	1	-
	60	101	83	20	2
	70	78	51	1	-
	80	11	5	3	1

Table 6. Periodic annual quadratic mean diameter, average dominant and codominant height, basal area, and cubic foot volume growth (PAI) by age and site index (25-year index age) classes for loblolly pine plantations in East Texas.

Measure	Site index (feet)	Age (years)			
		5	10	15	20
Quadratic Mean Diameter (inches)	50	1.1	1.9	1.8	-
	60	1.2	2.0	2.4	2.5
	70	1.1	2.0	2.4	-
	80	1.1	2.0	2.1	2.7
Height (feet)	50	6.7	12.0	14.0	-
	60	7.0	12.4	16.2	17.3
	70	6.5	12.7	16.4	-
	80	6.9	12.7	16.6	20.8
Basal Area (feet ²)	50	12.2	31.6	38.1	-
	60	12.9	32.6	34.3	39.9
	70	12.9	35.8	46.3	-
	80	13.2	35.5	41.6	25.7
Cubic foot volume (wood and bark)	50	126.0	484.4	659.7	-
	60	140.2	529.0	706.3	869.7
	70	136.5	586.4	955.1	-
	80	148.0	575.1	886.7	684.6
Observations	50	17	13	1	-
	60	101	83	20	2
	70	78	51	1	-
	80	11	5	3	1

Table 7. Mean annual quadratic mean diameter, average dominant and codominant height, basal area, and cubic foot volume growth (MAI) and yield by site index (25-year index age) and trees per acre classes for loblolly pine plantations in East Texas.

Measure	Trees per acre	Site Index (feet)			
		50	60	70	80
Quadratic Mean Diameter (inches)	300	-	0.6	0.6	0.5
	400	0.7	0.7	0.7	0.8
	500	0.7	0.7	0.7	0.7
	600	0.8	0.6	0.7	-
	700	0.5	0.5	0.7	0.5
	800	0.5	0.7	0.6	-
Height (feet)	300	-	3.6	3.5	3.4
	400	4.3	4.1	4.4	4.7
	500	4.3	4.1	4.2	4.6
	600	5.1	4.0	4.3	-
	700	3.6	3.6	4.2	4.0
	800	3.3	4.9	4.2	-
Basal Area (feet ²)	300	-	5.2	5.1	4.8
	400	8.2	7.8	7.8	10.1
	500	8.3	8.4	9.8	7.9
	600	10.9	9.4	9.0	-
	700	8.2	9.2	12.0	9.9
	800	9.2	12.5	10.7	-
Cubic foot volume (wood and bark)	300	-	107.5	90.6	109.3
	400	109.6	108.7	102.5	126.2
	500	103.2	115.4	138.0	94.9
	600	136.6	125.0	110.6	-
	700	105.6	133.5	164.3	165.8
	800	131.9	185.5	129.0	-
Cubic foot yield	300	-	1550.1	1057.6	1780.1
	400	866.2	974.0	802.3	842.3
	500	816.4	987.1	1173.7	700.7
	600	903.1	1099.0	816.7	-
	700	1065.5	1359.4	1398.4	1882.2
	800	1450.6	1445.0	910.7	-
Observations	300	-	13	2	2
	400	7	53	29	2
	500	17	80	35	10
	600	3	42	49	-
	700	3	13	9	6
	800	1	5	6	-

Table 8. Periodic annual quadratic mean diameter, average dominant and codominant height, basal area, and cubic foot volume growth (PAI) by site index (25-year index age) and trees per acre classes for loblolly pine plantations in East Texas.

Measure	Trees per acre	Site Index (feet)			
		50	60	70	80
Quadratic Mean Diameter (inches)	300	-	2.5	2.2	2.5
	400	1.6	1.7	1.5	1.7
	500	1.5	1.5	1.7	1.3
	600	1.4	1.5	1.3	-
	700	1.4	1.6	1.7	1.6
	800	1.7	1.5	1.2	-
Height (feet)	300	-	15.9	13.5	18.4
	400	9.6	9.8	8.6	10.1
	500	8.8	9.6	9.9	8.2
	600	8.3	9.6	8.2	-
	700	10.3	11.0	10.8	11.9
	800	11.9	11.3	8.2	-
Basal Area (feet ²)	300	-	24.0	19.8	25.3
	400	20.3	21.4	18.5	21.7
	500	20.0	22.0	25.4	17.6
	600	22.1	24.7	20.0	-
	700	24.9	29.8	32.0	33.8
	800	33.8	29.9	23.8	-
Cubic foot volume (wood and bark)	300	-	516.7	352.5	593.4
	400	288.7	324.7	267.4	280.8
	500	272.1	329.0	391.2	233.6
	600	301.0	366.3	272.2	-
	700	355.2	453.1	466.1	627.4
	800	483.5	481.7	303.6	-
Observations	300	-	13	2	2
	400	7	53	29	2
	500	17	80	35	10
	600	3	42	49	-
	700	3	13	9	6
	800	1	5	6	-

Table 9. Mean annual quadratic mean diameter, average dominant and codominant height, basal area, and cubic foot volume growth (MAI) and yield by age and trees per acre classes for loblolly pine plantations in East Texas.

Measure	Trees per acre	Age (years)			
		5	10	15	20
Diameter (inches)	300	1.0	0.6	0.6	0.4
	400	0.7	0.7	0.5	-
	500	0.7	0.6	0.5	-
	600	0.7	0.6	0.4	0.3
	700	0.6	0.5	0.4	-
	800	0.7	0.5	-	-
Height (feet)	300	5.3	3.6	3.6	2.9
	400	4.3	4.1	3.3	-
	500	4.4	3.9	3.4	-
	600	4.4	4.0	3.0	2.6
	700	4.2	3.8	3.2	-
	800	4.7	4.0	-	-
Basal Area (feet ²)	300	2.9	5.9	5.3	4.3
	400	6.3	10.2	8.4	-
	500	7.3	10.5	9.3	-
	600	7.9	11.6	8.6	7.5
	700	8.2	11.1	9.5	-
	800	11.0	11.7	-	-
Cubic foot volume (wood and bark)	300	24.8	94.2	117.9	108.3
	400	63.2	165.2	170.9	-
	500	75.4	172.9	188.9	-
	600	77.8	179.4	159.4	154.8
	700	77.8	170.7	188.3	-
	800	125.3	191.2	-	-
Cubic foot yield	300	99.3	1006.0	1737.3	2165.5
	400	361.7	1545.5	2435.3	-
	500	433.0	1690.3	2607.5	-
	600	408.0	1668.5	2325.4	2940.7
	700	403.5	1675.0	2741.2	-
	800	696.8	1852.5	-	-
Observations	300	1	4	10	2
	400	52	35	4	-
	500	81	58	3	-
	600	57	32	4	1
	700	9	18	4	-
	800	7	5	-	-

Table 10. Periodic annual quadratic mean diameter, average dominant and codominant height, basal area, and cubic foot volume growth (PAI) by age and trees per acre classes for loblolly pine plantations in East Texas.

Measure	Trees per acre	Age (years)			
		5	10	15	20
Quadratic Mean Diameter (inches)	300	1.3	2.1	2.7	2.7
	400	1.2	2.1	2.5	-
	500	1.2	2.0	2.3	-
	600	1.0	1.9	2.0	2.2
	700	1.0	1.8	1.9	-
	800	1.1	1.7	-	-
Height (feet)	300	7.0	12.6	17.4	19.6
	400	6.7	12.7	15.8	-
	500	7.0	12.7	15.9	-
	600	6.4	12.1	14.4	16.2
	700	6.7	12.2	15.6	-
	800	7.8	12.7	-	-
Basal Area (feet ²)	300	3.8	20.6	25.8	28.9
	400	11.4	31.5	40.0	-
	500	13.1	34.0	42.9	-
	600	13.1	35.3	41.4	47.8
	700	14.0	35.8	45.8	-
	800	19.8	37.5	-	-
Cubic foot volume (wood and bark)	300	33.1	335.3	579.1	721.8
	400	120.6	515.2	811.8	-
	500	144.3	563.4	869.2	-
	600	136.0	556.2	775.1	980.2
	700	134.5	558.3	913.7	-
	800	232.3	617.5	-	-
Observations	300	1	4	10	2
	400	52	35	4	-
	500	81	58	3	-
	600	57	32	4	1
	700	9	18	4	-
	800	7	5	-	-

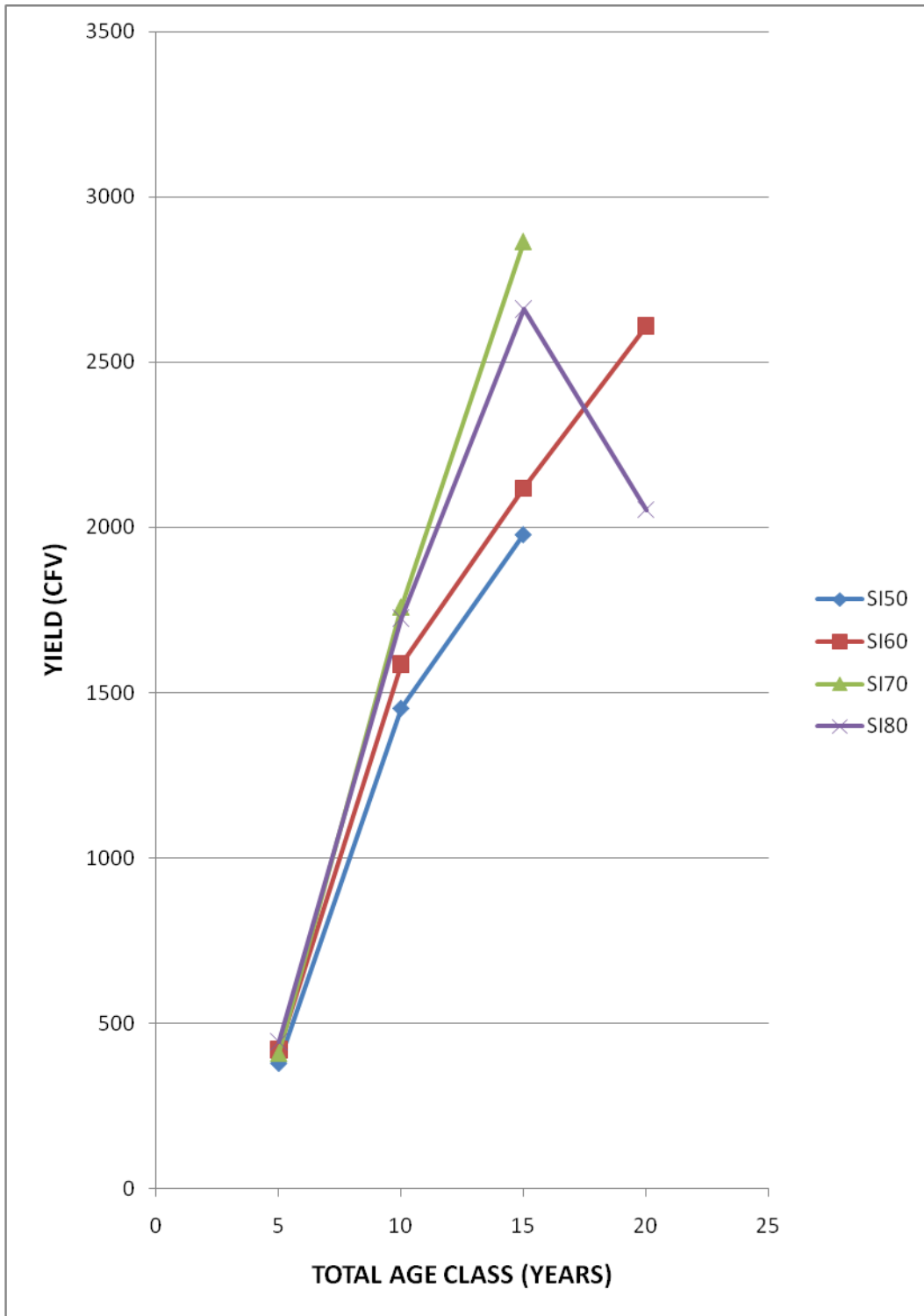


Figure 1. Observed yield (cubic foot volume per acre wood and bark) by total age and site index (25-year index age) classes for loblolly pine plantations in East Texas.

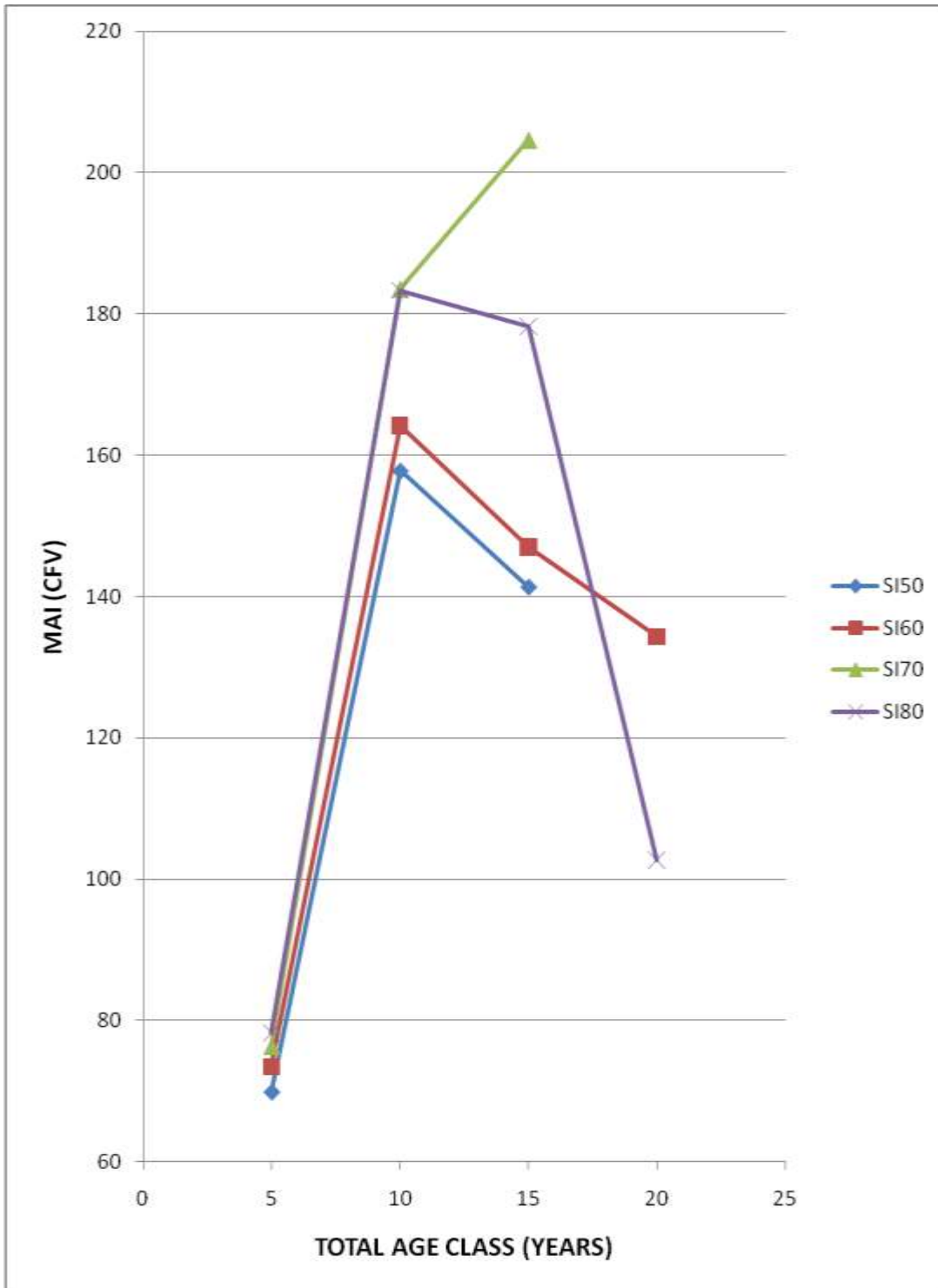


Figure 2. Observed mean annual volume growth (MAI, cubic foot volume per acre wood and bark) by total age and site index (25-year index age) classes for loblolly pine plantations in East Texas.

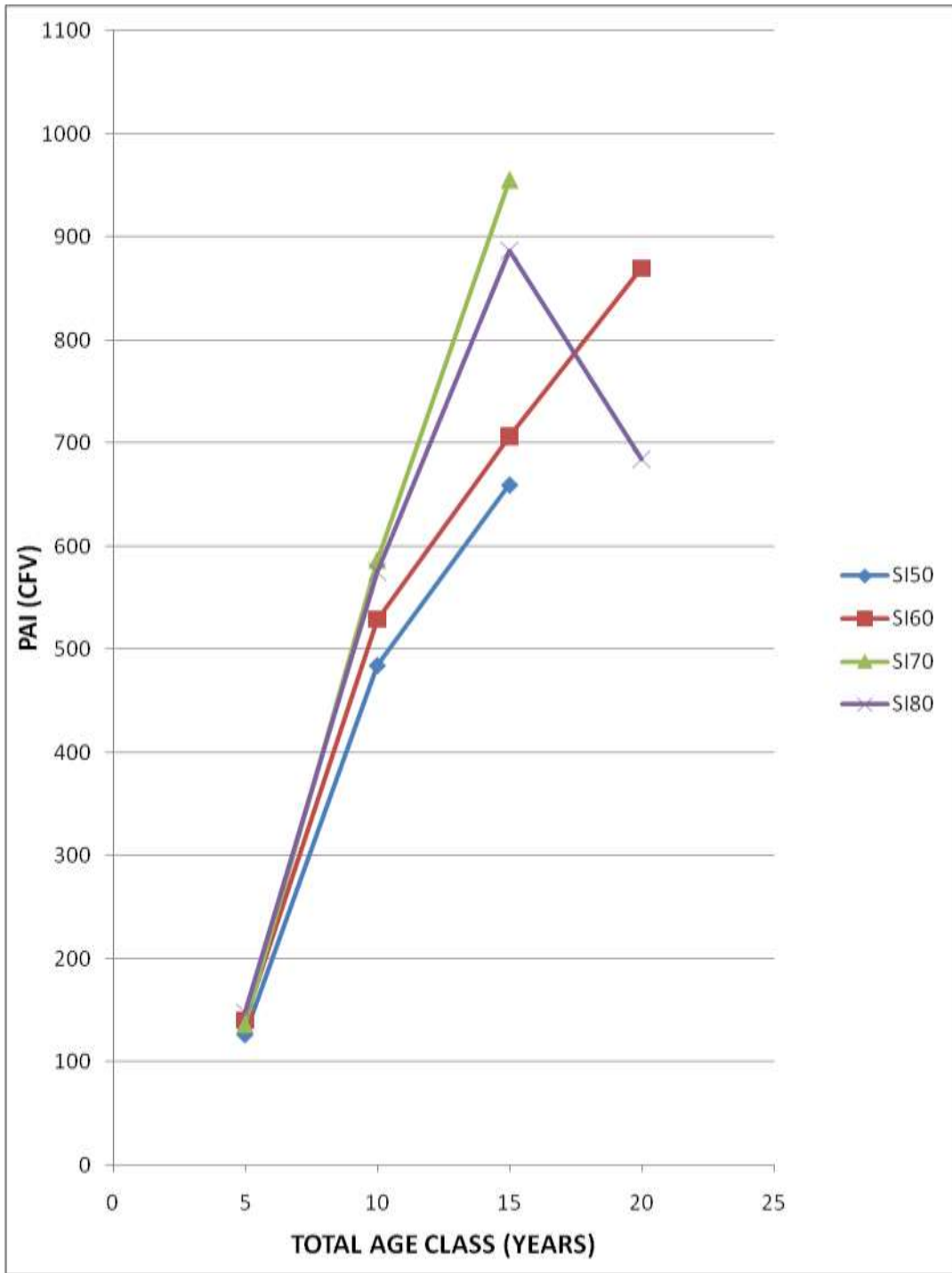


Figure 3. . Observed periodic annual volume growth (PAI, cubic foot volume per acre wood and bark) by total age and site index (25-year index age) classes for loblolly pine plantations in East Texas.

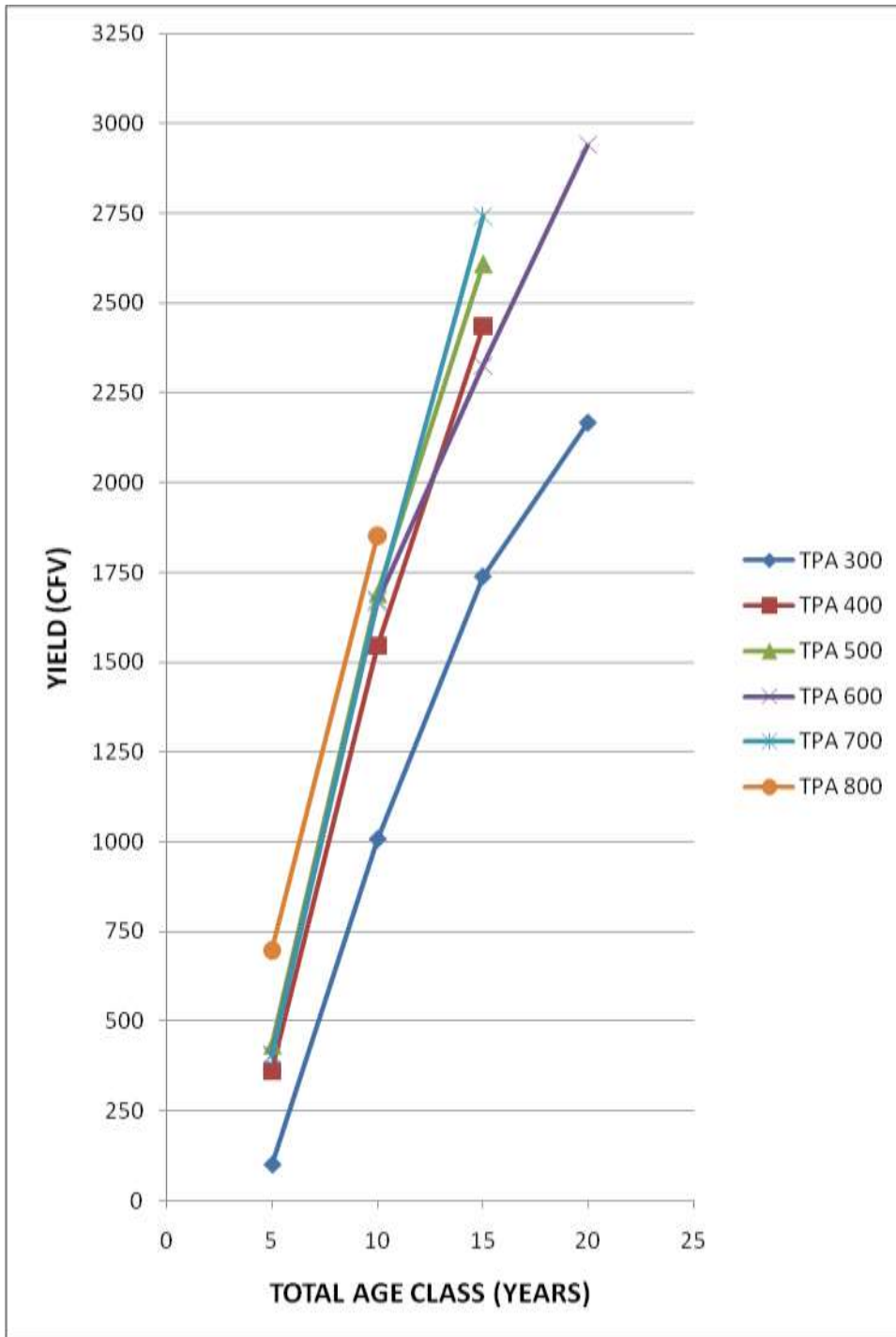


Figure 4. Observed yield (cubic foot volume per acre wood and bark) by total age (years) and trees per acre classes for loblolly pine plantations in East Texas.

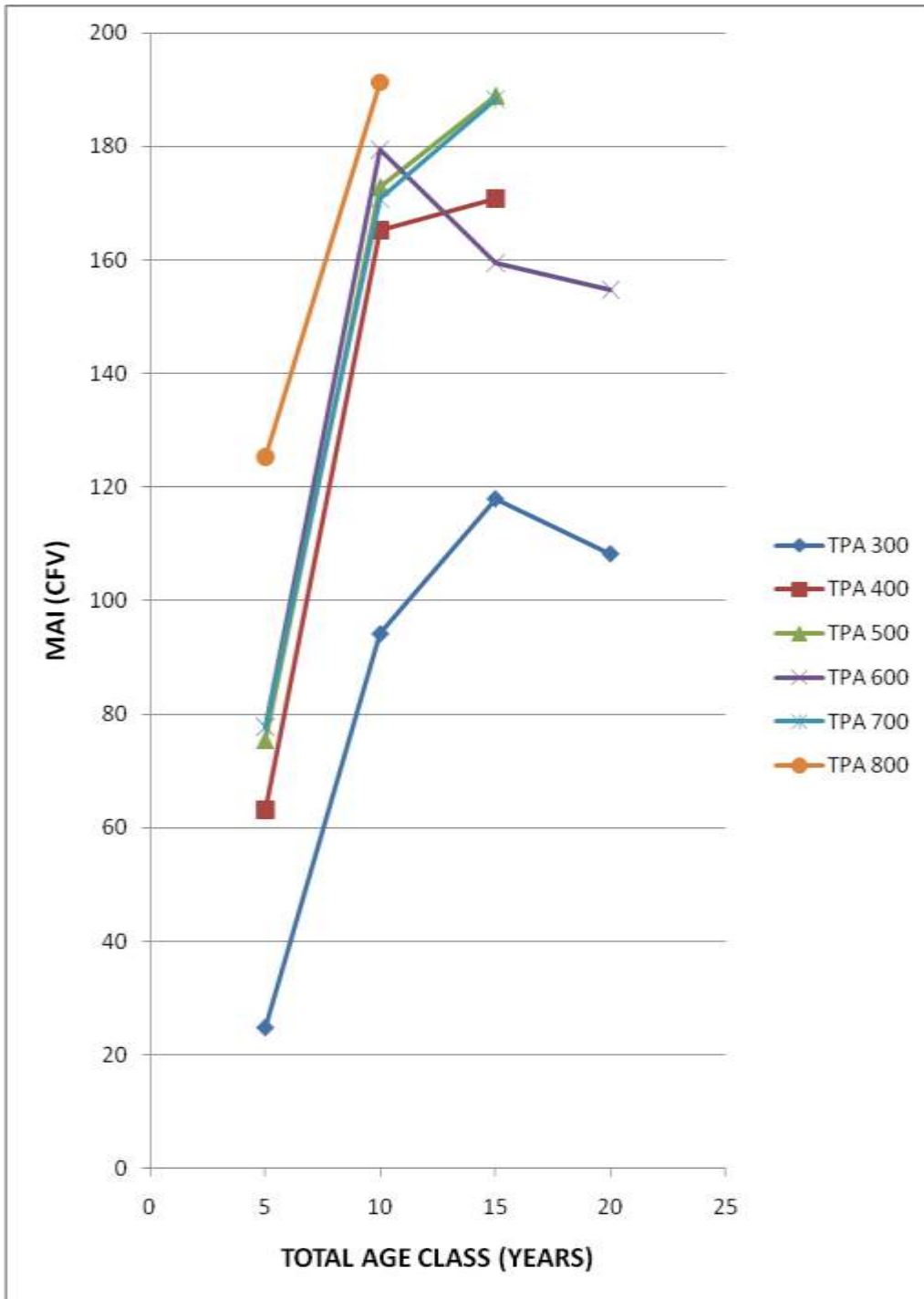


Figure 5. Observed mean annual volume growth (MAI, cubic foot volume per acre wood and bark) by total age (years) and trees per acre classes for loblolly pine plantations in East Texas.

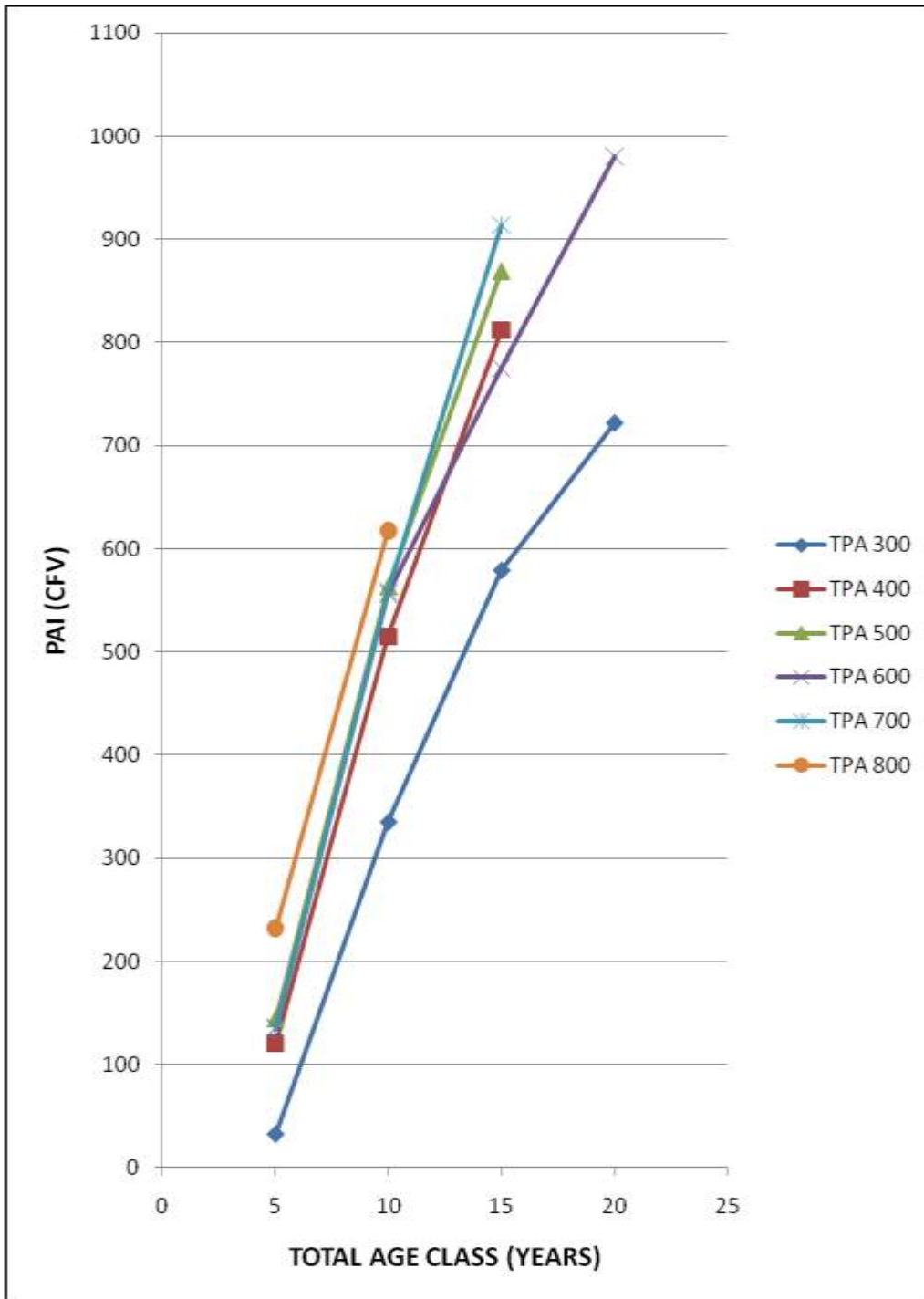


Figure 6. Observed periodic annual volume growth (PAI, cubic foot volume per acre wood and bark) by total age (years) and trees per acre classes for loblolly pine plantations in East Texas.