9-1994

Research Report No. 31, Observed Growth Rates of Loblolly and Slash Pine Plantations in East Texas

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OBSERVED GROWTH RATES OF LOBLOLLY AND SLASH PINE PLANTATIONS IN EAST TEXAS

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REPORT 31

FROM
THE

EAST TEXAS PINE PLANTATION RESEARCH PROJECT
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NACOGDOCHES, TX 75962

SEPTEMBER ... 1994

INTRODUCTION

Of the approximately 11.2 million acres of forest in East Texas, about 2.5 million acres have been planted with loblolly pine trees (*Pinus taeda* L.) and 500,000 acres with slash pine trees (*Pinus elliottii* Engelm.). These plantations are owned by public, industrial and non-industrial private entities with industrial ownership dominating. Even though most pine plantations in East Texas are relatively young (20 years or less), plantation information is needed for management decision-making.

Plantation growth information may assist foresters in deciding the timing and magnitude of plantation management operations. In particular, two possible timber growth questions that foresters may ask about unthinned East Texas pine plantations are:

- What are the average current growth rates?
- What are the average future growth rates?

However, a complete management decision-making process usually includes information on the many resources, uses and values that occur in East Texas plantations.

The purpose of this paper is to tabulate four observed average annual growth rates:

- Quadratic mean diameter,
- Average stand height,
- Basal area per acre and
- Cubic feet per acre

of unthinned East Texas loblolly and slash pine plantations by various age, site index and trees per acre classes.

PLANTATION MEASUREMENTS

Observed values were obtained from the East Texas Pine Plantation Research Project (ETPPRP). The ETPPRP is a long-term comprehensive study of the performance of loblolly and slash pine plantations in East Texas[1].

ETPPRP permanent plots were installed in pine plantations throughout East Texas during 1982-84. At this time, approximately 161 and 66 loblolly and slash pine plots, respectively, are still active. Numerous plots have been destroyed due to acts of nature and man. Each plot is in a separate plantation and is measured on a 3-year cycle. Since some plots have been destroyed since establishment due to acts of nature or man, data from two, three or four completed measurement cycles were available for this growth rate study.

Observations for each available measurement cycle for each active plot were summarized:

- Plantation age at time of measurement - years.
- Average total height of the ten tallest trees in a plot - feet.
- A site index value base age 25 years was calculated - feet.
- Number of trees per acre.
- Quadratic mean diameter - inches.
- Basal area per acre - sq. ft.
- Cubic foot volume per acre - total cubic feet wood and bark.

From the data, observations with zero values for total height, quadratic mean diameter, basal area or cubic foot volume were deleted. As a result, 597 observations from the loblolly pine ETPPRP plots and 276 observations from the slash pine ETPPRP plots were included in the data sets. The geographic distribution of the observations by county is depicted in Figures 1 and 2 for loblolly and slash pine, respectively. The loblolly observations are more widespread than slash pine. However, about 38% of the loblolly values are located in four counties - Polk, Tyler, Jasper and Newton.

[1] The support of the participating forest industries -- Champion International Corp., International Paper Company, Louisiana-Pacific Corp. and Temple-Inland Forest Products Corp. -- is appreciated.

Figure 1. Distribution of the 597 loblolly pine observations by county.

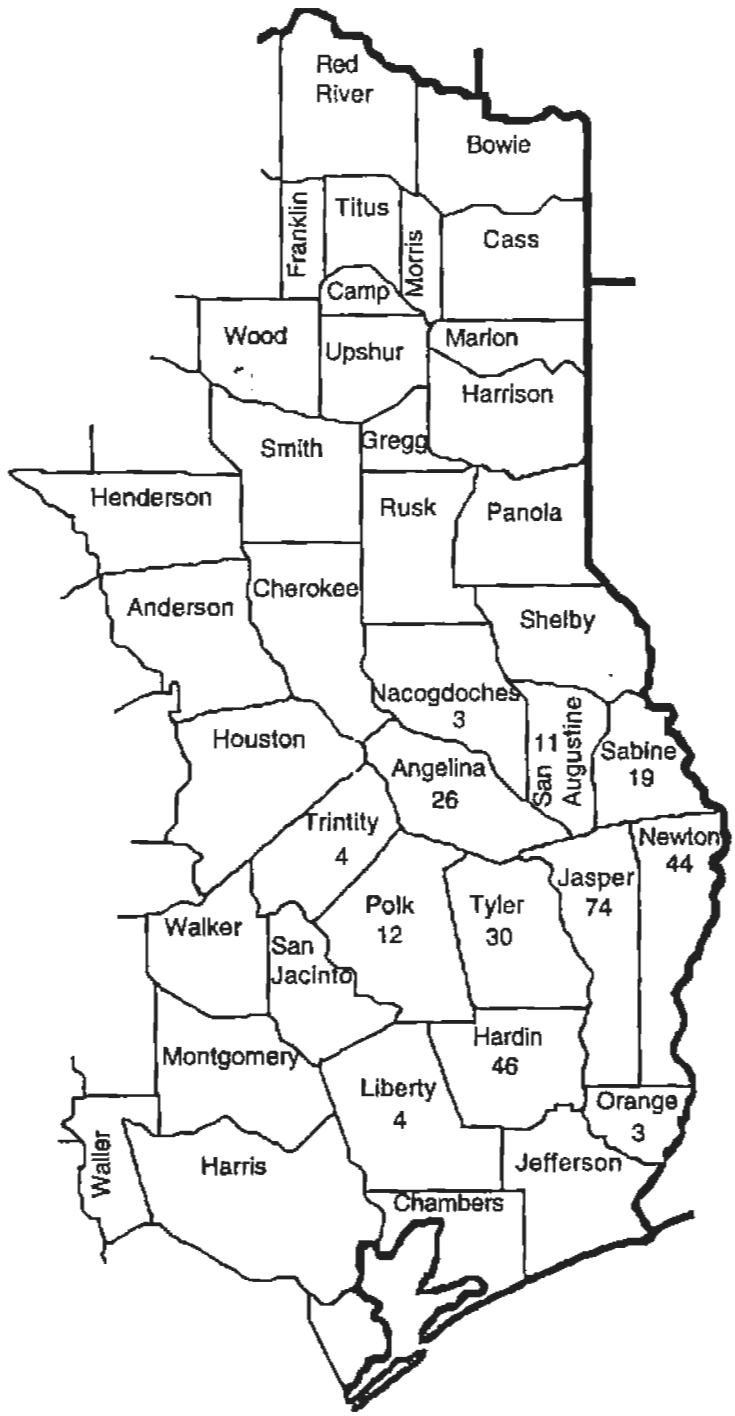

Figure 2. Distribution of 276 slash pine observations by county.

DETERMINATION OF AVERAGE ANNUAL GROWTH RATES

The first step was to calculate four annual growth rates for each observation for each species:

- Diameter growth = (Observed quadratic mean diameter - inches) / (Number of years to attain that diameter value).
- Height growth = (Observed total height of the ten tallest trees in a plot - feet) / (Number of years to attain that height value).
- Basal area growth = (Observed basal area per acre - sq. ft) / (Number of years to attain that basal area value).
- Cubic foot growth = (Observed cubic foot volume per acre of the entire tree stem) / (Number of years to attain that cubic foot volume value).

The results were 2,388 (597x4) observed annual growth rates for loblolly and 1,104 (276x4) observed annual growth rates for slash.

After appropriate groupings of the observed annual growth rates, four average annual growth rates for each species were computed for each of the following classifications of plantation characteristics:

- Overall:
  - Table 1 - Loblolly.
  - Table 11 - Slash.
- By site index classes:
  - Table 2 - Loblolly.
  - Table 12 - Slash.
- By trees per acre classes:
  - Table 2 - Loblolly.
  - Table 12 - Slash.
- By age classes:
  - Table 2 - Loblolly.
  - Table 12 - Slash.

- By age and site index classes:
  - Table 3 - Loblolly.
  - Table 13 - Slash.

- By age and trees per acre classes:
  - Table 4 - Loblolly.
  - Table 14 - Slash.

- By site index and trees per acre classes:
  - Table 5 - Loblolly.
  - Table 15 - Slash.

- For site index class 55 feet or less ... by age and trees per acre classes:
  - Table 6 - Loblolly.
  - Table 16 - Slash.

- For site index class 56 - 65 feet ... by age and trees per acre classes:
  - Table 7 - Loblolly.
  - Table 17 - Slash.

- For site index class 66 - 75 feet ... by age and trees per acre classes:
  - Table 8 - Loblolly.
  - Table 18 - Slash.

- For site index class 76 - 85 feet ... by age and trees per acre classes:
  - Table 9 - Loblolly.
  - Table 19 - Slash.

- For site index class 86 feet or more ... by age and trees per acre classes:
  - Table 10 - Loblolly.
  - Table 20 - Slash.

The 20 tables are presented in the last part of this report.

APPLICATIONS

Several examples of using the growth rate tables are:

- Perhaps in San Jacinto county, there is a 389 acre loblolly pine plantation. A forester has determined that age = 14 years, site index = 67 feet, and there are 504 trees per acre.

  An estimate of average growth rates can be obtained from Table 8:
  - Diameter = 0.5 inches per year.
  - Height = 3.4 feet per year.
  - Basal area = 8.0 square feet per acre per year.
  - Cubic feet = 147.2 per acre per year.

- A banker in Houston asks a colleague what is the average cubic feet growth rate for slash pine plantations in East Texas?

  The colleague finds an answer in Table 11:
  - On the average across all categories of age, site index and trees per acre:
    72.6 cubic feet per acre per year.

- Let us say that in the southern part of Newton county, a local landowner has approached a forest industry to see if they are interested in buying her slash pine plantation. During the conversation, all she can tell the company forester is that it is 505 acres in size and 12 years old.

  After she leaves, the forester determines initial estimates of average growth rates for all 12 year old slash pine plantations in East Texas by referring to Table 12:
  - Diameter = 0.5 inches per year.
  - Height = 3.4 feet per year.
  - Basal area = 5.4 square feet per acre per year.
  - Cubic feet = 97.2 per acre per year.

Perhaps the broad estimates of growth rates are encouraging, so during the next day, the forester does a reconnanisance of the 505 acre slash pine plantation and determines that site index = 72 feet and trees per acre = 382. With that information, more precise estimates of planted slash pine growth rates can be obtained from Table 18:

- Diameter = 0.5 inches per year.
- Height = 3.3 feet per year.
- Basal area = 5.6 square feet per acre per year.
- Cubic feet = 94.9 per acre per year.

The growth information may be helpful in deciding whether or not to buy the plantation from the landowner.

- In Shelby county, maybe a landowner is considering establishing a loblolly pine plantation on 294 acres. He has been told that the site index for the area is 70 feet, and he anticipates that trees per acre will be about 500 during the first 20 years after plantation establishment.

One of his management questions could be: Will the volume growth rate peak during the 20 year period?

From Table 8, it appears that volume growth may be expected to begin to decrease at about 18 years. In some cases, this may infer an optimum biological rotation age of 18 years. A possible scenario could have the landowner selling the 18 year old loblolly pines for small sawtimber.

However, that may not be correct, if a site index error has been made and instead of 70 feet, the true site index = 60 feet. From Table 7, optimum volume growth appears to occur at some point past 18 years.

Or if the true site index = 80 feet, instead of 70 feet, the peak in volume growth also appears to occur at some point beyond 18 years.

In this manner, the tables provide an opportunity to ask "what if" questions concerning possible plantation management decision-making procedures.

Table 1. Overall average annual diameter, height, basal area and cubic foot growth of loblolly pine plantations in East Texas.

Measure	Average annual growth[5]
Diameter[1] (in.)	0.5
Height[2] (ft)	3.4
Basal area[3] (sq. ft)	5.5
Cubic feet[4]	91.4

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.
[5]Values based on 597 observations.

Table 2. Average annual diameter, height, basal area and cubic foot growth by site index, trees per acre and age classes of loblolly pine plantations in East Texas.

	Average annual growth				
	Diameter[1] (in.)	Height[2] (ft)	Basal area[3] (sq. ft)	Cubic feet[4]	Observations
Site Index (ft)					
≤ 55	0.3	2.4	2.2	23.6	66
56 - 65	0.4	3.0	4.5	65.2	132
66 - 75	0.5	3.4	6.0	101.6	211
76 - 85	0.5	3.9	6.6	113.9	112
≥ 86	0.5	4.4	7.0	134.1	76
Trees per acre					
≤ 350	0.5	3.3	4.3	75.4	124
351 - 450	0.5	3.4	5.5	97.5	147
451 - 550	0.4	3.4	5.7	94.5	149
≥ 551	0.4	3.5	6.3	94.8	177
Age (yrs)					
≤ 4	0.2	3.0	0.7	3.4	48
5 - 6	0.4	3.4	3.1	25.7	75
7 - 8	0.5	3.4	5.0	54.9	98
9 - 10	0.5	3.6	6.5	91.0	111
11 - 12	0.5	3.6	7.2	124.1	87
13 - 14	0.5	3.4	6.9	132.9	72
15 - 16	0.4	3.3	6.7	143.6	40
17 - 18	0.4	3.2	6.9	158.9	38
≥ 19	0.4	3.1	6.5	173.2	28

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 3. Average annual diameter, height, basal area and cubic foot growth by site index and age classes of loblolly pine plantations in East Texas.

Measure	Site index classes (ft)	Age classes - (yrs) ≤4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16	17 - 18	≥19
		Averages								
Diameter[1] (in.)	≤ 55	0.1	0.2	0.3	0.3	0.3	0.4	0.3	0.3	-
	56 - 65	0.2	0.3	0.4	0.5	0.4	0.5	0.4	0.4	0.3
	66 - 75	0.2	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.4
	76 - 85	0.3	0.5	0.6	0.6	0.6	0.5	0.5	0.4	0.4
	≥ 86	0.3	0.6	0.6	0.6	0.6	0.6	0.5	0.5	-
Height[2] (ft.)	≤ 55	2.2	2.2	2.4	2.4	2.4	2.5	2.3	2.3	-
	56 - 65	2.6	2.7	3.0	3.1	3.1	3.1	2.9	2.9	2.8
	66 - 75	2.9	3.3	3.5	3.6	3.6	3.4	3.3	3.2	3.0
	76 - 85	3.3	3.8	4.0	4.0	4.1	4.0	3.9	3.8	3.7
	≥ 86	3.7	4.3	4.4	4.5	4.6	4.7	4.4	4.1	-
Basal area[3] (sq. ft.)	≤ 55	0.3	0.5	1.7	2.4	3.3	3.3	3.5	3.9	-
	56 - 65	0.5	1.6	3.3	4.9	5.8	6.2	6.3	6.1	5.9
	66 - 75	0.6	2.5	4.9	6.7	7.6	7.3	7.2	7.1	6.4
	76 - 85	0.8	3.7	7.1	8.2	8.3	8.6	7.7	8.5	8.3
	≥ 86	1.1	5.9	8.8	9.6	10.3	8.7	8.1	6.9	-
Cubic feet[4]	≤ 55	0.8	2.4	12.5	23.6	37.3	43.9	50.0	57.7	-
	56 - 65	1.9	10.2	28.7	58.3	82.9	104.8	112.5	122.5	127.1
	66 - 75	2.6	18.3	51.4	89.9	123.6	134.7	154.3	159.9	165.1
	76 - 85	4.2	30.5	83.6	123.7	154.7	184.5	191.7	228.0	248.6
	≥ 86	6.4	55.7	117.3	161.6	220.0	226.7	232.6	205.9	-
		Number								
Observations	≤ 55	4	11	15	12	8	8	5	2	-
	56 - 65	15	6	24	23	25	17	8	9	5
	66 - 75	8	25	26	43	25	29	20	19	16
	76 - 85	11	18	21	19	16	13	3	6	5
	≥ 86	10	15	12	14	13	5	4	2	-

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 4. Average annual diameter, height, basal area and cubic foot growth by trees per acre and age classes of loblolly pine plantations in East Texas.

Measure	Trees per acre	Age classes - (yrs) ≤4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16	17 - 18	≥19
		Averages								
Diameter[1] (in.)	≤ 350	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.4
	351 - 450	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.4	0.4
	451 - 550	0.2	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.3
	≥ 551	0.2	0.4	0.5	0.5	0.5	0.4	0.4	0.4	0.3
Height[2] (ft)	≤ 350	3.0	3.2	3.2	3.3	3.4	3.4	3.3	3.2	3.2
	351 - 450	3.0	3.3	3.3	3.6	3.5	3.5	3.3	3.3	3.2
	451 - 550	2.8	3.5	3.2	3.5	3.7	3.3	3.6	3.3	3.0
	≥ 551	3.1	3.6	3.8	3.8	3.6	3.5	3.0	3.1	3.1
Basal area[3] (sq. ft)	≤ 350	0.4	1.7	3.0	4.4	5.2	5.6	5.3	5.5	4.8
	351 - 450	0.7	2.6	3.8	6.4	6.7	7.2	7.3	6.8	6.7
	451 - 550	0.5	3.4	4.9	6.5	8.0	7.2	7.7	7.4	6.6
	≥ 551	0.9	3.7	7.0	7.9	8.5	6.9	6.9	7.5	7.7
Cubic feet[4]	≤ 350	2.1	13.2	31.9	62.6	87.6	111.5	116.3	133.5	132.1
	351 - 450	3.5	22.6	39.0	91.9	114.8	140.1	155.6	161.5	161.2
	451 - 550	2.5	29.7	52.0	85.8	137.3	131.6	180.8	170.0	176.6
	≥ 551	4.2	29.6	82.3	113.9	145.4	171.6	134.9	163.4	196.2
		Number								
Observations	≤ 350	6	11	17	26	16	22	12	7	5
	351 - 450	10	16	22	23	21	21	12	12	10
	451 - 550	12	17	29	25	21	20	7	9	8
	≥ 551	20	21	30	37	27	9	9	10	4

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 5. Average annual diameter, height, basal area and cubic foot growth by trees per acre and site index classes of loblolly pine plantations in East Texas.

Measure	Trees per acre	Site index classes- (ft) ≤55	56 - 65	66 - 75	76 - 85	≥86
		Averages				
Diameter[1] (in.)	≤ 350	0.3	0.5	0.5	0.6	0.6
	351 - 450	0.3	0.4	0.5	0.5	0.6
	451 - 550	0.3	0.4	0.5	0.5	0.6
	≥ 551	0.3	0.4	0.4	0.5	0.5
Height[2] (ft)	≤ 350	2.3	3.0	3.4	3.9	4.4
	351 - 450	2.4	3.0	3.4	3.8	4.5
	451 - 550	2.4	3.0	3.4	3.9	4.3
	≥ 551	2.3	3.0	3.4	3.9	4.3
Basal area[3] (sq. ft)	≤ 350	2.0	3.2	4.9	5.7	6.6
	351 - 450	1.6	4.7	6.0	6.1	8.1
	451 - 550	2.8	4.4	6.2	7.6	7.7
	≥ 551	2.4	5.2	6.5	6.9	7.4
Cubic feet[4]	≤ 350	23.5	45.6	86.0	103.0	165.1
	351 - 450	15.5	69.0	110.1	120.1	158.1
	451 - 550	29.3	64.2	102.7	137.4	138.9
	≥ 551	26.4	74.6	103.5	105.4	109.7
		Number				
Observations	≤ 350	27	22	41	28	11
	351 - 450	14	37	57	29	16
	451 - 550	16	35	61	21	18
	≥ 551	9	39	51	45	33

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Site Index class... ≤ 55

Table 6. Average annual diameter, height, basal area and cubic foot growth by trees per acre and age classes of loblolly pine plantations in East Texas with site index less than or equal to 55 feet.

Measure	Trees per acre	Age classes - (yrs) ≤4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16	17 - 18	≥19
		Averages								
Diameter[1] (in.)	≤ 350	-	0.3	0.4	0.3	0.3	0.4	0.4	-	-
	351 - 450	-	0.2	0.3	-	0.3	-	-	-	-
	451 - 550	0.1	0.2	0.3	0.3	-	0.3	-	-	-
	≥ 551	-	0.2	-	0.3	-	-	-	-	-
Height[2] (ft)	≤ 350	-	2.4	2.5	2.3	2.1	2.3	2.3	-	-
	351 - 450	-	2.2	2.3	-	2.5	-	-	-	-
	451 - 550	2.3	2.1	2.4	2.4	-	2.5	-	-	-
	≥ 551	-	2.2	-	2.7	-	-	-	-	-
Basal area[3] (sq. ft)	≤ 350	-	0.6	1.3	1.8	2.0	2.3	3.3	-	-
	351 - 450	-	0.4	1.2	-	2.9	-	-	-	-
	451 - 550	2.5	0.4	2.6	3.2	-	4.3	-	-	-
	≥ 551	-	0.7	-	3.4	-	-	-	-	-
Cubic feet[4]	≤350	-	2.9	9.7	18.0	20.6	30.1	51.6	-	-
	351 - 450	-	2.1	7.6	-	28.3	-	-	-	-
	451 - 550	0.8	1.5	20.3	29.7	-	57.3	-	-	-
	≥ 551	-	3.0	-	32.3	-	-	-	-	-
		Number								
Observations	≤ 350	-	3	6	7	3	4	3	-	-
	351 - 450	-	4	4	-	8	-	-	-	-
	451 - 550	2	2	5	2	-	3	-	-	-
	≥ 551	-	2	-	2	-	-	-	-	-

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 11. Overall average annual diameter, height, basal area and cubic foot growth of slash pine plantations in East Texas.

Measure	Average annual growth[5]
Diameter[1] (in.)	0.5
Height[2] (ft)	3.4
Basal area[3] (sq. ft)	4.4
Cubic feet[4]	72.6

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.
[5]Values based on 276 observations

Table 12. Average annual diameter, height, basal area and cubic foot growth by site index, trees per acre and age classes of slash pine plantations in East Texas.

	Average annual growth				
	Diameter[1] (in.)	Height[2] (ft)	Basal area[3] (sq. ft)	Cubic feet[4]	Observations
Site Index (ft)					
≤ 55	0.3	1.9	0.9	8.3	12
56 - 65	0.4	2.8	2.8	40.8	37
66 - 75	0.4	3.2	4.0	65.1	87
76 - 85	0.5	3.7	5.3	95.2	85
≥ 85	0.5	4.1	5.3	85.2	55
Trees per acre					
≤ 350	0.5	3.2	3.4	65.3	126
351 - 450	0.5	3.6	5.2	87.3	52
451 - 550	0.4	3.5	4.8	74.3	41
≥ 551	0.4	3.5	5.5	74.6	55
Age (yrs)					
≤ 4	0.3	3.5	1.4	7.1	24
5 - 6	0.5	3.4	3.4	31.5	40
7 - 8	0.5	3.4	4.1	51.0	47
9 - 10	0.5	3.5	5.1	75.9	43
11 - 12	0.5	3.4	5.4	97.2	53
13 - 14	0.5	3.4	4.8	103.8	30
15 - 16	0.5	3.3	4.6	104.3	18
17 - 18	0.4	3.2	5.0	134.0	21

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 13. Average annual diameter, height, basal area and cubic foot growth by site index and age classes of slash pine plantations in East Texas.

Measure	Site index classes (ft)	Age classes - (yrs) ≤ 4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16	≥ 19
		Averages							
Diameter[1] (in.)	≤ 55	-	-	0.2	0.2	0.2	0.3	-	-
	56 - 65	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4
	66 - 75	0.2	0.4	0.4	0.5	0.5	0.5	0.5	0.4
	76 - 85	-	0.5	0.5	0.5	0.5	0.5	0.5	0.4
	≥ 86	0.4	0.6	0.6	0.6	0.5	0.5	-	-
Height[2] (ft)	≤ 55	-	-	0.3	0.4	0.9	1.3	-	-
	56 - 65	0.5	1.4	2.4	5.0	4.6	3.4	4.3	4.1
	66 - 75	0.6	2.9	2.8	4.8	5.0	3.5	4.9	5.1
	76 - 85	-	3.7	5.7	5.3	5.9	5.7	4.6	5.2
	≥ 86	1.9	5.2	6.0	6.8	7.4	7.8	-	-
Basal area[3] (sq. ft)	≤ 55	-	-	0.3	0.4	0.9	1.3	-	-
	56 - 65	0.5	1.4	2.4	5.0	4.6	3.4	4.3	4.1
	66 - 75	0.6	2.9	2.8	4.8	5.0	3.5	4.9	5.1
	76 - 85	-	3.7	5.7	5.3	5.9	5.7	4.6	5.2
	≥ 86	1.9	5.2	6.0	6.8	7.4	7.8	-	-
Cubic feet[4]	≤ 55	-	-	2.2	3.1	7.4	17.2	-	-
	56 - 65	2.6	10.7	23.1	61.1	69.5	57.9	84.8	99.8
	66 - 75	2.6	23.3	30.2	53.0	82.9	85.7	104.7	128.0
	76 - 85	-	34.6	72.1	81.0	109.8	127.7	110.4	154.5
	≥ 86	10.0	52.1	85.3	116.7	151.2	196.5	-	-
		Number							
Observations	≤ 55	-	-	2	2	4	2	-	-
	56 - 65	5	7	9	3	5	2	2	4
	66 - 75	4	11	12	16	19	9	8	8
	76 - 85	-	10	17	14	14	14	6	9
	≥ 86	14	11	7	8	11	3	-	-

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 14. Average annual diameter, height, basal area and cubic foot growth by trees per acre and age classes of slash pine plantations in East Texas.

Measure	Trees per acre	Age classes - (yrs) ≤ 4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16	17 - 18
		Averages							
Diameter[1] (in.)	≤ 350	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.4
	351 - 450	0.4	0.5	0.5	0.5	0.5	0.5	0.4	-
	451 - 550	0.3	0.5	0.5	0.5	0.4	0.4	-	0.3
	≥ 551	0.3	0.5	0.5	0.5	0.4	-	-	-
Height[2] (ft)	≤ 350	2.8	3.1	3.2	3.4	3.2	3.3	3.3	3.2
	351 - 450	3.9	3.5	3.5	3.6	3.8	3.7	3.5	-
	451 - 550	3.4	3.6	3.5	3.7	3.8	3.2	-	3.0
	≥ 551	3.7	3.4	3.6	3.4	3.5	-	-	-
Basal area[3] (sq. ft)	≤ 350	0.5	1.8	2.5	3.4	3.6	3.9	4.1	4.5
	351 - 450	2.9	2.9	4.5	5.2	6.6	6.8	6.0	-
	451 - 550	1.0	3.5	4.5	6.3	6.5	5.7	-	5.8
	≥ 551	1.3	4.4	6.6	7.7	8.5	-	-	-
Cubic feet[4]	≤ 350	3.2	16.1	28.3	51.5	61.9	82.4	94.4	122.4
	351 - 450	11.2	25.3	60.1	75.4	126.7	154.2	137.6	-
	451 - 550	5.4	33.1	54.3	96.7	122.2	112.1	-	148.2
	≥ 551	6.1	39.8	81.3	108.3	147.8	-	-	-
		Number							
Observations	≤ 350	8	7	19	19	26	21	15	16
	351 - 450	4	7	12	6	14	6	2	-
	451 - 550	4	10	6	10	6	2	-	2
	≥ 551	11	16	10	8	7	-	-	-

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 15. Average annual diameter, height, basal area and cubic foot growth by trees per acre and site index classes of slash pine plantations in East Texas

Measure	Trees per acre	Site index classes- (ft) ≤ 55	56 - 65	66 - 75	76 - 85	≥ 86
		Averages				
Diameter[1] (in.)	≤ 350	0.3	0.4	0.5	0.5	0.6
	351 - 450	-	0.4	0.4	0.5	0.5
	451 - 550	-	0.4	0.3	0.5	0.5
	≥ 551	-	0.4	0.4	0.5	0.5
Height[2] (ft)	≤ 350	1.9	2.7	3.2	3.6	4.2
	351 - 450	-	2.8	3.3	3.7	4.1
	451 - 550	-	2.7	3.1	3.7	4.1
	≥ 551	-	2.9	3.2	3.7	4.1
Basal area[3] (sq. ft)	≤ 350	0.9	2.0	3.5	4.3	5.3
	351 - 450	-	2.3	4.1	5.8	5.8
	451 - 550	-	3.2	3.0	6.2	5.4
	≥ 551	-	5.5	5.7	6.6	4.7
Cubic feet[4]	≤ 350	9.2	33.1	63.1	90.6	113.8
	351 - 450	-	23.4	60.8	105.6	96.6
	451 - 550	-	47.3	40.4	104.1	83.2
	≥ 551	-	67.6	83.3	84.6	84.2
		Number				
Observations	≤ 350	10	22	48	41	7
	351 - 450	-	2	12	21	16
	451 - 550	-	7	8	11	15
	≥ 551	-	6	19	12	17

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Site index class... ≤ 55

Table 16. Average annual diameter, height, basal area and cubic foot growth by trees per acre and age classes of slash pine plantations in East Texas with site index less than or equal to 55 feet.

Measure	Trees per acre	Age classes - (yrs) ≤ 4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16	17 - 18
		Averages							
Diameter[1] (in.)	≤ 350	-	-	-	0.2	0.2	0.2	-	-
	351 - 450	-	-	-	-	-	-	-	-
	451 - 550	-	-	-	-	-	-	-	-
	≥ 551	-	-	-	-	-	-	-	-
Height[2] (ft)	≤ 350	-	-	-	1.6	1.9	2.3	-	-
	351 - 450	-	-	-	-	-	-	-	-
	451 - 550	-	-	-	-	-	-	-	-
	≥ 551	-	-	-	-	-	-	-	-
Basal area[3] (sq. ft)	≤ 350	-	-	-	0.4	0.9	1.3	-	-
	351 - 450	-	-	-	-	-	-	-	-
	451 - 550	-	-	-	-	-	-	-	-
	≥ 551	-	-	-	-	-	-	-	-
Cubic feet[4]	≤ 350	-	-	-	3.1	1.3	17.2	-	-
	351 - 450	-	-	-	-	-	-	-	-
	451 - 550	-	-	-	-	-	-	-	-
	≥ 551	-	-	-	-	-	-	-	-
		Number							
Observations	≤ 350	-	-	-	2	4	2	-	-
	351 - 450	-	-	-	-	-	-	-	-
	451 - 550	-	-	-	-	-	-	-	-
	≥ 551	-	-	-	-	-	-	-	-

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 17. Average annual diameter, height, basal area and cubic foot growth by trees per acre and age classes of slash pine plantations in East Texas with site index from 56 to 65 feet.

Measure	Trees per acre	Age classes - (yrs) ≤4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16	17 - 18
		Averages							
Diameter[1] (in.)	≤ 350	0.3	0.3	0.4	-	0.5	-	0.4	0.4
	351 - 450	-	-	0.3	-	-	-	-	-
	451 - 550	-	-	-	0.4	-	-	-	-
	≥ 551	-	0.3	-	-	0.4	-	-	-
Height[2] (ft)	≤ 350	2.6	2.8	2.8	-	3.0	-	2.8	2.7
	351 - 450	-	-	2.2	-	-	-	-	-
	451 - 550	-	-	-	3.0	-	-	-	-
	≥ 551	-	2.6	-	-	3.0	-	-	-
Basal area[3] (sq. ft)	≤ 350	0.4	1.0	1.7	-	2.4	-	4.3	3.9
	351 - 450	-	-	1.5	-	-	-	-	-
	451 - 550	-	-	-	4.2	-	-	-	-
	≥ 551	-	12.0	-	-	8.1	-	-	-
Cubic feet[4]	≤ 350	2.0	7.6	16.4	-	36.1	-	64.8	94.3
	351 - 450	-	-	15.8	-	-	-	-	-
	451 - 550	-	-	-	53.8	-	-	-	-
	≥ 551	-	14.0	-	-	119.5	-	-	-
		Number							
Observations	≤ 350	4	4	5	-	9	-	2	3
	351 - 450	-	-	2	-	-	-	-	-
	451 - 550	-	-	-	2	-	-	-	-
	≥ 551	-	3	-	-	2	-	-	-

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 18. Average annual diameter, height, basal area and cubic foot growth by trees per acre and age classes of slash pine plantations in East Texas with site index from 66 to 75 feet.

Measure	Trees per acre	Age classes - (yrs) ≤4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16	17 - 18
		Averages							
Diameter[1] (in.)	≤ 350	-	-	0.5	0.5	0.5	0.5	0.5	0.4
	351 - 450	-	0.4	-	0.5	0.5	-	-	-
	451 - 550	-	0.4	-	-	0.4	-	-	-
	≥ 551	0.2	0.4	0.4	0.5	0.5	-	-	-
Height[2] (ft)	≤ 350	-	-	3.2	3.3	3.2	3.2	3.2	3.1
	351 - 450	-	3.2	-	3.3	3.3	-	-	-
	451 - 550	-	3.0	-	-	3.2	-	-	-
	≥ 551	3.0	3.2	3.3	3.3	3.4	-	-	-
Basal area[3] (sq. ft)	≤ 350	-	-	2.3	3.3	4.0	3.3	4.0	4.3
	351 - 450	-	2.1	-	4.7	5.6	-	-	-
	451 - 550	-	2.9	-	-	3.8	-	-	-
	≥ 551	0.6	3.8	4.5	4.5	8.5	-	-	-
Cubic feet[4]	≤ 350	-	-	24.3	44.9	66.7	63.4	88.1	113.7
	351 - 450	-	16.2	-	62.1	94.9	-	-	-
	451 - 550	-	22.1	-	-	59.9	-	-	-
	≥ 551	2.8	31.5	47.1	98.2	145.8	-	-	-
		Number							
Observations	≤ 350	-	-	8	5	11	5	6	6
	351 - 450	-	4	-	2	3	-	-	-
	451 - 550	-	2	-	-	2	-	-	-
	≥ 551	3	4	2	5	3	-	-	-

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 19. Average annual diameter, height, basal area and cubic foot growth by trees per acre and age classes of slash pine plantations in East Texas with site index from 76 to 85 feet.

Measure	Trees per acre	Age classes - (yrs) ≤ 4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16	17 - 18
		Averages							
Diameter[1] (in.)	≤ 350	-	0.5	0.5	0.5	0.5	0.5	0.5	0.4
	351 - 450	-	0.5	0.6	0.5	0.5	0.5	-	-
	451 - 550	-	0.5	0.5	0.5	-	-	-	-
	≥ 551	-	0.5	0.5	-	-	-	-	-
Height[2] (ft)	≤350	-	3.7	3.8	3.7	3.7	3.7	3.6	3.5
	351 - 450	-	3.6	3.8	3.7	3.7	3.7	-	-
	451 - 550	-	3.6	3.5	3.7	-	-	-	-
	≥ 551	-	3.5	3.8	-	-	-	-	-
Basal area[3] (sq. ft)	≤ 350	-	3.0	3.6	3.9	4.9	4.9	4.2	4.9
	351 - 450	-	3.6	5.3	5.4	6.3	7.0	-	-
	451 - 550	-	3.1	5.6	7.3	-	-	-	-
	≥ 551	-	4.5	7.4	-	-	-	-	-
Cubic feet[4]	≤ 350	-	30.5	43.3	56.2	91.7	109.9	102.1	142.0
	351 - 450	-	32.9	68.0	82.1	117.2	160.8	-	-
	451 - 550	-	30.9	65.3	114.5	-	-	-	-
	≥ 551	-	39.4	97.6	-	-	-	-	-
		Number							
Observations	≤ 350	-	2	4	6	7	9	5	7
	351 - 450	-	2	4	4	5	4	-	-
	451 - 550	-	2	3	3	-	-	-	-
	≥ 551	-	4	6	-	-	-	-	-

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees in area.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.

Table 20. Average annual diameter, height, basal area and cubic foot growth by trees per acre and age classes of slash pine plantations in East Texas with site index greater than or equal to 86 feet.

Measure	Trees per acre	Age classes - (yrs) ≤ 4	5 - 6	7 - 8	9 - 10	11 - 12	13 - 14	15 - 16	17 - 18
		Averages							
Diameter[1] (in.)	≤ 350	-	-	-	0.6	-	-	-	-
	351 - 450	0.4	-	0.6	-	0.6	-	-	-
	451 - 550	0.4	0.5	-	0.6	0.5	-	-	-
	≥ 551	0.3	0.6	-	-	-	-	-	-
Height[2] (ft)	≤ 350	-	-	-	4.4	-	-	-	-
	351 - 450	3.9	-	4.3	-	4.1	-	-	-
	451 - 550	4.0	4.0	-	4.2	4.1	-	-	-
	≥ 551	4.0	4.1	-	-	-	-	-	-
Basal area[3] (sq. ft)	≤ 350	-	-	-	5.0	-	-	-	-
	351 - 450	2.9	-	5.0	-	7.4	-	-	-
	451 - 550	1.2	4.3	-	7.4	7.5	-	-	-
	≥ 551	1.6	6.3	-	-	-	-	-	-
Cubic feet[4]	≤ 350	-	-	-	91.8	-	-	-	-
	351 - 450	11.2	-	87.7	-	150.5	-	-	-
	451 - 550	7.3	43.0	-	120.8	150.3	-	-	-
	≥ 551	10.1	64.9	-	-	-	-	-	-
		Number							
Observations	≤ 350	-	-	-	8	-	-	-	-
	351 - 450	4	-	4	-	6	-	-	-
	451 - 550	2	5	-	3	3	-	-	-
	≥ 551	8	6	-	-	-	-	-	-

[1]Diameter = quadratic mean diameter.
[2]Height = average height of 10 tallest trees.
[3]Basal area = square feet per acre.
[4]Cubic feet = total stem cubic feet wood and bark per acre.