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Site Index Equations for Loblolly and Slash Pine Plantations on Non-Old-Fields in East Texas[1]

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*ABSTRACT. Equations to estimate site index (index age 25 years) for plantations of loblolly pine (*Pinus taeda *L.) and slash pine (*Pinus elliottii *Engelm.) on non-old-fields in East Texas have been developed. The height-prediction curves were based on the Richards' growth function and track well within the range of the data (1–17 years).*

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Two million acres of mixed pine–hardwood stands in East Texas have been harvested and planted to loblolly and slash pine. On these non-old-field sites, the conversion process may or may not have included intensive site-preparation methods. If the conversion continues at the current rate, by the year 2000 pine plantations may be growing on 4 million acres of non-old-fields in East Texas.

Estimation of the productivity of these non-old-field sites for growing planted loblolly and slash pine is a vital component in predicting future wood yields. Site index prediction equations, which may be suitable for planted slash pine in East Texas, were developed for cutover or problem-free sites in the West Gulf by Bailey, et al. (1973) and Zarnoch and Feduccia (1984). Popham, et al. (1979), produced equations for planted loblolly pine on cutover or problem-free West Gulf sites, while Amateis and Burkhart (1985) have developed loblolly pine site index curves for cutover, site-prepared lands southwide.

The purpose of this paper is to present equations to estimate site index for young loblolly and slash pine plantations on non-old-fields in East Texas.

THE DATA

Initial plantation age and tree height values obtained during installation of permanent plots in 178 loblolly pine and 78 slash pine plantations on non-old-field sites in East Texas were analyzed in this study. The plots were established during 1982, 1983 and 1984, by the School of Forestry at Stephen F. Austin State University on land owned by the four forest industry companies participating in the East Texas Pine Plantation Research Project.

Each plot consists of two adjacent (60 ft apart) 100 ft^2 (0.23 ac) subplots—one to remain unthinned and the other to be thinned. Depending on plantation age, the total tree height in feet and crown classification values, among other values, were recorded for each planted pine tree within a subplot. Since it was not possible in many of the younger plantations to classify tree crowns by their position in the canopy, the average height of the ten tallest trees in each subplot was selected as an indicator of site productivity.

The height values from the subplots-to-remain-unthinned were analyzed in this study to develop the height prediction equations, and the height values from the subplots-to-be-thinned were used for validation of the height prediction equations.

Data pairs available for analysis were reduced by 28 for loblolly and 3 for slash, because no height values were recorded in some instances due to ages of 1 or 2 years. The distribution of the available age and height data points from the subplots to-remain-unthinned by age and height classes is shown in Table 1 for loblolly and slash pine.

SITE INDEX PREDICTION

Loblolly

The Richards' (1959) function

$$Y = b_1 (1 - \mathrm{EXP}(-b_2 X))^{(1-b_3)^{-1}} \qquad (1)$$

was fitted to the 150 loblolly age and height data pairs from the subplots-to-remain-unthinned using nonlinear regression analysis. Resulting regression coefficient and symptotic standard deviation estimates are

$$\hat{b}_1 = 88.8715 \text{ with } S(\hat{b}_1) = 20.2877,$$
$$\hat{b}_2 = 0.08005 \text{ with } S(\hat{b}_2) = 0.02642, \text{ and}$$
$$\hat{b}_3 = 0.38596 \text{ with } S(\hat{b}_3) = 0.07542.$$

[1] This study is a result of work in the East Texas Pine Plantation Research Project. Support from Champion International Corporation, Owens-Illinois, Inc., International Paper Company and Temple-EasTex is gratefully acknowledged.

Table 1. Distribution of loblolly and slash pine data by age and average height of the ten tallest trees for the to-remain-unthinned subplots.

Species	Plantation Age (yr)	Height (ft) 1–5	6–10	11–15	16–20	21–25	26–30	31–35	36–40	41–45	≥46	TOTAL
Loblolly	1–2	20	4									24
	3–4	7	28	11	1							47
	5–6		5	1	8	1	1					16
	7–8				6	9	4	3				22
	9–10			1		2	2	5	3			13
	11–12							3	8	4	4	19
	13–17									4	5	9
	Total	27	37	13	15	12	7	11	11	8	9	150
Slash	1–2	10	7									17
	3–4	3	7	9	1							20
	5–6		1	1	8	2						12
	7–8			1	3	7	1	1				13
	9–10						1		2	1		4
	11–12									2	1	3
	13–17								1	3	2	6
	Total	13	15	11	12	9	2	1	3	6	3	75

Plottings of the residuals over age and predicted height values indicated no adverse trends or bias.

Substitution of the regression coefficients into Eq. 1 and simplification gave this equation

$$H = 88.8715 \, (1 - \text{EXP}\,(-0.08005A))^{1.62857}, \quad (2)$$

where

H = Average height (feet) of the ten tallest trees on the area of interest and

A = Number of growing seasons completed since plantation establishment.

Using Eq. 2, a predicted H was calculated for each of the 150 to-be-thinned subplots and then compared to the observed H. Residual (observed−predicted) values are listed in Table 2 by age class.

Overall the mean height difference was −0.09 ft, which using a paired t-test, is nonsignificant. Forty-two percent of the predicted values were within one foot of the observed value. Evaluation across age classes indicated no apparent bias.

Using procedures described by Clutter et al. (1983), Eq. 2, which is a guide curve, was converted into a generalized equation to estimate site index for loblolly pine plantations for any index age as

$$S = H\left(\frac{1 - \text{EXP}(-0.08005I)}{1 - \text{EXP}(-0.08005A)}\right)^{1.62857}, \quad (3)$$

where

S = Site index (ft) for index age I and

I = Index age (yr).

For loblolly pine plantations in East Texas, an appropriate index age may be 25 years. Eq. 3 was simplified for this index age as

$$S_{25} = H\left(\frac{0.86484}{1 - \text{EXP}(-0.08005A)}\right)^{1.62857} \quad (4)$$

Table 2. Differences between observed and predicted height values for subplots-to-be-thinned by age classes and species.

Species		Plantation Age (yr)	Observed minus predicted height values (ft): Overestimation ≥7	6	5	4	3	2	±1	Underestimation 2	3	4	5	6	≥7	Total
Loblolly		1–2						1	17	4	1	1				24
		3–4			2	3	5	1	22	7	5	1	1			47
		5–6	2	1		3			5	1	1	2			1	16
		7–8	1	3	2	1	1	2	4	2	1		1		4	22
		9–10	2	1	1	2		1	3	1			1		1	13
		11–12	2		1	1		1	8		2			1	3	19
		13–17			1			3	4			1				9
	Total		7	5	7	10	6	9	63	15	10	5	3	1	9	150
Slash		1–2					2	1	10	2	2					17
		3–4			1	1	3	1	6	2	2	2		2		20
		5–6	1			1	1	3	3	2			1			12
		7–8	2			2	2	2	3	1					1	13
		9–10						1		1			1		1	4
		11–12											1		2	3
		13–17	2					1	2						1	6
	Total		5	0	1	4	8	9	24	8	4	2	3	2	5	75

Equation 4 can be algebraically rearranged to estimate height for a given site index and age as

$$H = S_{25}\left(\frac{1 - \mathrm{EXP}(-0.08005\mathrm{A})}{0.86484}\right)^{1.62857}. \qquad (5)$$

Anamorphic site index curves based on Eq. 4 are shown in Figure 1. To illustrate the sensitivity of estimating site index (height at age 25) using young age values. Table 3 was developed to show predicted total height values between 1 and 5 years for the 5 site index classes. When determining the productivity of sites currently occupied by 1- to 5-year-old loblolly pines, the user should be cautious. At these young ages, height differences of 0.2 ft (age 1) to 2.1 ft (age 5) equate to 10-ft differences in site index.

Slash

Nonlinear regression analysis was also used to fit the Richards' function to the 75 slash pine age and height data pairs from the subplots-to-remain-unthinned. Regression coefficient and asymptotic standard deviation estimates are:

$\hat{b}_1$ = 85.5553 with S)$\hat{b}_1$)
= 30.7794,
$\hat{b}_2$ = 0.07489 with $S(\hat{b}_2)$
= 0.04952, and
$\hat{b}_3$ = 0.31046 with $S(\hat{b}_3)$
= 0.12541.

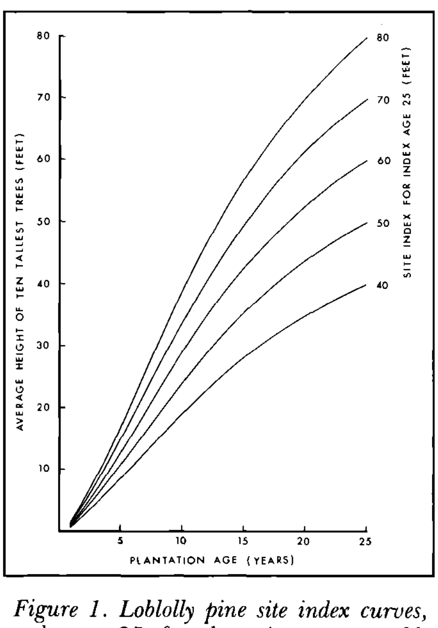

Figure 1. Loblolly pine site index curves, index age 25, for plantations on non-old-fields in East Texas.

Table 3. Average height of the ten tallest trees by site index for ages 1–5 years of loblolly and slash pine.

Species	Plantation age (yr)	Site index (ft)[1] 40	50	60	70	80
				ft		
Loblolly	1	0.8	1.0	1.2	1.4	1.6
	2	2.3	2.8	3.4	4.0	4.5
	3	4.1	5.1	6.2	7.2	8.2
	4	6.2	7.7	9.2	10.8	12.3
	5	8.3	10.4	12.5	14.6	16.6
Slash	1	1.1	1.4	1.7	2.0	2.3
	2	2.9	3.6	4.4	5.1	5.8
	3	5.0	6.2	7.5	8.7	10.0
	4	7.2	9.0	10.8	12.6	14.4
	5	9.4	11.8	14.1	16.5	18.8

[1] Index age = 25 years.

Residual analysis against age and predicted height values showed no bias or adverse trends.

Substitution of the regression coefficients into Eq. 1 resulted in

$$H = 85.5553\,(1 - \mathrm{EXP}(-0.07489A))^{1.45024}. \qquad (6)$$

To evaluate Eq. 6, a predicted H was calculated for each of the 75 to-be-thinned subplots. The differences between the observed and predicted height values are listed in Table 2. A paired t-test indicated the overall average difference of 0.11 ft was nonsignificant. Thirty-two percent of the predicted heights were within one foot of the observed height. No adverse trends are apparent in the height differences by age classes.

Eq. 6 was converted into a generalized slash pine site index prediction equation as

$$S = H\left(\frac{1 - \mathrm{EXP}(-0.07489I)}{1 - \mathrm{EXP}(-0.07489A)}\right)^{1.45024}. \qquad (7)$$

A slash pine site index prediction equation for index age of 25 years was developed from Eq. 7 as

$$S_{25} = H\left(\frac{0.84622}{1 - \mathrm{EXP}(-0.07489A)}\right)^{1.45024}. \qquad (8)$$

An algebraic rearrangement of Eq. 8 results in an equation to estimate height for a given site index and age as

$$H = S_{25}\left(\frac{1 - \mathrm{EXP}(-0.07489\mathrm{A})}{0.84622}\right)^{1.45024}. \qquad (9)$$

Anamorphic site index curves based on Eq. 8 are illustrated in Figure 2. As the case for loblolly pine, the preciseness of H values for younger slash pine trees (1–5 years) is critical for estimating H at age 25, Table 3. Changes of 0.3 ft in height at age 1 will change site index estimates at age 25 by 10 ft.

SUMMARY

Total tree height growth functions have been developed to predict the height of the 10 tallest trees in loblolly and slash pine

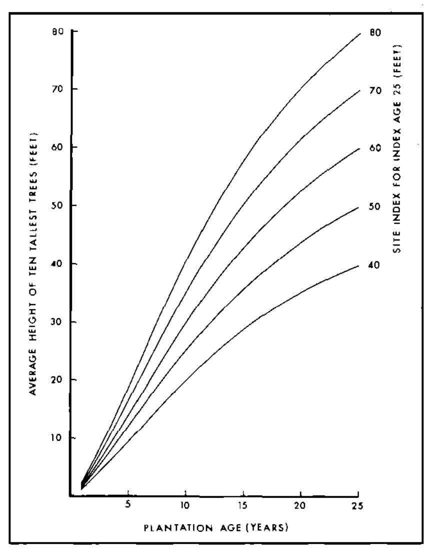

Figure 2. Slash pine site index curves, index age 25, for plantations on non-old-fields in East Texas.

plantations on non-old-fields in East Texas. Each function or guide curve was transformed into an anamorphic site index equation. The resulting site index equation can provide an indication of the productivity of the site based on plantation ages less than 5 years old. However, for ages less than 5 years old, the expected height at an index age of 25 years is very sensitive to the height value of the young trees. □

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Triadimefon Controls Fusiform Rust in Young Slash Pine Plantations

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*ABSTRACT. Triadimefon (Bayleton®) effectively controlled fusiform rust in a slash pine (*Pinus elliottii *Engelm. var.* elliottii*) plantation when three or more foliar sprays containing 600 ppm a.i. were applied annually (March to June) to runoff. Fewer foliar sprays and a top-dip applied at planting did not provide effective control of the disease. From the spray volumes applied over a five-year period, an estimated maximum of 505 mg a.i. triadimefon accumulated per tree. This amount did not reduce tree growth or survival.*

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Triadimefon (Bayleton®) is a systemic fungicide with both curative and preventive properties when used for control of fusiform rust in southern forest tree nurseries (Rowan 1984b, Kelley et al. 1984, Snow et al. 1979). Recent reports indicate that this fungicide may provide additional control of the disease in field plantings if applied as a slurry to seedling roots at lifting (Rowan 1984a) or as a foliar spray at two-week intervals from April 1 to June 1 (Burton and Snow 1983). In the latter study, approximately 2% of sprayed trees were infected during the first two years, significantly less than the 28% of nonsprayed trees. The Burton and Snow (1983) study and the study reported here were begun in 1979. Although Burton and Snow indicated that foliar sprays would control fusiform rust in outplantings, they did not indicate the efficacy of fewer sprays or of sprays begun earlier than April 1. Since nursery applications of the fungicide have protected susceptible tissue for up to 28 days, sprays applied at two-week intervals may be more frequent than necessary. The purpose of the study reported here was to determine the efficacy of triadimefon in field plantings and the minimum number of foliar sprays needed annually for effective control of the disease.

METHODS

A bulk lot of seeds from open-pollinated slash pine were sowed in the Georgia Forestry Commission Davisboro nursery in the spring of 1978. Seedlings were lifted and outplanted in April 1979 in Baldwin County, Georgia The soil in the outplanting site was a sandy loam with a pH of 5.5 and contained 38 kg phosphorus, 56 kg potassium, 44 kg magnesium, and 352 kg calcium per ha. The site, mowed prior to planting, was old farmland overgrown with broomsedge (*Andropogon* sp.), blackberry (*Rubus* sp.), and sumac (*Rhus* sp.). Rust hazard of the site was judged intermediate to severe at beginning of study but poor at study end because of low rust incidence.

The fungicide formulation was prepared by adding 1.2 g a.i. triadimefon (Bayleton 50 WP) to 1 liter of water and, while stirring, adding 2.5 ml of Agri-Dex adjuvant. A fresh mixture was prepared each day and used as a top-dip by immersing shoots for 10 minutes just before planting, or as a foliar spray applied (post-planting) to runoff to all foliage and stems with a hand-pumped backpack sprayer.