wide spacing, 13% of the pruned trees had live limbs. Branches observed probably developed following thinning prior to the twelfth year rather than immediately after pruning.

DISCUSSION AND CONCLUSIONS

The results from this study indicate no lasting detrimental effects from pruning on survival and growth where pruning removes from 42 to 65% of the mean total height in the third and fourth years. Season of pruning was not a factor; summer pruning produced fewer epicormic branches the first year (Krinard 1976), but by age 13 the percentage of trees with branches was similar between spring and summer pruning. Loss of growth during year of pruning and the following year may significantly lower average dbh at age 13 from 10 to 14%. However, pruning is essential to obtain higher quality sawlogs and veneer logs and dollar returns necessary to offset the high investment costs of establishing cottonwood plantations (Burkhardt and Screpetis 1980). Pruning wounds to 2 in. in diameter heal in a year or two, and then clearwood is produced (Johnson 1959).[1] Pruning has not resulted in insect and disease problems and should be concentrated on crop trees—trees of average or above average dbh.

[1] E. C. Burkhardt and George Screpetis, 1980. Evaluating quality of pruned and unpruned cottonwood plantation trees. Unpublished draft.

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Slash Pine Plantation Site Index Curves for the West Gulf

S. J. Zarnoch and D. P. Feduccia

ABSTRACT. New slash pine (Pinus elliottii *var.* elliottii *Engelm.) plantation site index curves have been developed for the West Gulf. The guide curve is mathematically simpler than other available models, tracks the data well, and is more biologically reasonable outside the range of data.*

Since the late 1930s, approximately 2.5 million acres of slash pine have been planted in the West Gulf region (Dell et al. 1979). The determination of site quality for this geographic area is a vital key to the efficient management of this resource. Site index curves presented in Miscellaneous Publication 50 (USDA Forest Service 1929) were developed from 111 plots in even-aged natural stands distributed over the natural range of slash pine, which excluded the West Gulf. Coile and Schumacher (1964) presented a series of slash pine site index curves for various land drainage classes, which are based predominantly on old-field plantation data in the southeast. A slash pine site index curve for old-field plantations developed from data in the middle coastal plain of Georgia and the Carolina Sandhills was given by Bennett et al. (1959). Bailey et al. (1973), utilizing a portion of the data base now available for the present study, found close agreement with the USDA Miscellaneous Publication 50 curves for ages 15 to 25 but suggested the use of their Chapman-Richards model for stands less than 15 years of age. The objective of this paper is to present site index curves for the expanded West Gulf data base.

DATA

The data consisted of plantation ages and average dominant/codominant heights from 247 plots some of which were measured repeatedly, yielding 886 data points. Both thinned and unthinned plots from problem-free[1] sites of the West Gulf were utilized. Plantation age is the number of growing seasons since plantation establishment, as opposed to age from seed. The average measurement was 22 years and ranged from 9 to 47 years. The height of dominants and codominants averaged 57 ft. and varied from 12 to 95 ft. The average number of trees for height measurement in each plot was 16. The distribution of the number of data points by age and site index class is given in Table 1.

Table 1. Number of data points used in modeling the site index guide curve classified by age and site index calculated by the selected model.[1]

Age (years)	Site index (ft.)[2] ≤40	41–50	51–60	61–70	71–80	≥81	Total
≤10			1	6			7
11–15	4	9	23	61	87		184
16–20	5	10	36	134	72	3	260
21–25		8	44	64	47		163
26–30		6	42	61	46		155
31–35		10	14	20	19		63
36–40				30	17		47
≥41			2	5			7
Total	9	43	162	381	288	3	886

[1] $S_{25} = H\{10^{-0.584459 + 2.922293A^{-1/2}}\}$.
[2] *Base age 25 years.*

RESULTS

The new site index equation generalized for any base age is

$$S_I = H\{10^{-2.922293(I^{-1/2} - A^{-1/2})}\} \quad (1)$$

where

S_I = Site index (feet) base age I
H = Average height (feet) of dominants and codominants
A = Plantation age (years)
I = Base age (years)

If one desires to predict the average height of dominants/codominants, the equation is

$$H = S_I\{10^{-2.922293(A^{-1/2} - I^{-1/2})}\} \quad (2)$$

Since interest is usually centered at base age 25, these equations are given as

$$S_{25} = H\{10^{-0.584459 + 2.922293A^{-1/2}}\} \quad (3)$$

$$H = S_{25}\{10^{0.584459 - 2.922293A^{-1/2}}\} \quad (4)$$

The site index curves are graphed in Figure 1 for base age 25. They were formulated from an anamorphic guide curve which modeled the average height of dominants/codominants as a function of plantation age. A graph of the distribution of the data around the guide curve is shown in Figure 2.

Although these site index curves were developed from data which were mostly obtained from plantations outside the natural range of slash pine, it is interesting to note the similarity of these curves to the site index curves in Miscellaneous Publication 50, which were based on natural, even-aged

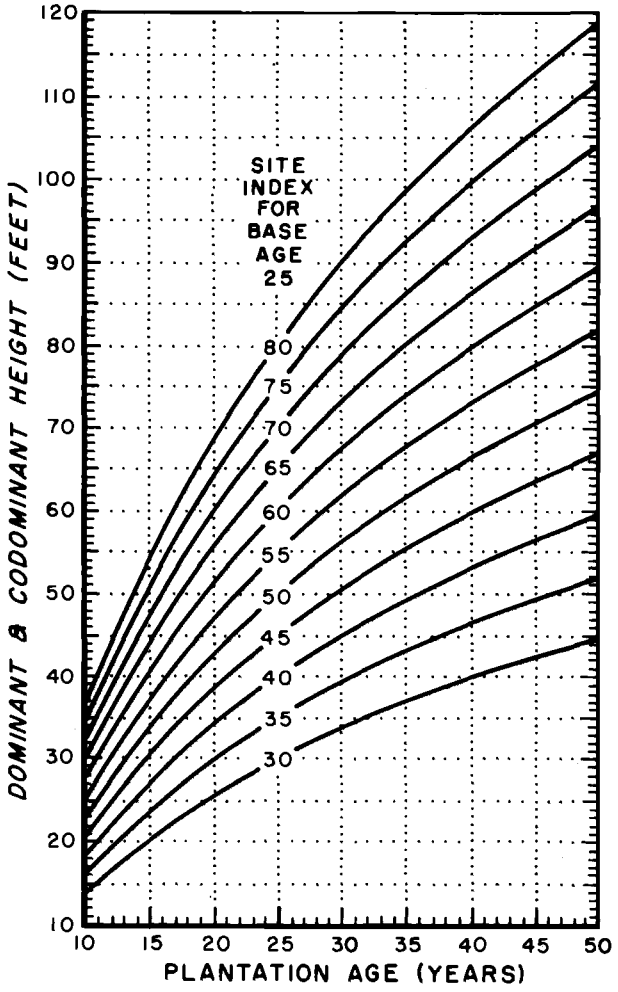

Figure 1. Slash pine site index curves, base age 25, for plantations on problem-free sites in the West Gulf.

[1] These sites are designated as problem-free because site preparation was not required although the land was never in row crops. Frequent wildfires had prevented natural regeneration and hardwood brush invasion.

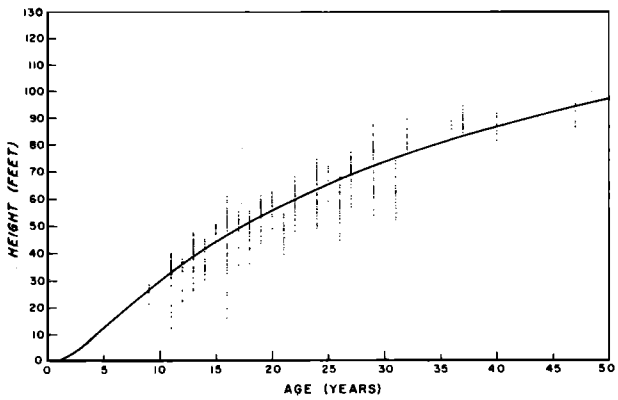

Figure 2. Site index guide curve based on the model

$$H = 10^{2.400747 - 2.922293A^{-1/2}}$$

where H is the average height (ft.) of dominants and codominants and A is plantation age (years).

stands within the natural range of slash pine. A graphical analysis of these two sets of site index curves revealed no visible differences for plantation ages of 10 to 30 years, which represented the range for the majority of the data. This shows a surprising consistency in the dominant/codominant height-age pattern over a broad geographical area.

In the development of the site index curves, five mathematical models were entertained as possible candidates for the site index guide curve. These models are defined in Table 2. Their parameter estimates were calculated with the BMDP3R Nonlinear Regression computer program (Dixon 1981). All models appeared to give similar fits within the range of the data as a graphical analysis

Table 2. Site index guide curve models.

Equation[1]	Standard error of estimate
$H = a(1 - e^{-bA})^c$	6.99
$H = 10^{a+bA^{-c}}$	6.99
$H^2 = 10^{a+bA^{-1/2}}$	7.02
$H = 10^{a+bA^{-1}}$	7.27
$H = 10^{a+bA^{-1}+cA^{-2}}$	7.02

[1] *where H = average height (ft.) of dominants and codominants*
A = plantation age (years)
a, b, c = parameters to be estimated.
[2] *the selected model for the site index guide curve used in this paper.*

and the standard errors shown in Table 2 indicate. No obvious trends were noted in the residuals and little correlation between the residuals and predicted height or between residuals and age were found. The selected model gave more reasonable results than the other models for ages less than 9 years. For age classes beyond 47 years, the curves seemed reasonable with each model and, hence, there was no basis for selecting a model based on this criterion. The selected model is a simple two-parameter form that can be linearized by a logarithmic transformation.

CONCLUSION

The given site index curves are applicable to problem-free land in the West Gulf. Good estimates of site index should be obtainable for plantation ages of 10 to 35 years; extrapolation outside these limits is questionable due to very little data for such ages. Since data are unavailable for site-prepared stands, the relationship of the present site index curves to site-prepared land is unknown. However, since the problem-free situation is approaching the site-prepared situation, the correspondence between these two site conditions may conceivably be strong. Until such data is available, this assumption must be used with caution.

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