PREDICTING AND PROJECTING STAND DOMINANT HEIGHT FROM INVENTORY DATA FOR YOUNG LONGLEAF PINE PLANTATIONS IN SOUTHWEST GEORGIA

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Abstract—A stand dominant height prediction technique, based solely on diameter distribution and total height data from standard inventory procedures, was investigated. The data consist of 15 managed longleaf pine (*Pinus palustris Mill.*) plantations that are part of a growth and yield study located in Worth, Mitchell, and Baker counties in southwest Georgia. A dominant height projection equation was also developed incorporating the results of this technique.

INTRODUCTION

In an effort to develop a dominant height projection equation as part of a growth and yield system for young longleaf pine (*Pinus palustris* Mill.) plantations, a practical method of estimating stand average dominant height from inventory data was investigated. A technique that utilizes standard inventory data has been successfully applied to site-prepared slash (Bailey and Brooks 1994) and loblolly pine (Bailey and Martin 1996) plantations. This technique was investigated for use with longleaf pine plantations in southwest Georgia that possess a wide range of initial planting densities, existing basal area per acre, and a limited range of stand ages.

STUDY DESCRIPTION

The longleaf pine data are part of a growth and yield study from 15 stands located in Worth, Mitchell, and Baker counties in southwest Georgia. Sample plots are approximately 0.1 acre (mean 0.10585) in size with stands ranging from 3 to 17 years old. Stand density ranges from 273 to 877 trees per acre and from 5 to 123 square feet of basal area per acre. Rectangular fixed area plots were established at different dates and have been remeasured annually; thus, the number of measurements available per plot ranges from two to seven. A total of 56 plot-measurement and remeasurement observations is available, providing 35 unique growth intervals.

At each measurement date, diameter at breast height (d.b.h.) was measured with a diameter tape and recorded for every tree to the nearest 0.1 inch. Total tree height was measured with a height pole or an Impulse 200 laser (depending upon tree size) and recorded to the nearest 0.1 foot. Trees less than 15 feet were measured with the height pole, whereas taller trees were measured with the laser. Initially, crown class was recorded for just the older stands (> 12 years) except for the most recent measurement period, where crown class was assigned to all trees, regardless of age. The traditional definition of crown class was slightly modified in order to assign crown class to the younger stands. The younger plantations generally have wider initial planting spacing, and, thus, all trees receive full sunlight. The codominant crown class was defined as those trees that make up the main crown canopy, whereas intermediate and suppressed classes were assigned to those trees visually shorter (and usually less vigorous) than the trees that constitute the average crown height.

PREDICTING AVERAGE DOMINANT HEIGHT

Bailey and Brooks (1994) reported that the average dominant height of a stand could be accurately estimated from a specified portion of a tree list sorted in descending diameter order without regard to crown class. Trees of the same d.b.h. measurement were also sorted in descending total height order. Starting with the largest diameter tree on the plot, smaller trees were consecutively included until the average tree height was equivalent to the measured average dominant height for the plot. It was found that the proportion of the diameter distribution that equated to the measured dominant height was quite stable. For planted slash and loblolly pine, this proportion was estimated to be 56.5 (Bailey and Brooks 1994) and 63.27 percent (Bailey and Martin 1996), respectively. This procedure was applied to all planted longleaf pine plot measurements that included a crown-class assignment. It was found that the average height of all trees in the upper 78.68 percent of the diameter distribution could be used as an estimate of dominant height, and that this proportion of the diameter distribution was quite stable, having a variance of 0.0045 square feet (table 1). The variance of this percentile was similar to that found in slash pine plantations (Bailey and Brooks 1994). The use of this average percentile to predict average domi-

Table 1—Descriptive statistics for the percentile of the diameter distribution that equates to average dominant height and the residuals and squared residuals based on the mean percentile (0.7868)

Statistic	PCT	$(\hat{DHT}-DHT)$	$(\hat{DHT}-DHT)^2$
n	33	33	33
Min	0.6338	-0.8880	0.0001
Max	0.9444	0.5415	0.7886
Sum		-1.1242	3.8991
Mean	0.7868	-0.0341	0.1182
Var	0.0045	0.1206	0.0267
RMSE			0.3438

$\hat{DHT}$ = predicted dominant height; DHT = measured dominant height.

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nant height resulted in a small negative bias (-1.124 feet), an average error of –0.03 foot, and a RMSE of 0.34 foot. The maximum residual in this dataset was only –0.88 foot (table 1). Of the predicted dominant height residuals, 79 percent were less than ± 0.5 foot, 97 percent were less than ± 0.75 foot, and 100 percent were less than 1.0 foot.

DOMINANT HEIGHT PROJECTION

A method of projecting dominant height as part of a growth and yield system was desired for all stand ages represented in this dataset. However, for most of the younger stands, only one remeasurement for each stand included the direct assignment of crown class. For those remeasurements where crown class was not measured, the preceding technique was used to estimate dominant height to provide additional growth intervals with which to fit the projection equation. Of the total plot measurements, 18 did not include a crown-class assignment. These were primarily the younger stands that were less than 10 years old. Average dominant height was predicted for these plots using the average height of the upper 78.68 percent of the diameter distribution. The fact that all residuals were less than 1 foot was felt to be an acceptably precise estimate. The algebraic difference equation form of the Chapman-Richards height/age projection function was selected as the model form:

$$DHT_2 = DHT_1 \left[\frac{1 - Exp(\beta_1 * A_2)}{1 - Exp(\beta_1 * A_1)} \right]^{\beta_2} \qquad (1)$$

where:

DHT_2 = projected dominant height at age A2,
DHT_1 = current dominant height at age A1,
β_1, β_2 = parameters to be estimated from the data.

This equation form has been used successfully in both loblolly (Pienaar and Shiver 1980) and slash (Pienaar and Shiver 1984) pine plantations. All possible non-overlapping growth intervals were used to fit this nonlinear, two-parameter model. The results of the nonlinear fitting procedure are shown in table 2. Residual analysis indicated no unusual trends in the data when reviewed by stand age, dominant height, basal area, or trees per acre. The sum of the residuals indicates a slight negative bias (-0.3415) and a RMSE of less than 1 foot (table 3).

RESULTS AND CONCLUSIONS

This study indicated that the average height of the largest 78.68 percent of the diameter distribution provides an accurate estimate of stand average dominant height for the age classes and stand conditions examined. Nearly all residuals were less than 1 foot with an average residual of –0.034 foot and a variance of 0.0045 square feet. It is interesting to note that the diameter distribution percentile is much larger than that found for planted slash (56.5 percent) or loblolly pine (63.27 percent). Because the oldest age class in this data set is only 17 years old, a possible explanation would be that longleaf pine may not differentiate crown class as early as loblolly or slash pine.

Table 2—Fit statistics and parameter estimates for the planted longleaf pine dominant height projection equation

		Asymptotic 95 percent confidence interval	
Parameter	Estimate	LCL	UCL
β_1	-0.085386	-0.111701	- 0.059071
β_2	2.146169	1.795929	2.496408

MSE = 0.4123; RMSE = 0.6421 foot; R^2 = 0.996; n = 35.

Table 3—Descriptive statistics for the residuals and squared residuals based on the proposed stand dominant height projection model

Statistic	$(\hat{DHT} - DHT)$	$(\hat{DHT} - DHT)^2$
n	35	35
Min	-1.4828	0.0007
Max	1.0731	2.1986
Sum	-0.3415	13.6054
Mean	-0.0098	0.3887

$\hat{DHT}$ = predicted dominant height; DHT = measured dominant height.

A dominant height projection equation was fitted to 33 unique growth intervals consisting of 51 plot-age combinations. A portion of the youngest remeasurement data did not contain a crown-class assignment. In these instances, average dominant height was predicted using the upper 78.68 percent of the diameter distribution. All the data were then employed to fit a dominant height projection equation. Residual analysis did not indicate any unusual trends by measurement age, trees per acre, or basal area per acre. The RMSE for the projection equation was 0.62 foot with an average residual of –0.001 foot. It should be noted that any variance statement may be underestimated due to fitting the model with predicted data.

The technique employed provides an accurate dominant height prediction and projection system for the longleaf pine plantations that comprise this dataset. Due to the limited size of the dataset, no independent verification of this prediction system was tested. In addition, the effects of potential correlation from the use of plot remeasurement data have not been investigated. This dataset does include a variety of densities and includes cutover as well as oldfield sites. Extrapolation to other datasets should be conducted with caution due to the limited age distribution. However, it does provide a system that should be applicable to plantations in this region whose ages are consistent with those currently in the Conservation Reserve Program.

LITERATURE CITED

Bailey, R.L.; Brooks, J.R. 1994. Determining site index and estimating timber volumes without measuring heights. Southern Journal of Applied Forestry. 18(1): 15-18.

Bailey, R.L.; Martin, S.W. 1996. Predicting dominant height from plantation age and the diameter distribution – site-prepared loblolly pine. Southern Journal of Applied Forestry. 20(3): 148-150.

Pienaar, L.V.; Shiver, B.D. 1980. Dominant height growth and site index curves for loblolly pine plantations in the Carolina flatwoods. Southern Journal of Applied Forestry. 4(1): 54-59.

Pienaar, L.V.; Shiver, B.D. 1984. The effect of planting density on dominant height in unthinned slash pine plantations. Forest Science. 30(4): 1059-1066.