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Modeling Thinning in East Texas Loblolly and Slash Pine Plantations

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MODELING THINNING IN EAST TEXAS LOBLOLLY AND SLASH PINE PLANTATIONS

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Abstract—A new thinning model was proposed for loblolly pine (*Pinus taeda* L.) and slash pine (*P. elliottii* Engelm.) plantations in east Texas. The new model follows the index of suppression methodology introduced by Pienaar (1979). It was implemented in a new whole stand growth model for loblolly and slash pine plantations in east Texas (Coble 2009). The new thinning model performed similarly to existing Pienaar-type models for east Texas and the Southeastern United States across a range of site quality. The predicted basal area development consistently approached the unthinned counterpart, which is consistent with results from other studies. The new thinning model should be fully tested when empirical data become available. In the meantime, it can be used to model thinned loblolly and slash pine plantations in east Texas ranging in age from 5 to 40 years.

INTRODUCTION

Plantations are routinely thinned to free growing space for residual trees to grow into larger, more valuable sawtimber-sized trees. Forest managers therefore need thinning response models to better understand the growth and yield of thinned plantations. Pienaar (1979) described a methodology that uses an index of suppression to model the growth of thinned plantations. His methodology has been subsequently used by others to model the growth of thinned plantations in the Southeastern United States (Borders and others 2004, Harrison and Borders 1996). Burrow (2001) applied Pienaar's methodology to east Texas loblolly pine (*Pinus taeda* L.) plantations and also provided a new formulation of the index of suppression.

The purpose of this study was to examine the behavior of Pienaar's and Burrow's indexes of suppression and propose a new thinning model that can be used in east Texas loblolly and slash pine (*P. elliottii* Engelm.) plantations. Currently, empirical data are unavailable to fully test a thinning model for east Texas. The proposed model in this study can be tested as thinning data become available. In the meantime, the proposed model was incorporated into a new whole stand growth-and-yield model for east Texas loblolly and slash pine plantations (Coble 2009) to examine the thinning response at three levels of site index.

METHODS

The thinning model of Pienaar (1979) is based on a competition index or index of suppression that describes the relative impact of competition among trees in thinned and unthinned stands. The competition index (CI) relates the basal area per acre of a thinned stand to an unthinned stand with the same dominant height, trees per acre, and age (the unthinned counterpart) (Borders and others 2004):

$$CI = 1 - \frac{B_{at}}{B_u} \tag{1}$$

where

B_{at} = basal area (square feet) per acre after thinning
B_u = basal area per acre of the unthinned counterpart

Since thinning prescriptions are typically expressed as residual trees per acre, basal area per acre removed should functionally relate to trees per acre removed from a row thin, select thin, or a row-select thin (Borders and others 2004:

$$\frac{B_t}{B} = \frac{N_r}{N} + \left[1 - \frac{N_r}{N}\right]\left[\frac{N_S}{N - N_r}\right]^{\gamma} \tag{2}$$

where

B_t = basal area (square feet) per acre removed in thinning
B = basal area per acre prior to thinning
N_r = trees per acre removed in row thinning
N_s = trees per acre removed in select thinning
N = trees per acre prior to thinning
γ = parameter

The CI must be projected to a future time to estimate the future basal area per acre of the thinned stand (Borders and others 2004, Pienaar 1979):

$$CI_2 = CI_1 e^{-\phi(A_2 - A_1)} \tag{3}$$

where

CI_i = CI at times i = 1 and 2
A_i = plantation age (years) at times i = 1 and 2
ϕ = parameter
e = exponential function

The CI at the projection age (time 2) can be expressed in terms of the equation 1 (Borders and others 2004):

$$CI_2 = 1 - \frac{B_{at_2}}{B_{u_2}} \tag{4}$$

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Equation 4 can be algebraically rearranged to find the basal area per acre of the thinned stand at the projection age, when the projected basal area per acre of the unthinned counterpart is known (Borders and others 2004):

$$B_{at_2} = B_{u_2}\left(1 - CI_2\right) \tag{5}$$

Based on Border and others (2004) and Burrow (2001) for loblolly pine and Pienaar (1979) for slash pine, the following hypothesized values will be assigned to the parameters in equations 2 and 3:

$\gamma = 1.2$
$\phi = 0.1$

Burrow (2001) also provided a new formulation of the CI that will also be examined in this study:

$$CI_2 = \left(\frac{A_1}{A_2}\right)CI_1 + b_1\left(\frac{A_1}{A_2} - 1\right)\left(\frac{A_2 - A_1}{A_2}\right) + b_2\left(\frac{A_1}{A_2} - 1\right)\left(\frac{SI}{A_2}\right) + b_3\left(\frac{A_1}{A_2} - 1\right)\left(\frac{CI_1}{A_2}\right) \tag{6}$$

where
SI = site index (index age = 25 years) (Coble and Lee 2006)
b_i = regression parameters

This thinning methodology was incorporated into a whole stand growth-and-yield model for loblolly and slash pine plantations in east Texas (Coble 2009) to examine thinning responses at low (SI = 50 feet), medium (SI = 70 feet), and high (SI = 90 feet) site quality. The parameter values *g* and *f* (equations 4 and 6, respectively) were changed to compare between the thinning models of this study—Burrow (2001) for loblolly pine in east Texas, Borders and others (2004) for the lower Coastal Plain, Borders and others (2004) for loblolly pine in the Upper Coastal Plain and Piedmont, and Pienaar (1979) for slash pine. Yield curves will be compared for a plantation with a planting density = 605 trees per acre (tpa) that was thinned to 250 tpa at 15 years old.

RESULTS AND DISCUSSION

For loblolly pine, the Pienaar-type thinning models (equation 4) are indistinguishable in their prediction of future basal area per acre after thinning for all levels of site quality (figs. 1A, 1B, and 1C). The modified competition index of Burrow (2001), equation 6, predicts greater basal area values than the Pienaar-type models (figs. 1A, 1B, and 1C). The Pienaar-type models all approach the unthinned counterpart at an increasing rate from lowest site quality (fig. 1A) to highest site quality (fig. 1C). At the highest site quality, the thinned stand approaches and then tracks the unthinned counterpart for all Pienaar-type models (fig. 1C). The modified competition index, equation 6, seems to approach a different unthinned counterpart than was defined in this study. In this study, the unthinned counterpart is defined as an unthinned stand that has the same density (tpa) as the thinned stand at the thinning age. Equation 6 appears to approach an unthinned counterpart defined as the unthinned version of the stand that got thinned. So, a forest manager could choose to redefine the unthinned counterpart, depending on whether they desired conservative (equation 4) or aggressive (equation 6) postthinning yield estimates from the model.

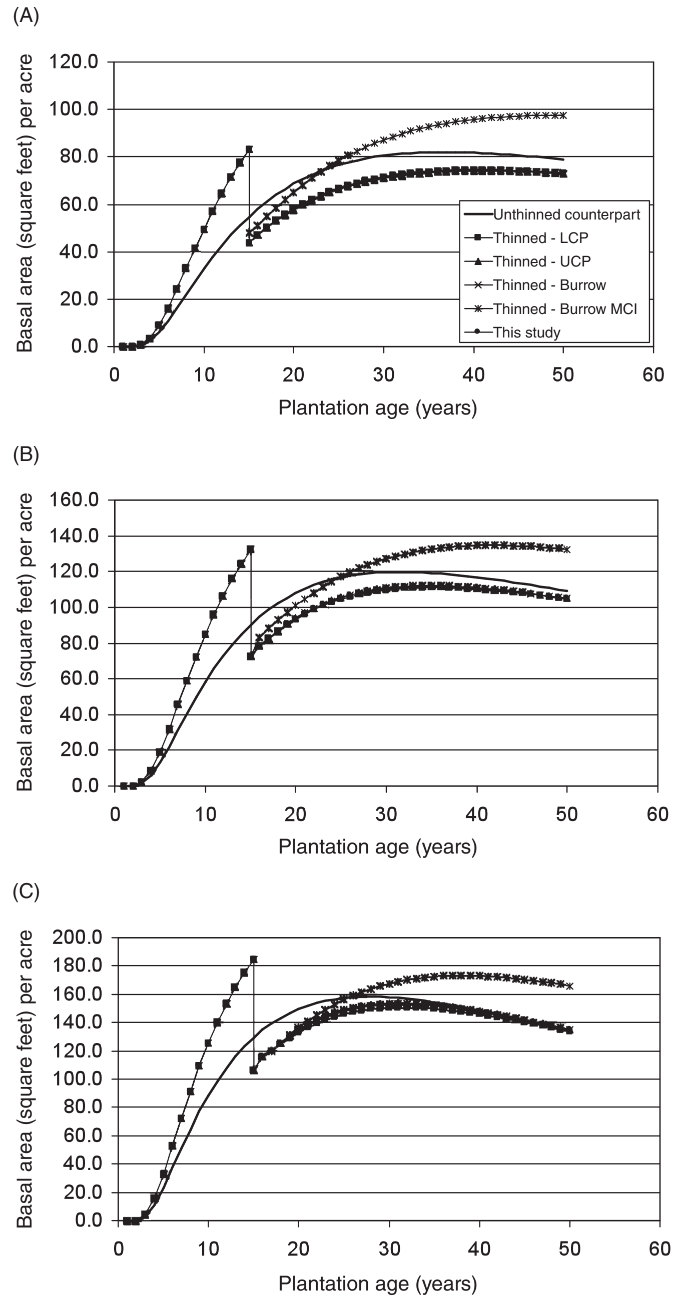

Figure 1—Projected basal area for the example loblolly pine plantation (this study) relative to its unthinned counterpart and four other thinning models at site indices: (A) 50 feet, (B) 70 feet, and (C) 90 feet.

For slash pine, the results are similar to those for loblolly pine. The models of this study and Pienaar (1979) are identical in their prediction of future basal area per acre after thinning for all levels of site quality (figs. 2A, 2B, and 2C). For low site quality, the thinned stands appear to parallel the unthinned

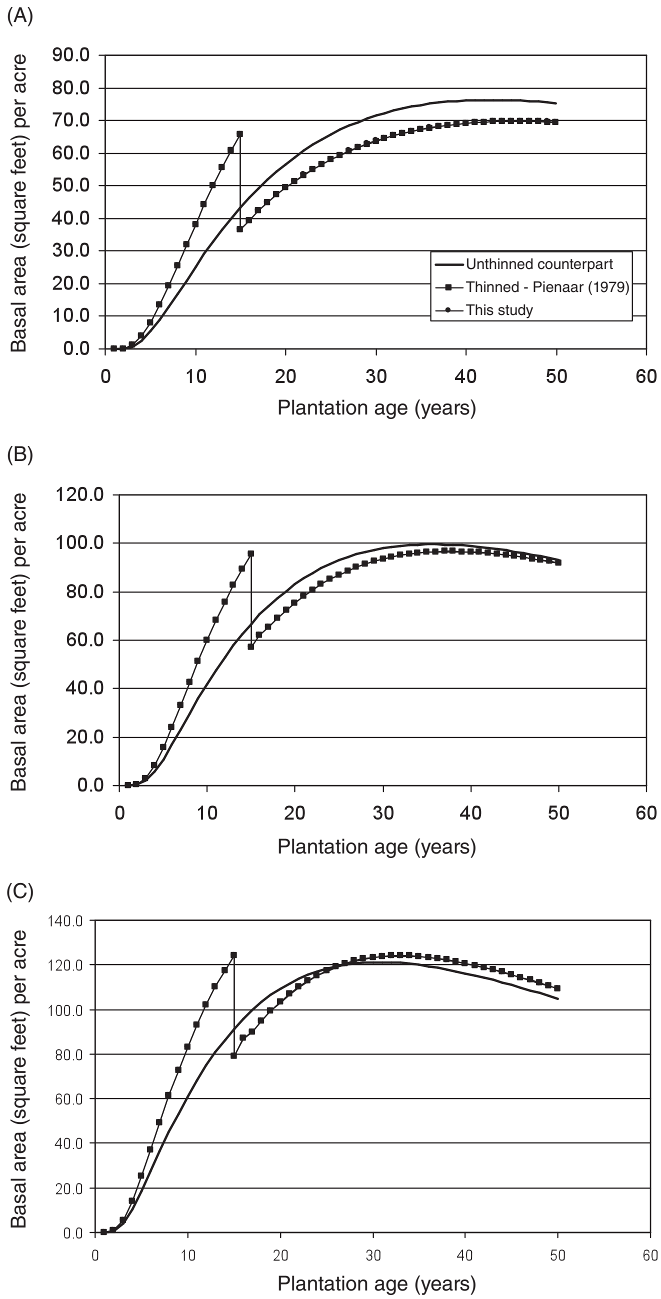

Figure 2—Projected basal area for the example slash pine plantation (this study) relative to its unthinned counterpart and four other thinning models at site indices: (A) 50 feet, (B) 70 feet, and (C) 90 feet.

counterpart (fig. 2A), but for medium site quality, they approach the unthinned counterpart (fig. 2B). For high site quality, the thinned stands approach and pass the unthinned counterpart (fig. 2C). This result for high site quality differs for that of loblolly pine. For loblolly pine, the Pienaar-type thinning models never exceed the unthinned counterpart.

CONCLUSIONS AND RECOMMENDATIONS

The Pienaar-type thinning models represented by equation 4 seem to predict postthinning basal area development reasonably well for low, medium, and high site qualities. The hypothesized parameter values in this study produce similar results as those estimated by Burrow (2001) and Borders and others (2004). Since data are unavailable to test a thinning model, I recommend a conservative approach to modeling thinning in east Texas pine plantations. Forest managers should utilize equation 4 and the hypothesized parameters in this study. When data become available, these hypothesized parameter values can be fully tested.

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