



**Series paper #8**

**Economics of growing loblolly, longleaf, and slash pine to various rotation ages with three stumpage price sets, four establishment cost sets, four discount rates, with and without pine straw – soil expectation value**

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**Abstract**

This economic series of papers is a follow-up to an economic series published in 2007 (Dickens and others. 2007). The reasoning for this new economic series is due to changing pine stumpage prices since the last series of papers and to dramatic changes in forest industry, forestland ownership, global markets, and wood supply and demand (pulpwood, sawtimber, chips, etc.) regionally and world-wide since late 1990's. Non-industrial private forest (NIPF) landowners in some areas have realized reduced product market availability and increased price uncertainty during this period in the southeastern United States. Lower Atlantic and Gulf Coastal Plain NIPF landowners seek management options utilizing three commonly available pine species; loblolly (*Pinus taeda* L.), longleaf (*Pinus palustris*, Mill.) and slash (*Pinus elliottii*, Engelm.) to enhance feasibility, profitability, and cash-flow of production forestry enterprises. At the same time, NIPF landowners' desire heightened flexibility across time required to achieve marketable forest products. This paper examines the feasibility and profitability of various rotation ages with management options for loblolly, longleaf, and slash pine plantations including competition control, fertilization, with and without pine straw harvests, four different site preparation and planting costs, and three different stumpage price sets. The financial measure of profitability used in this paper is soil expectation value (SEV). SEV is an economic decision making criteria that will allow one to compare discounted dollar per acre values using a number of rotation ages, since SEV assumes an infinite number of rotations under the same management and level of production. Loblolly pine rotation ages are 15- (pulpwood rotation), 24-, and 33-years. Slash pine rotations are 24- and 33-years. Longleaf pine rotation ages are 33- and 45-years.

## **Introduction**

Private non-industrial forest (NIPF) landowners in the Atlantic and Gulf Coastal Plain from South Carolina to Mississippi question whether to plant longleaf, slash, or loblolly pine on cut-over and old-field sites with the objective of sawtimber rotations. They also question spending moderate to relatively large sums of money in intensive forest management under the current and anticipated stumpage prices and economic uncertainty. To address these questions, we used the Georgia Pine Plantation (GaPPs 4.20) growth and yield Model developed by Bailey and Zhao (1998) for loblolly and slash pine. The SIMS model (Shiver and Borders 2009) was used for longleaf pine growth and yields. Depending on establishment costs, intermediate management costs, growth rates, other sources of income (in this paper series; pine straw), and stumpage prices shorter rotations for loblolly and slash pine are often financially attractive and are also addressed in companion papers in this series of economic manuscripts when solving for net revenue, NPV, and ROR..

## **Financial Calculations**

Soil expectation value (SEV) is also known as bare land value (BLV) or land expectation value (LEV). SEV is the present value of an infinite series of identical rotations calculated at some discount rate. Put another way, SEV uses the present value of a perpetual periodic series formula to calculate the present value of an infinite series of identical rotations (Bullard and Straka 1993). At a given discount rate various species' rotation ages can be compared with the highest SEV being the most attractive and the lowest SEV being least attractive. SEVs were calculated using the Biomass Green Weight Estimation and Financial Analysis Tool (Love, 2011) and checked for accuracy using FORVAL online (Bullard and others. 2001). This paper will illustrate all positive SEV values, while negative SEV values will not be shown due to the large number of cells in each table and the number of tables. Also a negative SEV value indicates that a given scenario was not financially attractive at the discount rate used.

## **Methodology**

### **Assumptions**

Fire protection cost was assumed \$2/acre/year, stand management at \$2/acre/year, and property taxes at \$6/acre/year. Thus, the total annual costs for each year of the rotation were \$10/acre. Results are reported in constant dollars, before federal and state income or capital gains taxes. It is assumed that land is already owned.

### *Site Preparation and Planting Costs*

Two site preparation and planting (SP+PL) costs were assumed:

- ▶ The “average” site preparation cost of \$110/acre included chemical site preparation @ \$75/acre and a site prep burn @ \$35/acre (current average costs for these activities in Georgia). This “average” site prep cost was for those acreages where a mechanical treatment was not warranted.
- ▶ The “high” site preparation cost of \$320/acre includes a chemical site preparation treatment as in the “average” treatment listed above plus a mechanical site prep treatment of shearing, piling and bedding (\$210/acre) assuming the site needs both treatments and a site prep burn for \$35/acre (Dubois and others. 2013).

Loblolly and slash seedlings were assumed to cost \$75 per 1000 and planted at 726/acre (6x10 ft spacing) for a per acre cost of \$55. Longleaf seedlings were assumed to cost \$210 per 1000 and planted at the same density as loblolly and slash pine for a cost per acre of \$152. Planting cost per acre for all three species was assumed to be \$80.

The total cost per acre for the “average” site preparation plus planting was \$245 and the total cost for the “high” site preparation and planting cost was \$455 for loblolly and slash pine and \$342 for the “average” and \$552 for the “high” site prep cost for longleaf pine. Other combinations of site preparation, burning (on no burning) and/or mechanical site preparation, seedlings and planting scenarios may also, cost-wise, be approximately equal to the total cost of the “average” or “high” establishment costs per are used here. Site preparation options and associated costs vary extensively by location, prior stand history, harvesting utilization, and contractor competition. Landowner objectives, monies available, and anticipated future stumpage value and demand also affect the site preparation method(s) chosen. The assumption used was that level of site preparation intensity was matched to level of competition control needed so that wood-flows were comparable within site productivity levels, after site preparation and planting.

### *Product class specifications*

Product class specifications are:

- ▶ pulpwood (PW) at a d.b.h. of 4.6 to 9 inches to a 3 inch top;
- ▶ chip-n-saw (CNS) at a d.b.h of 9 through 12 inches to 6 inch top; and,
- ▶ sawtimber (ST) with a d.b.h greater than 12 inches to a 10 inch top (inside bark) were assumed (Table 1).

Three sets of pine stumpage prices were used in this economic series. A “low”, “medium” and “high” pine pulpwood, chip-n-saw, and sawtimber set of prices were established using Timber Mart-South<sup>®</sup> (TM-S) stumpage values for Georgia for the period of 4<sup>th</sup> quarter 1976 through 2<sup>nd</sup> quarter 2013 (Figure 1). There were a total of 107 quarters of reported prices during this period. The “low” set of stumpage prices were the means of the 15 lowest price quarters for each of the product classes. The “average” set of stumpage prices were the mean of all the stumpage prices for each product class for the period from 4<sup>th</sup> quarter 1976 through 2<sup>nd</sup> quarter 2013. The “high” stumpage prices were the means of the 15 highest price quarters for each of the product classes. Loblolly and slash stumpage values were net of property taxes at harvest (2.5 percent) and net of marketing costs (7.5 percent). Cash and net converted prices are found in Table 2.

## Species specific assumptions

### *Loblolly pine*

The 15-year rotation mean annual increments (MAIs) were set at 6, 8 or 10 for the 15-year pulpwood rotation with no thinning. The 24-year rotation MAIs were 6.3 (no thin) and 6.1 tons/acre/year (one thin, Table 3). The 33-year rotation MAI was 5.76 tons/acre/year with two thinnings (at age 15- and 24-years, Table 4). The base loblolly woodflow was approximately 10 to 12 percent greater than the slash base woodflow (Shiver and others 1999) at age 24- and 33-years. The assumed fertilizer application at age 15-years increased merchantable volume for eight years (NCSUFNC 1998) and enhanced pine straw production in those scenarios where pine straw was raked.

### *Slash pine*

The 24-year rotation MAIs were 5.6 (no thin) and 5.4 tons/acre/year (one thin, Table 3). The slash pine MAI was 5.15 tons/acre/year @ age 33-years-old with two thinnings (at age 15- and 24-years, Table 4). The slash scenario woodflow was approximately 12 percent less than base loblolly woodflow (Shiver and others. 1999) at age 24- and 33-years. The assumed fertilizer application at age 15-years enhanced pine merchantable volume for eight years following treatment and enhanced pine straw production in the pine straw scenarios.

### *Longleaf pine*

The 33-year rotation MAI was 4.64 tons/acre/year with one thinning at age 20 years (Table 4). The 45-year MAI was 4.47 tons/acre/year with two thinnings at 20- and 33-years (Table 5). The longleaf MAI was 11 percent less than slash pine MAI and 24 percent less than loblolly pine for these 33-year rotation assumptions.

The pine species and rotation age cost assumptions are found in Tables 6-9. All the loblolly and slash pine scenarios had one woody control herbicide application at age 6-years and a single 170 N + 25 P per acre fertilizer treatment at age 15-years at a July 2013 cost of \$55/acre and \$165/acre, respectively. Longleaf pine scenarios had herbaceous weed control at age 1 years, and woody release at age 7-years at costs of \$35 and \$55/acre, respectively.

## Scenarios for the 15-year loblolly pine pulpwood rotation

The following are the twelve loblolly (Tables 11-13) pine scenarios:

- (1) Average site prep, fertilize at 1, 5, and 9 years, woody release at 4 years with an MAI of 6 tons/acre/year; no straw,
- (2) Average site prep, fertilize at 1, 5, and 9 years, woody release at 4 years with an MAI of 8 tons/acre/year; no straw,
- (3) Average site prep, fertilize at 1, 5, and 9 years, woody release at 4 years with an MAI of 10 tons/acre/year; no straw,
- (4) Average site prep, fertilize at 1, 5, and 9 years, herbaceous release at 4 years with an MAI of 6 tons/acre/year; raking straw from ages 6-15 years @ \$50/ac/yr,
- (5), Average site prep, fertilize at 1, 5, and 9 years, woody release at 4-years with an MAI of 8 tons/acre/year; raking straw from ages 6-15 years @ \$50/ac/yr,
- (6) Average site prep, fertilize at 1, 5, and 9 years, woody release at 4 years with an MAI of 10 tons/acre/year; raking straw from ages 6-15 years @ \$50/ac/yr,
- (7) High site prep, fertilize at 1, 5, and 9 years, woody release at 4 years with an MAI of 6 tons/acre/year; no straw,

- (8) High site prep, fertilize at 1, 5, and 9 years, woody release at 4 years with an MAI of 8 tons/acre/year; no straw,
- (9) High site prep, fertilize at 1, 5, and 9 years, woody release at 4 years with an MAI of 10 tons/acre/year; no straw,
- (10) High site prep, fertilize at 1, 5, and 9 years, woody release at 4 years with an MAI of 6 tons/acre/year; raking straw from ages 6-15 years @ \$50/ac/yr,
- (11) High site prep, fertilize at 1, 5, and 9 years, woody release at 4 years with an MAI of 8 tons/acre/year; raking straw from ages 6-15 years @ \$50/ac/yr,
- (12) High site prep, fertilize at 1, 5, and 9 years, woody release at 4 years with an MAI of 10 tons/acre/year; raking straw from ages 6-15 years @ \$50/ac/yr

### **Scenarios for the 24-year loblolly and slash pine rotations**

The following are the loblolly (Tables 14-15) and slash (Table 16-17) pine scenarios:

- (1) no thinning, no pine straw, \$245/acre establishment cost
- (2) no thinning, no pine straw, \$455/acre establishment cost
- (3) no thinning, rake pine straw @ \$50 (loblolly) or \$75/ac/yr (slash) from age 8- through 24-yr , \$245/acre establishment cost
- (4) no thinning, rake pine straw @ \$50 (loblolly) or \$75/ac/yr (slash) from age 8- through 24-yr , \$455/acre establishment cost
- (5) thin, (at age 15-years to 65 ft<sup>2</sup>/ac), no pine straw, \$245/acre establishment cost
- (6) thin at age 15-years, no pine straw, \$455/acre establishment cost
- (7) thin at age 15-years, rake straw @ \$50 (loblolly) or \$75/acre/year (slash) from age 8- through 15-years, \$245/acre establishment cost
- (8) thin at age 15-years, rake straw @ \$50 (loblolly) or \$75/acre/year (slash) from age 8- through 15-years, \$455/acre establishment cost

### **Scenarios for the 33-year rotation**

*The following are the loblolly (Table 18) and slash (Table 19) pine scenarios:*

- (1) thin at age 15- and 24-years to 65 ft<sup>2</sup>/ac, no pine straw, \$245/acre establishment cost
- (2) thin at age 15- and 24-years, no pine straw, \$455/acre establishment cost
- (3) thin at age 15- and 24-years, rake straw @ \$50 (loblolly) or \$75/acre/year (slash) from age 8- through 15-years, \$245/acre establishment cost
- (4) thin at age 15- and 24-years, rake straw @ \$50 (loblolly) or \$75/acre/year (slash) from age 8- through 15-years, \$455/acre establishment cost

*The following are the longleaf (Table 20) pine scenarios:*

- (5) thin at age 20-years to 65 ft<sup>2</sup>/ac, no pine straw, \$342/acre establishment cost
- (6) thin at age 20-years, no pine straw, \$552/acre establishment cost
- (7) thin at age 20-years, rake straw @ \$100/acre/year from age 8- through age 20-years, \$342/acre establishment cost
- (8) thin at age 20-years, rake straw @ \$100/acre/year from age 8- through age 20-years, \$532/acre establishment cost

### **Scenarios for the 45-year longleaf rotation (Table 21)**

- (1) thin at age 20- and 32-years to 65 ft<sup>2</sup>/ac, no pine straw, \$342/acre establishment cost
- (2) thin at age 20- and 32-years, no pine straw, \$552/acre establishment cost

(3) thin at age 20- and 32-years, rake straw @ \$100/acre/year from age 8- through age 20-years, \$342/acre establishment cost

(4) thin at age 20- and 32-years, rake straw @ \$100/acre/year from age 8- through age 20-years, \$532/acre establishment cost

## **Forest management activities**

### *Woody competition control*

Woody competition control with a single herbicide application occurred at age 6- (loblolly and slash pine) or 7-years (longleaf pine) to get the stand into pine straw production in the pine straw scenarios or to reduce under- and mid-story woody competition to enhance pine growth in the no pine straw scenarios (Table 3). The cost was assumed to be \$55/acre, a price often quoted for a single herbicide application in pine stands prior to canopy closure in Georgia in the last three years (2010-2013).

### *Thinning*

The thinning scenarios include no or one thinning for the loblolly and slash pine 24-year rotation scenarios and two thinnings at 15- and 24-years-old for loblolly and slash pine 33-year rotation. The longleaf pine scenarios had one thinning at age 20-years for 33-year rotation and two thinnings at age 20- and 33-years for the 45-year rotation. Residual basal area (RBA), after thinning (5<sup>th</sup> row with selection from below) was set at 65 square feet/acre.

### *Fertilization*

A single 175 N + 25 P fertilizer and application cost of \$165/acre (August 2013 cost for the Coastal Plain of Georgia) for slash and loblolly at age 15-years-old was assumed. Fertilization with 175 N + 25 P (as diammonium phosphate and urea) per acre was part of this scenario for loblolly and slash pine to enhance wood volume (NCSUFNC 1998), and change product class distribution (Peinaar and Rheney 1996, Dickens 2001). The fertilizer application was just after a thinning in the thinning scenario to put extra wood on the best trees and/or to maintain pine straw production in the unthinned scenario. Longleaf pine scenarios were not fertilized due to a lower N+P wood gain response than loblolly or slash pine.

### *Pine straw*

The pine straw income assumptions included were as follows: \$50, \$75, and \$100/acre/year raking income for the loblolly, slash, and longleaf scenarios, respectively have been noted in south (slash) and central (loblolly) Georgia between 1998 and 2010 (Doherty 2004, Dickens and others. 2012). Pine straw is raked starting in year 8 (approximating canopy closure) through the first thinning year for longleaf, slash, and loblolly pine (Table 5).

Typically pine straw raking in Georgia ceases after the first thinning due to large understory vegetation growth in thinned stands and the abundance of unthinned, relatively clean loblolly and slash pine stands available. Yet many acres of thinned loblolly and longleaf stands in South and North Carolina are raked. Some pine straw contractors in Georgia anticipate that some thinned loblolly, longleaf, and slash pine stands may be rakeable in the future (supply and demand).

## Results

### Soil expectation values

This paper's focus is on comparing the pine species and rotation ages using SEV as an economic decision making criteria. Previous papers in this economics series compared NPV, net revenues, and RORs within a given rotation age (Dickens et al. 2013, 2014, Sunday et al. 2013, 2014). Only positive SEVs are shown in the SEV tables 11-23. Negative SEVs were not included in this paper as (1) negative SEVs are not financially attractive and (2) the tables would be overwhelming if negative SEVs were included.

### Part I. Comparing rotations by pine species using the same establishment costs, stumpage price sets, discount rates, and no pine straw or with pine straw income

#### *Comparing the short rotation (15-years) loblolly pine pulpwood rotation to the 24- and 33-year loblolly rotations*

Loblolly pine at the 6 tons/acre/year MAI 15-year rotation (Table 11) produced the lowest SEVs when compared to the 8 and 10 tons/acre/year MAI 15-year rotations (Tables 12 and 13) and the 24- and 33-year rotations (Tables 14 and 18, respectively). The 6 tons/acre/year MAI 15-year rotation SEVs were much lower than corresponding SEVs for the 24- and 33-year rotations. The following are example comparisons of the 6 tons/acre/year MAI 15-year rotation and the 24- and 33-year rotations:

(1) When using a discount rate of 4%, the 15-year rotation SEV of \$146/acre for scenario 4 at the average pulpwood price in Table 11 and comparing the 24-year rotation SEVs of \$1154 and \$1227/acre for scenario 3 using the average stumpage price set in Tables 14 and 15, respectively and a SEV of \$1056/acre for the 33-year rotation, scenario 7 (Table 18) there were differences of \$1008, \$1081, and \$910/acre, respectively.

(2) When using a discount rate of 4%, the 15-year rotation SEV of \$179/acre for scenario 10 at the high pulpwood price in Table 11 and comparing the 24-year rotation SEVs of \$1606/acre and \$1956/acre for scenario 4 using high stumpage price set in Tables 14 and 15, respectively and a SEV of \$1691/acre for the 33-year rotation, scenario 8 (Table 18) there were differences of \$1427, \$1777, and \$1512/acre, respectively.

The loblolly 8 tons/acre/year SEVs (Table 12) were also lower than the 24-year no thin (Table 14) and 24-year thin (Table 15) rotations SEVs and the 33-year rotation SEVs. Examples of the differences between the 8 tons/acre/year MAI 15-year rotation SEVs and the 24- and 33-year rotations are as follows:

(1) When using a discount rate of 6%, the 15-year rotation SEV of \$87/acre for scenario 5 at the average pulpwood price in Table 12 and comparing the 24-year rotations SEVs of \$479/acre and \$536/acre for scenario 3 at the average stumpage prices in Tables 14 and 15, respectively and a SEV of \$390/acre for the 33-year rotation, scenario 7 (Table 18) there were differences of \$392, \$449, and \$303/acre, respectively.

(2) When using a discount rate of 8%, the 15-year rotation SEV of \$163/acre for scenario 5 at the high pulpwood price in Table 12 and comparing the 24-year rotations SEVs of \$402/acre and \$536/acre for scenario 3 at high stumpage prices in Tables 14 and 15, respectively and a SEV of \$347/acre for the 33-year rotation, scenario 7 (Table 18) there were differences of \$239, \$373, and \$260/acre, respectively.

The loblolly 10 tons/acre/year SEVs (Table 13) were lower than the 24-year no thin (Table 14) and 24-year thin (Table 15) rotations SEVs and the 33-year rotation SEVs (Table 18). Examples of the differences between the 10 tons/acre/year MAI 15-year rotation SEVs and the 24- and 33-year rotations are as follows:

- (1) When using a discount rate of 8%, the 15-year rotation SEV of \$27/acre for scenario 6 at the average pulpwood price in Table 13 and comparing the 24-year rotation SEVs of \$169 and \$215/acre for scenario 3 using the average stumpage price set in Tables 14 and 15, respectively and a SEV of \$97/acre for the 33-year rotation, scenario 7 (Table 18) there were differences of \$167, \$188, and \$70/acre, respectively.
- (2) When using a discount rate of 4%, the 15-year rotation SEV of \$1111/acre for scenario 12 at the high pulpwood price in Table 13 and comparing the 24-year rotation SEVs of \$1606/acre and \$1956/acre for scenario 4 using high stumpage price set in Tables 14 and 15, respectively and a SEV of \$1691/acre for the 33-year rotation, scenario 8 (Table 18) there were differences of \$497, \$854, and \$580/acre, respectively.

#### *Comparing the 24-year and 33-year loblolly pine rotations*

When comparing loblolly pine scenarios without pine straw, the 24-year, no thin scenarios (Table 14), at all discount rates, were lower than the 24-year, one thin (Table 15) and 33-year rotations (Table 18). Examples of SEV differences without pine straw income are as follows:

- (1) Using a discount rate of 4%, average stumpage and establishment prices, the 24-year, no thin SEV was \$396/acre (Table 14) compared to SEVs of \$808 and \$708/acre for the 24-year, one thin (Table 15) and 33-year (Table 18) rotations, respectively, differences of \$412 and \$312/acre.
- (2) Using a discount rate of 6%, high stumpage and establishment prices, the 24-year, no thin SEV was \$145/acre (Table 14) compared to SEVs of \$555 and \$357/acre for the 24-year, one thin (Table 15) and 33-year (Table 18) rotations, respectively, differences of \$310 and 212/acre.

When comparing the loblolly pine scenarios with pine straw, the 24-year, no thin scenarios (Table 14, scenarios 3 and 4) had greater SEVs at all discount rates and all stumpage price sets compared to the 33-year rotation (Table 18, scenarios 7 and 8), except when using the 4% discount rate and high stumpage prices. The pine straw SEV differences between the no thin 24-year rotation and the 33-year rotation ranged from \$85/acre in favor of the 33-year rotation (SEVs of \$1606 versus \$1691) to \$146/acre in favor of the 24-year, no thin rotation (SEVs of \$317 versus \$135/acre). The 24-year, one thin SEVs were generally higher than both the 24-year, no thin (with the exception of using low stumpage prices) and the 33-year rotations. The 24-year, one thin rotation produced SEVs greater than the 33-year rotation with differences ranging from \$48/acre (SEVs of \$463 versus \$415/acre) to \$320/acre (SEVs of \$2300 versus \$1980). Examples of SEVs with pine straw income are as follows:

- (1) Using a discount rate of 6%, average stumpage and establishment prices, the 24-year, one thin SEV was \$536/acre (Table 15) compared to SEVs of \$479 and \$390/acre for the 24-year, no thin (Table 14) and 33-year (Table 18) rotations, respectively, differences of \$57 and \$146/acre.



- (2) Using a discount rate of 8%, high stumpage and establishment prices, the 24-year, one thin SEV was \$307/acre (Table 15) compared to SEVs of \$152 and \$119/acre for the 24-year, no thin (Table 14) and 33-year (Table 18) rotations, respectively, differences of \$155 and \$188/acre.

*Comparing the 24-year, no thin to the 24-year, one thin and the 33-year, two thin slash pine rotations*  
When comparing the no pine straw income scenarios (scenarios 5 and 6), the slash pine 24-year rotation, no thin scenarios (Table 16) gave the lowest SEVs across the discount rates. The 24-year, one thin (Table 17) and 33-year two thins (Table 19) had similar SEV values where there was no pine straw income (scenarios 5 and 6). Example comparisons with no pine straw income are as follows:

- (1) Using a discount rate of 4% and average stumpage prices, the 24-year, no thin scenario 5 had a SEV of \$240/acre (Table 16), whereas the 24-year, one thin had a SEV of \$485/acre (Table 17) and the 33-year rotation had a SEV of \$536/acre (Table 19), differences of \$245 and \$296/acre, respectively.

- (2) Using a discount rate of 6% and high stumpage prices, the 24-year, no thin scenario 6 had a SEV of \$15/acre, whereas the 24-year, one thin had a SEV of \$263/acre (Table 17) and the 33-year rotation had a SEV of \$221/acre (Table 19), differences of \$248 and \$206/acre, respectively.

When comparing the slash pine rotation scenarios with pine straw income (scenarios 7 and 8), the slash pine, no thin scenarios (Table 16) generally gave greater SEVs than the 24-year, one thin or 33-year rotation (Table 19). This is mostly due to pine straw being harvested from age 8-years through age 24-years at \$75/acre/year in the no thin scenario versus pine straw being raked from age 8 through age 15-years (at the same annual price/acre) for the 24-year, one thin and 33-year rotations. When a discount rate of 8 or 10% was used and high stumpage prices the 24-year, one thin SEVs were just slightly lower (\$4 to \$8/acre differences) than the no thin SEVs under scenario 7 and 8 (Tables 16 and 17). This illustrates that as stumpage prices and discount rates increase, the benefit of additional pine straw income in the no thin 24-year rotation scenarios is lessened as reflected in smaller SEV differences compared to the one thin 24-year rotation and the 33-year rotation. Examples of SEV differences with pine straw income are as follows:

- (1) Using a discount rate of 6%, scenario 7 and average stumpage prices, the 24-year, no thin had a SEV of \$630/acre (Table 16), whereas the 24-year, one thin had a SEV of \$495/acre (Table 17) and the 33-year rotation had a SEV of \$427/acre (Table 19), differences of \$132 and \$200/acre, respectively.

- (2) Using a discount rate of 6%, scenario 8 and high stumpage prices, the 24-year, no thin had a SEV of \$706/acre, whereas the 24-year, one thin had a SEV of \$674/acre (Table 17) and the 33-year rotation had a SEV of \$584/acre (Table 19), differences of \$32 and \$122/acre, respectively.

*Comparing the 33-year rotation to the one thin 24-year slash pine rotations*

When comparing the slash pine 33-year rotation to the shorter 24-year rotations, the 33-year rotation (Table 19) had similar SEV values as the 24-year, one thin rotation (Table 17) across the discount rates, establishment costs, and pine straw or no pine straw income scenarios. The SEV value differences between the 33-year and 24-year, one thin rotations (without pine straw income, scenarios 5 and 6) ranged from \$105/acre in favor of the 33-year rotation to \$86/acre in favor of the 24-year rotation. The SEV value differences between the 33-year and 24-year, one thin rotations (with pine straw

income, scenarios 7 and 8) ranged from \$3/acre in favor of the 24-year, one thin rotation to \$110/acre in favor of the 24-year, one thin rotation (Tables 17 and 19). Examples of SEV differences between the 24-year, one thin and 33-year rotation are as follows:

- (1) Using a discount rate of 6%, scenario 6, and high stumpage prices, the 24-year, one thin had a SEV of \$263/acre (Table 17), whereas the 33-year rotation had a SEV of \$221/acre (Table 19) a difference of \$42/acre in favor of the 24-year, one thin rotation.
- (2) Using a discount rate of 6%, scenario 7, and average stumpage prices, the 24-year, one thin had a SEV of \$495/acre (Table 17), whereas the 33-year rotation had a SEV of \$427/acre (Table 19) a difference of \$68/acre in favor of the 24-year, one thin rotation.

#### *Comparing the 33-year to the 45-year longleaf rotation*

When comparing SEVs of the 33-year to the 45-year longleaf rotations, without pine straw income, the 45-year rotation generally had greater SEVs. Examples of these differences without pine straw income are as follows:

- (1) Using a discount rate of 4%, scenario 5, and high stumpage prices, the 33-year rotation had a SEV of \$483/acre (Table 20), whereas the 45-year rotation had a SEV of \$814/acre (Table 21) a difference of \$331/acre.
- (2) Using a discount rate of 4%, scenario 6, and high stumpage prices, the 33-year rotation had a SEV of \$193/acre (Table 20), whereas the 45-year rotation had a SEV of \$560/acre (Table 21) a difference of \$367/acre.

When comparing SEVs of the 33-year to the 45-year rotation with pine straw income, the SEV differences were relatively small (\$-1 to \$29/acre), generally favoring the 45-year rotation when using low or average stumpage prices and the average establishment cost (scenario 7, Table 20 and 21). When using high stumpage prices and the average establishment cost (scenario 7, Table 20 and 21), the 45-year rotation SEVs were \$2 (at 10% discount rate) to \$201/acre (at 4% discount rate) greater than the corresponding 33-year rotation SEVs. When using the higher establishment cost (scenario 8, Table 20 and 21), the SEV differences were somewhat larger between the 33- and 45-year rotations, favoring the 45-year rotation. These scenario 8 SEV differences ranged from \$18 to \$236/acre. Examples of these SEV differences are as follows:

- (1) Using a discount rate of 4%, scenario 7, and high stumpage prices, the 33-year rotation had a SEV of \$1528/acre (Table 20), whereas the 45-year rotation had a SEV of \$1729/acre (Table 21) a difference of \$201/acre.
- (2) Using a discount rate of 6%, scenario 8, and average stumpage prices, the 33-year rotation had a SEV of \$192/acre (Table 20), whereas the 45-year rotation had a SEV of \$240/acre (Table 21) a difference of \$48/acre.

## **Part II. Comparing rotations across pine species using the same establishment costs, stumpage price sets, discount rates, and no pine straw or with pine straw income**

### *A. Scenarios without pine straw income*

► The 15-year pulpwood short rotation loblolly pine scenario positive SEVs at 6 and 8 tons/acre/year MAIs (Tables 11 and 12) were not financially attractive when compared to the positive SEVs of the 24-year loblolly and slash rotations (Tables 14-17), the 33-year loblolly and slash rotations (Tables 18 and 19), and the 33- and 45-year longleaf rotations (Tables 20 and 21).

► The 15-year pulpwood short rotation loblolly pine scenario positive SEVs at 10 tons/acre/year MAIs (Table 13) were not financially attractive when compared to the positive SEVs of the 24-year loblolly and slash rotations (Tables 14-17), the 33-year loblolly and slash rotations (Tables 18 and 19), and the 45-year longleaf rotation (when using low or average stumpage prices Table 21). The 10 tons/acre/year MAI 15-year loblolly rotation's positive SEVs were greater than the positive SEVs of the 33-year longleaf rotation (Table 20).

The following are examples of SEV values without pine straw income at 4, 6, and 8% discount rates using the average or high establishment costs and average or high stumpage prices. The SEV values are listed in descending order in each example. The 15-year rotation 6, 8, and 10 tons/acre/year loblolly scenarios excluded as their SEVs were lower than the longer rotations except as noted above.

► The SEV per acre values of the average establishment cost, at the 4% discount rate using average stumpage prices are as follows: \$808 (24-year, one thin loblolly), \$708 (33-year loblolly), \$536 (33-year slash), \$485 (24-year, one thin slash), \$396 (24-year, no thin loblolly), \$240 (24-year no thin slash), \$223 (45-year longleaf), and a negative SEV (33-year longleaf).

► The SEV per acre values of the average establishment cost, at the 4% discount rate using high stumpage prices are as follows: \$1881 (24-year, one thin loblolly), \$1628 (33-year loblolly), \$1354 (33-year slash), \$1354 (24-year, one thin slash), \$1193 (24-year, no thin loblolly), \$938 (24-year no thin slash), \$814 (45-year longleaf), and \$483 (33-year longleaf).

► The SEV per acre values of the average establishment cost, at the 6% discount rate using average stumpage prices are as follows: \$262 (24-year, one thin loblolly), \$148 (33-year loblolly), \$84 (24-year one thin slash), \$65 (33-year slash), \$16 (24-year, no thin loblolly), and negative SEVs for the 24-year no thin slash, 33- and 45-year longleaf.

► The SEV per acre values of the average establishment cost, at the 6% discount rate using high stumpage prices are as follows: \$834 (24-year, one thin loblolly), \$603 (33-year loblolly), \$542 (24-year one thin slash), \$467 (33-year slash), \$424 (24-year, no thin loblolly), \$294 (24-year, no thin slash), \$98 (45-year longleaf), and a negative SEVs for 33-year longleaf.

► The SEV per acre values of the average establishment cost, at the 8% discount rate using average stumpage prices are as follows: \$16 (24-year, one thin loblolly) with the other rotation scenarios having negative SEVs.

► The SEV per acre values of the average establishment cost, at the 8% discount rate using high stumpage prices are as follows: \$357 (24-year, one thin loblolly), \$177 (24-year one thin slash), \$165

(33-year loblolly), \$91 (33-year slash), \$86 (24-year, no thin loblolly), \$11 (24-year, no thin slash), and a negative SEVs for 33-year and 45-year longleaf rotations.

► There was one positive SEV at the 10% discount rate at the average establishment cost using high stumpage prices, the 24-year, one thin loblolly rotation at \$104/acre (Table 15).

► The SEV per acre values of the high establishment cost, at the 4% discount rate using average stumpage prices are as follows: \$463 (24-year, one thin loblolly), \$415, (33-year loblolly), \$246 (33-year slash), \$141 (24-year, one thin slash), \$52 (24-year, no thin loblolly), and negative SEVs for the 24-year no thin slash, 33- and 45-year longleaf.

► The SEV per acre values of the high establishment cost, at the 4% discount rate using high stumpage prices are as follows: \$1537 (24-year, one thin loblolly), \$1339 (33-year loblolly), \$1065 (33-year slash), \$1007 (24-year, one thin slash), \$848 (24-year, no thin loblolly), \$594 (24-year no thin slash), \$560 (45-year longleaf), and \$193 (33-year longleaf).

► The SEV per acre values of the high establishment cost, at the 6% discount rate using average stumpage prices are as follows: \$262 (24-year, one thin loblolly), \$84 (24-year, one thin slash), with the remaining rotation scenarios having negative SEVs.

► The SEV per acre values of the high establishment cost, at the 6% discount rate using high stumpage prices are as follows: \$555 (24-year, one thin loblolly), \$357 (33-year loblolly), \$263 (24-year, one thin slash), \$221 (33-year slash), \$145 (24-year, no thin loblolly), \$15 (24-year, no thin slash), and negative SEVs for the 33- and 45-year longleaf rotations.

► There was one positive SEV at the 8% discount rate at the high establishment cost using high stumpage prices, the 24-year, one thin loblolly rotation at \$108/acre (Table 15).

Overall, the general SEV order without pine straw income using the 4, 6, and 8% discount rates was (ranking from highest to lowest SEV per acre): (1) the 24-year, one thin loblolly pine, (2) the 33-year loblolly, (3-4) the 24-year, one thin slash and the 33-year slash, (5) 24-year, no thin loblolly, (6) the 24-year, no thin slash, (7) the 45-year longleaf, and the 33-year longleaf rotation.

### *B. Scenarios with pine straw income*

SEV per acre values with pine straw income at 4, 6, 8, and 10% discount rates using the average or high establishment costs and low, average, or high stumpage prices are presented in this section.

The SEV values are listed in descending order in each example as follows using the average establishment cost (loblolly 15-year 6 and 8 tons/acre/year MAIs excluded due to SEVs being lower than the 10 tons/acre/year MAI included here):

► The SEV per acre values, at the 4% discount rate using low stumpage prices are as follows: \$953 (24-year, no thin slash), \$712 (45-year longleaf), \$710 (33-year longleaf), \$661 (24-year, no thin loblolly), \$564 (24-year, one thin slash), \$533 (24-year one thin loblolly), \$500 (33-year slash), \$421 (33-year loblolly), and \$247 (15-year loblolly at 10 tons/acre/year MAI).

- ▶ The SEV per acre values, at the 4% discount rate using average stumpage prices are as follows: \$1371 (24-year, no thin slash), \$1227 (24-year, one thin loblolly), \$1154 (24-year, no thin loblolly), \$1139 (45-year longleaf), \$1114 (24-year, one thin slash), \$1064 (33-year slash), \$1056 (33-year loblolly), \$1040 (33-year longleaf), and \$753 (15-year loblolly at 10 tons/acre/year MAI).
- ▶ The SEV per acre values, at the 4% discount rate using high stumpage prices are as follows: \$2300 (24-year, one thin loblolly), \$2068 (24-year, no thin slash), \$1981 (24-year, one thin slash), \$1980 (33-year loblolly), \$1951 (24-year, no thin loblolly), \$1882 (33-year slash), \$1729 (45-year longleaf), \$1595 (15-year loblolly 10 tons/acre/year MAI), and \$1528 (33-year longleaf).
- ▶ The SEV per acre values, at the 6% discount rate using low stumpage prices are as follows: \$409 (24-year, no thin slash), \$280 (33-year longleaf), \$278 (45-year longleaf), \$226 (24-year, no thin loblolly), \$205 (24-year, one thin slash), \$167 (24-year, one thin loblolly), \$152 (33-year slash), \$80 (33-year loblolly), and a negative SEV for the 15-year loblolly at 10 tons/acre/year MAI.
- ▶ The SEV per acre values, at the 6% discount rate using average stumpage prices are as follows: \$627 (24-year, no thin slash), \$536 (24-year, one thin loblolly), \$495 (24-year one thin slash), \$479 (24-year, no thin loblolly), \$466 (45-year longleaf), \$438 (33-year longleaf), \$427 (33-year slash), \$390 (33-year loblolly), and \$261 (15-year loblolly at 10 tons/acre/year MAI).
- ▶ The SEV per acre values, at the 6% discount rate using high stumpage prices are as follows: \$1108 (24-year, one thin loblolly), \$984 (24-year, no thin slash), \$953 (24-year one thin slash), \$887 (24-year, no thin loblolly), \$844 (33-year loblolly), \$829 (33-year slash), \$744 (15-year loblolly at 10 tons/acre/year), \$733 (45-year longleaf), and \$673 (33-year longleaf).
- ▶ The SEV per acre values, at the 8% discount rate using low stumpage prices are as follows: \$157 (24-year, no thin slash), \$64 (33-year longleaf), \$63 (45-year longleaf), \$34 (24-year, one thin slash), and \$24 (24-year, no thin loblolly), and negative SEVs for the 24-year, one thin loblolly, 33-year slash and loblolly, and 15-year loblolly at 10 tons/acre/year MAI.
- ▶ The SEV per acre values, at the 8% discount rate using average stumpage prices are as follows: \$279 (24-year, no thin slash), \$215 (24-year, one thin loblolly), \$205 (24-year one thin slash), \$169 (24-year, no thin loblolly), \$156 (45-year longleaf), \$149 (33-year longleaf), \$142 (33-year slash), \$97 (33-year loblolly), and \$27 (15-year loblolly at 10 tons/acre/year MAI).
- ▶ The SEV per acre values, at the 8% discount rate using high stumpage prices are as follows: \$536 (24-year, one thin loblolly), \$483 (24-year, no thin slash), \$477 (24-year one thin slash), \$402 (24-year, no thin loblolly), \$367 (33-year slash), \$347 (33-year loblolly), \$337 (15-year loblolly at 10 tons/acre/year), \$291 (45-year longleaf), and \$276 (33-year longleaf).
- ▶ The SEV per acre values, at the 10% discount rate using low stumpage prices had one positive SEV, the 24-year, no thin slash rotation (\$14). The rest of the rotation scenarios had negative SEV values.
- ▶ The SEV per acre values, at the 10% discount rate using average stumpage prices are as follows: \$88 (24-year, no thin slash), \$44 (24-year, one thin slash), \$40 (24-year one thin loblolly), \$2 (24-year, no thin loblolly), with the 15-year loblolly 10 tons/acre/year MAI, the 33-year loblolly, longleaf, and slash pine and the 45-year longleaf pine rotations having negative SEVs.

► The SEV per acre values, at the 10% discount rate using high stumpage prices are as follows: \$256 (24-year, one thin loblolly), \$215 (24-year, one thin slash), \$211 (24-year no thin slash), \$143 (24-year, no thin loblolly), \$122 (33-year slash), \$107 (15-year loblolly at 10 tons/acre/year), \$94 (33-year loblolly), \$58 (45-year longleaf), and \$56 (33-year longleaf).

The SEV values are listed in descending order with pine straw income in each example as follows using the high establishment cost (loblolly 15-year 6 and 8 tons/acre/year MAIs excluded due to SEVs being lower than the 10 tons/acre/year MAI pulpwood rotation included here):

► The SEV per acre values, at the 4% discount rate using low stumpage prices are as follows: \$603 (24-year, no thin slash), \$459 (45-year longleaf), \$421 (33-year longleaf), \$317 (24-year, no thin loblolly), \$220 (24-year, one thin slash), \$211 (33-year slash), \$135 (33-year loblolly), \$109 (24-year, one thin loblolly), and a negative SEV for the 15-year loblolly at 10 tons/acre/year MAI rotation.

► The SEV per acre values, at the 4% discount rate using average stumpage prices are as follows: \$1026 (24-year, no thin slash), \$885 (45-year longleaf), \$883 (24-year, one thin loblolly), \$810 (24-year no thin loblolly), \$775 (33-year slash), \$771 (33-year loblolly), \$770 (24-year, one thin slash), \$751 (33-year longleaf), and \$280 (15-year loblolly at 10 tons/acre/year MAI).

► The SEV per acre values, at the 4% discount rate using high stumpage prices are as follows: \$1956 (24-year, one thin loblolly), \$1724 (24-year, no thin slash), \$1691 (33-year loblolly), \$1636 (24-year, one thin slash), \$1606 (24-year, no thin loblolly), \$1593 (33-year slash), \$1475 (45-year longleaf), \$1239 (33-year longleaf) and \$1111 (15-year loblolly 10 tons/acre/year MAI).

► The SEV per acre values, at the 6% discount rate using low stumpage prices are as follows: \$131 (24-year, no thin slash), \$52 (45-year longleaf) and \$34 (33-year longleaf) with the rest of the rotations having negative SEVs.

► The SEV per acre values, at the 6% discount rate using average stumpage prices are as follows: \$348 (24-year, no thin slash), \$257 (24-year, one thin loblolly), \$240 (45-year longleaf), \$216 (24-year, one thin slash), \$200 (24-year no thin loblolly), \$192 (33-year longleaf), \$181 (33-year slash), \$144 (33-year loblolly), and a negative SEV for the 15-year loblolly at 10 tons/acre/year MAI rotation.

► The SEV per acre values, at the 6% discount rate using high stumpage prices are as follows: \$829 (24-year, one thin loblolly), \$706 (24-year, no thin slash), \$674 (24-year, one thin slash), \$608 (24-year, no thin loblolly), \$599 (33-year loblolly), \$584 (33-year slash), \$506 (45-year longleaf), \$427 (33-year longleaf), and \$384 (15-year loblolly at 10 tons/acre/year MAI).

► There were no positive SEV values at the 8% discount rate using low stumpage prices.

► There was one positive SEV at the 8% discount rate using average stumpage prices, the 24-year, no thin slash rotation (\$30).

► The SEV per acre values, at the 8% discount rate using high stumpage prices are as follows: \$307 (24-year, one thin loblolly), \$234 (24-year, no thin slash), \$226 (24-year one thin slash), \$152 (24-year, no thin loblolly), \$136 (33-year slash), \$119 (33-year loblolly), \$74 (45-year longleaf), \$48 (33-year longleaf) and \$31 (15-year loblolly at 10 tons/acre/year MAI rotation).

► There were no positive SEV per acre values, at the 10% discount rate using low or average stumpage prices.

► There was one positive SEV at the 10% discount rate using high stumpage prices, the 24-year, one thin loblolly rotation (\$23).

## Summary

The highest to lowest SEV's ranking without pine straw income using average establishment costs and a discount rate of 6% are as follows:

(1) Using average stumpage prices → the 24-year one thin loblolly (\$262/ac), 33-year loblolly (\$148/ac), 24-year one thin slash (\$84/ac), 33-year slash (\$65/ac), and the 24-year no thin loblolly (\$16/ac). The balance of the scenarios had negative SEVs (Table 22).

(2) Using high stumpage prices → the 24-year one thin loblolly (\$834/ac), 33-year loblolly (\$603/ac), 24-year one thin slash (\$542), 33-year slash (\$467/ac), 24-year no thin loblolly (\$424/ac), 24-year no thin slash (\$294/ac), 15-year loblolly 10 tons MAI (\$272/ac), 45-year longleaf (\$98/ac), and 15-year loblolly 8 tons MAI (\$2/ac). The balance of the scenarios had negative SEVs (Table 22).

Overall, the highest to lowest SEV value order for the rotations with pine straw are as follows with the average establishment cost:

(1) Using low stumpage prices → the 24-year no thin slash, the 45-year longleaf, the 33-year longleaf, the 24-year no thin loblolly, the 24-year one thin slash, the 24-year one thin loblolly, the 33-year slash, the 33-year loblolly, and the 15-year loblolly at 10 tons/acre/year MAI.

(2) Using average stumpage prices → the 24-year no thin slash (\$627/ac), the 24-year one thin loblolly (\$536/ac), the 24-year one thin slash (\$495/ac), the 24-year no thin loblolly (\$479/ac), the 45-year longleaf (\$466/ac), the 33-year longleaf (\$438/ac), the 33-year slash (\$427/ac), the 33-year loblolly (\$390/ac), the 15-year loblolly at 10 tons/acre/year MAI rotation (\$261/ac), and the 15-year loblolly at 8 tons/acre/year MAI rotation (\$87/ac, Table 23 using a 6% discount rate).

(3) Using high stumpage prices → the 24-year one thin loblolly (\$1108/ac), the 24-year no thin slash (\$984/ac), the 24-year one thin slash (\$953/ac), the 24-year no thin loblolly (\$887/ac), the 33-year loblolly (\$844/ac), the 33-year slash (\$827/ac), the 15-year loblolly 10 tons/acre/year MAI (\$744/ac), the 45-year longleaf (\$733/ac), the 33-year longleaf (\$673/ac), the 15-year loblolly 8 tons/acre/year MAI (\$474/ac), and the 15-year loblolly 6 tons/acre/year MAI (\$203/ac, Table 23 using a 6% discount rate).

The overall high establishment cost SEVs hierarchy was similar to the average establishment cost hierarchy. In general, the highest to lowest SEV value order for the rotations with pine straw are as follows with the high establishment cost:

(1) Using low stumpage prices → the 24-year no thin slash, the 45-year longleaf, the 33-year longleaf, the 24-year no thin loblolly, the 33-year slash, the 33-year loblolly, the 24-year one thin loblolly, and the 15-year loblolly at 10 tons/acre/year MAI. There were no positive SEVs at 8 and 10% discount rates.

(2) Using average stumpage prices → the 24-year no thin slash, the 24-year one thin loblolly, the 45-year longleaf, the 24-year no thin slash, the 24-year no thin loblolly, the 33-year longleaf, the 33-year slash, the 33-year loblolly, and the 15-year loblolly at 10 tons/acre/year MAI rotation.

(3) Using high stumpage prices → the 24-year one thin loblolly, the 24-year no thin slash, the 24-year one thin slash, the 24-year no thin loblolly, the 33-year loblolly, the 33-year slash, the 33-year longleaf, and the 10 tons/acre/year MAI rotation.

The addition of pine straw greatly improved SEVs as noted by the differences in SEV/ac values between table 22 and table 23.

## **Conclusions**

### **Wood flows, thinning, and pine straw**

These scenarios do illustrate that if the aforementioned base growth rates for slash, loblolly, and longleaf pine are assumed then the establishment expenditures (site preparation, seedling, and planting costs) need to be used wisely. In many cases the establishment phase decisions (site preparation type, timing, and quality, site preparation effects on near- or long-term site productivity, woody and herbaceous weed control efficacy, species selection, seedling genetics and size, seedling survival) can improve growth rates above those used here, therefore improving net revenue and rate of return values.

When wood value only is considered, loblolly produced more wood, more wood value, and higher SEVs with the aforementioned assumptions with the no pine straw scenarios. Recent studies (Shiver and others. 1999, Zhao and Kane 2012) have shown that loblolly will grow more wood than slash and longleaf pine on a number of soils where both species are grown. Loblolly's superior wood volume yields do not necessarily equate to higher per acre or per unit wood stumpage prices. Clark (2002) noted that slash pine yielded more number one lumber, had a slightly greater (4 to 11 percent greater) density, and 4 percent less moisture content than loblolly pine in growing in the same stand.

When pine straw income was included in the scenarios (with loblolly at \$50/acre/year income and slash at \$75/acre/year income assumptions from age 8- through 15-years and longleaf at \$100/acre/year from age 8- through 20-years), longleaf and slash pine generally produced slightly higher SEVs than loblolly pine using low and average stumpage prices.

## **Discussion**

Non-industrial private forest landowners do have some attractive forest management options with both slash and loblolly pine. To maximize net revenues, net present values, rates of return and SEVs, landowners need to be flexible when thinning or clearcutting their stands, possibly looking into a 3 to 5 year horizon and closely following local pine stumpage prices. Selling wood when stumpages are relatively high in these planning horizons can improve net revenues and RORs. Including pine straw income can improve SEVs and net revenues for loblolly, longleaf, and slash pine. The findings in this paper are specific to the assumptions made. Changes in assumptions will alter the results which can alter scenario attractiveness when compared than others. In this paper growth rates, pine straw income (when raked), establishment costs, and stumpage price sets may be different than what some forest landowners would use. Familiarize yourself with financial tools like the Biomass Green Weight Estimation and Financial Analysis Tool (Love, 2011) that was used here or FORVAL online (Bullard and others. 2001).



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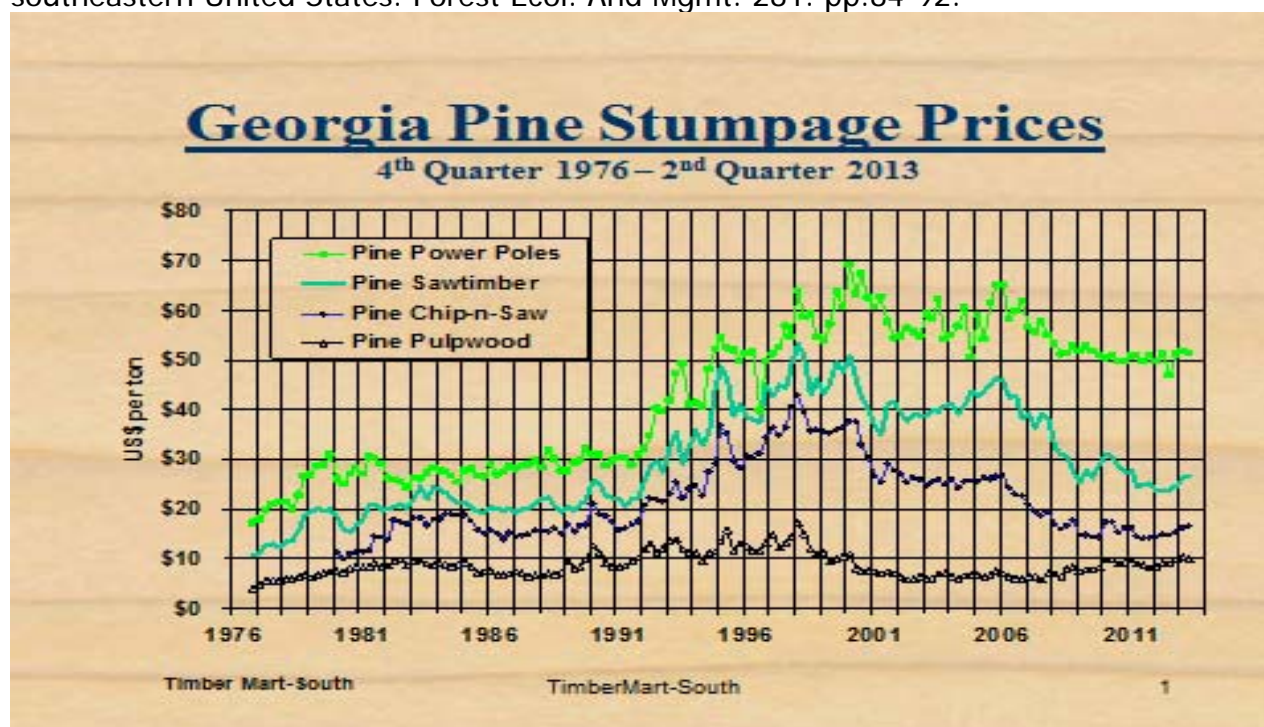


Figure 1. Georgia state-wide average pine stumpage prices from 4<sup>th</sup> quarter 1976 through 2<sup>nd</sup> quarter 2013 by product class

**Table 1.** Product class specifications.

Product/Item	Pulpwood	Chip-N-Saw	Sawtimber
Small end diameter (inches)	3	6	10
Minimum length (feet)	5	8	8
Length Increment (feet)	1	4	8

**Table 2.** Product prices, cash and net (90% of cash; net of property taxes and marketing costs) per ton stumpage prices used in the profitability analysis of slash and loblolly scenarios, Georgia state average, price per ton (4<sup>th</sup> Q 1976 through 2ndQ 2013 TM-S).

Item, Price level	Cash or net	Pulpwood (\$/Ton)	Chip-N-Saw (\$/Ton)	Sawtimber (\$/Ton)
Low	cash	6.00	13.00	15.00
	net	5.40	11.70	13.50
Average	cash	9.00	22.00	30.00
	net	8.10	19.80	27.00
High	cash	14.00	37.00	48.00
	net	12.60	33.30	43.20

**Table 3.** Loblolly and slash pine mean annual increment (MAI) and product class wood yields in the 24-year rotation scenarios.

Species	Thin (Y/N)	MAI (tons/ac/r)	Pulpwood	Chip-n-saw	Sawtimber
			----- tons/acre -----		
loblolly	N	6.3	92.3	54	6.2
	Y @ age 15-yrs	6.1	23.8	10.5	0
	CC @ 24-yrs		32.9	62.1	20.8
slash	N	5.6	82.9	50.5	2.2
	Y @ age 15-yrs	5.4	19.7	4.9	0
	CC @ 24-yrs		35.9	57.2	12.4

**Table 4.** Loblolly, slash, and longleaf pine wood yields in the 33-year rotation scenarios.

Species	Cut age (yrs)	MAI (tons/ac/r)	Pulpwood	Chip-n-saw	Sawtimber
			----- tons/acre -----		
loblolly	15	5.76	16.7	2.4	0
	24		19.2	24.0	1.6
	33		28.4	42.9	54.8
slash	15	5.15	14.9	3.2	0
	24		18.6	18.4	0.8
	33		25.1	38.6	50.5
longleaf	20	4.64	39.2	0.15	0
	33		68.1	19.5	26.2

**Table 5.** Longleaf pine wood yields in the 45-year rotation scenarios.

Rotation age (yrs)	Cut age (yrs)	MAI (tons/ac/r)	Pulpwood	Chip-n-saw	Sawtimber
			----- tons/acre -----		
45	20	4.43	39.23	0.15	0
	32		18.55	25.11	7.05
	45		22.70	6.58	80.15

**Table 6.** Fertilizer and woody release costs as used in the profitability analysis for 15-year loblolly short rotation scenarios

Rotation (yrs)	Stand age when applied (yrs)	Treatment	Cost (\$/ac)
15	1	200 lbs/ac DAP	80.00
	4	Arsenal @ 16 oz/ac	55.00
	5	125 lbs/ac DAP + 170 lbs/ac urea	110.00
	9	125 lbs/ac DAP + 275 lbs/ac urea	146.00

**Table 7.** Costs for the 24-year loblolly and slash rotations

Activity	Time of cost (yr)	Cost (total \$/acre)	
		Average SP+PL	High SP+PL
annual management fee	1 through 24	240	240
site prep and plant	0	245	455
herbicide	6	55	55
N+P fertilization	15	165	165
Total cost per acre		\$ 705	\$ 915

**Table 8.** Costs for the 33-year loblolly, slash, and longleaf rotations

Activity	loblolly and slash costs (\$/acre)			longleaf costs (\$/acre)	
	Cost time (yr)	Average SP+PL	High SP+PL	Average SP+PL	High SP+PL
annual mgmt fee	1 through 33	330	330	330	330
site prep & plant	0	245	455	342	552
herbaceous weed control	1	0	0	35	35
herbicide	6 or 7	55	55	55	55
N+P fertilization	15	165	165	0	0
Total cost per acre		\$ 795	\$ 1005	\$ 762	\$ 972

**Table 9.** Costs for the 45-year longleaf rotations

Activity	Cost time (yr)	45-year rotation costs (\$/acre)	
		Average SP+PL	High SP+PL
annual mgmt fee	1 through rotation age	450	450
site prep and plant	0	342	552
herbaceous weed control	1	35	35
herbicide	7	55	55
Total cost per acre		\$ 882	\$ 1092

**Table 10.** Pine straw periodic per acre income levels used in the profitability analysis of loblolly, slash and longleaf pine scenarios over a 15-, 24-, 33- and 45-year rotation.

Rotation age	Thin scenario	Annual income/acre (\$)
33 yrs.	Thin at age 15- or 15- and 24-years	50 or 0 <sup>1</sup> 75 or 0 <sup>2</sup>
	Thin at 20- or 20- and 33-years	100 or 0 <sup>3</sup>

<sup>1</sup> loblolly pinestraw raked in years 6-15 for the loblolly 15-year rotation, 8-15 with one thin or 8-24 with no thin for the 24-year rotation, and 8-15 for 33-year rotation.

<sup>2</sup> slash pinestraw raked in years 8-15 for the slash with one thin or 8-24 with no thin for the 24-year rotation, and 8-15 for 33-year rotation.

<sup>3</sup> longleaf pinestraw raked in years 8-20 for 33- (one thin at age 20-yrs) and 45-year rotation (two thinnings at ages 20- and 33-yrs).

**Table 11.** Soil expectation values (SEV<sup>1</sup>) at discount rates of 4, 6, 8, and 10 percent for 15-year loblolly pine scenarios #1, 4, 7, and 10 at a mean annual increment of 6 tons/acre/year.

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Rates \$/ton Pulpwood	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV @ 8% \$/ac	SEV @10% \$/ac
1	\$245	N	\$5.40				
			\$8.10				
			\$12.60				
4	\$245	Y	\$5.40				
			\$8.10	146			
			\$12.60	651	203		
7	\$455	N	\$5.40				
			\$8.10				
			\$12.60				
10	\$455	Y	\$5.40				
			\$8.10				
			\$12.60	179			

<sup>1</sup>Only positive SEVs are shown in the table. It is assumed that negative SEV values are financially unattractive.

**Table 12.** Soil expectation values (SEV) at discount rates of 4, 6, 8, and 10 percent for 15-year loblolly pine scenarios #2, 5, 8, and 11 at a mean annual increment of 8 tons/acre/year.

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Rates \$/ton Pulpwood	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV @ 8% \$/ac	SEV @10% \$/ac
2	\$245	N	\$5.40				
			\$8.10				
			\$12.60	262	2		
5	\$245	Y	\$5.40	20			
			\$8.10	449	87		
			\$12.60	1123	474	163	
8	\$455	N	\$5.40				
			\$8.10				
			\$12.60				
11	\$455	Y	\$5.40				
			\$8.10				
			\$12.60	651	113		

<sup>1</sup>Only positive SEVs are shown in the table. It is assumed that negative SEV values are financially unattractive.

**Table 13.** Soil expectation values (SEV) at discount rates of 4, 6, 8, and 10 percent for 15-year loblolly pine scenarios #3, 6, 9, and 12 at a mean annual increment of 10 tons/acre/year

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Rates \$/ton Pulpwood	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV @ 8% \$/ac	SEV @10% \$/ac
3	\$245	N	\$5.40				
			\$8.10	3			
			\$12.60	846	272	4	
6	\$245	Y	\$5.40	247			
			\$8.10	753	261	27	
			\$12.60	1595	744	337	107
9	\$455	N	\$5.40				
			\$8.10				
			\$12.60	374			
12	\$455	Y	\$5.40				
			\$8.10	280			
			\$12.60	1111	384	31	

**Table 14.** Soil expectation values at discount rates of four, six, eight, and ten percent for the no thin 24-year loblolly pine scenarios 1, 2, 3 and 4 at a mean annual increment of 6.3 tons/acre/year.

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Price sets	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV @ 8% \$/ac	SEV @10% \$/ac
1	\$245	N	Low				
			Average	396	16		
			High	1193	424	86	
2	\$455	N	Low				
			Average	52			
			High	848	145		
3	\$245	Y	Low	661	226	24	
			Average	1154	479	169	2
			High	1951	887	402	143
4	\$455	Y	Low	317			
			Average	810	200		
			High	1606	608	152	

**Table 15.** Soil expectation values (SEV) at discount rates of four, six, eight, and ten percent for 24-year rotation loblolly pine, thin @ age 15-years scenarios 5, 6, 7, and 8, at a mean annual increment of 6.1 tons/acre/year.

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Price sets	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV@ 8% \$/ac	SEV @10% \$/ac
5	\$245	N	Low	114			
			Average	808	262	16	
			High	1881	834	357	104
6	\$455	N	Low				
			Average	463			
			High	1537	555	108	
7	\$245	Y	Low	533	167		
			Average	1227	536	215	40
			High	2300	1108	536	256
8	\$455	Y	Low	109			
			Average	883	257		
			High	1956	829	307	23

**Table 16.** Soil expectation values (SEV) at discount rates of four, six, eight, and ten percent for the no thin 24-year slash pine scenarios 1, 2, 3, and 4 at a mean annual increment of 5.6 tons/acre/year.

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Price sets	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV @ 8% \$/ac	SEV @10% \$/ac
1	\$245	N	Low				
			Average	240			
			High	938	294	11	
2	\$455	N	Low				
			Average				
			High	594	15		
3	\$245	Y	Low	953	413	157	14
			Average	1371	630	281	89
			High	2074	988	485	212
4	\$455	Y	Low	603	131		
			Average	1026	348	30	
			High	1724	706	234	



**Table 17.** Soil expectation values (SEV) at discount rates of four, six, eight, and ten percent for the 24-year slash pine, thin at age 15-years scenarios 5, 6, 7, and 8 at a mean annual increment of 5.4 tons/acre/year.

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Price sets	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV @ 8% \$/ac	SEV @10% \$/ac
5	\$245	N	Low				
			Average	485	84		
			High	1352	542	177	
6	\$455	N	Low				
			Average	141			
			High	1007	263		
7	\$245	Y	Low	564	205	34	
			Average	1114	495	205	44
			High	1981	953	477	215
8	\$455	Y	Low	220			
			Average	770	216		
			High	1636	674	226	

**Table 18.** Soil expectation values (SEV) at discount rates of four, six, eight, and ten percent for the 33-year loblolly pine, thin at age 15- and 24-years scenarios 1, 2, 4, and 4 at a mean annual increment of 5.76 tons/acre/year.

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Price sets	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV @ 8% \$/ac	SEV @10% \$/ac
1	\$245	N	Low	68			
			Average	708	148		
			High	1628	603	165	
2	\$455	N	Low				
			Average	415			
			High	1339	357		
3	\$245	Y	Low	421	80		
			Average	1056	390	97	
			High	1980	844	347	94
4	\$455	Y	Low	135			
			Average	767	144		
			High	1691	599	119	

**Table 19.** Soil expectation values (SEV) at discount rates of four, six, eight, and ten percent for the 33-year slash pine, thin at age 15- and 24-years scenarios 1, 2, 4, and 4 at a mean annual increment of 5.15 tons/acre/year.

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Price sets	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV @ 8% \$/ac	SEV @10% \$/ac
1	\$245	N	Low				
			Average	536	65		
			High	1354	467	91	
2	\$455	N	Low				
			Average	246			
			High	1065	221		
3	\$245	Y	Low	500	152		
			Average	1064	427	142	
			High	1882	829	367	122
4	\$455	Y	Low	211			
			Average	775	181		
			High	1593	584	136	

**Table 20.** Soil expectation values (SEV) at discount rates of four, six, eight, and ten percent for the 33-year longleaf pine, thin at age 20-years scenarios 5, 6, 7, and 8 at a mean annual increment of 4.64 tons/acre/year.

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Price sets	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV @ 8% \$/ac	SEV @10% \$/ac
5	\$342	N	Low				
			Average				
			High	483			
6	\$552	N	Low				
			Average				
			High	193			
7	\$342	Y	Low	710	280	64	
			Average	1040	438	149	
			High	1528	673	276	56
8	\$552	Y	Low	421	34		
			Average	751	192		
			High	1239	427	48	

**Table 21.** Soil expectation values (SEV) at discount rates of four, six, eight, and ten percent for the 45-year longleaf pine, with two thinnings at age 20- and 33-years scenarios 1, 2, 3, and 4 at a mean annual increment of 4.37 tons/acre/year.

Scenario #	Est. Costs \$/ac	Pine Straw Y/N	Stumpage Price sets	SEV @ 4% \$/ac	SEV @ 6% \$/ac	SEV @ 8% \$/ac	SEV @10% \$/ac
1	\$342	N	Low				
			Average	223			
			High	814	98		
2	\$552	N	Low				
			Average				
			High	560			
3	\$342	Y	Low	712	278	63	
			Average	1139	466	156	
			High	1729	733	291	58
4	\$552	Y	Low	459	52		
			Average	885	240		
			High	1475	506	74	

**Table 22.** Soil Expectation Values (SEVs) at 6% discount rate using average (\$8.10, \$19.80, \$27.00/ton net) and high (\$12.60, \$33.30, \$43.70/ton net) stumpage prices and the average establishment cost (\$245/ac for loblolly and slash or \$342/ac for longleaf) for the no pine straw scenarios

Pine scenario	SEV \$/ac using average stumpage \$	SEV \$/ac using high stumpage \$
24-yr, one thin loblolly	262	834
33-yr loblolly	148	603
24-yr, one thin slash	84	542
33-yr slash	65	467
24-yr no thin loblolly	16	424
24-yr, no thin slash	-	294
45-yr longleaf	-	98
33-yr longleaf	-	-
15-yr loblolly 10 tons MAI	-	272
15-yr loblolly, 8 tons MAI	-	2
15-yr, 6 tons MAI	-	-

**Table 23.** Soil Expectation Values (SEVs) at 6% discount rate using average (\$8.10, \$19.80, \$27.00/ton net) and high (\$12.60, \$33.30, \$43.70/ton net) stumpage prices and the average establishment cost (\$245/ac for loblolly and slash or \$342/ac for longleaf) with pine straw income scenarios

Pine scenario	SEV \$/ac using average stumpage \$	SEV \$/ac using high stumpage \$ (rank)
24-yr, no thin slash	627	984 (2)
24-yr, one thin loblolly	536	1108 (1)
24-yr, one thin slash	495	953 (3)
24-yr, no thin loblolly	479	887 (4)
45-yr longleaf	466	733 (8)
33-yr longleaf	438	673 (9)
33-yr slash	427	829 (6)
33-yr loblolly	390	844 (5)
15-yr loblolly 10 tons MAI	261	744 (7)
15-yr loblolly, 8 tons MAI	87	474 (10)
15-yr loblolly, 6 tons MAI	-	203 (11)

Keywords: Loblolly, longleaf, slash pine, forest economics, pine straw, soil expectation value