Series paper #3

Economics of growing slash and loblolly pine to a 24-year rotation with and without thinning and pine straw – net revenue and rate or return

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E. David Dickens[1], John Sunday[2], and David J. Moorhead[1]; Forest Productivity Professor, Forest Investment Specialist, and Silviculture Professor, respectively, Warnell School of Forestry and Natural Resources The University of Georgia[1] and Georgia Forestry Commission[2]

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 feasibility, profitability, and cash-flow of relatively short-rotation (24-year) management options affecting wood-flow for slash and loblolly pine plantations including with and without a thinning, competition control and fertilization, with and without pine straw harvests, two different site preparation and planting costs, and three different stumpage price sets. Longleaf pine will be address in the 33- and 45-year rotation papers. The financial measure of profitability used in this paper is net revenue and rate of return (ROR). The mean annual increments of 5.7 to 6.3 tons/acre/year used for loblolly and slash pine for these 24-year rotations are considered somewhat conservative by today's standards under moderate to intensive management or growing on old-field sites.

Introduction

Private non-industrial forest (NIPF) landowners in the Atlantic and Gulf Coastal Plain from South Carolina to Mississippi question whether to plant slash or loblolly pine on cut-over and old-field sites with the objective of relatively short 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). The majority of stand and tree data to develop the GaPPs growth and yield models for slash and loblolly were in the 10- to 25-year age classes. Therefore we used a 24-year rotation age that had a mixed product class distribution of

pulpwood, chip&saw, and sawtimber. Work published by Piennaar and others (1996) note that generally culmination of merchantable volume mean annual increment occurs for both species on average to good sites and soils and moderate levels of management in the early 20-years. Recent loblolly and slash pine growth studies (Zhao and Kane 2012) using intensive management indicate that culmination of mean annual increment may occur earlier than the early 20-years. Depending on establishment costs, growth rates, and other sources of income (in this paper series; pine straw), shorter or longer rotation ages are often financially attractive and will be addressed in companion papers in this series of economic manuscripts.

Financial Calculations

Net revenue (NR) per acre is a straightforward economic calculation of adding up all revenues, adding up all costs, and then subtracting the total cost from the total revenue. The net revenue for each scenario is calculated with no discounting of costs or returns back to time zero or compounding forward costs and returns to the end of the rotation. For a scenario to be attractive, the net revenue has to be positive (total revenue > total cost). If a scenario net revenue is negative, then the net cash flow is negative (total cost > total revenue) equating to scenario being financially unattractive.
The rate or return (ROR) for a given scenario is the rate of compound interest that is earned by costs invested. ROR is the average rate of appreciation during the life of the project (Bullard and Straka 1993). ROR is calculated by finding the compound interest rate that is equal to the total present value of costs with the total present value of revenues; the interest rate where Net Present Value is equal to zero. ROR is also known as Internal Rate of Return (IRR) and Return on Investment (ROI). Rate of Returns 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).

Net Revenue and Rate or Return are useful when comparing scenarios of the same time duration (rotation age). A shortcoming of Net Revenue values is that they lack the time value of money. Some of the shortcomings of Rate or Return values are: (1) they lack scale (how large or small investments amounts are returning or loosing for each scenario) and (2) due to the mathematics to calculate ROR, intermediate costs and returns are assumed to be re-invested at the ROR interest rate calculated which may not be achievable in real-world scenarios.

Methodology

Common assumptions

The rotation age was set at 24-years for slash and loblolly pine plantations. 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).

Seedlings were assumed to cost $75 per 1000 and planted at 726/acre (6x10 ft spacing) for a per acre cost of $55. Planting cost per acre 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. 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© (TM-S) stumpage values for Georgia for the period of 4th quarter 1976 through 2nd 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 4th quarter 1976 through 2nd 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

The slash pine mean annual increment was 5.6 tons/acre/year @ age 24-years-old without thinning (Table 3) and 5.4 tons/ac/re/year for the thin scenarios were assumed. The no thin slash scenario woodflow was approximately 11 percent less than base loblolly woodflow (Shiver and others. 1999) at age 24-years. The assumed the fertilizer application at age 15-years enhanced pine merchantable volume for eight years following treatment as well as improved pine straw production for the pine straw scenarios.

The loblolly pine mean annual increment for loblolly was 6.3 tons/acre/year (Table 3) through age 24-years-old without thinning and 6.1 tons/acre/year with a thinning at age 15-years were assumed. The

base loblolly woodflow was approximately 12.5 percent greater than the slash base woodflow (Shiver and others 2000) at age 24-years. The assumed fertilizer application at age 15-years increased merchantable volume for eight years (NCSUFNC 1998) and improved pine straw production for the pine straw scenarios.

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 (Table 4).

Scenarios for the 24-year Rotation The following are the loblolly (Table 6 and 7) and slash (Table 8 and 9) 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-yrs, $245/acre establishment cost
(4) no thinning, rake pine straw @ $50 (loblolly) or $75/ac/yr (slash) from age 8- through 24-yrs, $455/acre establishment cost
(5) thin, (at age 15-years to 65 ft^2/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

Forest management activities

Woody competition control
Woody competition control with a single herbicide application occurred at age 6-years 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. 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 thinning or one thinning at 15-years-old. Total woodflow of scenario with thinning is approximately 95 percent of total woodflow of scenario without thinning for slash and loblolly. Residual basal area (RBA), after thinning (5^{th} row with selection from below) was set at 65 sq. ft/ac.

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 to maintain pine straw production rates (Dickens 1999), 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.

Pine straw

The pine straw income assumptions included were as follows: $50 and $75/acre/year raking income for the loblolly and slash 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) for 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. In this paper we assumed that pine straw income occurred in unthinned loblolly and slash stands from age 8- through age 24-years and in the thinned stands from age 8-years through age 15-years. 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

Net revenue and rate of return value ranges

In all cases net revenues were positive meaning the total revenue was greater than the total cost for all loblolly and slash scenarios. Across the eight scenarios for loblolly and slash pine net revenue (NRs) ranged from lows of $152 and $280/acre (Table 8 and 9; slash pine scenarios with high establishment cost, low stumpage prices, and no pine straw) to highs of $3516 and $3726/acre (Table 7 and 8; loblolly pine, high and average establishment costs, respectively, with pine straw and thin).

Rate of return (ROR) ranged from lows of 0.87% (slash pine scenario 2, without pine straw, high establishment cost, no thin, and low stumpage price, Table 8) and 1.60% (slash scenario 6 with high site prep costs, no pine straw, thin, and low stumpage prices, Table 9) to highs of 13.05% (slash pine scenario 7 with pine straw, average establishment cost, thin, and high stumpage prices, Table 9) and 13.33% (loblolly pine scenario 7 thin with pine straw, average establishment cost, and high stumpage prices, Table 7).

Impact of thinning on net revenue and rate or return

Thinning, without pine straw income, (scenarios #5 and 6) improved loblolly pine net revenues by $474 to $801/acre when compared to the no thin, no pine straw loblolly pine scenarios #1 and 2 (Table 6 and 7). Thinning, without pine straw, improved loblolly RORs (scenarios #5 and 6, Table 7) by 1.17 and 1.49 (at low stumpage prices), 1.67 and 2.06 (at average stumpage prices) and 2.00 and 2.47 percentage points (at high stumpage prices) when compared to the no thin, no pine straw scenarios #1 and 2 (Table 6) using high and average establish costs, respectively.

With pine straw income, the thinned loblolly pine scenarios #7 and 8 improved net revenues by $39 (using low stumpage prices), $24 (using average stumpage prices) and $351/acre (using high stumpage prices, Table 7) when compared to no thin with pine straw scenarios #1 and 2 (Table 6). At the low stumpage prices, the thinned loblolly pine scenarios, with pine straw, had slightly lower RORs; 0.42 and 0.54 percentage points using the high and average establishment cost, respectively than the unthinned loblolly pine scenarios with pine straw (scenarios #7 and 8 versus #1 and 2, Table 6 and 7). Using the average stumpage prices for loblolly pine, the thinned scenarios, with pine straw, had RORs (scenarios

#7 and 8, Table 7) that were slightly higher than their unthinned counterpart (scenarios #1 and 2, Table 6), by 0.41 and 0.63 percentage points for the high and average establishment costs, respectively. Using the high stumpage prices for loblolly pine, the thinned scenarios, with pine straw, had RORs (scenarios #7 and 8, Table 7), that were 1.11 and 1.46 percentage points higher than their unthinned counterpart (scenarios #1 and 2, Table 6) for the high and average establishment costs, respectively.

Thinning, without pine straw income, (scenarios #5 and 6) improved slash pine net revenues by $128 using low stumpage prices, $286 using average stumpage prices, and $486/acre using high stumpage prices when compared to the no thin, no pine straw slash pine scenarios #1 and 2 (Table 8 and 9). Thinning, without pine straw, improved slash pine RORs (scenarios #5 and 6, Table 9) by 0.73 and 1.25 at low stumpage prices, 1.14 and 1.40 at average stumpage prices, and 1.37 and 1.70 percentage points at high stumpage prices, when compared to the no thin, no pine straw scenarios #1 and 2 (Table 8) using high and average establish costs, respectively.

With pine straw income, the unthinned slash pine scenario #3 and 4 with the average establishment cost improved net revenues by $547 using low stumpage prices, $389 using average stumpage prices, and $189/acre using high stumpage prices (Table 8) when compared to thin with pine straw scenario #7 and 8 (Table 9). The unthinned slash pine scenario RORs, with pine straw, (scenarios #3 and 4, Table 8) were 1.66 and 1.69 percentage points higher using the low stumpage prices and 0.64 and 0.71 percentage points higher using the average stumpage prices for the average and high establishment costs, respectively when compared to their thinned counterpart (scenarios #7 and 8, Table 9). When high stumpage prices were used, the thinned slash pine with pine straw scenarios #7 and 8 (Table 9) had slightly higher RORs; 0.17 and 0.02 percentage points for the average and high establishment costs, respectively when compared to their counterpart unthinned scenarios #3 and 4 (Table 8).

Impact of pine straw income on net revenues and rate or return

Net revenue values improved in the no thin loblolly pine scenario #3 and 4 with pine straw income from age 8- through age 24-years by a straightforward $850/acre when compared to the no pine straw income scenarios #1 and 2 (Table 6). The pine straw income prior to thinning (age 8- through 15-yrs, at $50/acre/year) in the thin loblolly pine scenarios (#7 and 8) increased net revenues by a straightforward $400/acre when compared to the no pine straw scenarios #5 and 6 (Table 7). Using the average establishment cost scenario #1 (Table 6), the loblolly pine, no thin, no pine straw scenario RORs were 3.31%, 6.14% and 8.84% using the low, average, and high stumpage price sets, respectively. The loblolly pine, no thin, with pine straw counterpart (scenario #3, Table 6) had RORs of 8.36%, 10.03%, and 11.87% using the low, average and high stumpage price sets, respectively. The thinned loblolly pine with no straw income (scenario #5) RORs were 4.80%, 8.20%, and 11.31% for the low, average, and high stumpage price sets, respectively when using the average establishment costs (Table 7). Comparatively, the thinned loblolly pine with pine straw income (scenario #7) RORs were 7.94%, 10.66%, and 13.33% for the low, average and high stumpage price sets, respectively when using the average establishment costs (Table 7). The average ROR improvement (across the three stumpage price sets) for loblolly pine with versus without pine straw was 4.06 and 3.10 percentage points for the no thin, average and high establishment costs, respectively (Table 6) and 2.54 and 1.85 percentage points for the thin, average and high establishment costs, respectively (Table 7).

Net revenue values improved in the no thin slash pine scenarios #3 and 4 with pine straw income from age 8- through age 24-years by a straightforward $1275/acre when compared to the no pine straw

income scenarios #1 and 2 (Table 8). The pine straw income prior to thinning (age 8- through 15-yrs, at $75/acre/year) in the thin slash pine scenarios (#7 and 8) increased net revenues by a straightforward $600/acre when compared to the no pine straw scenarios #5 and 6 (Table 9). Using the average establishment cost scenario #1 (Table 8), the slash pine no thin, no pine straw scenario RORs were 2.55%, 5.37% and 8.10% using the low, average, and high stumpage price sets, respectively. The slash pine, no thin, with pine straw counterpart (scenario #3, Table 8) had RORs of 10.25%, 11.44%, and 12.88% using the low, average and high stumpage price sets, respectively. The thinned slash pine with no straw income (scenario #5) RORs were 3.80%, 6.77%, and 9.80% for the low, average, and high stumpage price sets, respectively when using the average establishment costs (Table 9). Comparatively, the thinned slash pine with pine straw income (scenario #7) RORs were 8.59%, 10.80%, and 13.05% for the low, average and high stumpage price sets, respectively when using the average establishment costs (Table 9). The average ROR improvement (across the three stumpage price sets) for slash pine with versus without pine straw was 6.18 and 4.87 percentage points for no thin using average and high establishment costs, respectively (Table 8) and 4.02 and 3.00 percentage points for the thin, average and high establishment costs, respectively (Table 9).

Impact of establishment costs on net revenues and rate or returns

The impact of establishment costs (site preparation and planting; SP+PL) was straight-forward with net revenues differing by $210/acre since these costs are incurred at time zero. The impact of establishment costs within a management level (scenario) was large enough ($210/acre) to illustrate the importance of choosing the right SP+PL for a given site. The impact of SP+PL in the loblolly scenarios showed the same trend as the slash pine scenarios.

Four examples of the impact of the establishment costs on RORs are as follows using average stumpage prices.

(1) The loblolly pine, no thin, no pine straw RORs were 6.14% using the average establishment cost (scenario #1, Table 6) and 4.22% using the high establishment cost (scenario #2, Table 6).

(2) The loblolly pine, thin with pine straw ROR was 10.66% with the average establishment cost (scenario #7, Table 7) and 7.69% using the high establishment cost (scenario #8, Table 7).

(3) The slash pine, no thin with pine straw ROR was 11.44% using the average establishment cost (scenario #3, Table 8) and 8.27% using the high establishment cost (scenario #4, Table 8).

(4) The slash pine thin, with no pine straw ROR was 6.77% using the average establishment cost (scenario #5, Table 9) and 4.63% using the high establishment cost (scenario #6, Table 9).

Using the average stumpage price set from Tables 6 and 7 for loblolly pine the average establishment cost RORs were 2.23 percentage points greater than the corresponding high establishment cost. Using Tables 8 and 9 for slash pine, the average establishment cost RORs were 2.61 percentage points greater than the corresponding high establishment cost.

Impact of using the low, average, or high pine stumpage price sets on net revenue and rate of return

The impact of using the low, average and high stumpage price sets on net revenue and rate or return values in the thinned or unthinned 24-year loblolly or slash pine rotation scenarios were generally large. Examples of the impacts on net revenue are as follows:

(1) Using loblolly pine scenario #1 the differences in the net revenues were $771/acre between the low ($509/acre) and average ($1280/acre) and $1245/acre between the average and high ($2525/acre) stumpage price sets (Table 6).

(2) Using loblolly pine scenario #4 the differences in net revenues were $771/acre between the low ($1149/acre) and average ($1920/acre) and $1245/acre between the average and high ($3165/acre) stumpage price sets (Table 6).

(3) Using loblolly pine scenario #6 the differences in net revenues were $756/acre between the low ($788/acre) and average ($1544/acre) and $1572/acre between the average and high ($3116/acre) price set (Table 7).

(4) Using slash pine scenario #2 , the differences in the net revenues were $662/acre between the low ($152/acre) and average ($814/acre) and $1090/acre between the average and high ($1904/acre) stumpage price sets (Table 8).

(5) Using the slash pine scenario #3, the differences in the net revenues were $662/acre between the low ($1637/acre) and average ($2299/acre) stumpage price sets and $1090/acre between the average and high ($3389/acre) stumpage price sets (Table 8).

(6) Using slash pine scenario #7 , the differences in the net revenues were $820/acre between the low ($1090/acre) and average ($1910/acre) stumpage price sets and $1290/acre between the average and high ($3200/acre) stumpage price sets (Table 9).

Examples of rate of return changes as a function of changing stumpage price sets are as follows with low, average, and high RORs listed in this respective order.

(1) Loblolly pine scenario # 1 (average establishment cost, no pine straw, no thin) had RORs of 3.31%, 6.14% and 8.84% (Table 6).

(2) Loblolly pine scenario #4 (high establishment cost, no thin with pine straw) had RORs of 5.59%, 7.28% and 9.11% (Table 6).

(3) Loblolly pine scenario #7 (average establishment cost, thin with pine straw) had RORs of 7.94%, 10.66%, and 13.33% (Table 7).

(4) Slash pine scenario #3 (average establishment cost, no thin with pine straw income) had RORs of 10.25%, 11.44%, and 12.88% (Table 8).

(5) Slash pine scenario #6 (high establishment cost, thin and no pine straw) had RORs of 1.60%, 4.63%, and 7.44% (Table 9).

(6) Slash pine scenario #8 (high establishment cost, thin with pine straw income) had RORs of 5.32%, 7.56%, and 9.79% (Table 9).

Impact of pine species growth rates on net revenue and rate of return

Loblolly pine, due to its higher growth rate and more wood produced across all three product classes produced higher net revenues and rates of return when pine straw was not part of the scenarios. Examples of net revenue differences are:
(1) scenario #1 for loblolly pine (Table 6) produced net revenues of $509, $1280, and $2525/acre while slash pine scenario #1 (Table 8) produced net revenues of $362, $1024, and $2114/acre using the low, average and high stumpage price sets, respectively.

(2) Loblolly pine scenario #6 (Table 7) produced net revenues of $788, $1544, and $3116/acre while the corresponding slash pine scenario #6 (Table 9) produced net revenues of $280, $1100, and $2390 using the low, average and high stumpage price sets, respectively.

Examples of ROR differences are:
(1) scenario #2 for loblolly pine (Table 6) produced RORs of 1.58%, 4.22%, and 6.77% while the slash pine scenario #2 (Table 8) produced RORs of 0.87%, 3.49%, and 6.07% using the low, average and high stumpage price sets, respectively.

(2) Loblolly pine scenario #5 (Table 7) produced RORs of 4.80%, 8.20% and 11.31% while the slash pine scenario #5 produced (Table 9) RORs of 3.80%, 6.77%, and 9.80% using the low, average, and high stumpage price sets, respectively.

When pine straw income was part of the scenarios, then slash pine's net revenues and RORs were higher than loblolly pine under the no thin scenarios but with very little difference when high stumpage prices were used. When pine straw income was included in the thin loblolly and slash pine scenarios, loblolly pine generally gave higher net revenues and higher RORs 1/2 the time. Examples of net revenue differences between species using the pine straw scenarios:

(1) no thin loblolly pine scenario #3 net revenues (Table 6) were $1359, $2130, and $3375/acre while the corresponding no thin slash pine scenario #3 (Table 8) net revenues were $1637, $2299, and $3389 using the low, average, and high stumpage price sets, respectively.

(2) thin loblolly pine scenario #8 (Table 7) net revenues were $1188, $1944, and $3516/acre while the corresponding thinned slash pine scenario #8 (Table 9) produced net revenues of $1090, $1910, and $3200/acre using the low, average, and high stumpage price sets, respectively.

Examples of ROR differences between the species using the pine straw scenarios:
(1) the no thin loblolly pine scenario #4 (Table 6) produced RORs of 5.59%, 7.28%, and 9.11% while the corresponding slash pine scenario #4 (Table 8) produced RORs of 7.01%, 8.27%, and 9.77% using the low, average, and high stumpage price sets, respectively.

(2) the thin loblolly pine scenario #7 (Table 7) produced RORs of 7.94%, 10.66%, and 13.33% while the corresponding slash pine scenario #7 (Table 9) produced RORs of 8.59%, 10.80%, and 13.05% using low, average, and high stumpage price sets, respectively.

Summary

Wood flows, thinning, and pine straw

The slash pine at 5.4 and 5.6tons/ac/yr and the loblolly pine at 6.1 and 6.3 tons/ac/yr productivity levels through age 24-years-old are realistic on most cut-over sites with chemical site preparation, planting quality, genetically improved seedlings, with single woody control post plant and N+P fertilizer treatments at age 6 and 15-years, respectively (Pienaar and Rheney 1996) and are conservative on most old-field sites. Exceptions would be problem soils such as deep sands (Typic Quartzipssamments) of the Sand Hills or shallow, rocky soils of the Piedmont physiographic region.

These scenarios do illustrate that if the aforementioned base growth rates for slash pine and loblolly 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-tern 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.

The woody vegetation release treatment at age 6-years @ $55/acre cost and the single N+P fertilization at age 15-years @ $165/acre cost was employed in these scenarios to improve loblolly and slash pine wood yields and get the stands ready for pine straw (woody vegetation control) in the pine straw scenarios (Jokela and Stearns-Smith 1993, Martin and others 1999, NCSFNC 1999). No increase in pine straw income per acre was assumed with fertilization. Fertilization studies (Blevins and others. 1996, Dickens 1999) illustrate that pine straw production can be increased by an average of 40 to 50 percent over unfertilized stands on marginal fertility soils. Fertilization was included in the pine straw production scenarios to maintain straw production as nutrients are removed/displaced with each raking.

When wood value only is considered, loblolly produced more wood, more wood value, and higher net revenues and rates of return 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 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), slash pine generally produced higher net revenues and RORs than loblolly pine under the no thin scenarios. Generally loblolly produced higher net revenues than slash pine under the thin and pine straw income scenarios with RORs being evenly split.

Within a loblolly or slash scenario, the impact of using the three different stumpage price sets was large on net revenue and ROR. Net revenue per acre differences of over $700 between the low and average stumpage price sets and over $1200 to over $1500 between the average and high stumpage price sets were common.

Thinning without pine straw gave higher net revenues and RORs for loblolly and slash pine compared to the no thin, no pine straw counterpart. The differences between the thin and no thin (without pine straw) scenarios became larger as stumpage prices increased.

Discussion

Non-industrial private forest landowners do have some attractive forest management options with both slash and loblolly pine. To maximize net revenues and RORs, 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 net revenues for loblolly 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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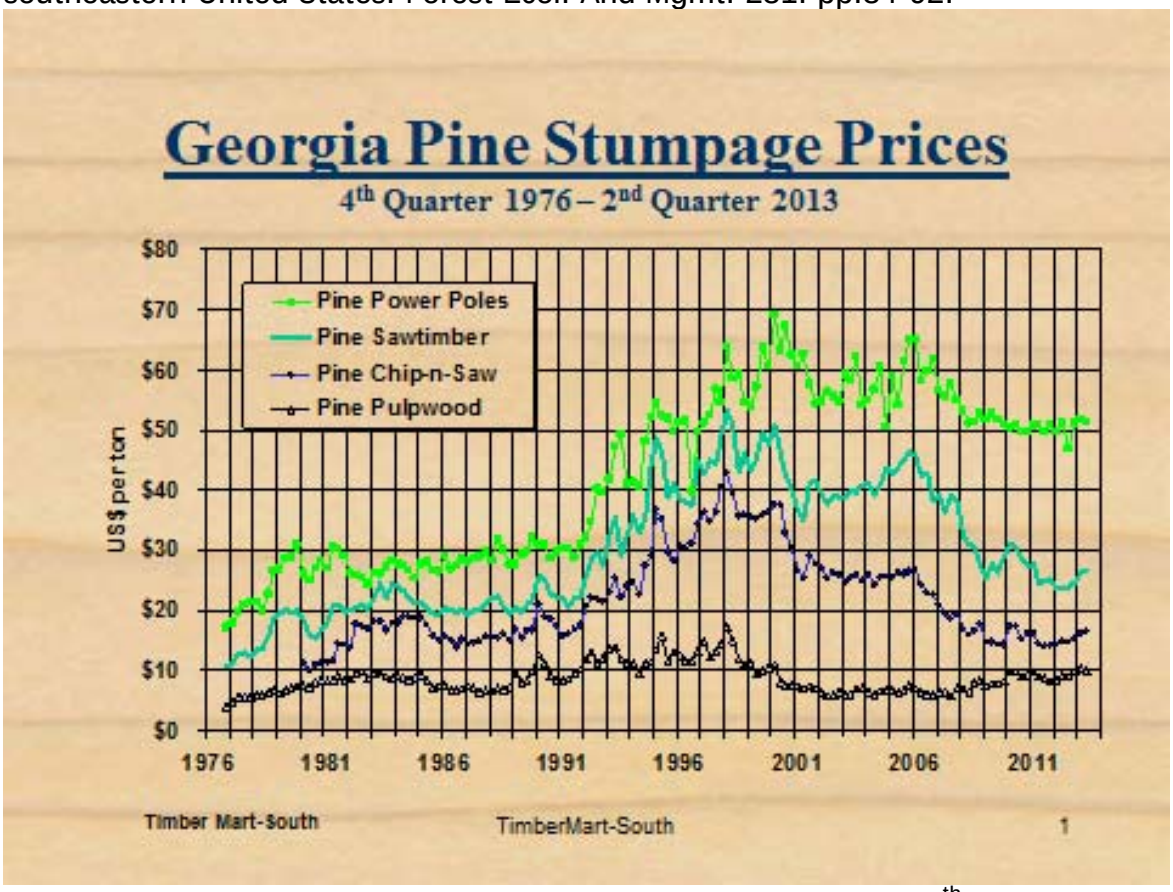

Figure 1. Georgia state-wide average pine stumpage prices from 4th quarter 1976 through 2nd quarter 2013 by product class

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 (4th 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. Costs for the 24-year loblolly and slash rotations

		Cost (total $/acre)	
Activity	Time of cost (yr)	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 4. Loblolly and slash pine 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 5. Pine straw periodic per acre income levels used in the profitability analysis of slash and loblolly pine scenarios over a 24-year rotation.

Rotation age	Thin scenario	Annual income/acre ($)
24 yrs.	Thin at age 15 years	50 or 0[1]
		75 or 0[2]
	No thin	50 or 0[3]
		75 or 0[4]

[1] With thinning, pinestraw raked in years 8-15, for 24-year rotation for loblolly pine.
[2] With thinning, pinestraw raked in years 8-15 for 24-year rotation for slash pine.
[3] With no thinning, pinestraw raked in years 8-24, for 24-year rotation for loblolly pine.
[4] With no thinning, pinestraw raked in years 8-24, for 24-year rotation for slash pine.

Table 6. Net Revenue and Rate of Return values 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	Net Revenue $/ac	Rate of Return %
1	$245	N	Low	+509	3.31
			Average	+1280	6.14
			High	+2525	8.84
2	$455	N	Low	+299	1.58
			Average	+1070	4.22
			High	+2315	6.77
3	$245	Y	Low	+1359	8.36
			Average	+2130	10.03
			High	+3375	11.87
4	$455	Y	Low	+1149	5.59
			Average	+1920	7.28
			High	+3165	9.11

Table 7. Net Revenue and Rate of Return values 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	Net Revenue $/ac	Rate of Return %
5	$245	N	Low	+998	4.80
			Average	+1754	8.20
			High	+3326	11.31
6	$455	N	Low	+788	2.75
			Average	+1544	5.89
			High	+3116	8.77
7	$245	Y	Low	+1398	7.94
			Average	+2154	10.66
			High	+3726	13.33
8	$455	Y	Low	+1188	5.05
			Average	+1944	7.69
			High	+3516	10.22

Table 8. Net Revenue and Rate of Return values 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	Net Revenue $/ac	Rate of Return %
1	$245	N	Low	+362	2.55
			Average	+1024	5.37
			High	+2114	8.10
2	$455	N	Low	+152	0.87
			Average	+814	3.49
			High	+1904	6.07
3	$245	Y	Low	+1637	10.25
			Average	+2299	11.44
			High	+3389	12.88
4	$455	Y	Low	+1427	7.01
			Average	+2089	8.27
			High	+3179	9.77

Table 9. Net Revenue and Rate or Return for the 24-year slash pine, thin at age 15-years scenarios 5, 6, 7, and 8 at a mean annual increment of 5.6 tons/acre/year.

Scenario #	Est. Costs $/ac	Pine Straw Y/N	Stumpage Price sets	Net Revenue $/ac	Rate of Return%
5	$245	N	Low	+490	3.80
			Average	+1310	6.77
			High	+2600	9.80
6	$455	N	Low	+280	1.60
			Average	+1100	4.63
			High	+2390	7.44
7	$245	Y	Low	+1090	8.59
			Average	+1910	10.80
			High	+3200	13.05
8	$455	Y	Low	+880	5.32
			Average	+1700	7.56
			High	+2990	9.79

Keywords: slash pine, loblolly pine, forest economics, pine straw, net revenue, rate of return