Daniel B. Warnell School of Forestry and Natural Resources
Forestry, Wildlife, Water and Soil Resources, Fisheries and
Aquaculture, Natural Resource Recreation and Tourism

Series paper #5

Economics of growing loblolly, longleaf, and slash pine to a 33-year rotation with three stumpage price sets, four establishment cost sets, with and without pine straw – net revenue and rate or return

May 2014

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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, profitability, and cash-flow of a 33-year rotation with management options for loblolly, longleaf, and slash pine plantations including competition control, fertilization (loblolly and slash only), with and without pine straw harvests, two different site preparation and planting costs, and three different stumpage price sets. The financial measure of profitability used in this paper is net revenue and rate of return (ROR). The mean annual increments of 5.76, 5.15, and 4.64 tons/acre/year used for loblolly, slash, and longleaf pine, respectively for these 33-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 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 was use for longleaf pine growth and yields. Depending on establishment costs, growth rates, other sources of income (in this paper series; pine straw), and stumpage prices shorter or longer rotation ages are often financially attractive and are 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 losing 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 33-years for longleaf, 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).

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. 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 loblolly pine mean annual increment (MAI) for loblolly was 5.76 tons/acre/year (Table 3) through age 33-years with two thinnings (at age 15- and 24-years) were assumed (Table 4). The base loblolly woodflow was approximately 10.5 percent greater than the slash base woodflow (Shiver and others 2000) at age 33-years. The assumed fertilizer application at age 15-years increased merchantable volume for eight years (NCSUFNC 1998).

The slash pine MAI was 5.15 tons/acre/year @ age 33-years-old with two thinnings (at age 15- and 24-years) scenarios were assumed (Table 4). The slash scenario woodflow was approximately 12 percent less than base loblolly woodflow (Shiver and others. 1999) at age 33-years. The assumed the fertilizer application at age 15-years enhanced pine merchantable volume for eight years following treatment.

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

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 3). 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 33-year Rotation

The following are the loblolly (Table 6) and slash (Table 7) pine scenarios:

(1) thin at age 15- and 24-years to 65 ft^2/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 8) pine scenarios:

(5) thin at age 20-years to 65 ft^2/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

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 two thinnings at 15- and 24-years-old for loblolly and slash pine and one thinning at age 20-years for longleaf pine. Residual basal area (RBA), after thinning (5th 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 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

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, longleaf, and slash pine scenarios. Across the scenarios for loblolly and slash pine, net revenues (NRs) ranged from lows of $708 and $907/acre (Table 6 and 7; slash and loblolly pine scenarios with high establishment cost, low stumpage prices, and no pine straw) to highs of $4554, $4764, $4980, and $5190/acre (Table 6 and 7; slash pine and loblolly pine, high and average establishment costs, respectively, with pine straw and high stumpage prices). The longleaf pine net revenues ranged from lows of $191 and $401/acre (low stumpage prices, with average or high establishment costs and no pine straw) to highs of $3466 and $3676/acre (high stumpage prices with pine straw income and high or average establishment costs, respectively, Table 8).

Loblolly and slash pine rates of return (ROR) ranged from lows of 2.42% (slash pine scenario 2, without pine straw, high establishment cost, and low stumpage price, Table 7) and 2.96% (loblolly scenario 2

with high site prep costs, no pine straw, and low stumpage prices, Table 6) to highs of 11.21% (loblolly pine scenario 3 with pine straw, average establishment cost, and high stumpage prices, Table 6) and 11.73% (slash pine scenario 2 with pine straw, average establishment cost, and high stumpage prices, Table 7). Longleaf pine ROR's ranged from lows of 0.73% and 1.83% (scenarios 6 and 5, using low stumpage prices, no pine straw income, and high or average establishment costs, respectively, Table 8) to highs of 9.77% and 10.75% (scenario 7, using average establishment cost, with pine straw income, and average or high stumpage prices, respectively, Table 8).

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

Net revenue per acre values improved the loblolly pine scenarios by $400 per acre (rake income from age 8- through age 15-years @ $50/acre/year), the slash pine scenarios by $600 per acre (rake income from age 8- through age 15-years @ $75/acre/year), and the longleaf scenarios by $1300 per acre (rake income from age 8- through age 20-years @ $100/acre/year) when comparing rake versus no rake cases. Examples of impact on net revenues with the addition of pine straw income are as follows:

(1) Loblolly net revenue increased from $2641/acre (scenario 1, using average stumpage prices, no straw income) to $3041/acre (scenario 3, with average stumpage prices, with straw income)
(2) Loblolly net revenue increased from $927/acre (scenario 2, using low stumpage prices and no pine straw income) to $1327/acre (scenario 4, using low stumpage prices with pine straw income, Table 6).
(3) Slash pine net revenue increased from $4164/ac (scenario 1, using high stumpage prices, no pine straw income) to $4764/acre (scenario 3, using high stumpage prices with pine straw income)
(4) Slash pine net revenue increased from $2047/acre (scenario 2, using average stumpage prices, no pine straw income) to $2647/acre (scenario 4, using average stumpage prices with pine straw income, Table 7)
(5) Longleaf pine net revenue increased from $401/acre (scenario 5, using low stumpage prices, no pine straw income) to $1701/acre (scenario 7, using low stumpage prices with pine straw income)
(6) Longleaf pine net revenue increased from $993/acre (scenario 6, using average stumpage prices, no pine straw income) to $2293/acre (scenario 8, using average stumpage prices with pine straw income, Table 8).

On a percentage point difference basis and comparing within pine species, rate of return values were improved by a low 1.23 percentage points (loblolly pine scenario 2 high stumpage price, no pine straw ROR of 7.59% compared to loblolly pine scenario 4, high stumpage price with pine straw ROR of 8.82%, Table 6) to a high of 7.07 percentage points (longleaf pine scenario 5 using low stumpage prices and no pine straw income ROR of 1.83% compared to longleaf pine scenario 7 using low stumpage prices with pine straw income ROR of 8.90%, Table 8). Basically the lower the wood yield, the lower the stumpage prices used, and the higher the pine straw value the greater the pine straw income impact is on ROR. Conversely, the higher the wood yields, and the higher the stumpage prices used, and the lower the pine straw value, the less the impact on ROR.

Loblolly pine ROR differences ranged from a low of 1.23 percentage points (scenario 2, high stumpage prices no pine straw income ROR of 7.59% versus scenario 4, high stumpage prices with pine straw income ROR of 8.82%, Table 6) to a high of 2.47 percentage points (scenario 1, low stumpage prices no pine straw income ROR of 4.41% versus scenario 3, low stumpage prices with pine straw income ROR of 6.88%, Table 6). Loblolly pine ROR's with pine straw income using low or average stumpage prices

were approximately 0.20 to 0.72 percentage points lower than corresponding no straw income scenarios using average or high stumpage prices (Table 6).

Slash pine ROR differences ranged from a low of 1.97 percentage points (scenario 2, high stumpage prices no pine straw income ROR of 7.05% versus scenario 4, high stumpage prices with pine straw income ROR of 9.02%, Table 7) to a high of 4.06 percentage points (scenario 1, low stumpage prices no pine straw income ROR of 3.82% versus scenario 3, low stumpage prices with pine straw income ROR of 7.88%, Table 6). Slash pine RORs with pine straw income and using low or average stumpage prices were approximately 0.15 to 1.38 percentage points greater than corresponding no straw income scenarios using average or high stumpage prices (Table 7).

Longleaf pine ROR differences ranged from a low of 3.73 percentage points (scenario 2, high stumpage prices no pine straw income ROR of 4.64% versus scenario 4, high stumpage prices with pine straw income ROR of 8.37%, Table 8) to a high of 7.07 percentage points (scenario 1, low stumpage prices no pine straw income ROR of1.83% versus scenario 3, low stumpage prices with pine straw income ROR of 8.90%, Table 8). Longleaf pine RORs with pine straw income and using low stumpage prices were approximately 1.64 to 4.91percentage points greater than corresponding no straw income scenarios using average or high stumpage prices (Table 8).

Impact of establishment costs on net revenues and rate or returns

The impact of site preparation was straight-forward with net revenues differing by $210/acre since these costs are incurred at time zero for all three pine species (Tables 3, 6-8). The longleaf seedling cost per acre ($152) versus loblolly and slash seedling cost per acre ($55) also had a minor impact on overall establishment costs when comparing these species. The impact of establishment costs within a management level (scenario) was large enough ($210/acre for site prep and $97/acre seedling cost differences) to illustrate the importance of choosing the right species, site prep, and planting method for a given site.

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

(1) The loblolly pine no pine straw RORs were 7.08% using the average establishment cost (scenario #1, Table 6) and 5.44% using the high establishment cost (scenario #2, Table 6).

(2) The loblolly pine with pine straw ROR was 9.15% with the average establishment cost (scenario #3, Table 6) and 6.87% using the high establishment cost (scenario #4, Table 6).

(3) The slash pine, with pine straw ROR was 9.87% using the average establishment cost (scenario #3, Table 7) and 7.20% using the high establishment cost (scenario #4, Table 7).

(4) The slash pine with no pine straw ROR was 6.50% using the average establishment cost (scenario #1, Table 7) and 4.91% using the high establishment cost (scenario #2, Table 7).

(5) The longleaf pine with no pine straw ROR was 3.99% using the average establishment cost (scenario #5, Table 8) and 2.80% using the high establishment cost (scenario #6, Table 8).

(6) The longleaf pine with pine straw ROR was 9.77% using the average establishment cost (scenario 7, Table 8) and 7.29% using the high establishment cost (scenario 8, Table 8).

Using the average stumpage price set from Table 6 for loblolly pine the average establishment cost RORs were 1.96 percentage points greater than the corresponding high establishment cost. Using Table 7 for slash pine, the average establishment cost RORs were 2.13 percentage points greater than the corresponding high establishment cost. Using Table 8 for longleaf pine, the average establishment cost RORs were 1.84 percentage points greater than the corresponding high establishment cost. The overall ROR percentage point differences for the three pine species averaged approximately 2 percentage points when using the average stumpage prices.

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

The impact of using low, average, and high stumpage price sets on net revenue and rate or return values in the 33-year loblolly, longleaf, 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 $1504/acre between the low ($1137/acre) and average ($2641/acre) and $2149/acre between the average and high ($4790/acre) stumpage price sets (Table 6). The differences were the same for scenario 2, 3 and 4 (Table 6).

(2) Using slash pine scenario 2 the differences in net revenues were $1339/acre between the low ($708/acre) and average ($2047/acre) and $1907/acre between the average and high ($3954/acre) stumpage price sets (Table 7). The differences were the same for scenarios 1, 3 and 4 (Table 7)

(3) Using longleaf pine scenario #7 the differences in net revenues were $802/acre between the low ($1701/acre) and average ($2503/acre) and $1173/acre between the average and high ($3676/acre) price set (Table 7). The differences were the same for scenarios 5, 6, and 8 (Table 8).

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

(1) Loblolly pine scenario 1 (average establishment cost, no pine straw) had RORs of 4.41%, 7.08% and 9.41% (Table 6).

(2) Loblolly pine scenario 3 (average establishment cost with pine straw) had RORs of 6.88%, 9.15% and 11.21% (Table 6).

(3) Loblolly pine scenario 4 (high establishment cost with pine straw) had RORs of 4.67%, 6.87%, and 8.82% (Table 6).

(4) Slash pine scenario 1 (average establishment cost no pine straw income) had RORs of 3.82%, 6.50%, and 8.82% (Table 7).

(5) Slash pine scenario 3 (average establishment cost with no pine straw) had RORs of 7.88%, 9.87%, and 11.73% (Table 7).

(6) Slash pine scenario 4 (high establishment cost with pine straw income) had RORs of 5.18%, 7.20%, and 9.02% (Table 7).

(7) Longleaf pine scenario 5 (average establishment cost, no pine straw) had RORs of 1.83%, 3.99% and 5.91% (Table 8).

(8) Longleaf pine scenario 7 (average establishment cost with pine straw) had RORs of 8.90%, 9.77% and 10.75% (Table 8).

(9) Longleaf pine scenario 8 (high establishment cost with pine straw) had RORs of 6.28%, 7.29%, and 8.37% (Table 8).

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 generally produced higher net revenues and rates of return, more-so when pine straw was not part of the scenarios and when using average to high stumpage prices. Loblolly pine did not produce the highest RORs when using average establishment costs and pine straw income (note ROR example 2 below) or high establishment costs and low or average stumpage prices when compared to slash or longleaf pine with straw income (note ROR example 3 below; longleaf scenario 8 and slash scenario 4 versus loblolly scenario 4). Examples of net revenue differences are:
(1) Scenario 1 for loblolly pine (Table 6) produced net revenues of $1137, $2641, and $4790/acre while slash pine scenario 1 (Table 7) produced net revenues of $918, $2257, and $4164/acre, and longleaf pine scenario 5 (Table 8) produced net revenues of $401, $1203, and $2376/acre using the low, average and high stumpage price sets, respectively.

(2) Loblolly pine scenario 3 (Table 6) produced net revenues of $1537, $3041, and $5190/acre while the corresponding slash pine scenario 3 (Table 7) produced net revenues of $1518, $2857, and $4764, and longleaf pine scenario 8 produced net revenues of $1701, $2503, and $3676/acre (Table 8) using the low, average and high stumpage price sets, respectively.

(3) Loblolly pine scenario 4 (Table 6) produced net revenues of $1327, $2831, and $4980/acre while the corresponding slash pine scenario 4 (Table 7) produced net revenues of $1308, $2647, and $4554, and longleaf pine scenario 8 produced net revenues of $1491, $2293, and $3466/acre (Table 8) 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 2.96%, 5.44%, and 7.59% while the slash pine scenario 2 (Table 7) produced RORs of 2.42%, 4.91%, and 7.05%, and longleaf pine scenario 6 produced RORs of 0.73%, 2.80% and 4.64% using the low, average and high stumpage price sets, respectively.

(2) Loblolly pine scenario 3 (Table 6) produced RORs of 6.88%, 9.15% and 11.21% while the slash pine scenario 3 produced (Table 7) RORs of 7.88%, 9.87%, and 11.73%, and longleaf pine scenario 7 produced RORs of 8.90%, 9.77%, and 10.75% using the low, average, and high stumpage price sets, respectively.

(3) Loblolly pine scenario 4 (Table 6) produced RORs of 4.67%, 6.87%, and 8.82%, while slash pine scenario 4 (Table 7) produced RORs of 5.18%, 7.20% and 9.02%, and longleaf pine scenario 8 (Table 8) produced RORs of 6.28% 7.29%, and 8.37% using the low, average, and high stumpage price sets, respectively.

Summary

Wood flows, thinning, and pine straw

The longleaf pine 4.64 tons/acre/year, the slash pine at 5.15tons/ac/yr, and the loblolly pine at 5.76 tons/ac/yr mean annual increment productivity levels through age 33-years-old are realistic on most cut-over sites with chemical site preparation, good quality seedlings and planting, (Pienaar and Rheney 1996) and woody competition control (plus post-plant herbaceous weed control for longleaf pine and N+P fertilization for loblolly and slash pine at age 15-years) 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, 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-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- or 7-years @ $55/acre cost (and a single post-plant herbaceous weed control herbicide treatment for longleaf pine @ $35/acre or the single N+P fertilization at age 15-years @ $165/acre cost for loblolly and slash pine) were employed in these scenarios to improve wood yields (Jokela and Stearns-Smith 1993, Martin and others 1999, NCSFNC 1999

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 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 RORs than loblolly pine using low and average stumpage prices. Loblolly produced higher net revenues than slash or longleaf pine with or without pine straw income, slightly more using low stumpage prices, and increasing in differences when using average then high stumpage prices.

Within a loblolly, longleaf, 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 $800 between the low and average stumpage price sets and over $1170 to over $2100 between the average and high stumpage price sets.

Pine straw gave higher net revenues and RORs for loblolly, longleaf, and slash pine compared to the no pine straw counterpart. The net revenue differences were $400/acre for loblolly pine, $600/acre for

slash pine and $1300 for longleaf pine. Rates of Return improved by 1.97 to 7.07 percentage points when pine straw income was included in the three pine species scenarios.

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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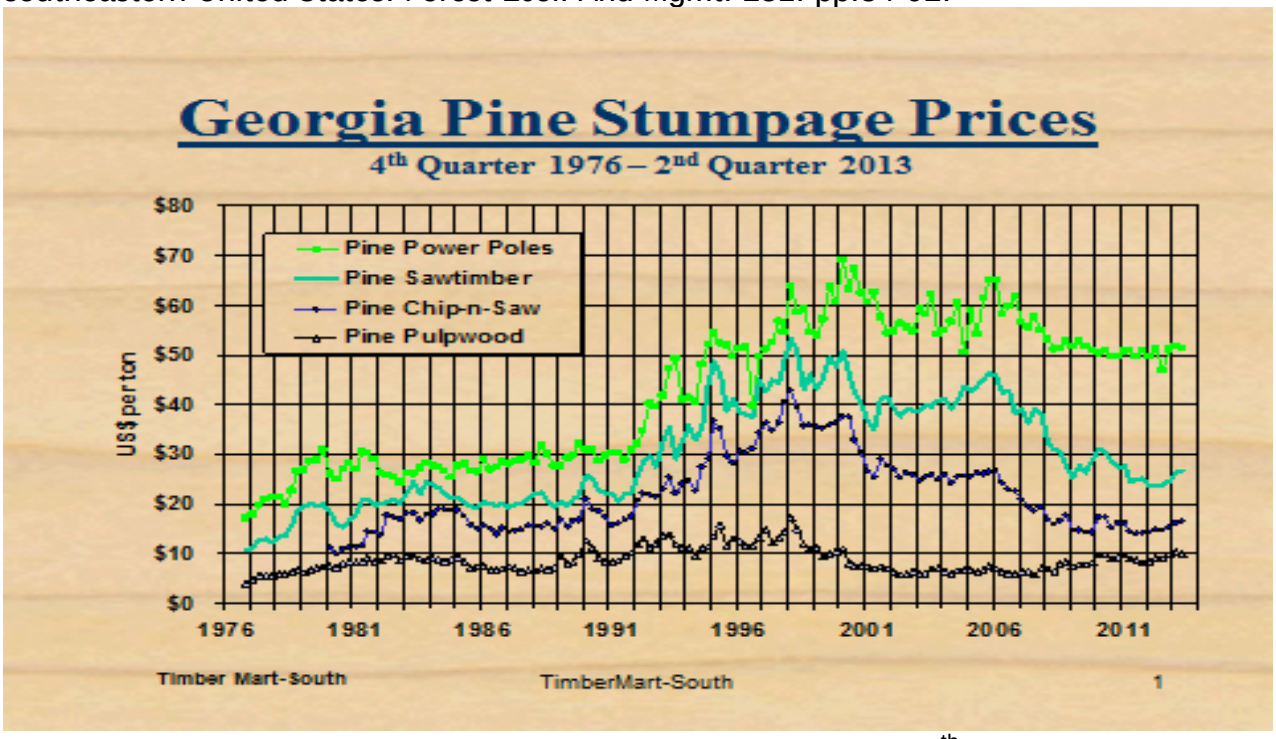

Figure 1. Georgia state-wide average pine stumpage prices from 4th quarter 1976 through 2nd quarter 2013 by product class

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 33-year loblolly, slash, and longleaf rotations

		loblolly and slash costs ($/acre)		longleaf costs ($/acre)	
Activity	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 and 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 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. Pine straw periodic per acre income levels used in the profitability analysis of loblolly, slash and longleaf pine scenarios over a 33-year rotation.

Rotation age	Thin scenario	Annual income/acre ($)
33 yrs.	Thin at age 15-years	50 or 0[1]
		75 or 0[1]
	Thin at 20-years	100 or 0[2]

[1] pinestraw raked in years 8-15 for 33-year rotation for loblolly and slash pine.
[2] pinestraw raked in years 8-20 for 33-year rotation for longleaf pine.

Table 6. Net Revenue and Rate of Return values for the two thinnings (at age 15- and 24-years) 33-year loblolly pine scenarios 1, 2, 3 and 4 at a mean annual increment of 5.76 tons/acre/year.

Scenario #	Est. Costs $/ac	Pine Straw Y/N	Stumpage Price sets	Net Revenue $/ac	Rate of Return %
1	$245	N	Low	1137	4.41
			Average	2641	7.08
			High	4790	9.41
2	$455	N	Low	927	2.96
			Average	2431	5.44
			High	4580	7.59
3	$245	Y	Low	1537	6.88
			Average	3041	9.15
			High	5190	11.21
4	$455	Y	Low	1327	4.67
			Average	2831	6.87
			High	4980	8.82

Table 7. Net Revenue and Rate of Return values for the 33-year rotation slash pine with two thinnings @ age 15- and 24-years scenarios 1, 2, 3, and 4, at a mean annual increment of 5.15 tons/acre/year.

Scenario #	Est. Costs $/ac	Pine Straw Y/N	Stumpage Price sets	Net Revenue $/ac	Rate of Return %
1	$245	N	Low	918	3.82
			Average	2257	6.50
			High	4164	8.82
2	$455	N	Low	708	2.42
			Average	2047	4.91
			High	3954	7.05
3	$245	Y	Low	1518	7.88
			Average	2857	9.87
			High	4764	11.73
4	$455	Y	Low	1308	5.18
			Average	2647	7.20
			High	4554	9.02

Table 8. Net Revenue and Rate of Return values for the 33-year rotation longleaf pine with one thinning @ 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	Net Revenue $/ac	Rate of Return %
5	$342	N	Low	401	1.83
			Average	1203	3.99
			High	2376	5.91
6	$552	N	Low	191	0.73
			Average	993	2.80
			High	2166	4.64
7	$342	Y	Low	1701	8.90
			Average	2503	9.77
			High	3676	10.75
8	$552	Y	Low	1491	6.28
			Average	2293	7.29
			High	3466	8.37

Keywords: Loblolly pine, slash pine, longleaf pine, forest economics, intensive management, pine straw, net revenue, rate of return