Series paper #1
Economics of growing loblolly pine to a 15-year rotation with fertilization and pine straw– net revenue and rate of return

December 2013

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

Abstract

This economic series of papers serves as an update to a published series in 2007 (Dickens and others 2007) due to changing stumpage prices and rising uncertainty in forest-based investments. Since early 1998 forest industry, forestland ownership, global markets, and wood supply and demand (pulpwood, sawtimber, chips, etc.) regionally and world-wide have changed dramatically. Non-industrial private forest (NIPF) landowners 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.), slash (*Pinus elliottii*, Engelm.), and longleaf (*Pinus palustris*) 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 short-rotation management options affecting wood-flow for loblolly pine plantations including fertilization and pine straw harvests under alternative levels of productivity, establishment costs, and pulpwood stumpage values. Series paper #1 discussed net present value (NPV) and this paper examines net revenue (NR) and rate of return (ROR). Soil expectation value (SEV) will be discussed in later additions to this series.

Introduction

Non-industrial private forest (NIPF) landowners in the Atlantic and Gulf Coastal Plain from South Carolina to Mississippi question whether to plant loblolly pine on cut-over and old-field sites under short rotations and high levels of management. Loblolly pine is considered to be the most responsive to intensive management and has the highest growth rate on most soils (). These landowners 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 assumed three different levels of productivity using mean annual increments of six, eight, and ten tons/acre/year to produce a single class of pulpwood products. Generally, culmination of merchantable volume mean annual increment occurs for loblolly pine on average to good sites and management in the early 20-

years (Pienaar and others 1996). Longer rotation ages are often more financially attractive and will be addressed in companion papers in this series of economic manuscripts.

Methodology

Common assumptions

The rotation age was set at 15-years for loblolly pine plantations. Net revenue was calculated as the sum of all revenues minus all costs in today's dollars. Rate of return, or internal rate of return, is the amount of gain or loss over a period of time when net present value equals zero. Rate of return is expressed as a percentage. Net revenues were calculated using a spreadsheet of investment income and expenditures. ROR's 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). Fire protection cost was assumed $2/ac/yr, stand management at $2/ac/yr and property taxes at $6/ac/yr. Thus, the total annual costs for each year of the rotation were $10/acre. Results are reported in constant dollars, before taxes. It is assumed that land is already owned.

Financial Criteria

Net revenue (NR) per acre is a straightforward economic calculation of adding up all revenues, adding up all costs, 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).

Like Net Present value, Net Revenue and Rate or Return are useful when comparing scenarios of the same time duration (rotation age). Net Revenue values lack the time value of money. Some of the shortcomings of Rate or Return are: (1) it lacks 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.

Site Preparation and Planting Costs

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

- The average site preparation included a chemical application @ $75/acre and prescribed burn @ $35/acre (current common costs per acre for these activities in Georgia). The total cost for the average site prep was $110/acre. Seedling costs were assumed @ $55/acre with a planting cost of $80/acre. Total SP+PL costs were $245/acre.
- The high site preparation included the chemical application and prescribed burn mentioned above with the addition of a mechanical site preparation of shearing, piling and burning @ $210/acre, warranted that the site needed both chemical, mechanical, and prescribed burn treatments

(Dubois and others 2013). Seedling costs were assumed @ $55/acre with a planting cost of $80/acre. Total SP+PL costs were $455/acre.

Site preparation options and associated costs vary extensively by location, prior stand history, harvesting utilization, landowner objectives, monies available, and anticipated future stumpage value and demand. 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

Pulpwood was assumed to be the only product class for this short rotation of 15-years.

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). The "low" set of stumpage prices were the means of the 15 lowest prices of each of the product classes. The "average" set of stumpage prices were the means 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 prices of the product class. 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.

Productivity assumptions

Three levels of productivity were assumed for loblolly pine on a 15 year rotation including mean annual increments of 6, 8, and 10 tons per acre per year. Three fertilizer applications at 1, 5 and 9 years, and a woody release at 4 years were assumed to maintain and enhance pine straw production and the total merchantable volume upon final harvest.

Scenarios for the 15-year Rotation

The following are the twelve loblolly (Table 7) 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, woody release at 4 years with an MAI of 6 tons/acre/year; raking straw from ages 6 15 years,
(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/

Forest management activities

Fertilization

Fertilization applications were assumed for all twelve scenarios over three different applications to enhance and maintain pine straw production and growth rates. Rates of 200 lbs/ac diammonium phosphate (36lbs/ac N + 40lbs/ac P) were assumed at year one to enhance wood volume for a total cost of $80/acre. Fertilizer was again assumed at age 5 (just prior to canopy closure) at the rates of 125 lbs/ac diammonium phosphate (22.5 lbs/ac N +25 lbs/ac P) and 170 lbs/acre urea (78 lbs/ac N) to advance wood volume and pine straw production. A third application was assumed at age 9 at the rate of 125 lbs/ac diammonium phosphate (22.5 lbs/ac N + 25 lbs/ac) and 275 lbs/ac urea (127 lbs/ac N) to sustain wood volume and pine straw production.

Woody Competition Control

A wood competition control treatment occurred at year four to enhance pine growth and to ready the site for pine straw harvesting. Cost of treatment was assumed at $55 per acre which is a common price for a single herbicide application prior to canopy closure in Georgia.

Pine straw

The pine straw income assumptions included were as follows: $50 income for the loblolly scenarios has been noted in south and central Georgia between 1998 and 2003 (Doherty 2004). Pine straw is raked starting in years 6 (approximating canopy closure) for loblolly pine. Intensive fertilization and chemical release applications for these scenarios allowed for pine straw raking beginning at age 6.

Results

Net Revenues and Rates of Return

Net Revenues ranged from -$510 per acre (Scenario #7 with low stumpage prices) to $1604 per acre (Scenario #6 with high stumpage prices). Ranking of scenarios by net revenues with low stumpage values were as follows: #7 (-$510/ac) <8 <1 <9 <2 <10 <3 <11 <4 <12 <5 <6 ($524/ac). Ranking of scenarios with average stumpage values were as follows: #7 (-$267/ac) 1< 8< 2< 9< 10< 3< 4< 11< 5< 12< 6 ($929/ac). With high stumpage prices are assumed, the scenarios ranked as follows: #7 ($138/ac)< 1< 8< 10< 2< 4< 9< 11< 3< 5< 12< 6 ($1604/ac). It is important to note that all twelve scenarios regardless of mean annual increment could provide positive net revenues depending on the stumpage values used.

Rates of return for the 15-year loblolly scenarios range from -6.30% (Scenario #7 with low stumpage prices) to 11.41% (Scenario # 6 with high stumpage prices). When low stumpage prices are assumed, the scenarios ranked by rate of returns as follows: #7 (-6.30%)< 1< 8< 2< 9< 10< 3< 11< 4< 12< 5< 6 (5.69%). Ranking of scenarios with average stumpage rates assumed are as follows: #7 (-2.71%)< 1< 8< 9< 2< 10< 3< 11< 4< 12< 5< 6 (8.33%). Ranking of scenarios with high stumpage rates is as follows: #7 (1.11%)< 1< 8< 10< 9< 2< 11< 4< 3< 12< 5< 6 (11.41%).

Impact of mean annual increment on net revenues and internal rates of return

Mean annual increments of 6, 8 and 10 tons/ac/yr were assumed for the 12 scenarios. Net revenues improved by $162, $243, and $378 across low, average, and high stumpage levels, respectively, as MAI increased by 2 tons/ac/yr (Tables 5, 6, & 7).

Internal rates of return improved across the assumed MAI's by 1.3 to 2.8 percentage points per each 2 tons/ac/yr increase or as much as 4.9 percentage points between 6 and 10 tons/ac/yr. For example, Scenario #1 (average SP+PL, no pine straw @ MAI 6 tons/ac/yr) improved ROR's by 2.8, 2.7 and 2.6 percentagepoints at low, average, and high stumpage rates, respectively, when MAI increases to 8 tons/ac/yr (Scenario #2), and an additional increase of 2.1, 2.0, and 2.0 percentage points across the three stumpage levels when increasing MAI to 10 tons/ac/yr (Scenario #3). Scenario #10 (high SP+PL, pine straw @ 6 tons/ac/yr) improved ROR by 1.6, 1.7, and 1.8 percentage points at low, average, and high stumpage rates, respectively, when MAI increases to 8 tons/ac/yr (Scenario #11), and an additional 1.3, 1.4, and 1.6 percentage points when across the three stumpage levels when MAI increases to 10 tons/ac/yr (Scenario #12).

Impact of pine straw income on net revenues and rates of return

Pine straw revenues ($50/ac from stand age 6-15; a ten year income period) were added to scenarios #4, 5, 6, 10, 11, and 12. Net revenues simply increased by $500/acre when pine straw revenues were added compared to similar scenarios without pine straw revenues (Tables 5, 6, & 7).

In the aforementioned scenarios, positive net revenues were realized as a result of pine straw revenues for scenario #4 at low and average stumpage rates ($200/ac and $443/ac, respectively; Table 5); scenario #5 at low stumpage rates ($362/ac; Table 6); scenario #10 at average stumpage rates ($233/ac; Table 5); scenario #11 at low and average stumpage rates ($152/ac and $476/ac, respectively; Table 6); and scenario #12 at low stumpage rates ($314/ac; Table 7). The above scenarios illustrate the significance of additional cash inflows for short-rotation investments when high stumpage rates are not obtainable.

Rates of return were significantly impacted by pine straw income. For sites with an MAI of 6 tons/ac/yr, ROR for average SP+PL (Scenario #4) across all stumpage levels were 2.69%, 5.04%, and 7.87% (Table 5). The same scenario at an MAI of 8 tons/ac/yr (Scenario #5;) had a ROR of 4.33%, 6.85%, and 9.83% across the three stumpage levels (Table 6). When MAI increases to 10 tons/ac/yr, pine straw raking applied to an average SP+PL (Scenario #9) had a ROR of 5.69%, 8.33%, and 11.41% across the three stumpage price levels (Table 7).

For scenarios #1 and 4 (Low SP+PL, MAI 6), the only difference in assumptions was the addition of pine straw raking. ROR increased by 7.25, 5.75, and 4.48 percentage points when pine straw revenues were added across low, average and high stumpage rates, respectively. Scenarios #9 and 12 (High SP+PL,

MAI 10) were also similar besides the addition of pine straw raking. ROR increased by 4.56, 3.60, and 2.79 percentage points when pine straw revenues were added across low, average, and high stumpage rates, respectively. Therefore, pine straw income can make a major difference and may be necessary, especially on lower site productivity levels. When comparing all the above scenarios that included pine straw income to scenarios without pine straw income, the rates of return increased by an average of 4.65 percentage points.

Impact of establishment costs on net revenues and rates of return

The impact of establishment costs (site preparation and planting; SP+PL) was straight-forward; net revenues differed between the $210/ac cost variance between the "average" and "high" SP+PL methods (Tables 5, 6, & 7).

The establishment costs and the associated productivity benefits from the site prep, seedling quality and genetics and planting quality) is an important forest management decision that will impact RORs. Two SP+PL rates were used to analyze the importance of choosing the proper amount of site preparation activity needed to successfully establish a stand. Reducing SP+PL costs by $210/acre increased the ROR by 1.74 to 3.16 percentage points. For example, Scenario #9 had an ROR of 5.46% (High Stumpage) at the $445/ac SP+PL level. Scenario #3, counterpart to Scenario #9, under the same high stumpage levels had a ROR of 8.04% at the $235/ac SP+PL level, for an increase of 2.58 percentage points (Table 7). Unlike pine straw revenues which increased ROR more as MAI decreased, lower establishment costs had an opposite effect increasing ROR as MAI increased, demonstrating the need to sufficiently apply your upfront SP+PL costs to successfully establish a stand based on site conditions.

Impact of stumpage values on net revenues and rates of return

Stumpage values are a very important component of a forest-based investment. The stumpage values used for this series represent the means of the lowest 15 quarters, means of the highest 15 quarters, and the average stumpage rates between the period of 4nd quarter 1976 through 2rd quarter 2013, established by Timber Mart-South© (TM-S). Net revenues simply improved by the assumed stumpage value multiplied by the assumed tonnage upon final harvest. At an MAI of 6 tons/ac/yr, net revenues improved by $243/ac from low-to-average stumpage and by $405/ac from average-to-high stumpage rates (Table 5). At an MAI of 8 tons/ac/yr, net revenues improved by $324/ac from low-to-average stumpage rates and improved by $540/ac from average-to-high stumpage rates (Table 6). At an MAI of 10 tons/ac/yr, net revenues improved by $405/ac and $675/ac from low-to-average and average-to-high stumpage rates, respectively (Table 7). In the above-mentioned scenarios, stumpage rates can improve net revenues $648-$1080 from low-to-high stumpage rates, depending on the mean annual growth of loblolly pine.

At the MAI of 6 tons/ac/yr, RORs increased by 2.26 to 3.85 percentage points from the low stumpage to average stumpage values used. From average to high stumpage values, RORs increased 2.69 to 4.02 percentage points. Stumpage values had the greatest increase on Scenario #1 at the MAI 6 level with an increase of ROR from low-to-high stumpage values of 7.95 percentage points (Table 5).

At the MAI of 8 tons/ac/yr, RORs increased by 2.41 to 3.78 percentage points when stumpage increased from low to average values and increased by 2.85 to 4.04 percentage points when stumpage increased from average to high values. Stumpage prices had the greatest influence on ROR for Scenario #2 with an increase of 7.82 percentage points from low-to-high stumpage values (Table 6).

When the MAI increased to MAI of 10 tons/ac/yr, RORs increased from 2.52 to3.74 percentage points when stumpage increases from low to average prices and 2.95 to 4.02 percentage points when stumpage increased from average to high prices. Stumpage prices had the most impact on Scenario #3 at an MAI of 10 tons/ac/yr, increasing RORs by 7.76 percentage points (Table 7). Stumpage rates have a significant role within a productivity level and even more so when SP+PL costs are low and timber harvesting is the only source of revenue as in Scenarios #1, 2, and 3.

Summary

Wood flow, pine straw, and stumpage prices

The above scenarios illustrate the possibility of managing loblolly pine on a short-rotation in the US South. It is very realistic to achieve the three productivity levels on most cut-over sites with proper site preparation, post-plant herbaceous weed control and fertilization, especially on 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.

Site preparation can have a significant impact on forest investments, especially on shorter rotations where revenue streams are limited as compared to longer rotations that include additional timber harvests. Proper 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, and seedling survival) can improve volume production and should be wisely considered.

Producing revenue as early as possible is extremely important in all investments, including forestry which typically has long periods between revenue streams. Pine straw revenues have a substantial impact on the worthiness of an investment and as in the aforementioned scenarios, can aide on sites with lower productivity. Stumpage values, often volatile, contributes as a key factor in forest investments and landowners should understand causes of their fluctuations (weather, location, hauling distance, harvest acreage, fuel prices, demand, competition, domestic and global economics, and timber quality) and track local stumpage prices at least two years before a planned harvest.

Discussion

Non-industrial private forest landowners do have some attractive forest management options with loblolly pine on a 15-year rotation. However, landowners need to remain flexible with their rotation lengths and harvesting plans. Growing loblolly pine at 6-10 tons per acre as maximum production under most management scenarios through age 15–years is possible (Zhao and kane 2012). Generally, average-to-high stumpage values are necessary in order for a landowner to reach a desired four and six percent return and additional revenue streams, such as pine straw, become extremely important as the productivity level decreases on a given site. Intensively-managed forests with high SP+PL costs, low stumpage rates when harvesting, and the absence of pine straw revenues will most certainly require a longer rotations to realize maximum potential.

Lower productivity levels (MAI of 6 tons/ac/yr) were assumed for scenarios #1, 4, 7, and 10. Landowners intensively managing their forests on a lower productivity site are very limited in their options to achieve an ROR greater than 6%. SP+PL costs need to remain on the lower level necessary

to successfully establish a fully-stocked stand, pine straw revenues need to be realized, and higher stumpage values are needed. Scenario #4 is the best option for growing with an expected MAI of 6 tons/ac/yr with a possible ROR of 7.87% and NR of $848/ac (Table 5).

Medium productivity levels (MAI of 8 tons/ac/yr) were assumed for scenarios #2, 5, 8, and 11. Intensively managing within these scenarios increases your chances of achieving an ROR greater than 6%. Scenario #5 is the best option at the medium productivity level to realize an ROR of 9.83% and NR of $1,226/ac with high stumpage values, average SP+PL, and pine straw revenues (Table 6).

Intensively managing loblolly pine on a 15-year rotation for a high productivity level (MAI 10 tons/ac/yr) provides the landowner many options to realize an ROR greater than 6%. High productivity levels were assumed for scenarios #3, 6, 9, and 12. Scenario #6 was the best option for all scenarios across any productivity level with an ROR of 11.41% and NR of $1,604/ac (Table 7).

Literature Cited

Bailey, R.L.; Zhao, B. 1998. GaPPS 4.20 Model. Warnell School of Forest Resources- UGA, Athens, GA.

Bullard, S.H. Straka. T.J. 1993. Basic concepts in forest valuation and investment analysis. Edition 1.0.3 GTR Printing, Starkville, MS. ISBN 0-9641291-0-8. 69 p.

Bullard, S.H.; Straka, T.J.; Landrum, C.B. 2001. FORVAL Online, Forestry Investment Calculations, Version 1.2. Department of Forestry- MSU, Mississippi State, MS.

Dickens, E.D. 1999. The effect of inorganic and organic fertilization on longleaf tree growth and pine straw production. In: Proceedings of the 10th Biennial So. Silvi. Res. Conf., Shreveport, LA, Feb 16-18, 1999. pp. 464-468.

Dickens, E.D. 2001.The effect of one-time biosolids application in an old-field loblolly pine plantation on diameter distributions, volume per acre, and value per acre. In: Proceedings of the 11th Biennial So. Silvi. Res. Conf., Knoxville, TN. March 19-22, 2001. pp. 15-19.

Doherty, B.A.; Teasley, R.J.; McKissick, J.C.; Givan, B. 2000. Nineteen ninety-nine farmgate value report. UGA CAES Center for Agribusiness and Econ. Dev., Center Staff Report No. 6. Athens, GA. 160 p.

Dubois, M.R.; McNabb, K.; Straka, T.K. 1999. Costs and cost trends for forestry practices in the South. *Forest Landowner* Magazine. March/April 1998. pp. 3-8.

Love, Joshua. 2011. Green Biomass Weight Estimation and Financial Analysis Tool, Version 1.0. Utilization and Marketing Department— Georgia Forestry Commission, Macon, GA.

Morris, L.A.; Jokela, E.J.; O'Connor, J.B., Jr. 1992. Silvicultural guidelines for pinestraw management in the SE US. GA Forest Res. Paper #88. GFC, Macon, GA. 11 p.

Pienaar L.V.; Rheney, J.W. 1996. Potential productivity of intensively managed pine plantations - Final Report. The GA Consortium for Tech. Competitiveness in Pulp and Paper. 41 p.

Shiver, B.D.; Rheney, J.W.; Hitch, K.L.. 1999. Loblolly pine outperforms slash pine in southeast Georgia and northern Florida. SJAF 24(1) pp. 31-36.

TM-S 1976 - 2013. Timber Mart So stumpage prices – 1st quarter Georgia 1976 through 2nd qtr 2013. UGA-WSFR, Athens, GA 30602-2152.

Zhao, D.; Kane, M.; Borders, B.E. 2011. Growth responses to planting density and management intensity in loblolly pine plantations in the southern USA Lower Coastal Plain. Annals of Forest Science, 68:625-635.

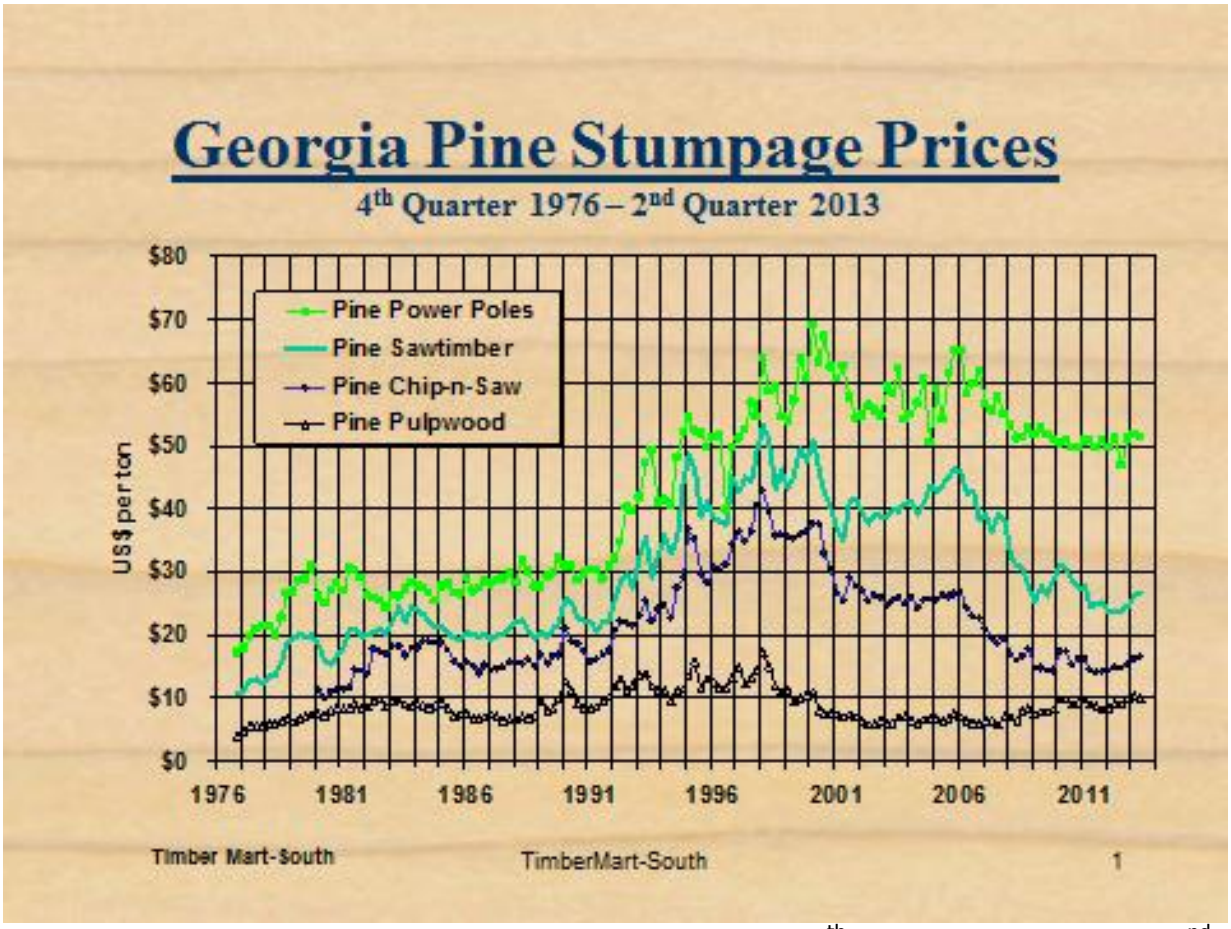

Figure 1. Georgia state-wide average pine stumpage prices from 4th quarter 1976 through 2nd quarter 2013 by product class.

Table 2. Pine pulpwood net stumpage prices used.

Pine stumpage price level	Net price ($/ton)
low	5.40
average	8.10
high	12.60

Table 3. 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 4. Pine straw periodic per acre income levels expressed as present values as used in the profitability analysis of loblolly pine scenarios over a 15-year rotation

Rotation age	Periodic income/ac/yr. raked ($/ac)	Total income for pine straw during the rotation ($/ac)
15 years	50 & 0[1]	500 & 0

[1] Pinestraw raked in years 6-15, for 15-year rotation.

Table 5. Rates of return and net revenues 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	Rate of Return %	Net Revenues $/ac
1	$245	N	$5.40	-4.6	-$300
			$8.10	-0.7	-$57
			$12.60	3.4	$348
4	$245	Y	$5.40	2.7	$200
			$8.10	5.0	$443
			$12.60	7.9	$848
7	$455	N	$5.40	-6.3	-$510
			$8.10	-2.7	-$267
			$12.60	1.1	$138
10	$455	Y	$5.40	-0.1	-$10
			$8.10	2.2	$233
			$12.60	4.9	$638

Table 6. Rates of return and net revenues 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	Rate of Return %	Net Revenue $/ac
2	$245	N	$5.40	-1.8	-$138
			$8.10	2.0	$186
			$12.60	6.0	$726
5	$245	Y	$5.40	4.3	$362
			$8.10	6.9	$686
			$12.60	9.8	$1226
8	$455	N	$5.40	-3.7	-$348
			$8.10	-0.2	-$24
			$12.60	3.6	$516
11	$455	Y	$5.40	1.5	$152
			$8.10	3.9	$476
			$12.60	6.7	$1016

Table 7. Rates of return and net revenues 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	Rate of Return %	Net Revenue $/ac
3	$245	N	$5.40	0.3	$24
			$8.10	4.0	$429
			$12.60	8.0	$1104
6	$245	Y	$5.40	5.7	$524
			$8.10	8.3	$929
			$12.60	11.4	$1604
9	$455	N	$5.40	-1.8	-$186
			$8.10	1.7	$219
			$12.60	5.5	$894
12	$455	Y	$5.40	2.8	$314
			$8.10	5.3	$719
			$12.60	8.3	$1394

Keywords: Loblolly pine, forest economics, intensive management, short rotation, pine straw, net revenue, rate of return