Series paper #2
Economics of growing loblolly pine to a 15-year rotation with intensive management–net present value

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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*, Mill.) 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. Financial measures of profitability calculated include net present value (NPV) using discount rates of four, six, eight, and ten percent. Net revenues (NR) and internal rates of return (IRR) were discussed in series paper #1. Soil expectation values (SEV) will be discussed in subsequent editions 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 of the Southern pines on most soils (Shiver et al. 1996). In addition, intensive management usually results in increased average diameters, average heights, basal area, and volume (Zhao et al. 2011). Landowners 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 assumed three different levels of productivity using mean annual increments of six, eight, and ten tons/acre/year to produce a single product class; pulpwood. Generally, culmination of merchantable volume mean annual increment occurs for loblolly pine on average to good sites and management in early 20-years (Pienaar et al.

1996). Recent Loblolly and Slash pine growth studies (Zhoa and Kane 2012) using intensive management indicate that culmination of mean annual increment may occur sooner than the early 20 years. Longer rotation ages can be more financially attractive and will be addressed in companion papers in this series of economic manuscripts.

Methodology

Financial Calculations

Net present value was the financial measure of profitability used for this economic paper. NPV is a common financial indicator defined as the difference between all the cash inflows and cash outflows over the investment period, discounted back to present day. The interest rate used in the calculation, known as the discount rate, is based on the estimated rate of return under an alternative investment with similar risks. NPV is useful in helping investors decide between two investments with the same length of time. At a given discount rate NPVs for different pine species and scenarios can be compared to each other with the highest ranking NPV being the highest value per acre and the lowest ranking NPV being the lowest value per acre. Generally, a positive NPV indicates that the investment is attractive at the interest rate used while a negative NPV indicates that the investment is not financially attractive. NPV's were calculated using the Biomass Green Weight Estimation and Financial Analysis Tool (Love. 2011) and checked for accuracy using FORVAL online (Bullard et al. 2001).

Common assumptions

The rotation age was set at 15-years for loblolly pine plantations. Net present value (NPV) was calculated using discount rates of four, six, eight, and ten percent. Fire protection cost was assumed at $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 dollars per acre, before state and federal 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 included a chemical application @ $75/acre and prescribe burn @ $35/acre (current common prices for these activities in Georgia). The total cost for the average site prep was $110/acre. Seedling costs were assumed @ $55/acre ($75 per 1000 planting 726/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 et al. 2013). Seedling costs were assumed @ $55/acre ($75 per 1000 planting 726/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. A mix of product classes, including pulpwood, chi-n-saw, and sawtimber were assumed in the longer 24, 33, and 45 year rotations in the companion economic papers.

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 stumpage values were net of property taxes at harvest (2.5 percent) and net of marketing costs (7.5 percent). Net converted prices are found in Table 1.

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

Forest management activities

Fertilization

Fertilization applications were assumed for all twelve scenarios over three different applications to enhance pine straw production and growth rates. Rates of 200 lbs/ac diammonium phosphate (36 lbs/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 P) at a cost of $110/acre and 275 lbs/ac urea (127 lbs/ac N) to sustain wood volume and pine straw production at a cost of $146/acre (current common prices in Georgia for NP fertilization).

Woody Competition Control

A woody vegetation 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 currently 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) and more recently. Pine straw is raked starting in year 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 Present Value

Net Present Values (NPV) ranged from -$655 (Scenario #7 with low stumpage prices and a 10% discount rate) to $709 per acre (Scenario #6 with high stumpage prices and a discount rate of 4%). Ranking of scenarios by NPV significantly fluctuates due to the effects of the differing stumpage values, MAIs and discount rates with scenarios #6 and #7 consistently performing the best and worst, respectively (Tables 4, 5 & 6).

At a 4% discount rate scenarios #5 and 6 produced positive NPVs when applied to low stumpage values, scenarios #3, 4, 5, 6, and 12 produced positive NPVs when applied to average stumpage values, and scenarios #2, 3, 4, 5, 6, 9, 10, 11, and 12 produced positive NPVs when high stumpage values were assumed. Positive NPVs ranged from $1 through $709 /acre at a 4% discount rate (Tables 4, 5, & 6).

At a 6% discount rate scenarios #5 and 6 produced positive NPVs when applied to low and average stumpage values. Scenarios #2, 3, 4, 5, 6, 11, and 12 surpassed the 6% discount rate when high stumpage values were assumed. Positive NPVs ranged from $1 through $434/acre at a 6% discount rate (Tables 4, 5, & 6).

Scenario #6 was the only scenario to produce a positive NPV when using an 8% discount rate at the low and average stumpage values, and scenario # 3, 5, 6, and 12 produced positive NPVs when applied to an 8% discount rate and high stumpage values. Positive NPVs ranged from $3 through $231/acre at an 8% discount rate.

None of the scenarios produced a positive NPV against a 10% discount rate when applied to low and average stumpage values; however, scenario #6 provided an NPV of $82/acre when compared to a 10% discount rate at the high stumpage price level (Tables 4, 5, & 6).

Impact of mean annual increment on net present values

Increasing mean annual increments, by two tons/ac/yr increments in this paper, had a tremendous effect on net present values, especially as stumpage values increased at lower discount rates. Under the low stumpage levels, NPVs improved by $90, $67, $51, and $38 per acre as annual growth increased at 2 tons/ac/yr increments at discount rates of 4, 6, 8, and 10 percent, respectively. As stumpage increased to the average price levels, NPVs improved by $133, $102, $76, and $58/acre at discount rates of 4, 6, 8, and 10 percent, respectively as annual growth increased by 2 tons/ac/yr. At the high stumpage levels, NPVs increased by $210, $158, $120, and $90/acre at discount rates of 4, 6, 8, and 10 percent, respectively as mean annual increments improved by 2 tons/ac/yr (Tables 4, 5, & 6).

Impact of pine straw income on net present values

Pine straw revenues ($50/ac from stand age 6-15) were added to scenarios #4, 5, 6, 10, 11, and 12. NPV increased by $190/acre when pine straw revenues were added at a discount rate of 10%, $228/ac at an 8% discount rate, $275/ac at a 6% discount rate and $334/ac at a discount rate of 4% compared to similar scenarios without pine straw revenues.

In the aforementioned scenarios, as a result of pine straw revenues, NPVs became positive (compared to being negative without pine straw) for the following cases: for scenario #4 (Table 4) at 4% discount rate and average stumpage price ($65/ac), at 4% high stumpage ($290/ac), and at 6% discount rate high stumpage ($118/ac); scenario #5 (Table 5) at a 4% discount rate low stumpage ($20/ac), 4% discount rate average stumpage ($200/ac), 6% discount rate average stumpage ($51/ac) and 8% discount rate high stumpage ($110/ac); scenario #6 (Table 6) at 4% discount rate low stumpage ($110/ac), 6% average stumpage ($152/ac), 8% discount rate average stumpage ($18/ac) and 10% discount rate high stumpage ($82/ac); scenario #10 (Table 4) at 4% discount rate high stumpage ($90/ac); scenario #11 (Table 5) at a 4% discount rate high stumpage ($290/ac) and 6% discount rate high stumpage ($66/ac); and scenario #12 (Table 6) at a 4% discount rate medium stumpage ($125/ac) and at a 6 and 8% discount rate with high stumpage rates ($224/ac and $21/ac).

Impact of establishment costs on net present values

The impact of establishment costs (site preparation and planting; SP+PL) was straight-forward; net present values differed between the $210/ac cost variance between the "average" and "high" SP+PL methods. SP+PL occurred in year 0; therefore the costs were not discounted back by the applicable interest rate.

Site preparation does hold a high level of significance within a management level. There is a major difference ($210/ac) in the SP+PL practices in that choosing the right level for a given site will impact the worthiness of your investment. For example: scenario #6 and 12 differ only by the levels of SP+PL ($245/ac for scenario #6 and $455/ac for scenario #12). Because of the lower SP+PL level, Scenario #6 was able to return a positive NPV of $82/ac (Table 6) while scenario #12 returned a NPV of -$128/ac (Table 6) at a 10% discount rate. This example highlights the importance of choosing the necessary SP+PL level based on site conditions and anticipated annual growth rate through the first 15-years, and in doing so, your investment may compare better with a higher interest rate.

Comparing the influences of stumpage values and pine straw on net present values

Stumpage values and pine straw revenues have a significant impact on NPVs within a given productivity level and discount rate. Stumpage values tend to fluctuate throughout the rotation (Figure 1) and can increase NPV by as much as $600/ac from low to high stumpage values on a high MAI level as in Scenario #6 (Table 6) with a 4% discount rate or have a slighter increase on NPV by $360/ac for a lower MAI level such as Scenario #1 (Table 4) with a 4% discount rate. However, as the discount rate used increases to 10%, the NPV increased by $259/ac and $155/ac for Scenarios #6 and 1, respectively, from low to high stumpage rates.

Pine straw revenues increased the NPV by $333/ac at a 4% discount rate when comparing similar scenarios with and without pine straw (Tables 4, 5, & 6). At the 10% discount rate, NPVs increased by $191/ac by adding pine straw income versus no pine straw income at the 6, 8 and 10 tons/ac/yr MAI scenarios (Table 4, 5, and 6). Stumpage value fluctuations generally have a more significant impact on NPV, although when applying a higher discount rate to a low MAI site level, early revenue streams, such as pine straw income, may have more of a significant impact on NPV.

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, early rotation woody release and fertilization. Fertilization studies (Blevins et al. 1996, Dickens 1999) illustrate that pine straw production can be increased by an average of 25 to 50 percent over unfertilized stands on marginal fertility soils. Exceptions would be problem soils such as excessively well drained 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. Pine straw revenues have a substantial impact on the worthiness of an investment and as in the aforementioned scenarios, can be the difference between a negative or positive NPV. 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, local and global economics, and timber quality) and track local stumpage prices at least two years before a planned harvest. There are cases and locations where pine pulpwood (and other pine and hardwood product class prices) can actually be greater or lower than the prices used in this series paper. Large increases in demand for certain product classes, lower supply, wet weather making logging sites less numerous can contribute to price increases, while mill shutdowns (for cleaning or other reasons), prolonged dry spells, or a poor demand for products can lower prices.

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. Choosing the right discount rate is also important when planning a reforestation investment with NPV as the economic measure of profitability. Growing loblolly pine at 6-10 tons per acre per year is possible as maximum production under most management scenarios occurs at a range of 10-15 years of age (Dickens et al. 2011). Generally, average-to-high stumpage values are necessary in order for a landowner to reach a desired four and six percent return on a short-rotation, intensive management regime and additional revenue streams, such as pine straw, become extremely important on lower productivity sites. 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 rotation to realize positive NPVs.

Lower productivity levels (MAI of 6 tons/ac/yr) were assumed for scenarios #1, 4, 7, and 10 (Table 4). Landowners intensively managing their forests on a lower productivity site are very limited in their options to achieve a positive NPV. 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 to beat a 4 or 6 percent interest rate. Scenario #4 is the best option for growing with an expected MAI of 6 tons/ac/yr.

Medium productivity levels (MAI of 8 tons/ac/yr) were assumed for scenarios #2, 5, 8, and 11 (Table 5). Intensively managing within these scenarios opens your chances of achieving a positive NPV when expecting average-to-high stumpage values. Scenario #5 is the best possibility to realize a return that beats a 4 and 6 percent interest rate, and can possibly reach above an 8 percent interest rate with high stumpage values, average SP+PL, and pine straw revenues.

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 surpass interest rates of 4, 6, 8, and possibly 10 percent with average-to-high stumpage values. High productivity levels were assumed for scenarios #3, 6, 9, and 12 (Table 6). Scenario #6 was the best option for all scenarios across any productivity level and the only option to beat a 10 percent interest rate.

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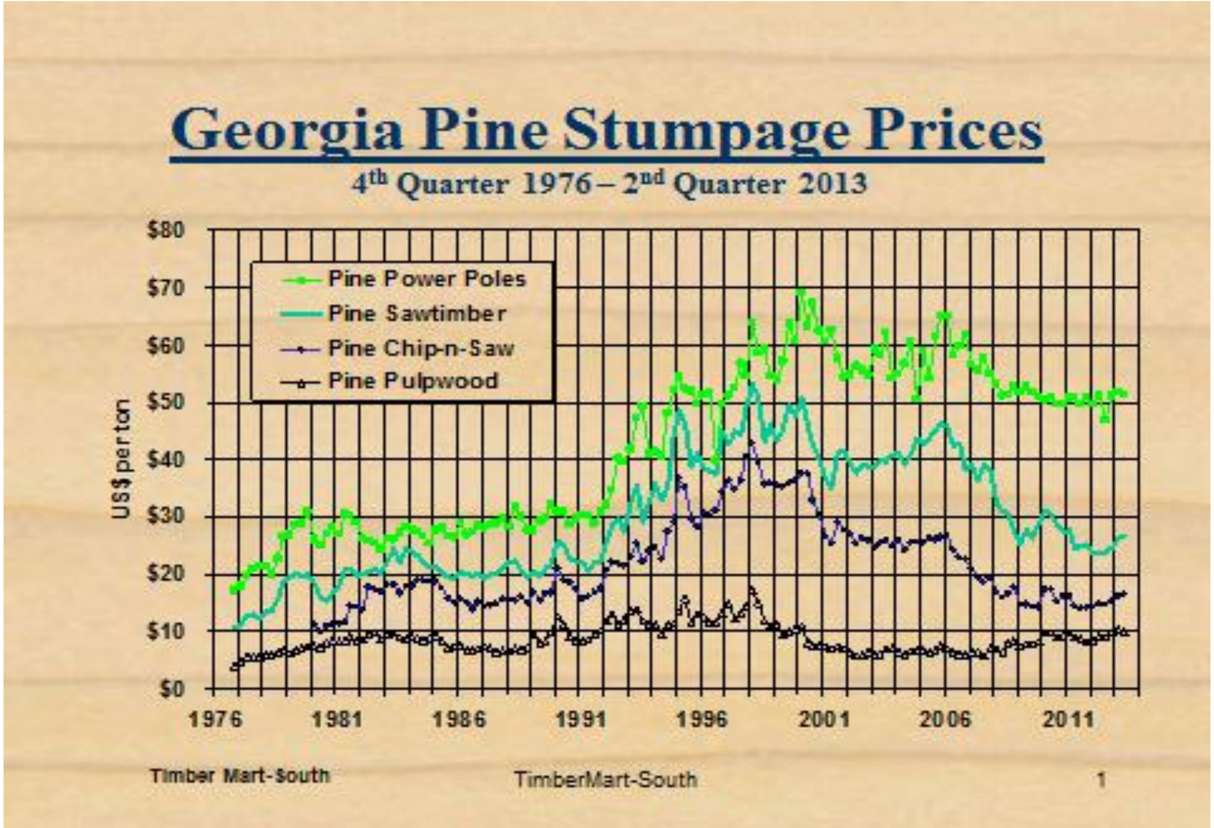

Figure 1. Georgia state-wide average pine stumpage prices from 4th quarter 1976 through 2nd quarter 2013 by product class.

Table 1. Pine pulpwood - Net stumpage prices.

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

Table 2. 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	Woody Control Herbicide Treatment	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 3. 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 4. Net present values at discount rates of 4, 6, 8, and 10 percent for 15-year loblolly pine scenarios #1, 4, 7, and 10 at a mean annual increment of 6 tons/acre/year.

Scenario #	Est. Costs $/ac	Pine Straw Y/N	Stumpage Rates $/ton Pulpwood	NPV @ 4% $/ac	NPV @ 6% $/ac	NPV @ 8% $/ac	NPV @10% $/ac
1	$245	N	$5.40	-403	-427	-440	-445
			$8.10	-269	-326	-363	-387
			$12.60	-44	-157	-236	-290
4	$245	Y	$5.40	-70	-152	-212	-255
			$8.10	+65	-51	-135	-196
			$12.60	+290	+118	-7	-99
7	$455	N	$5.40	-613	-637	-650	-655
			$8.10	-479	-536	-573	-597
			$12.60	-254	-367	-446	-500
10	$455	Y	$5.40	-280	-362	-422	-465
			$8.10	-145	-201	-345	-406
			$12.60	+80	-92	-217	-309

Table 5. Net present values at discount rates of 4, 6, 8, and 10 percent for 15-year loblolly pine scenarios #2, 5, 8, and 11 at a mean annual increment of 8 tons/acre/year.

Scenario #	Est. Costs $/ac	Pine Straw Y/N	Stumpage Rates $/ton Pulpwood	NPV @ 4% $/ac	NPV @ 6% $/ac	NPV @ 8% $/ac	NPV @10% $/ac
			$5.40	-313	-360	-389	-407
2	$245	N	$8.10	-134	-224	-286	-329
			$12.60	+166	+1	-116	-200
			$5.40	+20	-85	-161	-216
5	$245	Y	$8.10	+200	+51	-58	-138
			$12.60	+500	+276	+112	-9
			$5.40	-523	-570	-599	-617
8	$455	N	$8.10	-344	-434	-497	-539
			$12.60	-44	-209	-326	-410
			$5.40	-190	-295	-371	-436
11	$455	Y	$8.10	-10	-159	-268	-348
			$12.60	+290	+66	-98	-219

Table 6. Net present values at discount rates of 4, 6, 8, and 10 percent for 15-year loblolly pine scenarios #3, 6, 9, and 12 at a mean annual increment of 10 tons/acre/year

Scenario #	Est. Costs $/ac	Pine Straw Y/N	Stumpage Rates $/ton Pulpwood	NPV @ 4% $/ac	NPV @ 6% $/ac	NPV @ 8% $/ac	NPV @10% $/ac
			$5.40	-224	-292	-338	-368
3	$245	N	$8.10	+1	-123	-210	-271
			$12.60	+376	+159	+3	-109
			$5.40	+110	-17	-109	-177
6	$245	Y	$8.10	+335	+152	+18	-81
			$12.60	+709	+434	+231	+82
			$5.40	-434	-502	-548	-578
9	$455	N	$8.10	-209	-333	-420	-481
			$12.60	+166	-51	-207	-319
			$5.40	-100	-227	-319	-387
12	$455	Y	$8.10	+125	-58	-192	-290
			$12.60	+499	+224	+21	-128

Keywords: Loblolly pine, forest economics, intensive management, short rotation, pine straw, net present value