Series paper #1

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

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Abstract

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 two commonly available pine species; loblolly (*Pinus taeda* L.) 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 short-rotation management options affecting wood-flow for slash and loblolly pine plantations including thinning, fertilization, and pine straw harvests under alternative levels of productivity, establishment costs, and product prices. Financial measures of profitability calculated include net revenue and rate of return (ROR). Soil expectation value (SEV) and annual equivalent value (AEV) are discussed in series paper #2.

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. 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. Generally culmination of merchantable volume mean annual increment occurs for both species on average to good sites and management in the early 20-years (Pienaar and others 1996). Longer rotation ages are often financially attractive and will be addressed in companion papers in this series of economic manuscripts.

Methodology

Common assumptions

The rotation age was set at 24-years for slash and loblolly pine plantations. Net revenue was calculated as the sum of all revenues minus all costs in today's dollars. The rate of return (ROR) was calculated after using a discount rate of 8 percent for intermediate costs (fertilization) and returns (pine straw). Fire protection cost was assumed$2/ac/yr stand management at $2/ac/yr and property taxes at $5/ac/yr. Thus, the total annual costs for each year of the rotation were $9/acre. This value cost goes in the transaction table as an annual cost during the rotation. The present value of this net, annual cost flow is $94.75 during the 24-year rotation. Results are reported in constant dollars, before taxes. It is assumed that land is already owned.

Site Preparation and Planting Costs

Three site preparation and planting (SP+PL) costs rise in increments of $125/acre ($125, $250 and $375/acre). These costs represent the following site preparation and planting scenarios:

► The lower site preparation and planting cost of $125/acre could include machine planting and the use of a post plant herbicide to control herbaceous weeds on an old-field site or glyphosate @ 1 gallon/ac or prescribe burning (low level) site preparation and roughland planting on a cutover site.

► The more moderate ($250/acre) establishment cost could include a mechanical site prep treatment, burn and plant or a herbicide, burn, plant, and herbaceous weed control (Dubois and others. 1999).

► The higher ($375/acre) establishment cost could include a combination of chemical and mechanical site preparation as can be the case on many flatwoods cutover sites.

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

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).

Georgia stumpage Prices, reported through Timber Mart-South© (TM-S) for 1st quarter year 2004 average, used in this analysis for loblolly and slash were net of property taxes at harvest (2.5 percent) and net of marketing costs (8 percent). The low TM-S prices for pulpwood and chip&saw were used for thinning prices and average TM-S prices for pulpwood, CNS, and ST are used for the clearcut. Cash and net converted prices are found in Table 2.

Species specific assumptions

The slash pine scenarios assumed 500 living trees per acre (TPA) at age 5-years-old. A base mean annual increment of 2.09 cd/ac/yr (5.77 tons/ac/yr) @ age 24-years-old without fertilization and thinning was assumed (Table 6). The base slash scenario woodflow was approximately 15 percent less than base loblolly woodflow (Shiver and others 1999) at age 24-years. The assumed fertilizer applications increased merchantable volume by an average of 0.50 cd/ac/yr (1.38 tons/ac/yr) for eight to ten years following treatment (Jokela and Stearns-Smith 1996).

The loblolly pine survival was assumed to be 500 TPA at age 5-years-old. The base mean annual increment for loblolly was assumed to be 2.35 cds/ac/yr (6.48 tons/ac/yr, Table 7) through age 24-years-old without fertilization or thinning. The base loblolly woodflow was approximately 15 percent greater than the slash base woodflow (Shiver and others 2000) at age 24-years. The assumed fertilizer applications increased merchantable volume by an average of 0.65 cd/ac/yr (1.79 tons/ac/yr) for eight to ten years (NCSUFNC 1998).

Scenarios for the 24-year Rotation

The following are the nine slash (Table 6) and loblolly (Table 7) pine scenarios:
(1) no thinning, no pine straw income, and no fertilization,
(2) thin (at age 15-years to 65 ft^2/ac), no straw, no fertilization ,
(3) no thin, fertilize at age 16-years, no straw,
(4) no thin, fertilize @ 6-years and rake pine straw from age 8-years through age 23-years @ $50/ac/yr,
(5) no thin, fertilize at ages 6- and 16-years and rake pine straw from age 8-years through age 23-years @ $100/ac/yr,
(6) thin, fertilize after the thinning (age 16-years), no straw,
(7 and 8) thin, fertilize at age 6-years, and rake straw @ $50 or $100/ac/yr from age 8-through 14-years, and
(9) thin, fertilize at ages 6- and 16-years and rake pine straw at $100/ac in years 8 through 14 and $50/ac/yr in years 17 through 23-years.

Forest management activities

Thinning

The thinning scenarios include no thinning or one thinning at 15-years-old (scenario # 2 and 6-9). Total woodflow of scenario with thinning is approximately 95 percent of total woodflow of scenario without thinning for slash and loblolly without fertilization. Residual basal area (RBA), after thinning (5^{th} row with selection from below) is set at 65 sq. ft/ac.

Fertilization

A fertilizer and application cost of $100/ac for slash and loblolly per application at age 6-years and 16-years-old was assumed. Fertilization with 150 then 200 N + 40 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). Fertilization timing at age 6-years-old was two years prior to the initiation of straw raking (just prior to canopy closure). The second application, ten years later, was just after a thinning (thinning scenario) and after the response (wood and straw) to the first application has become negligible. The periodic fertilizer application costs are converted to present values (PV) in year one, then re-computed as annual equivalent values (AEV). These AEVs were then put in the transaction table as annual expense cash-flows (Table 3).

Scenarios with fertilization for both loblolly and slash pine were set-up as follows: (#3) to delay fertilization cost and/or to promote additional growth on best (leave) trees only after the thinning (age 16-yrs only), (#4) to maintain or enhance pine straw production from canopy closure (age 6-yrs only), (#5) to maintain pine straw production (age 6- and 16-yrs) through the rotation with a higher annual revenue, (#6) to change product class distribution and put extra growth on best trees after thinning (age 16-yrs only), (#7 and #8) to maintain or enhance pine straw production from just prior to canopy closure (age 6-yrs only) to the first thinning, and (#9) to maintain or enhance pine straw production from just prior to canopy closure (age 6-yrs) to the first thinning and to change product class distribution and put extra growth on best trees after thinning (age 16-yrs, Tables 6 and 7).

Pine straw

The pine straw income assumptions included were as follows: $50 and $100/ac/yr raking income for the slash and loblolly scenarios has been noted in south (slash) and central (loblolly) Georgia between 1998 and 2003 (Doherty 2004). Pine straw is raked starting in year 8 (approximating canopy closure) for slash and loblolly pine. Periodic pine straw income was converted to present values (PV) in year one, then re-computed as annual equivalent values (AEV) at the discount rate of 8 percent. These AEVs were then put in the transaction table as annual income cash-flows (Table 4).

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). Therefore we included a scenario for loblolly and slash pine with raking two years after thinning at half the income rate prior to the thinning. There was an associated clean-up cost to get the stand rakeable of $70/acre (Table 5). Scenarios that included pine straw income for both species are #'s 4, 5, and 7-9 (Table 6 and 7).

Results

Net revenues and rates of return ranges

Net revenues (NR) ranged from $1187 (base slash pine scenario with highest site prep and plant cost) to $4171 per acre (loblolly with pine straw @ $100/A/yr, no thin and fertilize twice and lowest site prep and plant cost, Table 6 and 7). Ranking of scenarios by NR within a SP+PL level were as follows: 5 > 9 > 8 > 4 > 7 > 6 > 3 > 2 > 1 for both loblolly and slash pine. Net revenues for slash pine (growing at approximately 15 percent less than loblolly) for slash pine were 15 to 20 percent less than corresponding loblolly scenarios (Table 6 and 7).

Rates of return (ROR) for both species and all scenarios (54 scenarios in all) had a very wide range: ranging between 5.48 – 6.16 percent (base slash and loblolly scenarios with highest site preparation and planting cost, respectively) to 24.64 – 24.96 percent (slash and loblolly pine scenarios with the lowest site preparation and planting cost, no thin, fertilize twice, and rake straw @ $100/ac/yr from age 8- through 23-years, respectively) using the aforementioned assumptions (Tables 6 and 7). Ranking of scenarios by IRR within a SP+PL level were as follows: 5 > 9 > 8 > 4 > 7 > 6 > 3 > 2 > 1 for both loblolly and slash pine. Generally, these levels of forest management are economically justifiable in these cases, even using low to medium 1st quarter 2004 stumpage prices (TM-S 2004) for Georgia.

Impact of thinning on net revenues and rates of return

Thinning also increased total harvest revenues and NR by $350 (slash) to $409/acre (loblolly) compared to the unthinned counterpart. Thinning slash and loblolly pine stands increased ROR by 1.19 to 1.59 percent (slash, Table 6) and by 1.35 to 1.87 percent (loblolly, Table 7) over unthinned, unraked stands (scenario #1 vs 2).

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

The pine straw income prior to thinning (age 8-14-yrs) increased NR by $285 and $635/acre in the thinned scenarios (scenario #7 and 8) over the thin, no pine straw scenario (scenario #2). When pine straw was performed before and after the thinning, (scenario #9) NR increased by $1390 to $1721 ($780/acre in net straw income) over the thin, no pine straw scenario (#2) for slash and loblolly, respectively (Table 6 and

7). In unthinned stands, pine straw income and fertilization (age 8 though 23-years) increased NR by $1168 to $2470/acre for both species ($700 and $1400/acre in net straw income, Table 6 and 7).

The addition of pine straw income for slash pine in the unthinned scenarios (#4 and 5) increased base scenario (#1) rates of return from 5.48 (@ $375/ac SP+PL), 6.96 (@ $250/ac SP+PL), and 9.30 (@ $125/ac SP+PL) percent to 8.77, 10.95, and 15.16 percent at the $50/ac/yr pine straw income rate in unthinned stands (Table 6). Raising the annual pine straw income to $100/ac/yr from age 8- through 23-years increased rates of return to 12.27 (@ $375/ac SP+PL), 15.71 (@ $250/ac SP+PL), and 24.64 (@ $125/ac SP+PL) percent (Table 6).

In thinned slash pine stands, pine straw income increased rates of return from 6.67, 8.28, and 10.89 percent (thin, no straw; scenario #2) to 8.53, 10.46, and 13.83 percent, for three $375, $250, and $125/ac SP+PL costs, respectively when $50/ac/yr pine straw revenue was realized from age 8- through 14-years (scenario #7, Table 6). Pine straw raking in the slash scenario prior to thinning only (age 8 through 14-years) at $100/ac/yr produced rates of return of 10.31, 12.87, and 18.12 percent (scenario #8). Pine straw raking in the slash scenario prior to thinning (age 8 through 14-years) at $100/ac/yr and after the thinning (ages 17- through 23-years) at $50/ac/yr produced rates of return of 11.12, 13.80, and 19.42 percent (scenario #9).

The addition of pine straw income for loblolly pine in the unthinned scenarios (#4 and 5) increased base scenario (#1) rates of return from 6.16 (@ $375/ac SP+PL), 7.66 (@ $250/ac SP+PL), and 10.04 (@ $125/ac SP+PL) percent to 9.24, 11.42, and 15.62 percent at the $50/ac/yr pine straw income rate in unthinned stands (Table 7). Raising the annual pine straw income to $100/ac/yr from age 8- through 24-years increased rates of return to 12.85 (@ $375/ac SP+PL), 16.24 (@ $250/ac SP+PL), and 24.98 (@ $125/ac SP+PL) percent (Table 7).

In thinned loblolly pine stands (scenario #2), pine straw income increased rates of return from 7.51, 9.18, and 11.91 percent to 9.18, 11.16, and 14.63 percent, for three $375, $250, and $125/ac SP+PL costs, respectively when $50/ac/yr pine straw revenue was realized from age 8- through 14-years (scenario #7, Table 6). Pine straw raking in the loblolly scenario prior to thinning only (age 8 through 14-years) at $100/ac/yr produced rates of return of 10.91, 13.51, and 18.83 percent (scenario #8). Pine straw raking in the loblolly scenario prior to thinning (age 8 through 14-years) at $100/ac/yr and after the thinning (ages 17- through 23-years) at $50/ac/yr produced rates of return of 12.08, 14.83, and 20.56 percent (scenario #9).

Impact of fertilization on net revenues and rates of return

In the unthinned scenarios, net revenues increased by $470 to $475/acre with fertilization at age 16-years (scenario #3) compared to the no fertilization scenario (#1) for both species (Table 6 and 7). In the thinned scenarios, fertilization just after

thinning (scenario #6) increased NR by $370 to $375/acre compared to the thin only scenario (#2, Table 6 and 7) for loblolly and slash pine.

Fertilization in unthinned slash pine stands with 200 N + 40 P/acre at age 16-years-old ($100/ac cost in yr 16), increased ROR by about 1 percentage point across the three SP+PL levels (scenario #1 vs #3, Table 6). Fertilization at age 16-years ROR (scenario #3) was about 0.10 to 0.70 percentage points below the thin only scenario (#2).

The combination of thinning slash pine at age 15-years and fertilization at age 16-years (scenario #6) improved ROR by 0.62 to 0.76 percent over the thin only scenario (#2) and increased harvest revenue by $475/ac.

Fertilization in unthinned loblolly pine stands with 200 N + 40 P/acre at age 16-years-old ($100/ac cost in yr 16), increased ROR by a 0.74 to 0.89 percentage point across the three SP+PL levels (scenario #1 vs #3, Table 7). Fertilization at age 16-years ROR (scenario #3) was about 0.46 to 1.15 percentage point below the thin only scenario (#2).

The combination of thinning loblolly pine at age 15-years and fertilization at age 16-years (scenario #6) improved ROR by 0.53 to 0.65 percent over the thin only scenario (#2) and increased harvest revenue by $472/ac.

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 differing by increments of $125/acre within a scenario by species. Establishment cost impact on the time-value of money though was significant.

The impact of establishment costs within a management level (scenario) was large enough to illustrate the importance of choosing the right SP+PL for a given site. The impact of SP+PL on internal rates of return became larger as management inputs increased for both species. For example: the base slash pine scenario (#1) of no thin, no fert, no straw had RORs of 5.48, 6.96, and 9.30 percent, differences of 1.48 and 2.34 percent. Slash pine scenario #5 had RORs of 12.27, 15.71, and 24.64 percent, differences of 3.44 and 12.37 percent compared to the base scenario (#1, Table 6). The impact of SP+PL in the loblolly scenarios showed the same trend as the slash pine scenarios.

Impact of management inputs on net revenues and rates of return

Generally, increasing management, whether through a thinning or with fertilization or clean-up for pine straw after a thinning with their associated costs, increased net revenue and rates of return for both species. Thinning improved net revenue by $350 to over $400/acre for slash and loblolly pine, respectively (Table 6 and 7). Fertilization increased NR by $350 to $475/acre over the unfertilized scenario counterparts. Adding pine straw increased NR by a wide range (from $285 to $1400/acre, Table 6 and 7). In

each case NR increased with increasing forest management within a given SP+PL level for both species.

Thinning (scenario #2) improved RORs for both species by 1.19 to 1.87 percent over the unthinned scenario (#1, Table 6 and 7). The exception was scenario #3 (fert @ age 16-yrs, no thin, no straw). The ROR for scenario #3 for slash (Table 6) and loblolly (Table 7) was lower by 0.14 to 1.15 percentage point than scenario #2 (no fert, thin, no straw).

Adding pine straw income greatly improved RORs for both species, by 2.80 to 6.42 percent for slash pine (scenario # 4 vs 3) and 2.19 to 4.86 percent for loblolly (scenario #4 vs 3) at the $50/ac/yr from age 8- through 23-years (no thin, Table 6 and 7). The $100/ac/yr pine straw revenue from age 8- through age 23-years further improved RORs by 2.94 to 8.03 percent for slash pine (scenario #5 vs 4) and by 3.61 to 9.36 percent for loblolly pine (scenario #5 vs 4) over the $50/ac/yr income rate.

Summary

Wood flow, fertilization responses, and pine straw

The 2.09 (5.77 tons/ac/yr) and 2.35 cd/ac/yr (6.48 tons/ac/yr) productivity levels at age 24-years-old for slash and loblolly, respectively, are very realistic on most cut-over sites with chemical site preparation and post-plant herbaceous weed control (Pienaar and Rheney 1996) and is 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 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 rates of return.

The 0.50 cd/ac/yr (1.37 tons/ac/yr) for slash and 0.65 cds/ac/yr (1.79 tons/ac/yr) for loblolly average increase in wood production is consistent with published reports (Jokela and Stearns-Smith 1993, Martin and others 1999, NCSFNC 1999) with nitrogen plus phosphorus fertilization at ages 6- and 16-years. 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 a higher net revenue and ROR with the aforementioned assumptions. Recent studies (Shiver and others 1999) 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.

Discussion

Non-industrial private forest landowners do have some attractive forest management options with both slash and loblolly pine even when using low to medium stumpage prices. Generally, increasing forest management activities (thinning, fertilization, adding pine straw) increased rates of return at the wood growth increments used.

If a rate of return of 8 percent or better is a landowner goal with the stumpage prices used (Georgia 1st Qtr 2004, TM-S 2004) and the wood production rates of 2 cd/ac/yr or better, then the thin scenario (#2) for both loblolly and slash pine at the lower two site preparation and planting establishment costs achieved that. At the highest SP+PL level, an ROR of 8 percent or better was achieved only when pine straw pine straw income @ $50/ac/yr or better was realized for both species (scenarios 4, 5, 7-9, Table 6 and 7).

If a rate of return of 10 or better is a landowner objective under the aforementioned assumptions, then pine straw production to achieve $100/ac/yr for both loblolly and slash pine is required @ the highest SP+PL level. A 10 percent or better ROR can be realized at the moderate SP+PL cost with the rake @ $50/ac/yr, fertilize once, and thin or no thin scenarios (#4 and 7) for both species (Table 6 and 7). At the lowest SP+PL cost all scenarios but scenario #1 for slash pine had an ROR greater than 10 percent.

A rate of return of 12 percent or better is realized at the highest SP+PL level when $100/ac/yr pine straw income, no thinning, and fertilize twice is realized for slash and loblolly pine and the $100/ac/yr pine straw income, fertilize twice, thin, clean-up, and rake @ $50/ac/yr to clearcut scenario (#9) for loblolly. At the moderate SP+PL level, a ROR of 12 percent or better was realized with the rake @ $100/ac/yr, fertilize twice, no thin (scenario #5), or rake @ $100/ac/yr prior to thinning, fertilize, thin and rake or no-rake straw (scenarios 8 and 9) for loblolly and slash pine (Table 6 and 7).

Literature Cited

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

Blevins, D.;Allen, H.L.; Colbert, S; Gardner, W. 1996. Nutrition management for longleaf pinestraw - Woodland Owner Notes. NC Coop. Ext Serv. Paper.

Clark III, A., Daniels, R.F. 2002. Wood quality of slash pine and its effect on lumber, paper, and other products. Presentation at the Slash Pine Symposium. Jekyll Island, GA. April 23-25, 2002.

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.

Jokela, E.J.; Stearns-Smith, S.C. 1993. Fertilization of established southern pine stands: Effects of single and split nitrogen treatments. SJAF 17(3):135-138.

Martin, S.W.; Bailey, R.L.; Jokela, E.J. 1999. Growth and yield predictions for lower coastal plain slash pine plantations fertilized at mid-rotation. SJAF 23(1): 39-45.

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.

NCSFNC. 1998. North Carolina State University Forest Nutrition Coop - 26th Annual report. 23 p. School of Forest Resources, NCSU, Raleigh, NC.

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.

Peinaar, L.V.; Shiver, B.D.; Rheney, J. W. 1996. Yield prediction for mechanically site-prepared slash pine plantations in the Southeastern Coastal Plain. PMRC Tech. Rep. 1996-3. 57 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 2004. Timber Mart So stumpage prices – 1st quarter South Georgia 2004. UGA-WSFR, Athens, GA 30602-2152.

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 (net of property taxes and marketing costs) per cord stumpage prices used in the profitability analysis of slash and loblolly scenarios, Georgia State average, price per ton (1stQ TM-S 2004).

Item, Price level	Cash or net	Pulpwood ($/Ton)	Chip-N-Saw ($/Ton)	Sawtimber ($/Ton)
Low	cash	5.04	21.36	35.91
	net	4.51	19.12	32.14
Medium	cash	6.42	25.80	40.97
	net	5.75	23.09	36.51

Table 3. Fertilizer costs at $100/acre per application expressed as present values and annual equivalent values (AEV), as used in the profitability analysis for 24-year slash and loblolly scenarios calculated at 8%.

Rotation (yrs)	Applied (yrs)	Present value of a periodic cost ($/ac)	Annual equivalent value of the periodic cost ($/ac/yr)
24	6	63.02	5.99
	16	29.19	2.77
	6, 16	92.21	8.76

Table 4. Pine straw periodic per acre income levels expressed as present values and annual equivalent values (AEV) as used in the profitability analysis of slash and loblolly pine scenarios over a 24-year rotation calculated at 8%.

Item Rotation	Thin scenario	Periodic income/ac/yr. raked ($/ac)	Present value of periodic income ($/ac)	AEV of periodic income ($/ac/yr)
24 yrs.	Thin at age 15 years	50 & 0[1]	140.64	13.36
		100 & 0[1]	281.28	26.72
		100 & 50[2]	351.64	33.40
	No thin	50[3]	239.11	22.71
		100[3]	478.21	45.42

[1] With thinning, pinestraw raked in years 8-14, for 24-year rotation.
[2] With thinning, pinestraw raked in years 8-14 and 17-23, for 24-year rotation.
[3] With no thinning, pinestraw raked in years 8-23, for 24-year rotation.

Table 5. Clean-up cost, in year 16, after thinning of slash and loblolly pine scenarios over a 24-year rotation, expressed as present values and annual equivalent values (AEV) as used in the profitability analysis calculated at 8%.

Rotation	Clean-up cost in year 16 ($/ac)	Present value of clean-up cost ($/ac)	AEV of clean-up cost ($/ac/yr)
24 years	70	20.43	1.94

Table 6. A comparison of **slash pine plantation** management scenarios[1] under a 24-year rotation and their effect on net revenue and rate of return (ROR), with site prep and plant (SP&PL) cost of **$125, $250, and $375/acre**.

Treatment					SP&PL @ $125		SP&PL @ $250		SP&PL @ $375	
Scenario # Fert. @ Yr.	Thin yr 15	Pine straw ($/ac)	% PW	MIA[2] Tons/Cords	Net Revenue[3] ($/ac)	ROR[4] (%)	Net Revenue [3] ($/ac)	ROR[4] (%)	Net Revenue [3] ($/ac)	ROR[4] (%)
1 N	N	N	60	5.77, 2.09	1437	9.30	1312	6.96	1187	5.48
2 N	Y		46	5.55, 2.01	1787	10.89	1662	8.28	1537	6.67
3 Y, 16	N	N	48	6.28, 2.28	1912	10.19	1787	7.96	1662	6.53
4 Y, 6		50[5]	52		2605	15.16	2480	10.95	2355	8.77
5 Y, 6, 16		100[5]	43	6.82, 2.48	3686	24.64	3561	15.71	3436	12.27
6 Y, 16	Y	N	40	6.16, 2.23	2162	11.51	2037	9.00	1912	7.43
7 Y, 6		50 & 0[6]	43		2447	13.83	2322	10.46	2197	8.53
8 Y, 6		100 & 0[6]			2797	18.12	2672	12.87	2547	10.31
9 Y, 6, 16		100 & 50[7]	38	6.57, 2.38	3302	19.42	3177	13.80	3052	11.12

Table 7. A comparison of **loblolly pine plantation** management scenarios[1] under a 24-year rotation and their effect on net revenue and rate of return (ROR), with site prep and plant (SP&PL) cost of **$125, $250, and $375/acre**.

Treatments					SP&PL @ $125		SP&PL @ $250		SP&PL @ $375	
Scenario # Fert. @ Yr.	Thin yr 15	Pine straw ($/ac)	% PW	MIA[2] Tons/Cords	Net Revenue[3] ($/ac)	ROR[4] (%)	Net Revenue[3] ($/ac)	ROR[4] (%)	Net Revenue[3] ($/ac)	ROR[4] (%)
1 N	N	N	60	6.48, 2.35	1701	10.04	1576	7.66	1451	6.16
2 N	Y		46	6.24, 2.26	2110	11.91	1985	9.18	1860	7.51
3 Y, 16	N	N	48	7.15, 2.59	2173	10.76	2048	8.50	1923	7.05
4 Y, 6		50[5]	52		2871	15.62	2746	11.42	2621	9.24
5 Y, 6, 16		100[5]	43	7.94, 2.88	4171	24.98	4046	16.24	3921	12.85
6 Y, 16	Y	N	40	6.99, 2.53	2481	12.44	2356	9.81	2231	8.17
7 Y, 6		50 & 0[6]	43		2751	14.63	2626	11.16	2501	9.18
8 Y, 6		100 & 0[6]			3101	18.83	2976	13.51	2851	10.91
9 Y, 6, 16		100 & 50[7]	38	7.68, 2.78	3831	20.56	3706	14.83	3581	12.08

1 Uninflated, 8% discount rate, before income taxes, GaPPS v 4.20

2 MAI = Mean Annual Increment of wood growth, Tons & Cords/A/yr.

3 Net Revenue = Harvest revenue(s) – SP+PL cost – (annual cost x 24 yrs) – fert cost(s) – clean up cost + pine straw revenues (today's $).

4 ROR = Rate of Return (percent).

5 With no thinning, pinestraw raked years 8-23.

6 With thinning, pinestraw raked years 8-14.

7 With thinning, pinestraw raked years 8-14 and 17-23