Series paper #5

Economics of growing slash and loblolly pine on a 33-year rotation with and without thinning, fertilization, and pine straw – annual equivalent value and soil expectation value

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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 mixed product class 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 annual equivalent value (AEV) and soil expectation value (SEV). Net revenue and rate of return (ROR) are discussed in series paper #4 for the 33-year rotation scenarios.

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. Many NIPFLs speculate how attractive chip-n-saw / sawtimber rotations with thinning are for southern pines. To address these questions, we used the Georgia Pine Plantation (GaPPs 4.20) growth and yield Model developed by Bailey and Zhao (1998).

Methodology

Common assumptions

The rotation age was set at 33-years for slash and loblolly pine plantations. Annual equivalent value (AEV) and soil expectation value (SEV) were calculated. A discount rate of 8 percent was used 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 $103.63 during the 33-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 relatively low 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 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 high ($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© (TMS) 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 TMS prices for pulpwood and chip&saw were used for thinning prices and average TMS prices for pulpwood, CNS, and ST are used for the clearcut. Cash and net converted prices are found in Table 2. It is assumed that land is owned throughout the scenarios.

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 1.91 cd/ac/yr (5.26 tons/ac/yr) @ age 33-years-old without fertilization and thinning was assumed (Table 7). The base slash scenario woodflow was 12 percent less than base loblolly woodflow (Shiver and others 1999) at age 33-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 2.15 cds/ac/yr (5.95 tons/ac/yr, Table 8) through age 33-years-old without fertilization or thinning. The base loblolly woodflow was 12 percent greater than the slash base woodflow (Shiver and others 2000) at age 24-years. The assumed fertilizer applications aggressively increased merchantable volume by an average of 0.65 cd/ac/yr (1.79 tons/ac/yr) for eight to ten years (NCSUFNC 1998). Figures 1, 2, and 3 show wood flow for scenarios #1, 2, and 3 (scenario #4, 5, and 6 have same wood flows as #1, 2, and 3, respectively).

Scenarios for the 33-year Rotation

The following are the seven slash (Table 7) and loblolly (Table 8) pine scenarios:
(1) thin @ age 15- and 24years to 65 ft^2/ac, no straw, no fertilization ,
(2) thin @ age 15- and 24years to 65 ft^2/ac, no straw, fertilize @ age 25-years,
(3) thin @ age 15- and 24years to 65 ft^2/ac, no straw, fertilize @ ages 16- and 25-years,
(4) thin @ age 15- and 24 years to 65 ft^2/ac, pine straw @ $50/ac/yr from age 8- through age 14-years, no fertilization,
(5) thin @ age 15- and 24 years to 65 ft^2/ac, pine straw @ $100/ac/yr from age 8- through age 14-years, fertilize @ age 6-years,
(6) thin @ age 15- and 24 years to 65 ft^2/ac, pine straw @ $100/ac/yr from age 8- through age 14-years, fertilize @ age 6- and 25-years, and
(7) thin @ age 15- and 24 years to 65 ft^2/ac, pine straw @ $100/ac/yr from age 8- through age 14-years, clean-up in year 16, pine straw @ $50/ac/yr from age 17- through age 23-years, fertilize @ age 6-, 16-, and 25-years.

Forest management activities

Thinning

All scenarios for both pine species include two thinnings; @ age 15- and 24-years-old. Residual basal area (RBA), after thinning (5^{th} row with selection from below) is set at 65 sq. ft/ac.

Fertilization

Either no fertilization (scenario #1 and 4) or a fertilizer and application cost of $100/ac for slash and loblolly per application at age 6-, 16-, and/or 25-years were 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 25-year fertilizer application was made to increase sawtimber volume. 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: (#2) to delay fertilization cost and/or to promote additional growth on best (leave) trees only after the 2nd thinning (age 25-years only), (#3) to fertilize residual trees after each thinning (ages 16- and 25- years), (#5) to maintain or enhance pine straw production from canopy closure (age 6-years only), (#6) to maintain pine straw production (age 6- and 25-years) to the 1st thinning then put more growth on sawtimber trees after 2nd thin, and (#7) 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 1st and 2nd thinning (age 16- and 25-years, Table 7 and 8).

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 re-commencing 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 incomes for both species are #s 4 through 7 (Table 7 and 8).

Results

Annual equivalent value and soil expectation value ranges

Annual equivalent values (AEVs) ranged from -$12 (base slash pine scenario with highest site prep and plant cost) to $47/ac/yr (loblolly with pine straw @ $100/A/yr; age 8-14 yrs and $50/A/yr age 17-23 yrs, fertilize three times with lowest site prep and plant cost, Table 7 and 8). Ranking of scenarios by AEV within a SP+PL level were as follows: 7 > 6 > 5 > 4 = 3 > 2 > 1 for slash pine. Ranking of scenarios by AEV within a SP+PL level were as follows: 7 > 6 > 5 > 4 > 3 > 2 > 1 for loblolly pine. AEVs for slash pine (growing at approximately 15 percent less than loblolly) were less than corresponding loblolly scenarios (Table 7 and 8).

Soil expectation values (SEVs) for all scenarios (42 scenarios in all) for both species ranged from -$144/ac and -$96/ac (base slash and loblolly scenarios with highest site preparation and planting cost, respectively) to $496/ac and $589/ac (slash and loblolly pine scenarios with the lowest site preparation and planting cost, fertilize three times, and rake straw @ $100/ac/yr from age 8- through 14-years and $50/ac/yr from age 17- through age 23-years, respectively) using the aforementioned assumptions (Table 7 and 8). Ranking of scenarios by SEV (within a SP+PL level) were as follows: 7 > 6 > 5 > 4 > 3 > 2 > 1 for loblolly pine (with the 0.65 cd/ac/yr fertilizer response). Ranking of the slash pine scenarios by IRR (within a SP+PL level) were as follows: 7 > 6 > 5 > 4 > 3 ≈ 2 > 1 (with the 0.50 cd/ac/yr fertilizer response).

Pine straw income impact on annual equivalent value and soil expectation value

Pine straw income prior to thinning (age 8-14-yrs) increased AEV by $12 to $13/ac/yr, (scenario #4, pine straw only), $22/ac/yr (scenario #5, straw + extra wood), and $23 to $27/ac/yr (scenario #6, straw + extra wood) compared to the no pine straw, no fertilization scenario (#1) for slash and loblolly pine (Table 7 and 8). When pine straw was performed before and after the thinning, (scenario #7) AEV increased by $30 and $33/ac/yr over the no pine straw, no fertilization base scenario (#1) for slash and loblolly, respectively (Table 7 and 8).

The addition of pine straw income (@ $50/ac/yr from age 8 – 14 years) for slash and loblolly pine in scenario #4 increased base scenario (#1) SEVs by $152 to $153/ac (Table 7 and 8). Raising the annual pine straw income to $100/ac/yr from age 8- through 14-years and fertilizing twice (scenario #6) increased SEVs by $288 (slash pine) to $338/ac (loblolly pine) compared to scenario #1. Pine straw raking prior to thinning (age 8 through 14-years) at $100/ac/yr and after the 1st thinning (ages 17- through 23-years) at $50/ac/yr (scenario #7) increased SEVs by $368 (slash pine) to $419/ac (loblolly pine) over the base scenario (#1, Table 7 and 8).

Impact of fertilization on annual equivalent value and soil expectation value
Annual equivalent values increased slightly (by $2/ac/yr) with fertilization at age 25-years (scenario #2) compared to the no fertilization scenario (#1) for slash and loblolly pine (Table 7 and 8). Fertilization after both thinnings (scenario #3) improved AEVs slightly ($2/ac/yr for slash pine and $6/ac/yr for loblolly pine) compared to the thin only scenario (#1, Table 7 and 8).

Fertilization in slash pine stands with 200 N + 40 P/acre after the first thinning increased SEVs by $20 to 21/ac across the three SP+PL levels and loblolly SEVs by $19/ac (scenario #1 vs #2, Table 7 and 8). Fertilization at age 16-and 25-years SEVs (scenario #3) were essentially the same ($1/ac less than) as fertilize once after the first thinning scenario (#2) for slash pine. Fertilization at age 16-and 25-years SEVs for loblolly pine (scenario #3) were improved by $51/ac over fertilize once after the first thinning scenario (#2).

Impact of establishment costs on net annual equivalent value and soil expectation value
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 AEVs and SEVs became larger as management inputs increased for both species. For example: the base slash pine scenario (#1) of thin twice, no fertilization, no pine straw had SEVs of -$144, -$8, and $127/ac/yr for the $375, $250 and $125/acre SP+PL costs, respectively with differences of $135 and $271/ac. Slash pine scenario #7 had SEVs of $225, $360, and $496/ac; differences of #135 and $271/ac as well (Table 7). The impact of SP+PL in the loblolly scenarios showed the same trend as the slash pine scenarios. The base loblolly pine scenario (#1) SEVs were -$96, $40, and $176/ac for the $375, $250 and $125/acre SP+PL costs, respectively with differences of $136 and $271/ac (Table 8). Loblolly pine scenario #7 SEVs were $318, $453, and $589; differences of $135 and $271/ac.

Impact of management inputs on annual equivalent value and soil expectation value
Generally, increasing management, whether through fertilization or with pine straw increased AEV and SEV for both species. Fertilization improved AEVs by $2/ac/yr and SEVs by $19 to $20/ac for slash pine (Table 7). Fertilization improved AEVs by $2 to $6/ac/yr and SEVs by $19 to $51/ac for loblolly pine (table 8). Adding pine straw increased SEVs by $153 to $368/acre for slash pine and by $152 to $418/acre (pine straw + extra wood) for loblolly pine (scenario #4 and 7 vs #1, Table 7 and 8).

Summary

Wood flow, fertilization responses, and pine straw
The 1.91 (5.26 tons/ac/yr) and 2.15 cd/ac/yr (5.95 tons/ac/yr) base productivity levels through age 33-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 may be 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 fertilization response for slash pine of an average of 0.50 cd/ac/yr (1.38 tons/ac/yr) for 8 to 10 years (Jokela and Stearns-Smith 1993, Martin and others 1999) is realistic assuming the site is deficient in N or N+P and the genetics and stocking are not response limiting. The fertilization response average of 0.65 cd/ac/yr (1.79 tons/ac/yr) for loblolly pine over 8 to 10 years is slightly above an average response (NCSFNC 1999), therefore the site must be very deficient in N or N+P, leaf area is low and genetic and stocking are not growth limiting. 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. Adding potassium (K), magnesium (Mg), sulfur (S), calcium (Ca) and/or micro-nutrients (boron, manganese, or copper) to the above assumed N+P application(s) may be necessary based on site and stand needs which should increase fertilization cost.

When wood value only is considered, loblolly produced more wood, more wood value (a diameter driven function), and a higher AEV and SEV 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.

Adding fertilization to stand management increased AEVs and SEVs slightly over the unfertilized scenario. Adding pine straw (@ $50 or $100/ac/yr) increased AEVs and SEVs to a greater extent (no cost initially to rake and annual returns early the rotation).

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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, $100/acre/periodic application, per acre cost levels expressed as present values and annual equivalent values (AEV), as used in the profitability analysis for the 33-year slash and loblolly scenarios discounted at 8%.

Rotation (yrs)	Applied (yrs)	Present value of a periodic cost ($/ac)	Annual equivalent value of the periodic cost ($/ac/yr)
33	6	63.02	5.47
	6, 16	92.21	8.01
	6, 25	77.62	6.74
	16, 25	43.79	3.80
	6, 16, 25	106.81	9.28
	25	14.60	1.27

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 the 33-year rotation discounted at 8%.

Rotation	Thin scenario	Periodic income/ac/yr. raked ($/ac)	Present value of periodic income ($/ac)	AEV of periodic income ($/ac/yr)
33 yrs	Thin at age 15 & 25 years	50 & 0[1]	140.64	12.21
		100 & 0[1]	281.28	24.43
		100 & 50[2]	351.64	30.54

[1] With thinning, pinestraw raked in years 8-14.
[2] With thinning, pinestraw raked in years 8-14 and 17-23.

Table 5. Clean-up cost, in year 16, after thinning of slash and loblolly pine scenarios over the 33-year rotation, expressed as present values and annual equivalent values (AEV) as used in the profitability analysis discounted at 8%.

Rotation	Clean-up cost in year 16 ($/ac)	Present value of clean-up cost ($/ac)	AEV of clean-up cost ($/ac/yr)
33 years	70	20.43	1.77

Table 6. Stand management cost including active stand management, fire protection, and prescribed fire for loblolly and slash plantations 33-year rotation discounted at 8%.

Rotation	Management cost ($/ac/yr)	Present value of Management cost year 1, ($/ac)
33 years	9	103.62

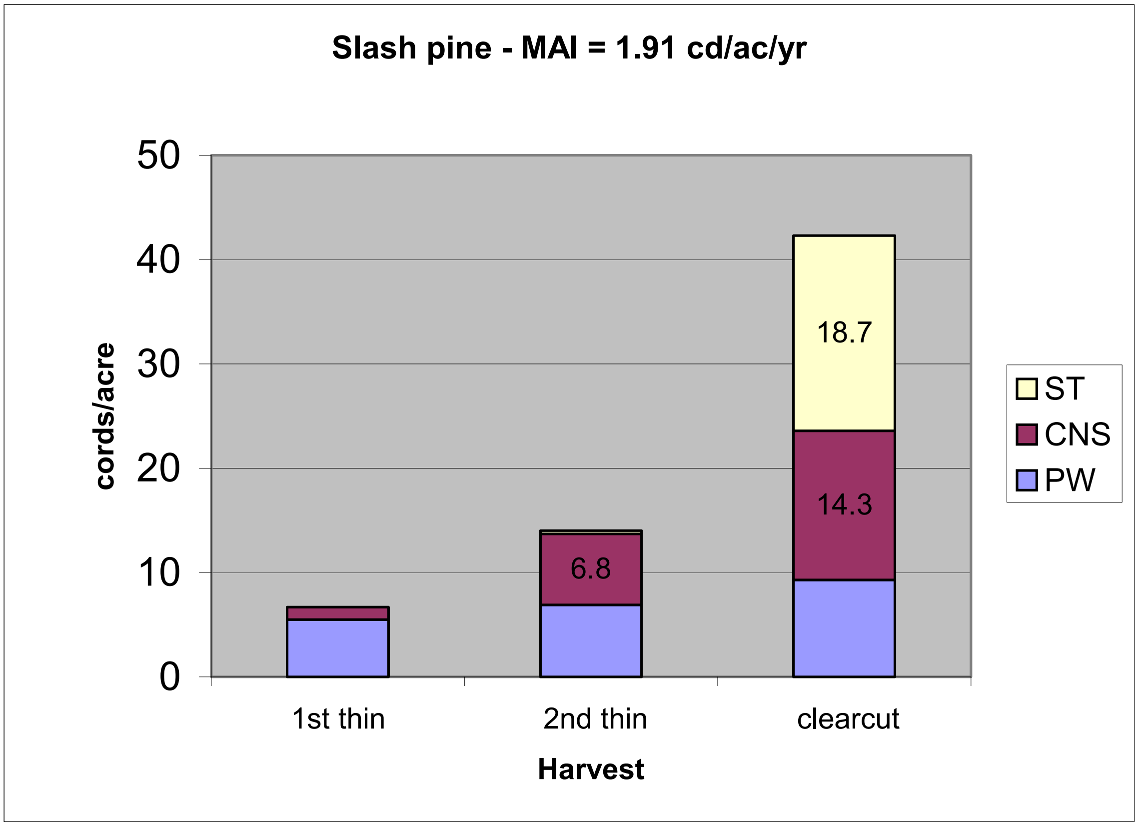
Table7. A comparison of **slash pine plantation** management scenarios[1] under a **33-year rotation** with thinning in years 15 and 24 and their effect on economic variables, with site prep and plant (SP&PL) cost of **$125, $250, and $375/acre**.

Treatments						SP&PL @ $125		SP&PL @ $250		SP&PL @ $375	
Scenario # Fert. @ yr.	Pine straw ($/ac)	% PW	% CNS	% St	MAI[2] Ton, Cord	AEV[3] ($/ac/yr)	SEV[4] ($/ac)	AEV[3] ($/ac/yr)	SEV[4] ($/ac)	AEV[3] ($/ac/yr)	SEV[4] ($/ac)
1 N		35	35	30	5.26, 1.91	10	127	-1	-8	-12	-144
2 Y, 25	N	34	34	32	5.58, 2.02	12	148	1	12	-10	-124
3 Y, 16, 25		33	32	35	5.86, 2.13	12	147	1	11	-10	-125
4 N	50 & 0[5]	34	35	30	5.26, 1.91	22	280	12	144	1	9
5 Y, 6	100 & 0[5]	34	34	32	5.58, 2.02	32	401	21	265	10	129
6 Y, 6, 25		33	32	35	5.86, 2.13	33	415	22	280	12	144
7 Y, 6, 16, & 25	100 & 50[6]	32	31	37	6.26, 2.27	40	496	29	360	18	225

Table 8. A comparison of **loblolly pine plantation** management scenarios[1] under a **33-year rotation** with thinning in years 15 and 24 and their effect on economic variables, with site prep and plant (SP&PL) cost of **$125, $250, and $375/acre**.

Treatments						SP&PL @ $125		SP&PL @ $250		SP&PL @ $375	
Scenario # Fert. @ yr.	Pine straw ($/ac)	% PW	% CNS	% St	MAI[2] Ton, Cord	AEV[3] ($/ac/yr)	SEV[4] ($/ac)	AEV[3] ($/ac/yr)	SEV[4] ($/ac)	AEV[3] ($/ac/yr)	SEV[4] ($/ac)
1 N		34	36	29	5.95, 2.15	14	176	3	40	-8	-96
2 Y, 25	N	34	34	32	6.45, 2.34	16	195	5	59	-6	-77
3 Y, 16, 25		33	32	35	6.99, 2.54	20	246	9	110	-2	-26
4 N	50 & 0[5]	34	36	29	5.95, 2.15	26	328	15	193	5	57
5 Y, 6	100 & 0[5]	34	34	32	6.45, 2.34	36	447	25	312	14	176
6 Y, 6, 25		33	32	35	6.99, 2.54	41	514	30	379	19	243
7 Y, 6, 16, & 25	100 & 50[6]	32	31	37	7.38, 2.68	47	589	36	453	25	318

[1] Uninflated, 8% discount rate, before taxes, GaPPS v 4.20.
[2] MAI = Mean Annual Increment of wood growth for 33 yrs., tons & cords/A/yr.
[3] AEV = Annual Equivalent Value, net present worth as an annuity.
[4] SEV = Soil Expectation Value, calculated from perpetual rotations.
[5] With thinning, pinestraw raked years 8-14.
[6] With thinning, pinestraw raked years 8-14 and 17-23.



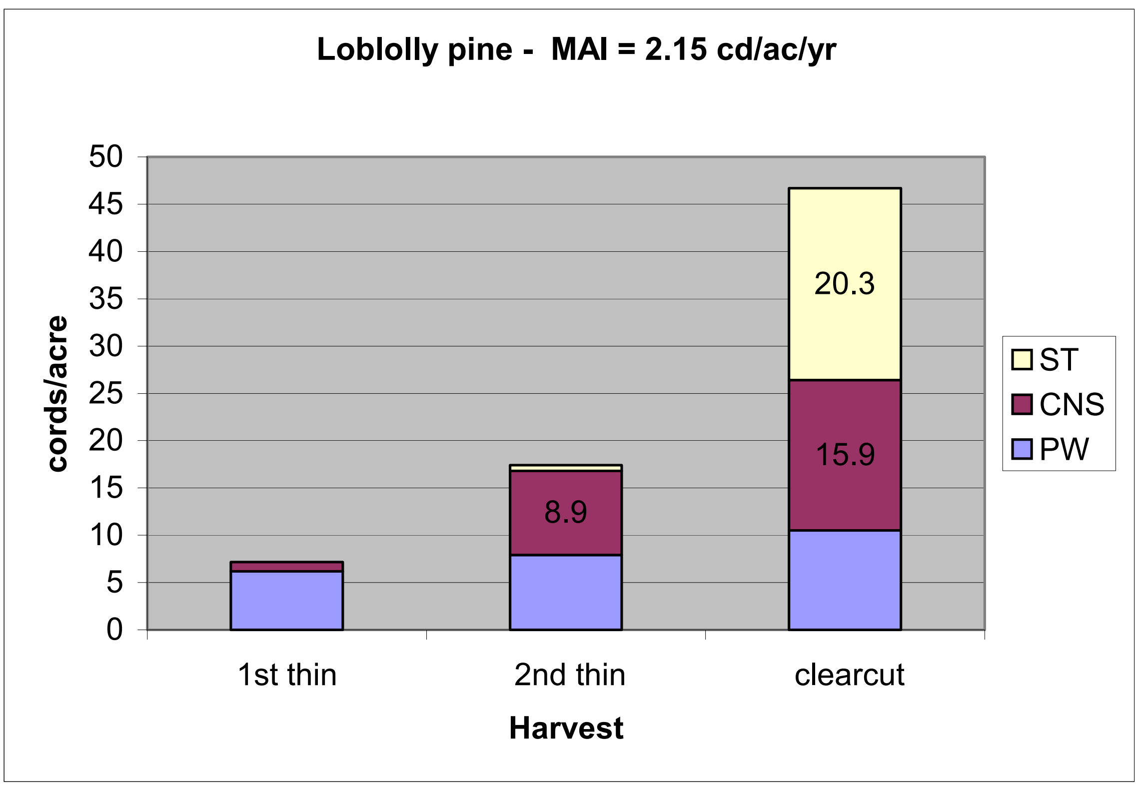


Figure 1. Slash and loblolly pine 33-year rotation wood flow for scenario #1 and #4. (PW=pulpwood; CNS=chip-n-saw; ST=sawtimber; MAI=mean annual increment)

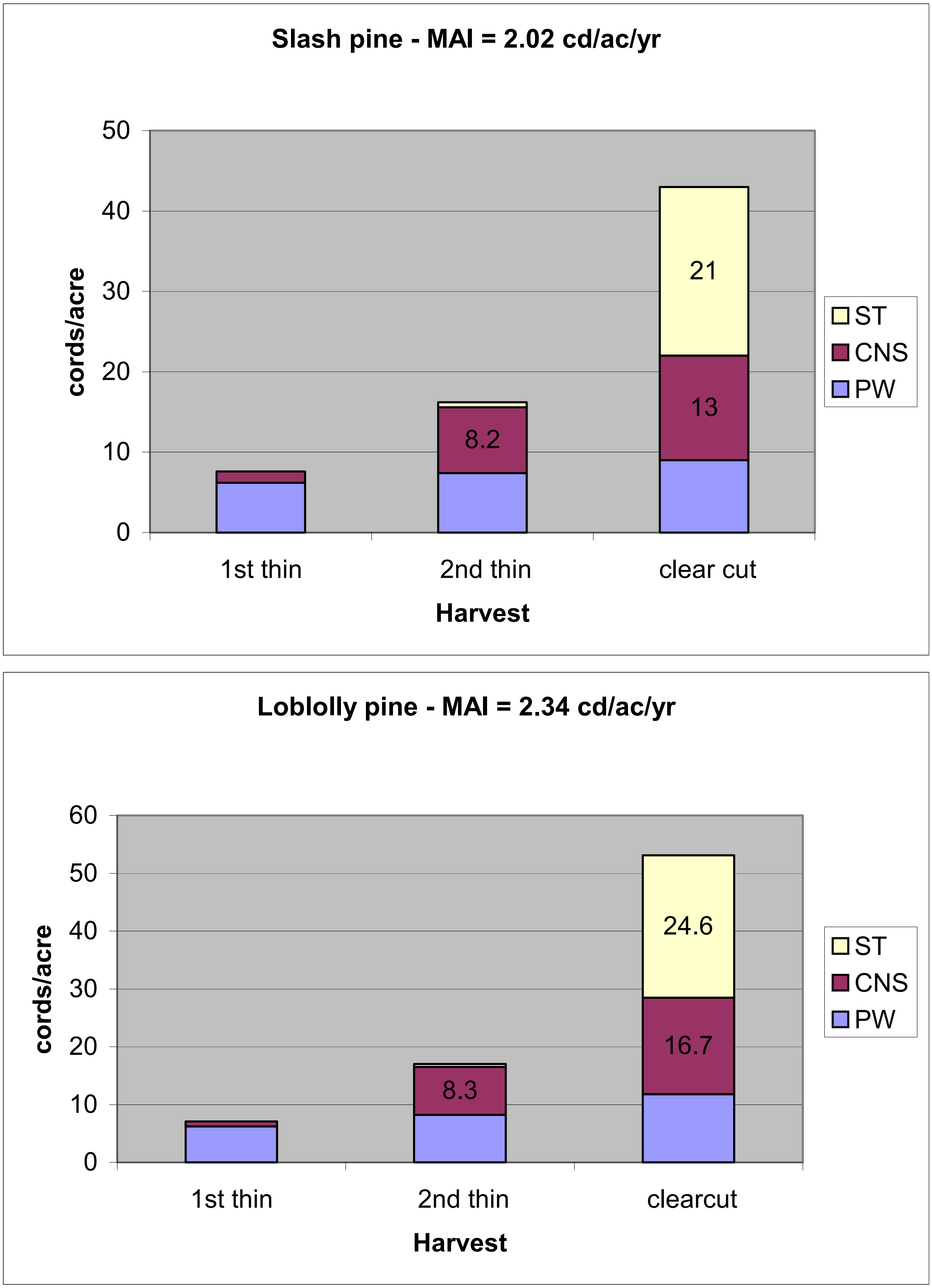


Figure 2. Slash and loblolly pine 33-year rotation, fertilized at age 25-years, wood flow for scenario #2 and #5. (PW=pulpwood; CNS=chip-n-saw; ST=sawtimber; MAI=mean annual increment)

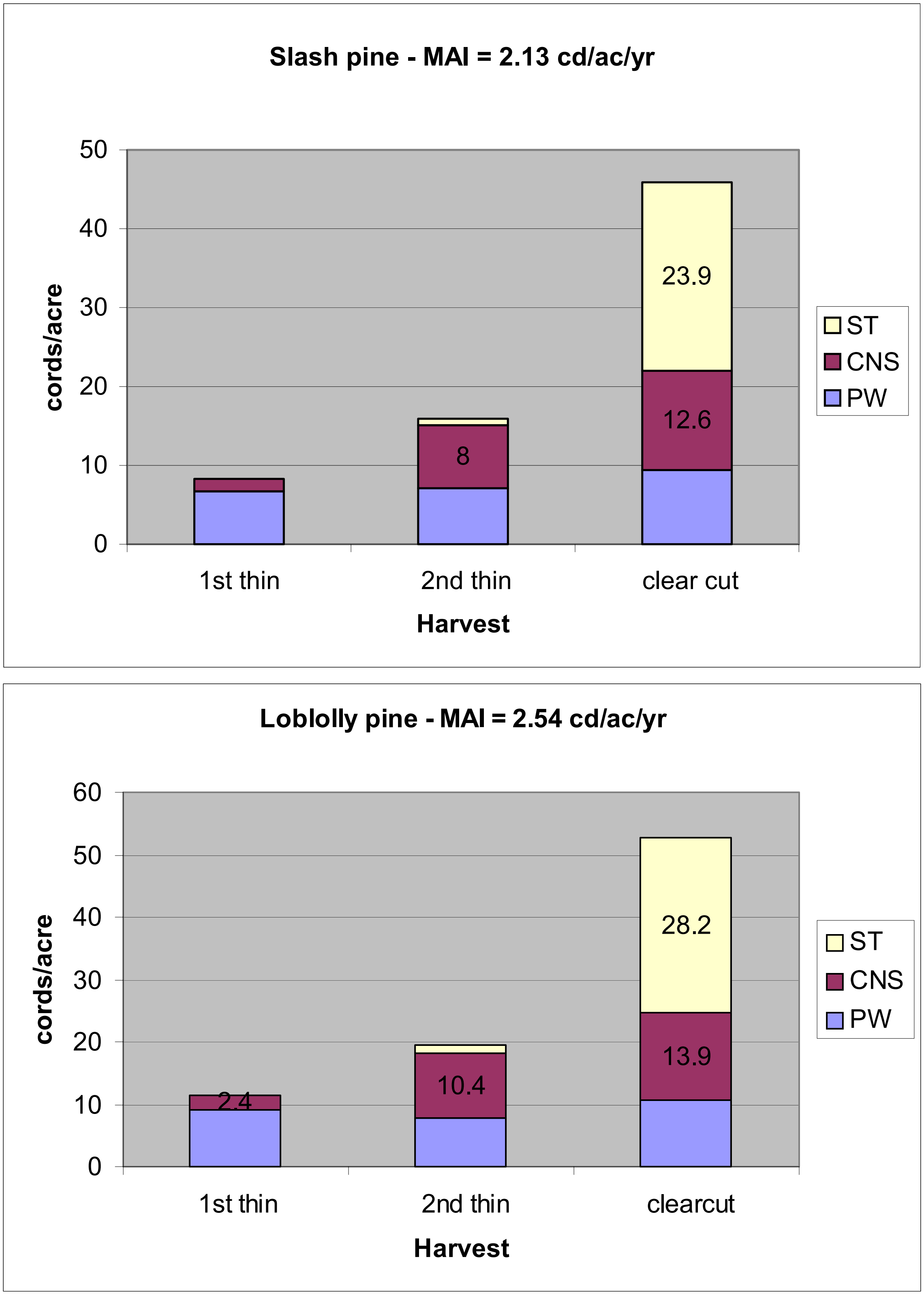


Figure 3. Slash and loblolly pine 33-year rotation wood flow for scenario #3 and #6. (PW=pulpwood; CNS=chip-n-saw; ST=sawtimber; MAI=mean annual increment)