COST EFFECTIVENESS OF NATURAL REGENERATION FOR SUSTAINING PRODUCTION CONTINUITY IN COMMERCIAL PINE PLANTATIONS

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Abstract—Reforestation is a key to production continuity in commercial pine plantations. Although natural and artificial regeneration methods have been used successfully for pine seedling establishment, it is seedling growth during early stage of plantation development that affects the financial potential of a pine plantation. A study was initiated to determine the effect of regeneration method on seedling growth and development. A seed tree regeneration harvest was compared to a clear cut and plant regeneration harvest. The growth of the natural stand was compared to planted plantations with initial stocking densities of 1,200 and 680 seedlings per acre. In addition, the impact of mechanical and chemical site preparation, and herbaceous weed suppression was evaluated. Merchantable volume at age 15 varied between reforestation methods, seedling stocking densities and vegetation management practices being 540, 1,715, 2,730 and 3,440 feet^3 per acre for natural plantation and three planted plantations, respectively. Age 15 land expectation values for the respective reforestation methods were 135, 170, 785 and 1,053 dollars per acre.

INTRODUCTION

On cut over timber land, productivity of commercial loblolly pine (Pinus taeda L.) plantations depends on seedlings competing successfully for finite levels of soil resources. Reforestation phase of plantation development includes site preparation, regeneration (seedling establishment) and post-establishment weed suppression. Although competitive pressure exerted by an existing plant community hampers early seedling growth, seedling establishment plays a pivotal role in the reforestation process. Regenerated stands should be adequately stocked with well distributed seedlings to optimize soil exploitative potential during the first growing season.

During the first growing season, competition from hardwood brush and herbaceous weeds reduces seedling survival and decreases early diameter and height growth. Thorough site preparation suppresses this initial interference, but as the growing season progresses, encroaching vines, resurgent hardwood brush and unwanted pine seedlings begin to compete vigorously for growing space. Regeneration method, natural or artificial, can have a significant impact on mitigating competitive interference during the seedling stage of plantation development.

Natural regeneration methods have been used successfully to establish seedlings on cut over pine plantations but seedling density is usually excessive. Since, pine diameter growth loss has been detected in both dominant and intermediate crown classes of 3-year-old plantations at seedling densities that exceed 500 trees per acre (TPA) (Sprinz and others 1979), natural regeneration may not be a cost effective seedling establishment method for commercial pine plantations. A study was initiated to determine the cost effectiveness of reforestation methods on growth and development of commercial pine plantations. Growth of a seed tree regenerated plantation will be compared to clear cut and plant regenerated plantations with seedling planting densities of 1,200 and 680 seedlings per acre.

METHODS

Data from two studies were used to compare natural and artificial regenerated pine plantation development and growth. The studies were established at the Hill Farm Research Station on the same site but in different years, 1955 and 1984. Predominant soil types are Mahan fine sandy loam (clayey, kaolinitic, thermic Typic Halpludults) and Wolfpen loamy sand (loamy, siliceous, thermic Arenic Paleudalfs) with a 25 year site index for loblolly pine of 70 feet.

1955 Study

The study was initiated during 1955 in a 25-year-old understock stand of old field loblolly and shortleaf pine (Pinus enchinata Mill) that had a stocking density of 167 TPA and mean DBH of 7.7 inches. The stand was subdivided into sixteen 0.5 acre plots. Twelve plots were randomly selected for a seed tree regeneration harvest that left a residual stand of approximately seven loblolly pines per plot. The four remaining plots were clear cut and prepared to plant pine seedlings. The study treatments were as follows: 1) Seed Tree Harvest and seedbed preparation by disking (STD); 2) Seed Tree Harvest and seedbed preparation by burning (STB); Seed Tree Harvest and no seedbed preparation (STCK); and Clearcut Harvest, mechanical site preparation and plant at 1,200 TPA, 6 ft x 6 ft spacing, (PMS). All logging slash was piled and burned in

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Table 1—Age 15 stand growth attributes by reforestation treatment[a]

Reforestation Treatment	Stand Density	DBH	Height	Basal Area
	Trees/Acre	Inches	Feet	Feet^2/Acre
Seed Tree (Disced)	1,400	3.5	33	94
Seed Tree (Burned)	1,421	3.5	32	95
Seed Tree (Untreated)	1,407	3.5	33	94
Planted MS(1200 TPA)	618	6.4	42	138
Planted CS(680 TPA)	534	7.0	45	142
Planted CS(680 TPA HWS)	581	7.4	47	175

[a]All trees greater than 1.0 inch dbh

August 1955 followed by seedbed and mechanical site preparation treatments. The STD treatment was broadcast disked to a depth of 4 inches with a standard lift-type tandem disk harrow, the STB treatment was burned in September and the PMS treatment was burned and then disked. Treatments were replicated four times and randomly assigned to the designated harvest plots. After 5 years, all seed trees were removed.

1984 Study

This study was initiated following a clear cut harvest of the 1955 Study. The study area was chemically site prepared with glyphosate applied at 4 lbs. a.i./acre and loblolly pine seedlings were planted at a 8 ft x 8 ft spacing (680 TPA). Three levels of herbaceous weed and two levels of woody brush suppression were combined in a factorial manner to establish six vegetation management regimes of varying intensity. Vegetation management regimes, in descending order of intensity, were: VMR 1) post-planting herbaceous weed suppression for 2 years and woody brush (hardwood and pine) suppression; VMR 2) post-planting herbaceous weed suppression for 1 year and woody brush suppression; VMR 3) no herbaceous weed suppression and woody brush suppression; VMR 4) post-planting herbaceous weed suppression for 2 years and no woody brush suppression; VMR 5) post-planting herbaceous weed suppression for 1 year and no woody brush suppression; and VMR 6) no herbaceous weed suppression and no woody brush suppression. Regimes were replicated six times and assigned in completely random manner to 36 0.3 acre plots. Herbaceous weed suppression treatment was applied with a backpack sprayer using sulfometuron methyl at 1.5 oz. a.i./acre in early spring of the first and second growing seasons. Woody brush suppression treatment was a backpack application of triclopyr amine at 2 lbs. ae/acre in the spring of the fourth growing season to suppress hardwood brush and woody vines and to eliminate every third row of pine seedlings. Pine stocking density in the woody brush suppression treatment plots was reduced to approximately 350 TPA. Growth data from the VMR 5 (PCSHWS) and VMR 6 (PCS) plots were used for the natural and artificial regeneration comparisons.

Growth data for both studies were collected periodically through age 15. Age 15 DBH and height were used to compute age 15 individual pine merchantable volume at a 3-inch inside bark diameter (Van Duesen and others 1981). Actual and published cost and revenue values were used to compute treatment net present value (NPV) and land expectation value (LEV). Growth data within studies were analyzed using SAS general linear model analysis of variance procedures at a 0.05 level of probability. NPV and LEV were used to compare treatment cost effectiveness among studies.

Table 2—Age 15 product volume distribution by reforestation treatment

Reforestation Treatment	Product Volume: Total	Pulpwood	C-N-S	Sawtimber
	Feet^3/Acre			
Seed Tree (Disced)	540	540	-----	-----
Seed Tree (Burned)	545	545	-----	-----
Seed Tree (Untreated)	540	540	-----	-----
Planted MS (1200 TPA)	1,715	1,005	710	-----
Planted CS (680 TPA)	2,730	670	2,030	40
Planted CS (680 TPA HWS)	3,440	690	2,690	90

Table 3—DBH size class distribution by reforestation treatment

	Reforestation Treatment					
DBH Class	Seed Tree Disced	Seed Tree Burned	Seed Tree Untreated	Planted MS-1200	Planted CS-680	Planted CS-680-HWS
Inches	Trees/Acre					
<1.5	1,147	1,614	653	61	-----	-----
1.6-3.5	731	743	734	1	-----	-----
3.6-5.5	667	666	660	127	-----	-----
5.6-7.5	2	2	2	418	138	90
7.6-9.5	-----	-----	-----	71	382	430
>9.6	-----	-----	-----	-----	14	61
Total	2,547	3,025	2,049	678	534	581

RESULTS

1955 Study Growth

Stand growth differences were detected among reforestation treatments. Although seed tree seedbed preparation did not affect stand productivity, mean seed tree treatment and the PMS treatment growth attributes were significantly different (table 1) . Mean seed tree treatment merchantable tree density exceeded the PMS treatment density by 800 TPA (table 1). However, seed tree basal area and merchantable volume were 47 and 60 percent less than the PMS treatment (tables 1 and 2). Pulpwood and chip-n-saw volume differed between seed tree and PMS treatments with seed tree respective volumes being 465 and 710 feet^3 per acre less than the PMS treatment (table 2). Tree diameter distribution varied between seed tree and PMS treatments. Fifty two percent of the seed tree merchantable stems fell within the 2 to 4 inch DBH class, while 91 percent of the PMS stems were greater than 4 inches (table 3).

1984 Study Growth

Mean tree DBH and height, and stand basal area and merchantable volume differed significantly between treatments (tables 1 and 2). No stand density differences were detected at age 15, but tree survival rates averaged 78 and 85 percent for the PCS and PCSHWS treatments. Although the PCS treatment had 47 fewer trees, mean tree DBH and height were 0.4 inches and 2 feet less than the PCSHWS treatment. Basal area and merchantable volume treatment differences were 33 feet^2 per acre and 710 feet^3 per acre. Treatment volume differential was reflected in product volume distribution, PCSHWS chip-n-saw and sawtimber volumes exceeded the PCS volumes by 690 feet^3 per acre (table 2). Tree DBH distribution varied between treatments with PCSHWS treatment having 95 more trees in the 8 inch and larger DBH class, and 66 percent were 10 inches or larger (table 3).

Financial Comparisons

Since seed tree treatment growth was similar for all seedbed preparation treatments, two seed tree options were compared by pooling growth data, assuming no seedbed preparation cost and leaving or removing seed tree stand for the 15 year comparison period. Therefore, financial comparisons treatments were seed tree with no seed tree removal, seed tree with seed tree removal at age 5, PMS, PCS and PCSHWS. Cost values were determined by actual and published costs (Dubois and others 1999). Revenue values were based on the mean 10-year Louisiana stumpage prices for pulpwood, chip-n-saw and sawtimber between 1991 and 2000. Seed tree treatment costs included the value of the residual seed trees, while planted treatment costs included site preparation, seedling purchase and planting, and herbaceous weed suppression for the PCSHWS treatment. All costs and revenues were discounted at a 8 percent interest rate.

Table 4—Age 15 financial comparisons by reforestation treatment

Reforestation Treatment	Costs	Revenues	NPV	LEV
	Dollars/Acre			
Seed Tree (No Harvest)	440	48	(-392)	(-244)
Seed Tree (Harvest)	440	532	92	135
Planted MS(1200 TPA)	194	311	117	170
Planted CS(680 TPA)	164	702	538	785
Planted CS(680 TPA HWS)	200	921	721	1,053

Regeneration method did influence the financial potential of commercial pine plantations. At an 8 percent discount rate, failure to capture seed tree value resulted in a negative NPV and LEV at age 15 (table 4). Although seed tree removal at age 5 produced positive NPV and LEV values, these values were less than any of the planted treatments. Initial planting density and site preparation method impacted the financial potential of the planted treatments, PMS treatment NPV and LEV were $422 and $615 per acre less than PCS treatment (table 4). Although there was no cost differential between mechanical and chemical site preparation, chemical site preparation provided better vegetation suppression during early seedling growth and development. First year herbaceous weed suppression (PCSHWS) improved the financial potential of chemically site prepared planted plantations, increasing NPV and LEV by $187 and $188 per acre.

CONCLUSIONS

Reforestation practices had a significant impact on the financial potential of commercial pine plantations:

1. Seed tree regeneration method was the least cost effective reforestation method. Excessively stocked plantations were susceptible to intraspecific competi tion which reduced growth productivity.
2. In planted plantations, chemical site preparation was more cost-effective than a low intensity mechanical treatment.
3. Wider spaced planting density and first year weed suppression improved reforestation cost effectiveness on the planted plantations

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