EFFECTS **OF OPENING SIZE AND SITE PREPARATION METHOD ON VEGETATION DEVELOPMENT AFTER IMPLEMENTING GROUP SELECTION IN A PINE-HARDWOOD STAND.**
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ABSTRACT

Three opening sizes (0.25, 0.625, and 1.0 ac) and three site preparation methods (herbicides, **mechanical, and an** untreated control) were tested in a pine-hardwood stand dominated by loblolly and shortleaf pines (***Pinus taeda* L. and** *P. echinata* Mill.) and mixed oaks (*Quercus* spp.) that was being converted to uneven-aged **structure using group** selection. The study was a 3x3 factorial in a randomized co mplete block design with three replicates. **Site preparation** in the openings was delayed for 2 years after harvest until an ad equate pine seed crop was forecast. At 3 **years after the** group-selection cut and 1 year after site preparation, pine seedling stocking was higher (P=0.01) in **the 0.25-ac openings** (89%) when compared to the 0.625-ac openings (71%) or the 1.0-ac openings (66%). Mechanical **site preparation** resulted in higher *(P=0.*03) pine seedling density (5,272 stems/ac) compared to the control (2,490 stems/ac) **or chemical** site preparation (3,044 stems/ac), but both the mechanical and chemical treatments had better (P=0.03) **stocking (82%)** of pine seedlings than the control (61%). Both mechanical and chemical site preparation were effective **in reducing** *(P<0.0\)* the density (85% less) and stocking (75% less) of nonpine woody saplings compared to **the control, but size** of opening had no effect on density of nonpine woody seedlings or saplings at 1 year after site **preparation.**

INTRODUCTION

Group selection is an uneven-aged reproduction cutting method that is reputed to favor the more **shade-intolerant species** by creating larger openings than single-tree selection. Howe ver, less is known about group selection **than about any of** the other natural reproduction cutting methods (5). The goal of group selection is to **create or maintain an uneven-aged** stand by making a number of openings during each cutting cycle, in addition to thinning the **residual stand as needed.** The regeneration effort is focused within these distinctive openings that are usually ≤**1** ac. If **group selection is applied** over several cutting cycles, a fragmented stand composed of small even-aged groups should **result. The larger openings** provided with group selection do not appear to be needed for pine regeneration when traditional **stocking guidelines for** single-tree selection are followed (1). However, group se lection seems to have merit when **a significant hardwood** component is desired because the larger openings provide the higher light intensities needed by the **shade-intolerantpines** and the intermediate-tolerant oaks.

The environmental requirements for regeneration of targ eted species are critical to setting **suitable opening sizes.** Experience suggests that large openings will favor the establishment and development of **the more shade-intolerant** species, but large openings are perceived to have poor visual qualities by some forest users. Thus, **the optimum opening** size would be the smallest one that provides a favorable environment for regenerating targeted species. **This study was** installed in north central Louisiana to provide information on suitable opening sizes and site **preparation methods for** applying the group selection system in pine-hardwood stands; first-year results after site preparation **are presented in this** paper.

METHODS

Study Area

The study was installed in a 120-ac, second growth pine-hardwood stand located on the Winn **Ranger District of the** Kisatchie National Forest in Grant Parish, LA. Soils in the study area were mapped as the Cadeville **series (Albaquic** Hapludalfs) with smaller amounts of the Metcalf series (Aquic Glossudalfs) (4). These soils **are somewhat poorly** drained and have a loamy surface layer with a clayey subsoil. Based on measurement of 20 dominant **and codominant** ioblolly pines on the study area, site index averaged 91 ft fo r loblolly pine at 50 years; the trees had **a mean age of 59** years.

Before harvesting, merchantable (>3.5 inches dbh) basal areas averaged 74 ft Vac for loblolly and shortleaf pines **and** 54 ft^2/ ac in midcanopy hardw-oods. Oaks (*Quercus* spp.) were the dominant hardwood species, accounting for 66% of hardwood basal area. Pines in designated openings averaged 3,000 ft Vac in total merchantable volume **and 2,850 ft** Vac and 14,000 bd ft/ac (Doyle) in sawlog volume. Hardwoods averaged 1,120 ft Vac in merchantable **volume.**

Study Design and Treatment Implementation

Three blocks were established that were approximately 40 ac in area. The blocking factor was **proximity to** an intermittent drainage. Treatments were opening size and site preparation. Within each block, **boundaries were located** for nine circular openings with areas of 0.25, 0.625, and 1.0 ac. Diameters for these openings would be about 1.2, 2.0, and 2.5 rimes the height of the dominant pines which averaged 95 ft tall in the surrounding stand. **Openings were to be** systematically located so that adjacent openings were separated by at least 100 ft, but the opening area **was randomly** assigned. Openings of a block were then randomly assigne d to one of the three site preparation methods **(chemical,** mechanical, or untreated control). About 14% of the total area of a block would be in openings. After **boundaries were** established for each opening, all merchantable pines and hardwoods occurring within the area were marked for harvest. The stand between the openings was marked to leave 70 ft Vac in pine basal area; marking was for an improvement cut focusing on the pine sawtimber component. No hardwoods or pine pulpwood were harvested outside the openings.

Harvesting was completed during October 1991. The only restriction imposed on loggers was that no trees from one opening could be skidded through another opening; this prevented greater traffic from occurring in the openings near landings. The loggers removed pine sawtimber first and then pine and hardwood pulpwood. Inspection of pine tops after harvest indicated very few mature cones and virtually no conelets, suggesting that the next two pine seed crops would be inadequate for natural regeneration. Thus, it was decided to delay site preparation until an adequate seed crop was predicted by counting the number of cones on bordering trees, which occurred 2 years later in 1993.

Chemical site preparation consisted of a broadcast application of glyphosate ' (2% in a water base with a surfactant) using backpack sprayers to wet unwanted vegetation in late July 1993. Existing pine seedlings were not intentionally treated. An average of 21 gal/ac of solution were applied in openi ngs; application time averaged 1.9 person-hr/ac. Within openings, residual hardwoods z 1 inch dbh were stem injected at waist height with triclopyr (50% in a water base) using the hack-and-squirt method in late September 1993. Hard-to-kill species, such as red maple (*Acer rubrum)* and blackgum *(Nyssa sylvatica*), were frilled edge-to-edge, placing 1 ml of solution in each cut. Other species were treated by making frills at 3-inch intervals and placing 1 ml of solution in each cut. An average of 222 stems/ac with a basal area of 7.0 ft Vac was treated with herbicide, and this took an average of 1.5 person-hr/ac and used 1.3 qts/ac of solution.

Mechanical site preparation was applied in mid-September 1993. Residual hardwoods a 3 inches dbh were chain-saw felled in advance of using a John Deere * 45 0C dozer to remove smaller hardwoods and to scarify the soil where logging debris and herbaceous vegetation occurred; no attempt was made to concentrate or pile de bris. The dozer operator was instructed to avoid any patches of advanced pine regeneratio n that were visible. Chain-saw felling took an average of 0.8 person-hr/ac and the dozer 1.2 hr/ac. The number of sawn stems was not counted, but based on the tally for injection work, there were 54 stems/ac with a basal area of 5.6 ft Vacre. No site preparation tr eatment was imposed on control plots.

Measurements

Pine seed production was monitored for 3 winters (1991,1992,1993) from October thro ugh February using three 0.9-ft^2 seed traps (2) per opening; traps were located 20 ft from the opening center in a triangular pattern. Seeds were collected during the middle and end of each October-to-February period. Seed viability was determined by splitting seeds and inspecting the contents. Seeds with full, firm, undamaged, an d healthy tissue were judged to be potentially viable and were recorded as sound seeds.

Within each opening, permanentpoints were systematically located after harvesting to monitor regeneration and seedbed conditions. There were 9,13, and 17 points in each of the 0.25-, 0.625-, and 1.0-ac openings, respectively. The sample points were located so that each represented an equal area, which prevented any bias caused by bordering trees. One point was located at the opening center. The remaining points were located along eight radii, beginning at 0° (north) and repeated at 45° intervals.

In mid-September 1993, circular 0.001 -ac subplots (3.72 ft radius), centered around the permanentpoints, were evaluated for coverage of understory vegetation and seedbed condition. Coverage of living vegetation was visually estimated by the following groups: grasses, forbs, vines, hardwoods, sh rubs, pines, and total vegetation. Seedbed conditions were evaluated on control and mechanical treatments; the percen tage of subplot area was visually estimated as follows: undisturbed litter, slightly disturbed litter or dead vegetation, fine slash (<1.0 inch from either site preparation or harvesting), large slash (>. 1.0 inch from either site preparation or harvesting), exposed mineral soil, and piled vegetative debris (2:2.0 inches in depth) which was often intermixed with soil and logging slash.

Regeneration inventories were conducted at the permanent points during mid-August 1994,1 year after site preparation. Woody plants in the seedling size class (<. 0.5 inches dbh) were counted as pines or nonpines in 0.001 -ac circular subplots centered around each permanent point. Seedlings with multip le stems were tallied as one rootstock. Stems of woody plants in the sapling size class (0.6 to 3.5 inches dbh) were counted by 1 -inch dbh classes as pines or nonpines in 0.01 -ac circular plots (11.78 ft radius) around each permanent point.

Data Analysis

Mean values were calculated across subplots for each opening. Subplots were considered stocked by pine or hardwood regeneration if at least one seedling or sapli ng represented the species or species group.

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Analysis of variance for a 3x3 factorial, randomized, complete block design was used to test for differences in factors. Because of so few significant interactions between opening size and site preparation, only the main effects are presented here. Differences among factors were isolated using the Ry an-Einot-Gabriel-Welsch Multiple Range Test (6) at the 0.05 probability level (*P*). Percentage data were arcsine transformed before analysis, but only nontransformed means are presented.

RESULTS AND DISCUSSION

Seedbed Conditions

Mechanical site preparation modified the existing seedbed conditions by exposing mineral soil and redistributing slash and logging debris. With mechanical treatment, undisturbed seedbed conditions were reduced ($P<0.01$) by 73 percentage points compared to control plots (Table 1). The best s eedbed conditions for natural pine regeneration were exposed mineral soil and the presence of fine slash. These two conditions were enhanced ($P<0.01$) by 48 percentage points on mechanically treated plots versus control plots. In general, the smaller the opening, the greater the incidence of disturbance to the seedbed. For example, 37% of the area in 0.25-ac openings had fine litter or mineral-soil exposure as compared to 27% of the area in 1.0-ac openings.

Pine Seed Supply

An average seed crop needed for loblolly and shortleaf pines to produce an adequate stand of seedlings is a 40,000 sound seeds/ac (3). In this study, an adequate pine seed crop di d not occur until the third year after the group-selection harvest; therefore, site preparation was timed to coincide with that seed crop. During the third winter, seed production averaged about 500,000 sound seeds/ac. Altho ugh there were no significant differences ($P>0.05$) in seed production among group openings, the dispersal of sound seeds tended to decrease from the smaller (0.25 ac) to the larger openings (1.0 ac), as distance from the seed source increased.

Regeneration Density and Stocking

Size of opening had no effect on pine seedling density, which averaged 3,602 stems/ac 1 year after site preparation (Table 2). However, stocking of pine seedlings in 0.25-ac openings exceeded ($P=0.0l$) that in the larger openings by 20 percentage points. Because of improved seedbed conditions, mechanical site preparation resulted in **91% more** ($P=0.03$) pine seedlings than the mean of control and chemically treated plots (Table 2). Still, both chemical **and** mechanical site preparation improved ($P=0.03$) the stocking of pine seedlings by 21 percentage points over **untreated** controls. Some pine regeneration was already in place befo re the group-selection cut, and the density and stocking of saplings were not affected by size of opening or s ite preparation at 3 years after harvest (Table 2).

Across openings, woody nonpine seedlings averaged about 8,000 rootstocks/ac with 98% stocking 1 year after site preparation, and there were no differences (Pa0.63) among the openings (Table 3). Chemical site preparation was effective in reducing ($P<0.01$) the density of woody nonpine seedlings by 38% compared to control plots, but stocking of these seedlings was not affected by site preparation and averaged 98%. Density of woody nonpine saplings **averaged** 61 stems/ac. As with seedlings, sapling numbers were not affected ($P=0.06$) by size of opening, but control plots had from six to eight times more ($P<0.01$) hardwood saplings than did chemically- or mechanically-treated plots, respectively. Stocking of hardwood saplings was lowest on the 0.25-ac plots and was 21 percentage points less ($P=0.01$) than on the 1.0-ac plots. Both mechanical and chemical site preparation had similar impacts on stocking of hardwood saplings 1 year after treatment by reducing their distribution by 39 percentage points over untreated control plots.

Vegetation Ground Cover

For individual vegetation components, opening size had no significant effect (Pa 0.15) on ground cover at 1 year after site preparation (Table 4). Yet, total ground cover in 1.0-ac openings was 4 percentage points higher ($P=0.04$) than in 0.25-ac openings. With the exception of forbs and vines, control plots tended to have more ground cover from vegetation than site-prepared plots. Although chemically-treated plots had less ($P=0.01$) grass cover than mechanically-treated plots, these two site-preparation techniques were comparable in the degree of cover from other vegetation components. Compared to control plots, ground cover from shrubs and hardwoods was reduced ($P<0.0\backslash$) by both chemical and mechanical site preparation.

CONCLUSIONS

Smaller openings generally had less disturbance from logging than larger openings but somewhat more pine seeds dispersed to the interior of smaller openings. Since increases in both disturbance and seed supply tend to favor the establishment of pine regeneration, their opposing relationship with opening size essentially cancelled out so that opening size had little net effect on pine regeneration. On the other hand, pine seed crop failures during the 2 years following group-selection harvesting allowed enough time for competing vegetation to encroach in the openings and potentially impede the future development of established pine regeneration. From that standpoint, both mechanical and chemical site preparation were generally effective in reducing the density and stocking of woody, nonpine seedlings and saplings when compared to areas where no site preparation was used in advance of pine seed dispersal.

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Table 1. Percent of area disturbed in openings 2 years after a group selection harvest and 4 weeks after mechanical site preparation.

Seedbed condition	Site preparation treatment: Control	Site preparation treatment: Mechanical	Mean square error	*P>F*
	Percent	*Percent*		
Undisturbed	90a[1]	17b	0.0192	<0.01
Slightly disturbed	Ob	17a	0.0006	<0.01
Mineral soil exposed	lb	18a	0.0128	<0.01
Fine slash[2]	7b	38a	0.0035	<0.01
Large slash[3]	2b	7a	0.0021	<0.01
Piled slash"	Ob	3a	0.0068	<0.01

[1] Row means followed by the same letter are not significantly different at the 0.05 level.
[2] Slash <1.0 inch in diameter.
[3] Slash ;> 1.0 inch in diameter.
[4] Mound (^2.0 inches in depth) of competing vegetation and/or fine slash.

Table 2. Density and stocking of natural pine seedlings and saplings 3 years after a group selection harvest and 1 year after site preparation.

Treatment and statistics	Pine seedlings		Pine saplings	
	Density	Stocking	Density	Stocking
Opening size (ac)	*Stems/ac*	*Percent*	*Stems/ac*	*Percent*
0.25	4,691a[1]	89a	6a	4a
0.625	3,376a	71b	30a	5a
1.0	2,739a	66b	18a	7a
P>F	0.17	0.01	0.50	0.79
Site preparation				
Control	2,490b	61b	12a	6a
Chemical	3,044b	83a	38a	8a
Mechanical	5,272a	81a	5a	3a
P>F	0.03	0.03	0.24	0.51
Mean square error	4.51E06	0.047	1753	0.041

[1] Columnar means followed by the same letter within treatments are not significantly different at the 0.05 level.

Table 3. Density and stocking of woody, nonpine seedlings and saplings 3 years after a group selection harvest and 1 year after site preparation.

Treatment and statistics	Woody nonpine seedlings		Woody nonpine saplings	
	Density	Stocking	Density	Stocking
Opening size (ac)	*Rootstocks/ac*	*Percent*	*Stems/ac*	*Percent*
0.25	7,840a[1]	98a	44a	16b
0.625	7,538a	98a	56a	26ab
1.0	8,484a	99a	82a	37a
P>F	0.63	0.67	0.06	0.01
Site preparation				
Control	9,844a	100a	140a	52a
Chemical	6,101b	97a	25b	15b
Mechanical	7,917ab	98a	17b	lib
P>F	<0.01	022	<0.01	<0.01
Mean square error	4.37E06	0.013	993	0.038

[1] Columnar means followed by the same letter within treatments are not significantly different at the 0.05 level.

Table 4. Percent ground cover from vegetation components 3 years after a group selection harvest and 1 year after site preparation.

Treatment and statistics	Vegetation components						
	Grasses	Forbs	Vines	Shrubs	Hardwoods	Pines	Total[1]
Size of opening (ac)				*Percent cover*			
0.25	26a[2]	13a	34a	11a	11a	4a	82b
0.625	25a	17a	32a	9a	12a	4a	85ab
1.0	28a	17a	29a	9a	14a	3a	86a
P>F	0.73	0.15	0.54	0.82	0.17	0.65	0.04
Site preparation							
Control	32a	9b	32a	16a	17a	5a	89a
Mechanical	29a	17a	29a	7b	11b	3a	83b
Chemical	18b	21a	34a	6b	9b	3a	81b
P>F	0.01	<0.01	0.49	<0.01	<0.01	0.22	<0.01
Mean square error	0.0104	0.0054	0.0113	0.0094	0.0020	0.0050	0.0013

[1] Within rows, the sum of individual cover components can exceed 100% because of multi-layered vegetation.
[2] Columnar means followed by the same letter within treatments are not significantly different at the 0.05 level.

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