A COMPARISON OF OAK REGENERATION CONDITIONS FOLLOWING MIDSTORY INJECTION AND PARTIAL OVERSTORY REMOVAL IN A TOMBIGBEE RIVER TERRACE

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Abstract—Bottomland hardwood stands comprised of a large oak component can be regenerated through natural oak regeneration. To maximize oak regeneration potential, the stand manager must practice silvicultural techniques that allow for necessary sunlight penetration to reach the forest floor. Control of stems occupying the midstory/understory and partial overstory removal are steps that may be required to ensure adequate stocking levels of natural regeneration. While the need for midstory/understory control has been documented, questions often arise regarding the level of intensity of overstory removal. Natural regeneration responses of oak species were observed 1 year after a midstory/understory injection treatment and partial overstory removal. Treatments were conducted on a bottomland hardwood stand near Bellamy, AL. The study area consisted of four 12-acre blocks with three 4-acre treatment units located in each block. The study design is a randomized complete block. Injection treatments using imazapyr were applied during late fall of 2001. There was no negative impact from the injection observed on non-target stems, and seedling establishment generally increased. Partial overstory removal treatments were completed with operational harvests, leaving residual stand basal areas of 30, 50, and 70 square feet. Seedling survival was observed from data collected from 108 0.01-acre sample plots. Results indicate that seedling survival was impacted by harvest. Damage occurring from logging operations was also evaluated on all residual trees.

INTRODUCTION

To establish natural regeneration in a hardwood stand, land managers need an understanding of silvicultural procedures involved. Silvicultural applications such as midstory/understory control and partial harvests may be required to ensure adequate stocking of oak regeneration to promote the future stand. Control of undesirable species using imazapyr causes mortality to injected stems, enhances regeneration, and does not damage crop stems (Ezell and others 1999). The level of the partial harvest intensity may impact the amount of advance reproduction present following harvesting activity. The intensity of partial harvest affects the amount of sunlight penetration that reaches the forest floor. Gardiner and Hodges (1998) found that oak seedling growth was maximized when sunlight availability was between 27-53 percent. Low understory light levels present in bottomland stands may be the most limiting factor on the establishment and growth of oaks (Hodges and Gardiner 1993). Thus, land managers need to understand how these practices can influence oak regeneration.

The amount of harvesting damage occurring to residual stems following harvesting activity is also an important consideration. Potential losses due to reduction of residual stems' log grade can be assessed if an estimation of damage can be depicted. The intensity of partial harvesting might also impact the amount of initial oak regeneration following harvesting. The objectives for this study are (1) to evaluate the effect of midstory/understory control on initial oak regeneration, (2) determine the impact of harvesting activity on initial oak regeneration, and (3) to evaluate damage resulting from varying harvest intensities.

MATERIALS AND METHODS

Study Site Description

The study site is located near Bellamy, AL on property owned by Delaney Development, Inc. and managed by Springdale Land Management. The hardwood stand is situated on a terrace micro-geographical position along the Tombigbee River. Stand composition is a mixed oak bottomland forest with a well developed midstory. Species occupying the overstory include water oak (*Quercus nigra* L.), swamp chestnut oak (*Q. michauxii* Nutt.), white oak (*Q. alba* L.), cherrybark oak (*Q. pagoda* Raf.), sweetgum (*Liquidambar styraciflua* L.), and various hickory species (*Carya* spp.). The understory and midstory tree species primarily consist of American hornbeam (*Carpinus caroliniana* Walt.), eastern hophornbeam (*Ostrya virginiana* Mill.), American beech (*Fagus grandifolia* Ehrh.), and winged elm (*Ulmus alata* Michx.), with scattered oak species.

STUDY DESIGN

The study was arranged as a randomized complete block design. The research site consisted of four rectangular blocks that were 12.06 acres in size. Three of these blocks were utilized as "treatment areas" while retaining one block as control. A midstory/understory control treatment using imazapyr was applied during the dormant season of 2001-2002. All four blocks were divided into three treatment units encompassing an area of 4.02 acres each. The experimental unit consisted of treatment unit conditions prior to and following partial harvests which maintained residual basal areas of 70, 50, and 30 square feet. These partial harvest intensities were replicated once in treatment units for each of the three "treatment areas."

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The partial harvest activity occurred during September of 2002. These harvests were conducted by Kynard Logging contracted by Springdale Land Management. Large diameter trees were felled with chainsaws then topped, delimbed, and cut to length prior to being skidded. Stems with large canopies used for pulpwood were topped and limbed in place. Smaller sized stems used for pulpwood were topped and delimbed at the loading decks. Wheeled, articulated skidders were used to move raw wood materials to loading decks located at the east boundaries of the treatment blocks. Weather conditions during the time of harvest were dry.

DATA COLLECTION AND ANALYSIS

Pre-harvest overstory basal area was inventoried on the site. All overstory stems were measured for diameter at breast height (d.b.h.). Basal area for individual stems was determined using the formula:

basal area = $d.b.h.^2 * 0.005454$.

These data allowed for estimations of basal area for all species occupying treatment units and served as a basis for determining trees to be removed to achieve desired basal areas following partial harvests.

Oak regeneration sampling was conducted on 108 0.01-acre sample plots. Oak seedlings within these plots were tallied by species and height classes. Height classes included seedlings less than 1 foot in height and 1-3 feet in height. Sampling was conducted prior to harvesting activity during April 2002 and following harvesting activity in November 2002. Harvesting damage occurring on residual stems was also quantified. Damage was categorized by height classes and damage area or size classes. Height classes occurred at three-foot intervals starting at ground level. Size classes had a range of 40 square inches (e.g., 0-40, 41-80, etc.).

RESULTS AND DISCUSSION

Regeneration sampling data indicated that the majority of oak seedlings were in the height classes of < 1 foot and 1-3 feet for both pre- and post-harvest measurements. Pre-harvest measurements were analyzed to determine the impact of applying midstory/understory control. These data compared the three treated blocks against the control block. Results derived from sampling data showed that oak regeneration generally increased following the midstory/understory control treatment. Results for block 1 indicate that oak regeneration decreased by 5.57 percent compared to control. Blocks 2 and 3 increased by 71.08 percent and 79.44 percent, respectively, compared to control. The increased amount of oak regeneration can be attributed to greater amounts of sunlight penetration reaching the forest floor. The increased abundance of sunlight results from the control of live stems occupying the midstory/understory level of the stand.

The intensity of harvesting activity also impacted the amount of oak regeneration following partial harvest. Evaluations to determine the impact harvesting intensity had on oak regeneration were derived by comparing pre-harvest measurements to post-harvest measurements for the nine treatment units on blocks 1 to 3. Three treatment units suffered the greatest decreases in oak regeneration due to excessive skidding activity. These units were located adjacent to logging decks. These blocks were excluded in the analysis to determine initial oak regeneration responses to partial harvesting intensity. The two treatment units that had residual basal areas of 50 square feet showed the largest increases in initial oak regeneration. This intensity of partial harvest promoted greater regeneration due to the combination of harvest activity and light penetration. Individual treatment unit percentages of increase/decrease are depicted in table 1.

Another observation made from regeneration data was that water and willow oak seedlings increased in abundance more than other oak species. This response was observed on the four treatment units that had increased percentages of initial oak regeneration. These two species had a bumper acorn crop during the fall of 2001. Partial harvest activity occurred following this year, which may have promoted the increase of seedlings from these two species. Findings from this study tend to indicate that conducting harvesting activity following good seed crop years can increase oak regeneration success.

Analysis to determine the impact of harvesting intensity on damage occurring to residual stems showed similar trends between treatments. The majority of damage occurred below 3 feet on the butt logs of the residual trees. Greater than half of the residual trees were undamaged on all treatment units. This indicated that regardless of the partial harvest intensity applied, the majority of residual stems will be undamaged following harvest activity. Treatment units with residual basal areas of 70 square feet had the lowest percentage of damaged residual stems among the three treatments. The percentages of damage occurrence for the three residual basal areas are illustrated in table 2.

Table 1—Harvesting impacts on regeneration

	Treatment—residual basal area	Oak seedling change	Adjacent to loading deck
	square feet	*percent*	
Block one	50	-59.50	Yes
	30	-3.05	No
	70	-13.45	No
Block two	30	-53.10	Yes
	70	30.22	No
	50	101.00	No
Block three	70	-32.07	Yes
	50	115.93	No
	30	8.15	No

Table 2—Percentage of damage occurrence on residual stems by height class

Height	Basal area (*square feet*)		
classes	30	50	70
feet	- - - - - - - -	*percent*	- - - - - - - -
0–3	87.91	77.95	86.51
3–6	9.89	18.90	11.11
6–9	2.20	3.15	2.38

The size of damaged areas on residual stems also showed a similar pattern between treatments. Generally, smaller "damage zones" occurred more frequently than larger "damage zones." The majority of stems had damage areas of less than 80 square inches in size. This can be attributed to proper logging techniques employed by the loggers. The percentages of damage area size compared to residual basal area are presented in table 3.

Table 3—Percentage of residual stems exhibiting various amounts of harvest damage by treatments

		square inches		
Basal area	No damage	< 80	81-160	> 161
square feet	- - - - - - - - - - - - - *percent* - - - - - - - - - - - -			
30	50.57	36.78	9.77	2.87
50	54.89	32.34	5.96	6.81
70	74.84	19.31	2.82	3.04

SUMMARY

The two types of silvicultural treatments conducted during this experiment tended to show positive effects on initial oak regeneration. Midstory/understory control promoted regeneration of desirable species while removing less desirable stems and increasing sunlight penetration to the forest floor. Oak regeneration reached the highest levels on the treatment units that received partial harvests leaving a residual basal area of 50 square feet. The amount and type of initial regeneration was dependent on species present in the stand. This was clearly evident in the case of water and willow oak. Results showed that harvesting in conjunction with a good mast crop tended to enhance initial regeneration.

This study also found that there was a strong negative association between skidder activity and oak regeneration. Areas closer to loading decks had a larger reduction in the amount of visible initial regeneration due to increased usage by large machinery. These areas of high impact may, however, regenerate in the future. The majority of damage resulting from harvesting activity will generally tend to be located between the ground and the first 3 feet of butt logs on residual trees. Smaller damaged areas will be more prevalent than larger areas on these logs as well. To reduce the amount of damage occurring to regeneration and residual stems, land managers may opt to either consolidate or spread skid trails out over harvest areas while also ensuring proper logging techniques are applied to hardwood stands.

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