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SIXTH-YEAR OAK REGENERATION IN BOTTOMLAND HARDWOOD SHELTERWOOD CUTS IN MISSISSIPPI

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ABSTRACT

Bottomland hardwood sites have some of the most productive forest soils and high species richness ratings found in North America. However, fertile soils often lead to intense vegetative competition and difficulty establishing oaks after harvesting operations across the South. Shelterwood harvesting is often prescribed as a regeneration option with a basal area (BA) target of 50 ft²/ac. Four, 20-acre study areas representing typical bottomland hardwood sites were selected in Mississippi. Stands selected averaged 83 years in age and possessed oak overstory canopies. Six overstory removal treatments were designed to leave various residual BA targets. These treatments were used in conjunction with midstory removal to determine which residual BA created appropriate growing conditions for maximizing regeneration. At six years, 50 ft²/ac BA areas yielded greatest seedling densities.This study indicates that managers may target a wider, more flexible BA range than typically prescribed in these systems.

INTRODUCTION

Increasing the prevalence of oak species improves forest stand composition and timber value in bottomland hardwood systems. However, insufficient light availability often limits regeneration of these species (Peairs et al. 2004). Research has shown oak seedlings require 25 percent or greater available light for survival (Gardiner and Hodges 1998); however, closed canopy hardwood forests often provide less than 10 percent (Lockhart et al. 2000). In addition to reduced light levels resulting from closed canopies, further light interception occurs in the midstory level. Often silvicultural operations including partial harvest and midstory control are needed to increase light availability for seedling germination on the forest floor.

Harvesting less desirable upper canopy stems in conjunction with midstory control can benefit regeneration efforts in bottomland hardwood forests through the removal of light obstructing vegetation. This, in turn, promotes adequate stocking of advanced oak regeneration prior to final harvest. Partial harvesting alone may not increase available light to a sufficient level due to midstory competition among dense shade-tolerant species. These species are often the primary factor limiting seedling development on bottomland sites (Clark 1993). Correspondingly, midstory injection alone may not allow sufficient light through the overstory canopy to the forest floor (Janzen and Hodges 1989). The combined effect of these two treatments ensures light availability. Peairs et al. (2004) reported the effectiveness of combining partial harvesting with midstory control. They reported an increase of 1,142 oak seedlings per acre in treated compared to untreated areas. In addition, they found the quantity of oak seedlings increased by an average of 75.3 percent in partial harvest treatment areas compared to non-harvested areas.

Problems with natural regeneration of oaks typically occur due to a lack of planning. Regeneration attempts are often a single treatment lacking the necessary preparatory steps provided when using a planned process (Clark 1993). Combinations of partial harvesting and midstory control can be used to combat regeneration failure in these attempts (Barry and Nix 1993, Peairs et al. 2004). While several studies have pointed to a residual oak BA of 50 ft²/ac as a "target" in partial harvest treatments, little literature exists regarding the exact residual BA deemed optimal. This research was performed in an effort to quantify the influence of various residual BA levels in partial harvests and midstory control on the success of oak regeneration.

MATERIALS AND METHODS

Site Description

Four study areas were located in Oktibbeha and Winston Counties in Mississippi. Two independent study areas were established along minor river systems on each John W. Starr Memorial Forest and C.A. Barge Timberlands LLC. All four areas possessed similar site characteristics including species composition, topography, flooding regimes, and soil characteristics. Study areas had an overstory comprised of 67.5 percent oak with sawtimber sized trees (DBH ≥ 11 inches) constituting 87.7 percent of stems. Overstory age distribution among areas ranged from 71 to 97 years, averaging 83 years, and initial BA ranged between 92 ft²/ac and 122 ft²/ac. Overstory oak species were predominantly cherrybark oak (*Quercus pagoda*), water oak (*Quercus nigra*), swamp chestnut oak (*Quercus michauxii*), and willow oak (*Quercus phellos*). Midstory species, shade tolerant species of limited timber value, comprised predominantly of red maple (*Acer rubra*), American hornbeam (*Carpinus caroliniana*), and elms (*Ulmus* spp.). Due to overstory and midstory canopy closure, very little ground cover vegetation, including advanced oak regeneration, was present. Soil series ranged from loam to sandy loams with a pH range of 4.5 to 5.2.

Experimental Design

A randomized complete block design was used for this study. The study was blocked by study site using one replication per site for a total of four replications. Each replication encompassed an area of 20 acres that was further divided into four, five-acre treatment plots. Experimental units were the treatment plots within each study site (e.g. five-acre treatment plot). Each treatment plot was randomly assigned one of six specific residual BA partial harvest treatments. Oak regeneration data were collected via a gridded fixed-radius plot inventory utilizing nine 1/100th acre regeneration measurement subplots in each treatment plot.

Treatments

Each treatment represented a hardwood timber management option. Each of the four treatment plots within a block was randomly assigned a treatment in the form of a specific target residual BA as well as the associated midstory control or an untreated control. The original study plan was designed to maintain an untreated control treatment and utilize partial harvesting to achieve three residual BA treatments (70 ft²/ac, 50 ft²/ac, and 30 ft²/ac). Partial harvest treatment areas received midstory control treatment the year prior to harvest. This midstory control treatment was performed in August 2009 using the “hack and squirt” method with a 20 percent aqueous solution of a 52.6 percent imazapyr product.

Timber was marked in accordance with Putnam’s hardwood tree classification method (Putnam et al. 1960) and all harvesting occurred between August 2010 and the first week of November 2010. Technical issues associated with harvesting operations presented a challenge to achieving precise residual basal areas. In addition, wind damage from an April 2011 storm system resulted in reductions to residual BA on all four study areas. Consequently, residual timber was re-inventoried and two additional residual BA treatments were established. By assigning treatment plots residual BA designations based on being within 5 ft²/ac of target BA, new residual BA treatments were determined to be: 70 ft²/ac, 60 ft²/ac, 50 ft²/ac, 40 ft²/ac, 30 ft²/ac, and the untreated control.

Oak Regeneration Measurements

Oak seedlings falling inside subplot boundaries were classified into height categories and recorded. Height classifications were less than one foot, one to three feet, and greater than three feet. Stocking calculations were performed using methodology established by Belli et al. (1999) in an effort to establish a realistic expectation of actual success regarding oak seedling numbers. Year six regeneration data was collected between September and October 2016.

Data Analysis

All statistical analyses were performed using Statistical Analysis System (SAS). The study was replicated at all four sites using a randomized complete block design. Regeneration observations were recorded on an individual subplot basis. Subplot observations were transcribed into stocking point values using methodology established by Belli et al. (1999). Regeneration data from 144 subplots were analyzed with nine subplots comprising the treatment plot. Subplot data were averaged by treatment plot and used for comparative purposes with corresponding residual BA. Total seedling tally, average seedlings per acre, and overall stocking score were response variables with residual BA as the independent variable. Using a one-way classification of analysis of variance, the model fit ($R^2 = 0.7783$) and PROC GLM was used to analyze main effects and interactions. A Fisher's least significant difference option was used in comparing means among treatments. Differences were considered significant at the $\alpha = 0.05$ level of significance.

RESULTS AND DISCUSSION

Analysis detected a significant interaction between oak regeneration and residual BA ($F = 7.95$, $p = <0.0001$). Oak seedling abundance across all subplots in different residual BA treatment plots indicated that regeneration was maximized in 50 ft²/ac areas (6,192 seedlings per acre). (Table 1). In comparison, 60 ft²/ac areas averaged 4,491 seedlings per acre, which was statistically different from all other treatments. Seedling numbers in 70 ft²/ac and 30 ft²/ac BA treatment areas (3,124 and 3,006 seedlings per acre, respectively) did not differ significantly, but were greater than seedling numbers in 40 ft²/ac areas (1,000 seedlings per acre). Control areas exhibited the lowest seedling average at 269 seedlings per acre. Overall, these rankings are not surprising with the exception of seedling density in 40 ft²/ac areas. Typically, seedling density in this treatment would be expected to fall somewhere between those observed in 50 ft²/ac and 30 ft²/ac BA treatment areas. It is possible that a combination of light level, herbaceous and wood vegetation encroachment, and residual overstory stem density created conditions conducive to increased herbivory of acorns, germinated seedlings, or both by some unidentified animal. However, field observations throughout the 2011 growing season did not note the presence of such.

Table 1—Year six oak regeneration and stocking point averages by basal area treatment.

Residual basal area	Average number of seedlings per acre	Average stocking points at subplot level
30	3,006 c	134.2 b
40	1,000 d	46.6 d
50	6,192 a	275.5 a
60	4,491 b	154.6 b
70	3,124 c	86.1 c
Control	269 e	8.2 e

Means followed by the same letter within a column are not significantly different at 0.05 level.

Stocking point values calculated using method established by Belli et al. (1999).

Average stocking points (Table 1) followed the same pattern of significance as seedling density with maximum subplot stocking occurring in 50 ft^2/ac areas (275.5 points) and the lowest stocking point average occurring in control areas (8.2 points). Belli et al. (1999) created this stocking point system in an attempt to estimate probability of one “free to grow” seedling three years after harvest using the current level of advanced regeneration on hardwood bottoms in Mississippi. Using this system, a point total of 34 yields a 95 percent probability of at least one “free to grow” seedling/sapling at the end of the third growing season. Stocking point averages for all residual BA treatments exceeded the 95 percent probability level and, as such, should be considered successful in this particular study.

A target of 50 ft^2/ac of residual basal area is often recommended as optimal in shelterwood regeneration attempts in bottomland hardwood systems. While this target typically provides greater levels of advanced regeneration, other residual target overstory densities are capable of providing an adequate quantity of advanced regeneration prior to final overstory removal harvests. This information may be useful when performing partial harvesting with operational logging crews, or when initial levels of overstory oak are too low to provide the optimum residual target of 50 ft^2/ac.

CONCLUSIONS

Treatment areas receiving midstory injection and partial harvesting to 50 ft^2/ac residual BA, exhibited greater seedling numbers and stocking point values compared to all other treatments. However, all residual BA treatments yielded quantities of advanced regeneration sufficient for regeneration success. The potential exists for expansion of the acceptable BA target range in bottomland hardwood shelterwood cuts. Stands with low oak components that are sometimes considered unsuitable for shelterwood harvests may be viable candidates for this system. An expanded range of acceptable stands for shelterwood efforts offers economically conscious land managers a venue for regeneration at substantial cost savings. As of 2020, the average per acre cost encumbered when artificially regenerating bottomland hardwood stands is between $200 - $250. Natural regeneration using the methods described above can typically be achieved at a cost of $60 - $100 per acre. Coupled with time value of money over rotation lengths approaching 80 years, natural regeneration offers an attractive option when possible.

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