DEVELOPMENT OF ADVANCED OAK REGENERATION FROM TWO-AGE RESERVE TREES

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INTRODUCTION

The two age system uses methods or treatments which retain a limited number of older canopy trees (reserve trees) along with a cohort of younger regenerating stems. Methods such as “irregular shelterwood” or “shelterwood with reserves” developed from treatments such as deferment cuts can be used successfully in many hardwood stands. This method has been used as an aesthetic alternative to clearcutting and as a means of potentially developing a limited number of large diameter high value sawtimber trees in a stand. A shelterwood with reserves differs from a traditional shelterwood in that reserve trees will be maintained for a second rotation length rather than removed after regeneration goals have been met. To allow for continued rapid development of the younger age class the reserve trees must be scattered and few in number (10-30 ft^2 of basal area a^{-1}). In this case, the term shelterwood with reserves is misleading as the goal is not to shelter or modify regeneration but to allow it to develop relatively unhindered. The reserve trees must be of proper vigor, landscape position, species, age, and potential tree grade so that they will survive and provide a viable product after two rotations. Not all stands and species can be managed using the two age system. Species which are relatively long lived and are commercially important make good candidates for reserve trees.

The two age system also can be used to “life boat” species which do not have viable reproductive life forms at the time of cutting. A traditional clearcut essentially stops sexual reproduction in the stand for a substantial portion of the rotation and can limit the potential for the development of viable advanced regeneration. The reserve trees in the two age system provides for the potential for continued sexual reproduction in the stand and the ability to develop advanced regeneration which can be manipulated prior to the second regeneration cut. The maintenance of sexual reproduction throughout a rotation or a significant portion of it may be important for sporadic producers such as oak species. This study was designed to determine if small sawtimber reserve white oak (*Quercus alba*) trees left after a two-age treatment could effectively initiate the development of advanced regeneration.

METHODS

The study was located at Robinson Forest, the University of Kentucky research and demonstration forest located in the Cumberland Plateau Physiographic Province in southeastern Kentucky. Twelve 2 acre 60- to 90-year-old white oak dominated stands were used in this study. Each stand was randomly assigned one of 3 treatments including an uncut treatment, a treatment leaving only 20 canopy trees per acre, and one leaving only 34 canopy trees per acre. The treatments were imposed by full crown touching release of selected canopy trees (reserve trees). These trees were of average dbh for co-dominant and dominant trees in these stands. No site preparation treatments were used. One-half acre growth and yield plots were established in the middle of each treated stand. Trees > 2.54 cm dbh were tagged and survival and growth monitored and ten 1/100th acre regeneration plots were also randomly established in each growth and yield plot.

This study reports the development of new seedlings and advanced regeneration from white oak reserve trees 15 years after treatment. Regeneration measurements were taken during July and included the number and height of each white oak stem established after treatment. To provide a relative gauge of canopy light interception and the light environment at each regeneration plot a concave spherical crown densitometer™ (Forestry Suppliers, Inc. 24 quarter inch cross hairs) reading was taken at plot center. Data was recorded and is expressed in this paper as the number of cross-hairs where open sky was observed. At the same time a series of five photosynthetic photon flux density (PPFD) measures ($\mu mol\ m^{-2}s^{-1}$ PAR) were taken at a height above ground equal to the average height of the advanced regeneration (30 cm) at every other plot center using a quantum sensor (LI-COR, Inc.) and the values averaged by plot. All PPFD and densitometer readings were taken under clear sky conditions. Advanced regeneration data were pooled by treatment and subjected to statistical analysis using ANOVA and LSD(t) to determine treatment effects. Simple linear regression was used to establish the relationship between PPFD (dependent variable) and densitometer reading (independent variable) and advanced regeneration height (dependent variable) and densitometer reading (independent variable) pooled over all treatments. The Levenberg-Marquardt algorithm was used to establish best-fit coefficients of nonlinear functions for regeneration density (dependent) and densitometer reading (independent) pooled over all treatments.

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RESULTS

Highly significant differences ($p<0.001$) were found among treatments for white oak advanced regeneration density, advanced regeneration height and densitometer readings (Table 1). The 20 reserve tree per acre treatment developed twice the number of regenerating white oak trees as the other treatments. The height of the white oak regeneration established after the treatment was greater for both cut treatments compared to the uncut treatment. The average height of the regeneration is relatively small at this point in time and would not be expected to be competitive if the stands were regenerated at this time. It is probable that some form of manipulation will be necessary to develop high vigor advanced regeneration prior to a future regeneration harvest. However, the advanced regeneration that developed after treatment indicates that the reserve trees are providing viable propagules which are developing advanced regeneration for future manipulation and stand regeneration. Densitometer readings were also higher for the cut stands compared to the uncut stands.

A positive linear relationship ($y = 0.016 + 0.00724$ (densitometer reading), $R^2=0.733$) was found between densitometer reading and PPFD indicating a relationship between measurable canopy density and light levels at advanced regeneration height (Figure 1). A positive relationship was also found between densitometer reading and advanced regeneration height (Figure 2) and densitometer reading and advanced regeneration density (Figure 3). An exponential relationship was found between densitometer reading and regeneration density ($y = 43.615 + 22.373*\exp(-\text{densitometer reading}/-2.489)$, $R^2=0.974$) while a linear relationship existed between densitometer reading and regeneration height ($y=0.549+0.0705$ (densitometer reading), $R^2=0.743$).

The results of this study indicate that small sawtimber sized co-dominant reserve white oak trees are capable of successfully producing advanced regeneration which will potentially aid in the long-term maintenance of this species after future regenerative treatments. A positive correlation between canopy density and regeneration height along with the positive correlation between canopy density and light level indicates that light levels developed from the treatments encouraged regeneration development. This data indicates dramatic increases in advanced regeneration density can be obtained when the combined understory, midstory, and overstory exhibit a densitometer reading greater than 6.

Table 1—Density and height of *Quercus alba* advanced regeneration developed from reserve trees in two age stands

	Density	Height	Densitometer reading
	No./ha	*Cm*	
Uncut	227^{b1}	19.8^{b}	5.72^{c}
20 per acre	930^{a}	35.0^{a}	7.16^{a}
35 per acre	450^{b}	29.9^{a}	6.47^{b}

[1]Values with different letters are significantly different ($p<0.01$) using ANOVA and LSD(t).

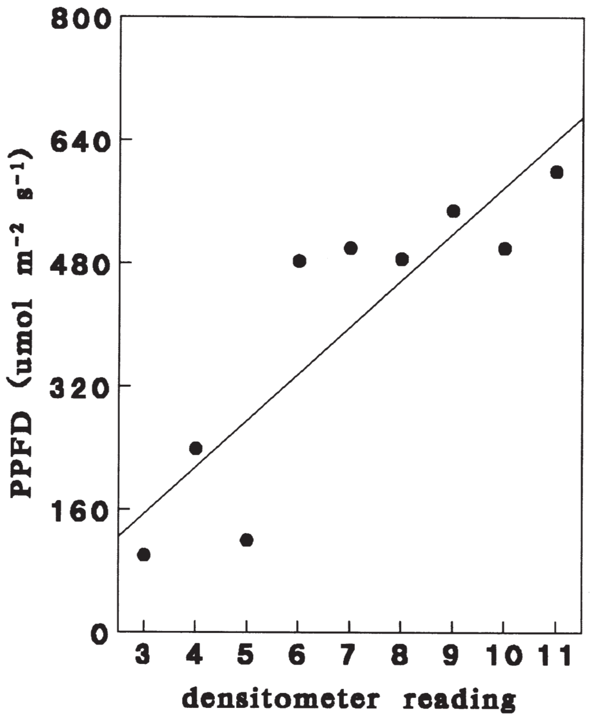

Figure 1—Data points represent average PPFD for each densitometer reading. The line represents a positive linear relationship ($y = 0.016 + 0.00724(x)$, $R^2=0.733$) between densitometer reading and PPFD.

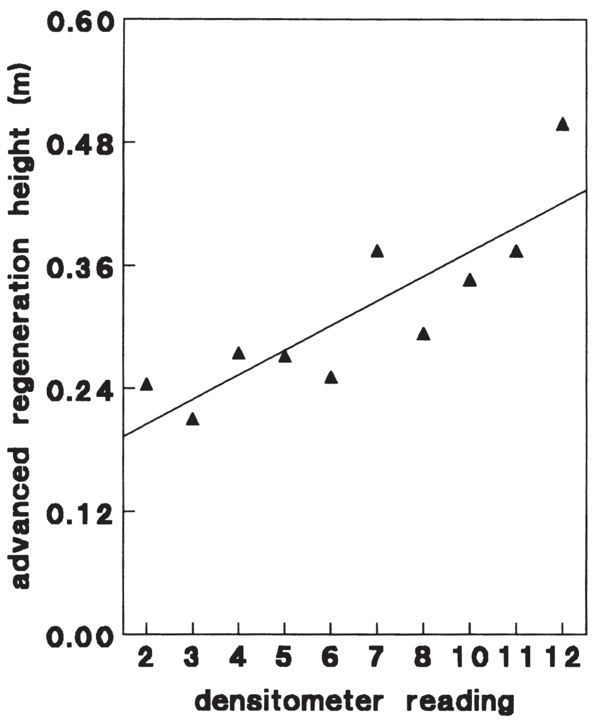

Figure 2—Data points represent average *Quercus alba* advanced regeneration stem density for each densitometer reading. The line represents an exponential relationship between densitometer reading and regeneration density (y = 43.615 + 22.373*exp(-x/-2.489), R^2=0.974).

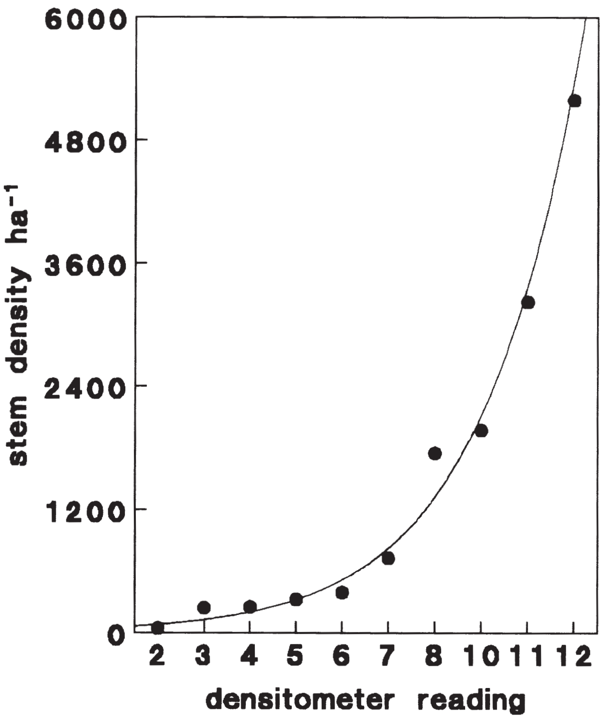

Figure 3—Data points represent average *Quercus alba* advanced regeneration height for each densitometer reading. The line represents a linear relationship between densitometer reading and regeneration height (y=0.549+0.0705(x), R^2=0.743).