THE IMPACT OF STRIP CLEARCUTTING ON RED OAK SEEDLING DEVELOPMENT

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Abstract.—A mature upland yellow-poplar/red oak stand was harvested using an alternating strip clearcut method. Red oak seedlings were planted across a light gradient between the cut and residual strips to assess the potential ability of the residual strips to foster the development of competitive oak seedlings over time. After one growing season, no differences in seedling diameter and height growth or survival were detected across the planting positions. Planting shock and drought were assumed to have affected year 1 results.

INTRODUCTION

The challenge of regenerating oak species (*Quercus* spp.) is a widespread and well-known problem throughout eastern hardwood forests. Numerous studies have reported on harvesting techniques to regenerate oak species (e.g., Schuler and Robison 2009). When harvests occur in oak-dominated stands, the subsequent reproduction, although usually present in adequate numbers, often has limited representation of oak species (Dey 2014). Oaks are considered disturbance-dependent species whose successful regeneration is often the combined result of several fortuitous and well-planned events. Oak species regenerate over time, rather than from a single establishment event (e.g., harvest). The process involves the development of competitive sources of reproduction and their timely release into the overstory (Dey 2014, Loftis 2004). The unavailability of competitive seedlings often limits the success of oak regeneration following a harvest.

The general paucity of competitive oak seedlings under mature forests is attributed to low light levels in the understory of the multilayered canopies of undisturbed hardwood forests. With light levels near 5 percent or less of full sun (Gottschalk 1994, Miller et al. 2004, Schweitzer and Dey 2015), oak seedlings rarely persist long enough to achieve competitive status (>3 feet tall) (Brose et al. 2008) and are replaced by more competitive seedlings after a regeneration treatment (Dey et al. 2007). Following harvesting, shade-tolerant advance reproduction outcompetes newer oak germinants; on higher-quality sites, new germinants of fast-growing intolerant species such as yellow-poplar (*Liriodendron tulipifera*) can quickly overtop smaller oak seedlings (Loftis 1990). To make oak seedlings more competitive, treatments that moderate understory light conditions are often recommended well in advance of harvesting (i.e., 10 years), to provide the time necessary to create established and competitive advance reproduction.

A midstory removal treatment that removes or deadens suppressed and intermediate trees to allow increased light to penetrate to the understory layer is a common prescription ahead of a regeneration harvest. This increases light levels to 12-25 percent, a range that improves the survival and growth of oak seedlings compared to seedlings growing in deep shade (Craig et al. 2014, Gottschalk 1985, Miller et al. 2004, Ostrom and Lowenstein 2006). The challenge associated with midstory treatments is that they stimulate the growth of competing species such as red maple (*Acer rubrum*) and sugar maple (*A. saccharum*) (Craig et al. 2014, Schweitzer and Dey 2015); therefore, controlling pre-existing competition is often warranted.

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Despite its demonstrated effectiveness, widespread adoption of midstory removal treatments is hindered by high costs (Bailey et al. 2011, Rathfon 2011), limited markets for small-diameter stems, and the need for immediate landowner income. Therefore, low-cost alternatives that provide meaningful harvest volumes are needed. We hypothesized that a strip clearcut harvest, where 50 percent of the area is cut and the remaining 50 percent is harvested once regeneration is well established (e.g., 5-10 years) is a viable alternative for many landowners. Strip clearcuts are usually prescribed where windthrow is a concern, where seed dispersal distances are limited, and where the impacts of clearcutting need to be lessened (Nyland 2002). Strip clearcutting has been employed in oak stands (Allison et al. 2003, Shostak et al. 2002, Williams 1995). It may provide a means to improve light conditions that are favorable to oak seedlings and provide income from harvesting, without the need for expensive midstory removal treatments.

When designed and implemented appropriately, strip clearcutting creates a gradient of light conditions (Marquis 1965), where the centers of the cut strips have the most light and the centers of the residual strips have conditions that are more similar to the original uncut stand. Orientation of the strips in a north–south direction facilitates moderated light conditions into both sides of the residual strips as the sun progresses from east to west over the course of the day. During the morning hours, light penetrates the eastern edges of the residual strips; by afternoon, light penetrates the western side of each residual strip. This creates elevated light conditions within each strip that affect oak regeneration density and height (Lhotka and Stringer 2013). The increased light conditions are expected to be similar to stands with midstories removed (e.g., 10–20 percent total photosynthetically active radiation). Oak reproduction within the cut strips will depend almost exclusively on advance reproduction, because large harvested oak trees have low sprouting probabilities (Gould et al. 2007, Sands and Abrams 2009). The cut areas are likely to regenerate to a faster-growing, intolerant species such as yellow-poplar. Instead of spending time and money trying to redirect regeneration here, we elected to focus on the residual strips as the major sources of oak for the next stand.

Given the highly variable nature of natural regeneration, both spatially and temporally, we elected to plant northern red oak seedlings (*Q. rubra*) across the light gradient to control for some of this variability. The objective of this study was to assess oak seedling survival and growth along a light gradient from residual strips and extending through the cut strips as a proxy to determine the effectiveness of strip clearcutting to promote oak seedling recruitment.

METHODS

The study was conducted in the central Appalachians on the West Virginia University Research Forest in Preston County, WV. The site lies on a north-facing aspect with 20 percent average slopes. Soils were mapped as Dekalb channery sandy loam. The site index averages 70-75 feet (base age 50) for upland oak using site index curves from Schnur (1937). Overstory species composition was largely yellow-poplar, northern red oak, black cherry (*Prunus serotina*), and red maple, which represented 66 percent, 21 percent, 5 percent, and 3 percent of the harvested volume and 55 percent, 21 percent, 6 percent, and 13 percent of the basal area, respectively. The study site encompasses about 35 acres, with about one-half of the acreage regenerated in fall 2014 using the alternating strip clearcut method. Harvest and residual strips were each 150-feet wide and oriented in a north–south direction. All stems >1 inch diameter at breast height were felled using conventional equipment for the region (e.g., chainsaws and rubber-tired cable skidders). No additional treatments were applied to the site. The residual strips are expected to be harvested in 5-10 years.

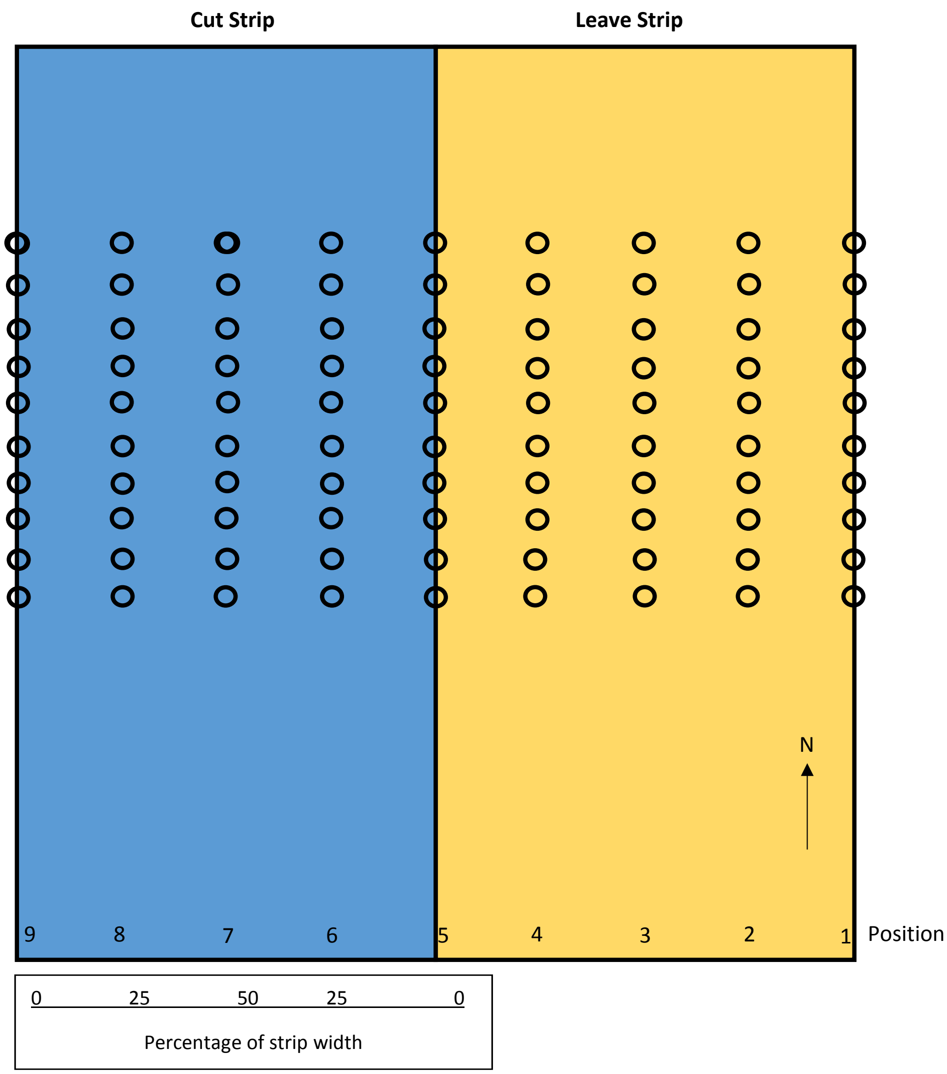

Figure 1.—Illustration showing block layout and planting position. Positions 1, 5, and 9 represent locations along the edges, positions 2, 4, 6, and 8 are 37.5 feet from the nearest edge, and positions 3 and 7 are in the center of each strip.

In April 2015, 360 2-0 northern red oak seedlings were planted across the site. Ten seedlings were planted 5 feet apart in each of nine locations within each residual/cut strip pairing that represented a gradient of light conditions (Fig. 1). Positions 1, 5, and 9 represent locations along the edges of the cut/leave strips. Positions 3 and 7 are in the center of each strip, and the remaining locations (positions 2, 4, 6, and 8) are halfway between the center and the nearest edge.

Four separate strip pairings were used as replication blocks. Each block was consistent relative to slope position, stoniness, and distance from skid trail. The best 360 of 500 seedlings based on morphological characteristics were selected. The seedlings selected for planting had the following average characteristics: 0.32 inch root collar diameter (RCD), 17.6 inches in height, and 7.4 first-order lateral roots (FOLRs) (Table 1). Fern competition developed during the first part of the growing season and was controlled midsummer using a directed application of Oust® herbicide.

Table 1.—Morphological characteristics of the planted seedlings

Characteristic	Average	Range	Recommended[a]
RCD (inches)	0.32	0.23-0.55	0.39
Height (inches)	17.6	11-28	20
No. FOLR	7.4	4-21	5

[a] Based on recommendations in Dey et al. 2012.

Initial measurements recorded for each seedling were RCD, total height, and the number of FOLRs. Basal diameter and total height were measured after the first growing season. In addition, a spherical densitometer was used to estimate overhead canopy cover. Readings were taken in early September 2015 from the center of each 10-seedling row.

Data were analyzed as a randomized complete block design (n = 4) with subsampling (10 seedlings per location per block) using analysis of variance to test the hypothesis that seedling growth varies for the nine positions within the cut/leave strip pairing. Initial seedling height and diameter were used as covariates. Statistical tests were conducted using an alpha = 0.05 level of significance.

RESULTS

Densitometer measures showed distinct differences in canopy coverage by position within the strip clearcuts (Table 2). The interior portions of the residual strips (positions 2, 3, and 4) had almost complete canopy coverage (~95 percent), the edges (positions 1, 5, and 9) had moderate coverage (49-76 percent), and the interior positions (positions 6, 7, and 8) of the cut strips had 11–31 percent coverage. After one growing season, the position across the residual and cut strips had no significant effects on height growth, diameter growth, or survival (Table 3). Although not significant, the height growth trend was that the east edge of the residual strips, which received mostly morning sun, had more growth than the other positions. For diameter growth, seedlings planted entirely within the cut strips and those planted on the west edge of the residual strips tended to have more growth. Survival varied from 87.5 percent to 100 percent across all positions. Two of the three exposed positions (within the cut areas) had the lowest survival; however, these were not significantly different.

Table 2.—The average canopy cover along a light gradient estimated by spherical densiometer in an Appalachian strip clearcut

Position[a]	Canopy coverage (%)
1	76
2	97
3	97
4	95
5	49
6	12
7	11
8	31
9	68

[a] Position descriptions are given in Figure 1.

Table 3.—Height and diameter growth one growing season after being planted in a strip clearcut

Position[a]	Height (cm)	Diameter (mm)	Survival (%)
1	7	-0.0	95
2	8	-0.3	95
3	5	-0.3	98
4	4	0.0	95
5	3	0.4	100
6	6	0.2	88
7	5	1.0	88
8	4	0.3	95
9	5	0.0	95

[a] Position description provided in Figure 1.

DISCUSSION

The strip thinning approach used here was a regeneration method that provided a compromise between a landowner's need for immediate income and the desire to maintain a strong oak component in the new stand. The continued monitoring of this enrichment planting will enable us to determine whether the gradient of illumination within the residual strips and edges of the cut strips will promote the development of oak seedlings and facilitate their growth into competitive sources.

Oak seedlings, whether natural or planted, require sufficient light resources to survive and grow into competitive sizes. The understories of mature oak stands often have light levels that are at or lower than the compensation point for oak seedlings (3-5 percent of full light) (Johnson et al. 2009). At those levels, oak survival is low. For example, 2-year survival of oak seedlings planted in unmanipulated, intact stands in Tennessee was 58 percent (Oswalt et al. 2006). Midstory removal treatments generally increase light levels to 10-20 percent of full light (Miller et al. 2004), although this response may be short-lived (Schweitzer and Dey 2015). Although no midstory was treated in the residual strips of the strip clearcut, the interior portion of the residual strips is expected to retain higher light levels for a prolonged period of time compared to typical midstory release treatments because of the reduced side shading associated with the strip cuts. With midstory treatments, light levels need to penetrate the overstory canopy before reaching the understory. In strip cuts, the sun will also penetrate laterally from the sides because most of the intercepting canopy is much higher than 50 feet. We have no photosynthetically active radiation data because midsummer to late summer 2015 had no overcast days (Parent and Messier 1996).

Treatments using harvesting equipment, herbicides, and prescribed fires have been used to increase light levels in oak stands. The degree to which canopies are opened up, however, depends on the type and nature of the competition. Care is needed on sites with aggressive intolerant species, where light conditions need to be tempered to not provide too much light that will favor their establishment. On our strip clearcut site and many other higher-quality sites in the Appalachian region, yellow-poplar, a fast-growing, shade-intolerant species, can quickly overtop oak seedlings on harvested sites (Beck and Hooper 1986, Loftis 1990) and lead to failed plantings (Schuler and Robison 2010). The center of the cut strips receives the most light (Marquis 1965), which will promote the development of species such as yellow-poplar and black cherry. Both are important and valuable species in the central Appalachian region. We are focusing on the shaded areas within and proximate to the residual strips for developing the oak component.

Artificial regeneration techniques have been used with mixed results in clearcuts and under shelterwoods. Poor growth and survival of plantings are often due to poor planting stock and competition (Dey et al. 2012). The planting stock used for this study was typical of seedlings grown at commercial nurseries in the area. In all, we culled roughly 30 percent of the seedlings purchased before planting the best available seedlings. Still, the seedlings were generally lower than current grading recommendations (Table 1), especially for height and RCD. Only 15 percent and 25 percent of the planted seedlings met the current guidelines for RCD and height, respectively; 96 percent met the guidelines for FOLRs.

After 1 year, none of the seedlings were considered competitive (i.e., >3 feet tall), nor were they expected to reach competitive status. Transplant shock probably best explains why no differences were found between positions across residual and cut strips. Transplant shock, a common occurrence after planting bareroot seedlings, is generally considered to be the result of

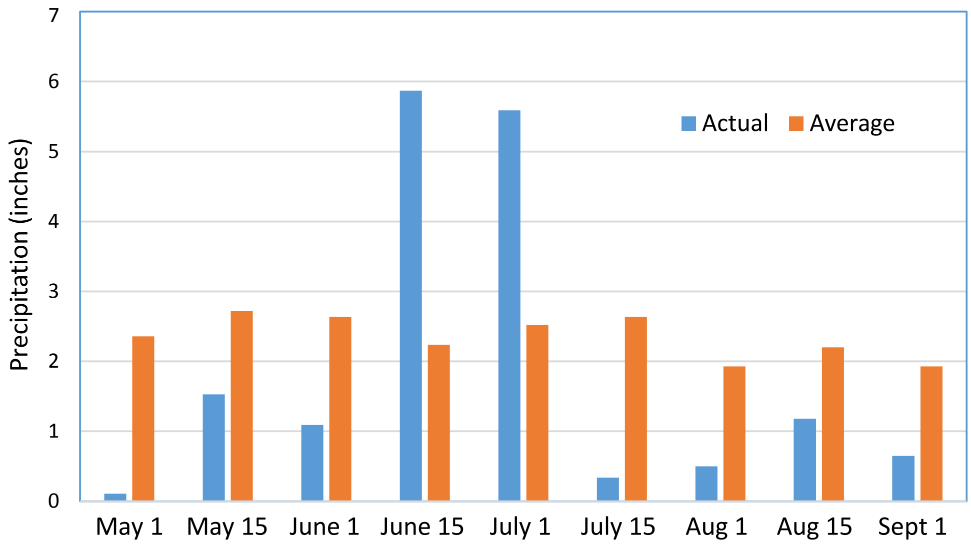

Figure 2.—Semi-monthly precipitation data for the West Virginia University Research Forest, 2015.

a disruption of water uptake caused by damaged root systems (Burdett 1990). Recently planted northern red oak bareroot seedlings under drought stress conditions have decreased biomass accumulation and root growth (Jacobs et al. 2009). Seedlings were planted for this study during early and late summer droughts (Fig. 2). More time will be required to determine if the modified light regime in the strip clearcut is successfully promoting the seedlings and simultaneously retarding the development of faster-growing species.

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