STUMP SPROUTING OF OAK SPECIES IN THREE SILVICULTURAL TREATMENTS IN THE SOUTHERN APPALACHIANS

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Abstract.—Harvesting practices in the southern Appalachians have been moving towards partial harvests, which leave some desired species as residuals after an initial harvest. This study investigated differences among two partial harvest treatments and a clearcut on oak stump sprouting in seven southern Appalachian hardwood stands. The sites were in southwest Virginia and east central West Virginia. The three silvicultural treatments consisted of a leave-tree (5 m^2 per ha), a shelterwood (12 to 14 m^2 per ha), and a silvicultural clearcut. Three permanent plots were randomly located in each treatment, inventoried and tagged prior to harvest. All tree species >5m in height were tagged and measured. Each stand was harvested during 1995-1998. During the summers of 2006 and 2007, the plots were inventoried and measurements were taken and recorded to quantify stump sprouting. Analysis of the data was performed using a z-test for comparing two binomial proportions: those that sprouted versus those that did not. Results show that the stumps in the clearcut had higher rates of sprouting than those in the leave-tree ($p<0.001$), which in turn had higher rates of sprouting than those in the shelterwood ($p=0.024$).

INTRODUCTION

The southern Appalachian region has long been known as a source for quality hardwood production. Oak (*Quercus* spp.) are the cornerstone species in this region (Appalachian Hardwood Manufactures 2007). However, harvesting methods and disturbance regimes in the Appalachians have changed over time, from mostly clearcutting and frequent wildfires to partial harvests and fire suppression (Yarnell 1998). Two common alternative silvicultural systems to a clearcut are a leave-tree and shelterwood. Both systems leave residual trees, which can influence stand regeneration (Loftis 1990, Miller and others 2006).

Oak reproduction originates from three sources: seedlings, advance regeneration, or stump sprouts. Stump sprouting has been found to be more important in this region than elsewhere (Cook and others 1996). The quality of trees which result from stump sprouts equal other forms of oak regeneration if stands are properly harvested and stump heights are kept low (Groninger and others 1998). Additionally, oak stump sprouts are often more competitive than the other two sources of regeneration. Stump sprouts have a large established root system which supports more rapid growth, and allows the sprouts to be more competitive. Newly established seedlings are frequently overtopped by faster-growing competitors (Larsen and Johnson 1998).

Site quality has been shown as an important factor determining regeneration success. In full-light conditions, shade-intolerant species, such as yellow-poplar (*Liriodendron tulipifera* L.), can out-compete oak stump sprouts on excellent sites (24m SI_{50}). Oak stump sprouting is most effective as a form of regeneration on fair to good sites (18 to 21 m SI_{50}) (Wendel and Trimble 1968). A stump's ability to sprout can also be affected by the silvicultural system. Those systems that leave residuals alter the regeneration conditions compared to systems that do not retain any trees.

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The leave-tree, also known as a deferment cut, is commonly used as a more aesthetically pleasing alternative to clearcutting. It is a two-age method in which a few individual stems (30 to 40 reserve trees per ha) are left for another full rotation, creating two distinct age classes (Nyland 2002). Logging damage is often a concern for these residuals as is epicormic branching and wind-throw (Smith and others 1989). These trees have also been shown to influence regeneration within a certain area surrounding them. Additionally, the open conditions lead to crown expansion in the residuals, which has been shown to be significantly different based on species (Miller and others 2006). This system relies on multiple sources of regeneration, including stump sprouts and advance regeneration, as well as seed from those residuals remaining in the stand.

The shelterwood relies on retaining enough individuals after the initial harvest to form a partial-light environment to favor the formation and accumulation of advance oak regeneration (Loftis 1990). This condition is designed to allow the oak, which are intermediately shade tolerant, to accumulate advance regeneration, while less shade-tolerant competitors cannot survive in these conditions. After 10 to 15 years the residuals will be removed and the advance regeneration should be large enough to out-compete fast-growing recently germinated shade-intolerant species.

OBJECTIVES

This paper looks specifically at stump sprouts as a form of oak regeneration in the southern Appalachians. The goals of this investigation were to quantify and compare the sprouting of different species of harvested oaks in the southern Appalachians and to determine if oak sprouting is influenced by species or silvicultural treatment.

SITES AND EXPERIMENTAL DESIGN

This investigation was conducted as part of a larger project known as the Southern Appalachian Silviculture and Biodiversity Project. This project was established in the early 1990s to study the effects of alternative silvicultural treatments in the southern Appalachians on even-aged oak dominated stands. Seven sites were established in Virginia and West Virginia (Fig. 1). The five sites in Virginia are located in the Jefferson National Forest. Three were located in the Ridge and Valley physiographic province (BB1, BB2, and NC) and two were located on the Appalachian Plateau (CL1 and CL2). The two West Virginia sites (WV1 and WV2) are located on the MeadWestvaco Wildlife and Ecosystem Research Forest (MWERF). The MWERF sites are located on the Appalachian Plateau. The sites were located in stands 60 to 120 years of age, growing on moderate slopes, and occupying a midslope position with a southern exposure. The site index base age 50 years, for upland oak, averaged 20 to 23 m. The plateau sites tended to be of higher site quality (Table 1).

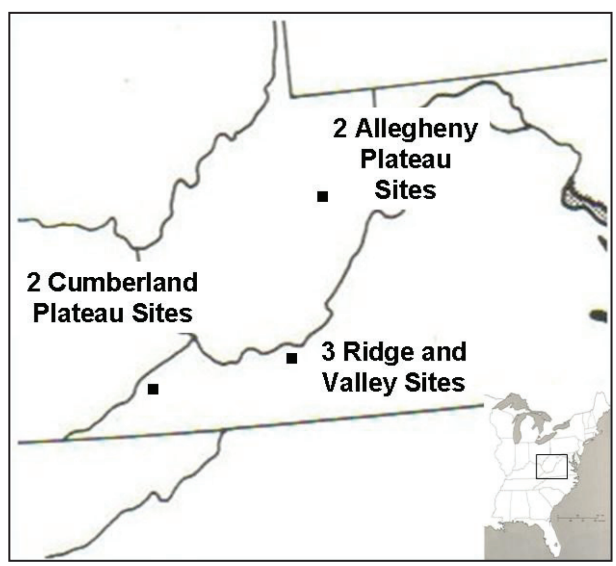

Figure 1.—Site locations.

Table 1.—Site Descriptions

Site	County, State	Oak S.I. 50yrs (m)	Age (yrs)	Year of Harvest Completions	Years Inventoried	Age at measurement (yrs)	QMD (cm)	Basal Area (m^2/ha)
BB1	Montgomery, VA	23	100	1995	1993,2006	11	19.8	25.5
BB2	Montgomery, VA	22	99	1996	1995,2006	10	18.2	26.8
CL1	Wise, VA	18	100	1998	1993,2007	9	21.2	29.2
CL2	Wise, VA	20	76	1998	1995,2007	9	19.2	29.1
NC	Craig, VA	18	62	1996	1995,2006	10	17.4	24.2
WV1	Randolph, WV	23	73	1997	1996,2007	10	17.8	35.2
WV2	Randolph, WV	24	63	1998	1997,2007	9	18.2	32.5

Adapted from Hammond 1997, Hood 2001, Lorber 2002.

Each site had seven treatments, but this investigation looked at three of those treatments: shelterwood, leave-tree, and silvicultural clearcut. Each treatment area was 2 ha. The shelterwood retained 12 to 14 m^2 per ha of residual basal area in dominant or codominant crown classes during the initial harvest. The residual overstory remained on site at the time of this inventory. The leave-tree left approximately 25 to 45 trees per ha totaling 5 m^2 per ha of basal area in dominant and codominant crown classes after the initial harvest; these trees will remain through the next rotation. The silvicultural clearcut removed all stems greater than 5 cm diameter at breast height (d.b.h.). The overall study design was a randomized complete block design with subsampling. Treatments were not replicated at each site; rather, each site served as a replication. In each 2-ha treatment there were three 24 m x 24 m tree plots. All of the tree plots were located at least 22 m from the treatment borders.

Prior to harvest all stems greater than 5 m tall were tagged and measured. The location of each tree within the larger tree plot was recorded. Plots were remeasured in 2006-2007, approximately 9 to 11 years after the initial harvest. Data were recorded on any sprouts present on the tagged stumps. The data taken were date, site, location, tree plot, tree number, diameter at ground per stump level (d.g.l.), d.b.h., height, and canopy class for each sprout on the stump. A z-test for comparing two binomial proportions was used with the categorical variable "sprout" or "no sprout" to compare the treatments (Ott and Longnecker 2001).

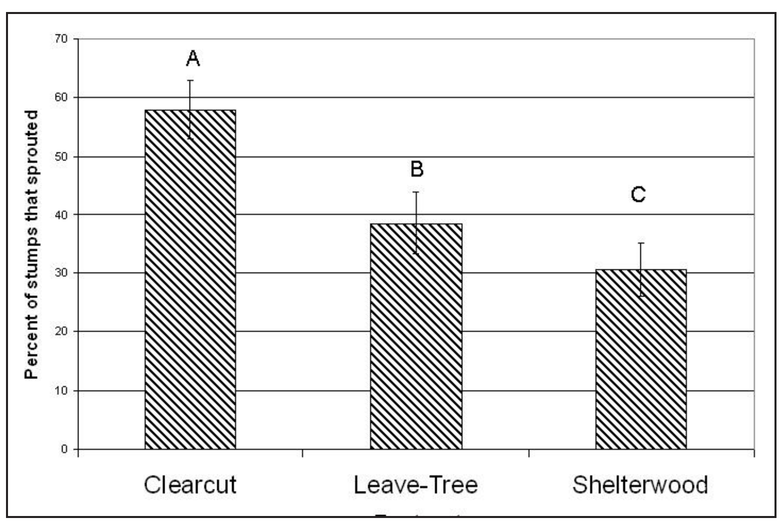

Figure 2.—Average percent of oak stumps that sprouted as affected by silvicultural treatment. Bars with different letters are significantly different (α=0.05).

RESULTS AND DISCUSSION

Data analysis revealed differences in stump sprouting among treatments (Fig. 2). Results indicated the clearcut was different with regard to number of stumps that sprouted from both the leave-tree and the shelterwood (p<0.01). The leave-tree and shelterwood were also different (p=0.025). Lorber (2002) indicated that post-harvest light conditions in the clearcut were significantly higher than the others, but similar in the shelterwood and leave-tree. Light levels could partially explain the difference between the clearcut and the other treatments, but not the difference between the leave-tree and shelterwood. These stands were of similar age and size (Table 1), so differences based on stump age or original tree diameter could not explain the different results, in contrast with similar studies (Johnson and others 2002).

A difference was found between physiographic provinces for each of the three treatments. The ridge and valley province sites had higher stump sprouting than the plateau sites for each treatment (Fig. 3). The plateau sites are of higher quality, but did not show greater stump sprouting ability contrary to other findings (Johnson and others 2002, Weigel and Peng 2002).

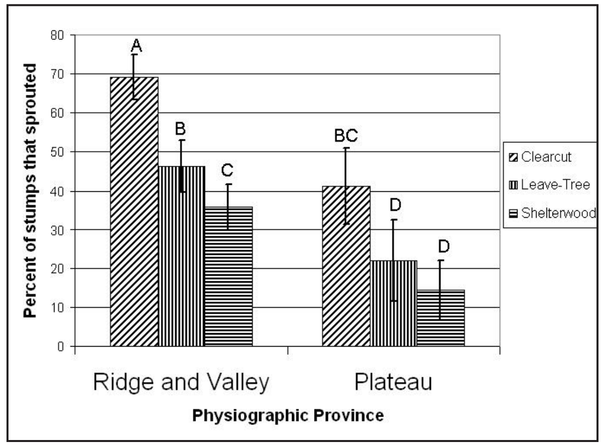

Figure 3.—Average percent of oak stumps that sprouted as affected by silvicultural treatment and physiographic province. Bars with different letters are significantly different (α=0.05).

Differences were also found among species within species groups by treatment (Fig. 4). White oak (*Q. alba* L.) sprouted the least of all oak species and was not affected by treatment. Overall sprouting percent was greatest in chestnut oak (*Q. prinus* L.). It was similar in the clearcut and leave-tree, but declined in the shelterwood. Sprouting percentages in scarlet oak (*Q. coccinea* Muenchh.), black oak (*Q. velutina* Lam.), and red oak (*Q. rubra* L.) were similar, and tended to fall between those of white oak and chestnut oak. All three species' sprouting tended to decrease in the leave-tree and the shelterwood compared to the clearcut.

The results of this study suggest that on fair to good quality sites in the southern Appalachians, silvicultural systems with residuals can significantly reduce the number of harvested oak stumps which sprout. Forest managers must take into consideration these findings when deciding which systems to use in the southern Appalachians, where stump sprouts are an important form of oak regeneration.

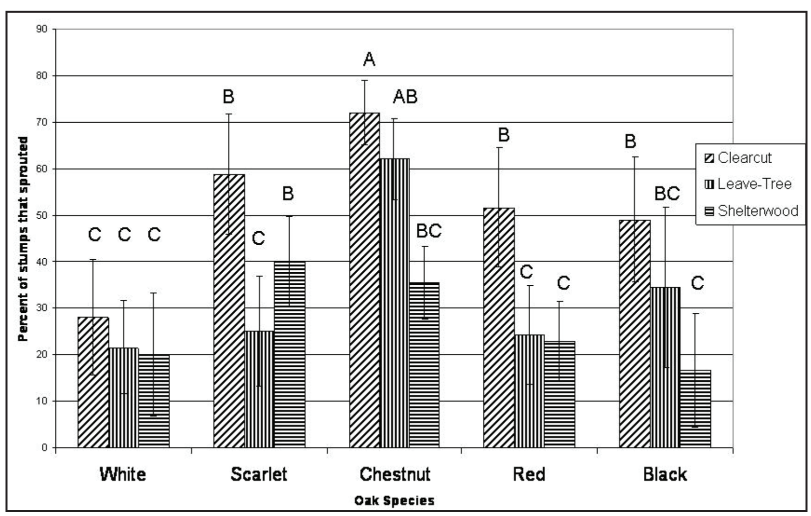

Figure 4.—Average percent of oak stumps that sprouted as affected by species and silvicultural treatment. Bars with different letters are significantly different (α=0.05).

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