# SPROUTING CAPABILITY OF SHORTLEAF PINE SEEDLINGS FOLLOWING CLIPPING AND BURNING: FIRST-YEAR RESULTS

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**Abstract--**Shortleaf pine (*Pinus echinata* Mill.) is one of the few southern pine species with the ability to sprout after disturbance during the seedling age range, but little is known about sprouting success based on the type of disturbance. This study evaluates sprouting success after controlled burning conditions or manually clipping as compared to untreated controls of planted shortleaf pine 1-0 seedlings approximately 1 month after planting and on subsequent sprout production and growth one growing season following planting. As part of a larger study, randomized plots of 50 seedlings (3 blocks per treatment) were planted on February 25, 2011 at the University of Tennessee Cumberland Forest located in the foothills of the Cumberland Mountains in Morgan County, TN. The burn and clip treatments were conducted in April 2011. Survival, number of sprouts, and height of the tallest sprout were recorded for each seedling in the winter of 2012-2013. The clip treatment and the control had the same survival rate (75.3 percent) and displayed greater survival than the burn treatment. Clipping produced more sprouts and taller sprouts on average compared to the burn treatment, yet the clip treatment sprouts were approximately half the height of the control seedlings. More data on seedling response to these disturbances at older ages will be collected as the study continues. One-year-old planted seedlings do not appear to show high survival rates or produce prolific numbers of sprouts in response to early growing season burns.

## INTRODUCTION

The native range of shortleaf pine (*Pinus echinata* Mill.) covers a vast area of approximately 440,000 square miles from eastern Texas north to New Jersey and Pennsylvania (Lawson 1990). The species typically grows on dryer, well-drained sites but can be found in a variety of topographic positions and soils throughout its range. The species can thrive on sites with poor edaphic conditions, primarily due to its extensive taproot, and is capable of forming nearly pure stands (e.g. Ouachita Mountains of Arkansas, and previously the Cumberland Plateau of Tennessee) (Coffey 2012, Lawson 1990, Williams 1998 ). The species' good growth form (self-pruning ability), disease resistance, fire tolerance, and cold hardiness make it a suitable constituent species for many management objectives (Phelps and Czabator 1978, Guldin 1986). The ability to sprout sets shortleaf pine apart from other southern pine species.

Shortleaf pine sprouts prolifically after the stem is damaged or killed. The species can sprout from the seedling through the pole size ranges, and individual stems may exhibit this sprouting response up to 6 to 8 inches in diameter at breast height (d.b.h.). Other tree species decline in areas with frequent disturbance, whereas shortleaf pine's sprouting ability allows it to continue to occupy an area after repetitive disturbances (Lawson 1990). Sprouting is enabled by a J-shaped basal crook, which contains axillary dormant buds. The crook forms 2 to 3 months after germination, and sprouts typically appear from the root collar directly above the basal crook (Guldin 1986, Lilly and others 2010).

The shortleaf pine resource has been declining. USDA Forest Service Forest Inventory and Analysis data have shown a decrease of stems ≥ 1 inch d.b.h. since the early 1980s (Oswalt 2012). In the middle to second half of the 20th century, factors such as fire suppression, declines in free-range livestock grazing, southern pine beetle outbreaks, and increased urbanization have combined to reduce the prevalence of shortleaf pine across its native range (Birch and others 1986, Coffey 2012). Industry preference for loblolly pine (*P. taeda* L.)

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and succession of shortleaf pine stands into mixed hardwood stands have contributed to the species' decline as well (Birch and others 1986, Dennington 1992).

Interest in restoring degraded shortleaf pine ecosystems, such as shortleaf pine-bluestem and shortleaf pine-oak savannas, has increased over the last several years, especially in the western portion of the species' range (Elliot and others 2012, Guldin 2007, Guldin and others 2004). Adequate regeneration of shortleaf pine from both artificial and natural means is necessary for restoring these systems. Regeneration from sprouting is typically more advantageous in situations where new age cohorts are desired due to unpredictable seed production and the exacting environmental conditions that are often required to successfully perpetuate shortleaf pine from seed (Guldin 1986, Lawson 1986). Few studies have investigated clipping (Campbell 1985) and fire (Cain and Shelton 2000, Lilly and others 2012) to determine their effects on shortleaf pine sprouting, especially in favorable areas east of the Mississippi River such as the Cumberland Plateau region of Tennessee.

## OBJECTIVES

The goals of this study were to: (1) determine survival differences among 1-year-old seedlings that were burned or clipped early in the growing season and untreated controls, (2) compare sprouting numbers among the three treatments, and (3) compare differences in dominant sprout height between burned and clipped seedlings. In addition, this study sought to determine if a relationship existed between the number of sprouts and the height of the tallest sprout on seedlings that survived the treatments.

## METHODS

The study was located at the University of Tennessee Forest Resources Research and Education Center's Cumberland Forest Unit in Morgan County, TN. This area of Tennessee is part of Walden Ridge, a subregion of the Cumberland Plateau, and is characterized by broad, rolling ridges and weakly dissected plateau surface (Smalley 1982). A previously maintained 5,796 square foot square field was chosen for planting 1-0 stock bare-root shortleaf pine seedlings on February 25, 2011. The seedlings were purchased from the Tennessee Division of Forestry Nursery at Delano, TN. Fifty seedlings were planted on 1- by 1-foot spacing in 4- by 9-foot plots oriented from north to south. Soils consisted of fine-loamy, siliceous, semiactive, mesic Typic Hapludults on 5 to 12 percent slopes from the Lonewood series with a shortleaf pine site index of 70 feet at base age 50 years (NRCS 2012). Three treatments each within three blocks were designated. The three treatment plots in each block are part of a larger, longer term study. The three treatments analyzed in this study included an early growing season burn conducted on April 14, 2011, early growing season clipping applied on the same date, and an untreated control.

For all three burn plots, the same methodology was used to ensure similar burning conditions across blocks. Proximate white pine (*P. strobus* L.) plantations provided needles that were used as a fuel source for ground fires. Needles were dried approximately 2.5 hours in full sunlight during mid-afternoon on April 14, 2011 and placed within burn plots in approximately equal volumes using 5-gallon buckets to ensure similar burn conditions. Homogeneity among burns (duration and temperature) was determined using a stopwatch and a Kintrex digital infrared thermometer, which determined burn temperatures approximately 70 inches away from the center of each plot. Temperatures were recorded every 15 seconds until complete flame-out.

Seedlings that received the clip treatment were cut approximately 1 to 2 inches above ground level so as not to damage the basal buds and limit sprouting. In addition to clipping the main stem, any other sprouts below the 1-inch threshold were clipped to reduce variation among seedlings.

Survival counts and measurements of seedlings/sprouts were carried out in January

2013, one full growing season after treatments. In order to assist counts and measurements, grasses and weeds were clipped and a 2-ounce-per-gallon solution of glyphosate (Cornerstone Plus®) was applied in September 2012 by sponge-wicking around sprouts and seedlings. Determination of whether a seedling was dead or alive, number of sprouts per seedling, and height of the tallest sprout per seedling were recorded for each treatment. Analysis of variance was used to test for treatment differences with each variable. Data were analyzed as a randomized complete block experimental design using PROC MIXED in SAS 9.3 (SAS Institute 2012). Least squares means were separated using Fisher's protected least significant difference, and a significance level of P = 0.05 was used for all analyses. Data for each variable were transformed as needed using either square root or arc sine square root transformations. Untransformed means and standard errors are reported for each analysis.

## RESULTS

No significant differences were found among survival rates (P = 0.067), yet the burn treatment had a much lower numeric survival rate than either the clip or control treatments, which had the same rate of survival (table 1). For the burn plots, temperatures ranged from 512° to 770 °F, and flame-out occurred in 6 minutes on all three plots. The analysis of dominant sprout height indicated significant differences among treatments (P = 0.001). The clip treatment produced dominant sprouts that were approximately 7 inches taller on average than the burn treatment. Compared to the untreated control seedlings, the clip treatment seedlings were approximately 11 inches shorter on average (table 2). The cumulative height of the control seedlings over the 2 years was 48.6 +/- 2.9 inches. Significant differences in sprout numbers among treatments were found (P = 0.003). The clip treatment produced more sprouts on average than the burn treatment. Both the clip and burn treatment seedlings produced more sprouts than the untreated control seedlings (table 3). The correlation between sprout height and sprout number for the burn and clip treatments was significant (P = 0.0001). The relationship was moderately negative (r = -0.433), indicating that as dominant sprout height increased, sprout number decreased.

**Table 1—Mean survival percentages and standard errors one full growing season after treatments were applied. Surviving seedlings were 2 years old at time of counting. BM is burning in March; CL is clipping in March; and CO represents untreated controls**

| Treatment | Mean | Std. error |
|---|---|---|
| | --%-- | |
| BM | 42.6a | 0.078 |
| CL | 75.3a | 0.078 |
| CO | 75.3a | 0.078 |

[a]Treatments with the same letter in the mean column do not differ significantly at P = 0.05.

**Table 2—Mean heights and standard errors one full growing season after treatments were applied. Seedlings were 2 years old when measured. Height of the tallest sprout was measured for each sprout clump. BM is burning in March; CL is clipping in March; and CO is the second-year growth of the untreated controls**

| Treatment | Mean | Std. error |
|---|---|---|
| | *inches* | |
| BM | 19.2a | 2.97 |
| CL | 26.2b | 2.90 |
| CO | 37.5c | 2.89 |

[a]Treatments with the same letter in the mean column do not differ significantly at P = 0.05.

**Table 3—Mean and standard errors of the number of sprouts (green needles present) per seedling produced one full growing season after treatments were applied. Seedlings were 2 years old when sprouts were counted. BM is burning in March; CL is clipping in March; and CO represents untreated controls**

| Treatment | Mean | Std. error |
|---|---|---|
| | *--no.--* | |
| BM | 4.8a | 0.49 |
| CL | 6.2a | 0.42 |
| CO | 1.3b | 0.42 |

[a]Treatments with the same letter in the mean column do not differ significantly at P = 0.05.

## DISCUSSION AND CONCLUSION

The clip and control treatments had similar survival rates (75.3 percent). Little and Somes (1956) reported that clipping near the root collar where the majority of the dormant buds are located could reduce the number of sprouts. Care was taken in this study to clip the seedlings 1 to 2 inches above the ground line or the root collar to ensure that the dormant buds were not damaged. Although the formation of new roots has been observed as the single most important factor in survival of planted bare-root southern pine seedlings, the presence of undamaged dormant buds on the clipped seedlings did not impact survival when compared to the controls (Brissette and Chambers 1992). A clipping study with 4-year-old seedlings in Arkansas revealed that clipping in February at similar heights above ground level had lower survival rates at 48 percent compared to the 1-year-old seedlings in this study (Campbell 1985). In another related study on the Coastal Plain of Arkansas, untreated controls had a 91 percent survival rate that was greater than the survival rate in this study (Cain and Shelton 2000). Differences in survival rate between studies could be attributable to the planting shock associated with lifting, storage, transport and planting processes for seedlings, planting site variations, and soil fertility. The burn treatment had a lower survival rate than the clip or control treatments. The survival rate for the burn treatment was similar to that reported by for late dormant season/early growing season burns on 4- to 6-year-old seedlings (37 percent) (Lilly and others 2012). Variations in litter/soil depth, flame intensity, seedling bark thickness, and seedling age can impact the insulation of the basal, dormant buds and seedling survival after burns (Cain and Shelton 2000, Lilly and others 2012, Little and Somes 1956).

Height differences between the clipped and burned seedlings differed statistically. The short amount of time between planting and treatment application (7 weeks) may have contributed to these height differences. Most seedlings following planting are under soil-water-root and carbohydrate-storage stress as they try to establish a root system in their new environment (Grossnickle 2005, Rietveld 1989). Seedling growth resources were stretched during establishment after outplanting as well as in responding to a disturbance, both of which affected the above-ground stem. Coupled with the absence of thick bark that older seedlings and saplings have to protect them from fire, the burn probably set back height growth in the 1-year old seedlings much more so than clipping alone (Guldin 1986, Fan and others 2012). The burn killed or damaged the basal buds, resulting in less of an ability to sprout and in fewer sprouts that were shorter in height than the other two treatments. The control seedlings were 1.4 times as tall as the clipped seedlings and 1.9 times as tall as the burn seedlings over one full growing season, indicating that the species is capable of fast growth in open conditions on these plateau sites.

No significant differences for sprout number existed among treatments. Burned and clipped seedlings both produced more sprouts than the controls, demonstrating that seedlings are more likely to produce sprouts with disturbance than without it. Numerically, clipping produced more sprouts (6.2 +/- 0.4) than burning (4.8 +/- 0.4). Once again, unlike the buds for seedlings in the clip treatment, burning most likely damaged the basal buds. Also unlike this study, in a similar study focused on the effects of fertilizer and sprouting on older 6-year- old seedlings in New Jersey, the mean number of sprouts produced was significantly different between burning and clipping (Grossmann and Kuser 1988). In a study with older seedlings (Lilly and others 2012), more sprouts on average (8.8 +/- 0.7) occurred with burning than in this study. Young seedlings do not appear to be capable of producing as many sprouts as older seedlings.

The moderately negative correlation between dominant sprout height and sprout number probably was due to limits on resource allocation, especially in recently outplanted seedlings. Factors such as root-water relations, root-soil relations, a lack of fine roots, and weather conditions such as temperature and moisture can affect how well the seedlings respond to disturbance and resultant sprout growth and frequency (Burdett 1990, Rietveld 1989). This relationship may change as seedlings become more established and with increasing age, which would allow them to recover from disturbances more easily.

One-year-old clipped seedlings had better survival rates, attained greater heights, and produced more sprouts than burned seedlings. This study was conducted under open growing conditions. However, seedlings growing in partial shade may perform favorably because shortleaf pine has more shade tolerance in the seedling age range than in mature trees (Shelton 1995). The early results of this study and past research suggests that managers interested in favoring shortleaf pine over other species through burning should wait to implement treatments until the trees are more than 1-year-old (especially for outplanted shortleaf pine) to obtain better survival, sprouting numbers, and heights (Fan and others 2012). More research is needed to determine how well seedlings sprout and grow at different ages and with burns applied during various times throughout the year.

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