UNDERPLANTING SHORTLEAF PINE IN THE MISSOURI OZARKS

Jason Jensen, Cliff Smith, Mark Johanson and David Gwaze[1]

ABSTRACT.—A study was established on Clearwater Conservation Area in the Missouri Ozarks in which shortleaf pine (*Pinus echinata* Mill.) seedlings were underplanted in mature mixed oak and oak/pine stands. Overstory trees were harvested a few months after planting, leaving different levels of residual overstory stocking. The different overstory treatments included 1) uneven-aged management with group openings; 2) clearcut; 3) shelterwood treatment with overstory reduction to B-level stocking; and 4) shelterwood treatment with overstory reduction to C-level stocking. Seven years after treatment application, clearcut stands had the best stocking and growth of planted shortleaf pine seedlings. The clearcut stands also had the highest number of free-to-grow seedlings. The higher the retained overstory stocking, the lower the number of free-to-grow shortleaf pine seedlings, and the lower the stocking and growth of underplanted shortleaf pine seedlings. Group openings established in uneven-aged management treatments appear to work, but the results suggest that they should be much larger to effectively regenerate pine. Growth of natural advance reproduction while in the understory, and released after clear cut harvesting was similar to growth of underplanted shortleaf pine seedlings and released after clearcut harvest, seven years after planting. This suggests that underplanting was effective in allowing planted pine seedlings time to become established and, therefore, capable of responding once released. Findings of this study suggest that clearcutting is the best method of regenerating pine, and that the higher the stocking rate of the residual overstory, the poorer the growth and stocking of the underplanted seedlings. The results also suggest that retaining the overstory for 7 years adversely affects stocking and growth of shortleaf pine seedlings and, thus, early release of underplanted seedlings is likely to result in a greater increase in stocking and growth.

INTRODUCTION

Shortleaf pine is an important source of food and habitat for many birds and mammals and it produces high quality sawtimber on dry, nutrient-poor sites (Lawson 1990). Shortleaf pine forests in Missouri have declined from 6.6 million acres to 397,100 acres since Euro-American settlement (Essex and Spencer 1976) The recent oak decline has underlined the importance of maintaining the shortleaf pine component in the pine-hardwood forests of Missouri because loss of oaks is greatest on sites that once had greater shortleaf pine stocking, and pine is well adapted to these sites for which they are considered a desirable species.

Currently, there is considerable interest in restoring shortleaf pine into areas where it has been lost due to past excessive logging, fire suppression, annual burning by farmers, highgrading, conversion to range and overgrazing. Underplanting is a potentially viable silvicultural option for restoring shortleaf pine. Underplanting is useful to establish advance reproduction where natural reproduction of shortleaf pine is lacking. Conceptually, underplanting will result in vigorous root systems that will provide the growth potential for seedlings when the mature trees are removed provided there is adequate light for net positive biomass production (Johnson 1993). Underplanting allows the control of the potential grow surge of competing hardwoods and allows removal of the overstory when the pine is established. Herbicide release may not be needed for underplanted seedlings. It is also easier, and hence cheaper, to hand plant before harvest because of lack of physical barriers at planting. Success of underplanting pine is not well known, and could be limited by the fact that shortleaf pine requires abundant light for rapid growth (Lawson 1990). However, Becton (1936) reported that shortleaf pine seedlings can become established under a dense canopy and persist for several years before dying, suggesting that newly established pine seedlings are moderately shade tolerant but become more shade intolerant with age.

The objectives of the study were to 1) compare seven-year stocking and growth of shortleaf pine seedlings planted underneath various overstory densities; and 2) evaluate influence of hardwood competition on growth and stocking of underplanted shortleaf pine seedlings.

[1]Resource Forester (JJ), Missouri Department of Conservation, RR 4 Box 1002, Piedmont, MO 63957; Resource Forester (CS), Missouri Department of Conservation, Ellington, MO 63638; Private Lands Conservationist (MJ), Missouri Department of Conservation, PO Box 248, Sullivan, MO 63080; Resource Scientist (DG), Missouri Department of Conservation, 1110 S. College Avenue, Columbia, MO 65201.DG is corresponding author: to contact call (573)882-9909 ext. 3320 or email at David.Gwaze@mdc.mo.gov

MATERIALS AND METHODS

Site Description

The study was located in compartment 7 on the Clearwater Conservation Area of the Missouri Department of Conservation. The Clearwater Conservation Area (CCA) is located in the Reynolds and Shannon Counties located in southeast Missouri. The study site is located completely within the Current River and Black River oak-pine woodland/forest hills Land Type Association (Nigh and Schroeder 2002). These land types are characterized by hilly landscapes with narrow ridges, narrow valleys and steep slopes with 150 to 250 feet of local relief. The ridges and upper slopes are formed from the Roubidoux Formation whereas the lower hillslopes and valleys cut into the Gasconade Formation. Historically, this area was dominated by shortleaf pine and shortleaf pine-oak woodland complexes.

The compartment was managed to favor pine in the late 1990s. March 23 through March 29, 1998, 234.6 acres were planted with 97,741 shortleaf pine 1-0 bare-root seedlings. In May of 1998 the Conservation Commission approved the sale of 1,085,391 board feet of mixed hardwood saw timber from this compartment. The forester administering the sale used different management prescriptions to monitor pine seedling response to increasing overstory density and to determine the optimal overstory density for pine regeneration development. Overstory manipulations per stand were as follows: clearcut, unevenaged management with group openings, shelterwood treatment with overstory reduction to B-level stocking and shelterwood treatment with overstory reduction to C-level stocking.

Sampling Procedure

In November 2005, we assessed these stands to learn more about the successes and failures of the artificial regeneration techniques. We surveyed stands each with the following treatments:

1) Clearcut and planted with 1-0 shortleaf pine seedlings at 12 x 12 ft (CC).
2) Clearcut and not planted (CCN).
3) Thinned using uneven aged management guidelines (UAM) (see Missouri Department of Conservation Guidelines 1986) and planted with 1-0 shortleaf pine seedlings at 12 x 12 ft. UAM guidelines include group openings.
4) Thinned to B-level stocking (Gingrich 1967) and planted with 1-0 shortleaf pine seedlings at 12 x 12 ft (B-level).
5) Thinned to C-level stocking (Gingrich 1967) and planted with 1-0 shortleaf pine seedlings at 12 x 12 ft (C-level).

The goal was to retain a residual basal area of approximately 70 ft^2/acre for B-level and UAM treatments, and 55 ft^2/acre for C-level treatments. Group openings were one tree height (70 feet) in diameter. In the clearcut stands, all trees were cut except shortleaf pine trees.

In each stand we established six plots along one or more transects. Each transect followed the slope. Each plot was 60 ft x 40 ft and was meant to include 20 planted shortleaf pine seedlings. The stocking and height of each planted shortleaf pine seedling was assessed. Competition was assessed several ways. First, overstory basal area was measured by a prism count at the center of each plot. Second, number of hardwoods midstory species were counted within a 1/100th acre plot located within the center of each plot. Third, competition was assessed by measuring free-to-grow status of pine seedlings. Pine seedlings were assessed as being overtopped by hardwood competition or free-to-grow. Vegetation was considered competing with shortleaf pine seedlings if a leaf or branch of competing vegetation covered the pine's terminal leader or was close to the terminal leader; otherwise the shortleaf pine seedlings were judged as free-to-grow.

Statistical Analyses

Plot means were used for all analyses. Using the PROC GLM procedure in SAS Version 9.1 (SAS Institute Inc., Cary, NC), one-way analyses of variance (ANOVAs) were used to test for significant differences among treatments for growth and competition. All analyses were carried out at the $P \leq 0.05$ probability level. Where significant differences were detected among treatments, Duncan's Multiple Range Test was used to compare means.

RESULTS

Stocking of Shortleaf Pine Seedlings

After seven growing seasons, stocking of planted shortleaf pine was highest in the clearcut treatment and least in the unevenaged management treatment (Fig. 1). Stocking of shortleaf pine seedlings was estimated to be 12 percent in the UAM, 28 percent in the C-level, 52 percent in the B-level and 63 percent in the clearcut stand. The few trees observed in the UAM stand were in group openings, particularly in the center of the opening. The unplanted clearcut stand had a significantly higher stocking of shortleaf pine seedlings than planted stands with high residual overstory densities (UAM, B-level and C-level). Stocking of shortleaf pine seedlings did not differ significantly in unplanted (CCN) and planted clearcut (CC) treatments. The unplanted clearcut stand was not planted due to adequate advanced pine regeneration.

Growth of Shortleaf Pine Seedlings

Height of planted shortleaf pine seedlings was best in the clearcut treatment (Fig. 2). Height of planted shortleaf pine seedlings in clearcuts was more than twice the height

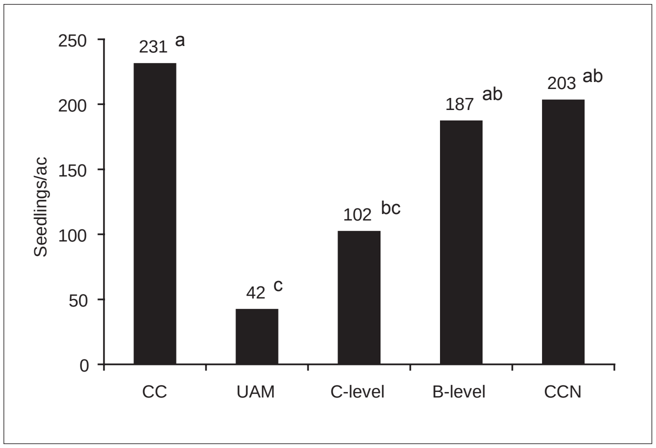

Figure 1.—Stocking of underplanted shortleaf pine seedlings 7 years after establishment. CC = clearcut and planting; UAM = uneven-aged management and plant; C-level = thin to C-level stocking and plant, B-level = thin to B-level stocking and plant; CCN = clearcut and no planting. Numbers on bars are treatment means. Different letters indicate significant differences among treatments based on the Duncan's Multiple Range Test. Same or shared letters indicate no significant difference at α = 0.05 level.

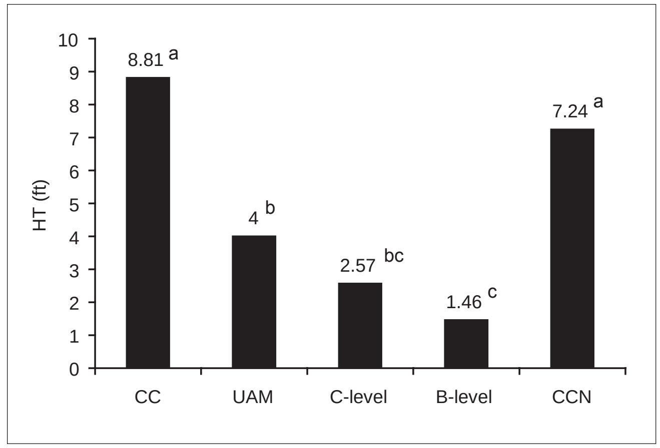

Figure 2.—Height growth of shortleaf pine trees 7 years after establishment. CC = clearcut and planting; UAM = uneven-aged management and plant; C-level = thin to C-level stocking and plant, B-level = thin to B-level stocking and plant; CCN = clearcut and no planting. Numbers on bars are treatment means. Different letters indicate significant differences among treatments based on the Duncan's Multiple Range Test. Same or shared letters indicate no significant difference at α = 0.05 level.

of those in the other treatments. Group openings made a difference in the UAM because the tallest seedlings were found in the center of the group openings. These seedlings were as tall as those in the clearcut stand. In clearcuts, planted and naturally regenerated shortleaf pine seedlings were not significantly different in height.

Competition

Overstory competition consisted of hardwoods and mature shortleaf pine trees retained as seed trees. As expected, the overstory competition was lowest in the clearcut stands (Fig. 3) and consisted of few scattered shortleaf pine seed trees. Midstory competition was inversely related to the amount of residual overstory trees, being highest in the clearcut treatments and least in the treatments with higher amount of residual overstory (Fig. 4). The high number of midstory trees in the UAM compared to the B and C-level stocking was due to high density of midstory trees in group openings.

Many of the shortleaf pine trees in clearcuts were judged as free-to-grow while the majority of the trees in the other treatments were suppressed (Fig. 5). While over 65 percent of the planted shortleaf pine seedlings were judged as free-to-grow in the clearcut stands, less than 25 percent were judged as free-to-grow in stands with a high residual overstory density. Shortleaf pine seedlings in the clearcuts were mainly overtopped by midstory hardwood sprouts, while those in the other treatments were overtopped by overstory hardwoods.

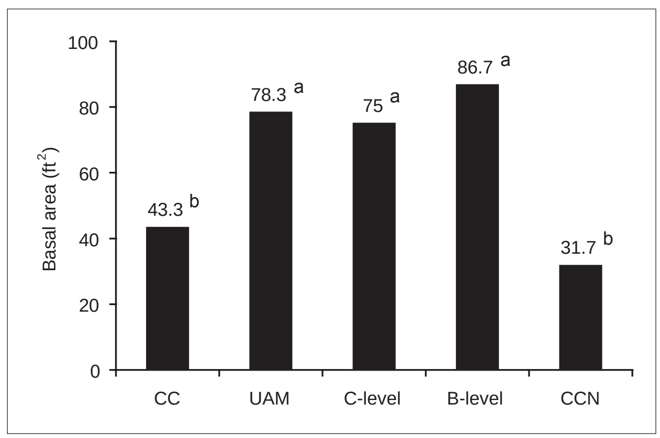

Figure 3.—Basal area of overstory trees 7 years after establishment. CC = clearcut and planting; UAM = uneven-aged management and plant; C-level = thin to C-level stocking and plant, B-level = thin to B-level stocking and plant; CCN = clearcut and no planting. Numbers on bars are treatment means. Different letters indicate significant differences among treatments based on the Duncan's Multiple Range Test. Same or shared letters indicate no significant difference at α = 0.05 level.

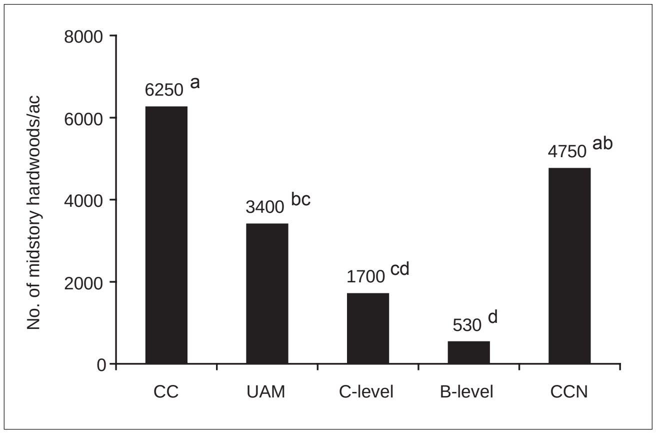

Figure 4.—Density of midstory hardwoods 7 years after establishment. CC = clearcut and planting; UAM = uneven-aged management and plant; C-level = thin to C-level stocking and plant, B-level = thin to B-level stocking and plant; CCN = clearcut and no planting. Numbers on bars are treatment means. Different letters indicate significant differences among treatments based on the Duncan's Multiple Range Test. Same or shared letters indicate no significant difference at α = 0.05 level.

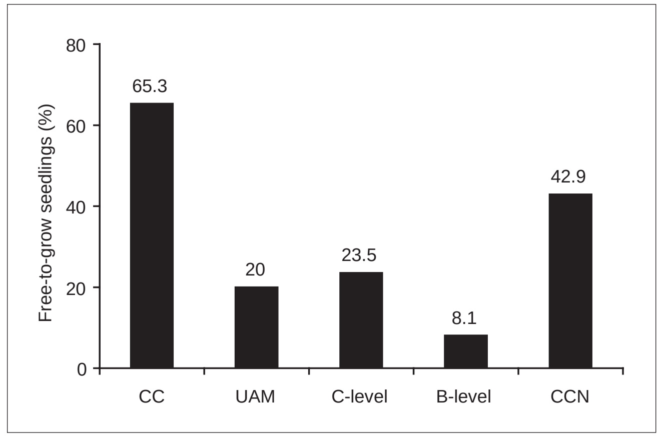

Figure 5.—Free-to-grow shortleaf pine seedlings 7 years after establishment. CC = clearcut and planting; UAM = uneven-aged management and plant; C-level = thin to C-level stocking and plant, B-level = thin to B-level stocking and plant; CCN = clearcut and no planting. Numbers on bars are treatment means.

DISCUSSION AND CONCLUSION

Results from our study indicate that shortleaf pine seedlings in the clearcuts had higher stocking than those in other treatments. Brinkman and Liming (1961) underplanted 1-0 shortleaf pine seedlings in 40-year-old oak-pine forest on the Mark Twain National Forest and removed the overstory leaving different residual densities (0, 27, 53 and 79 ft^2/acre). When they removed the overstory in the year of planting they found no significant differences in survival 11 years after planting. However, they found that survival of underplanted shortleaf pine was drastically reduced from 74 percent to 10 percent when the overstory release by clearcutting was delayed one year after planting. According to Liming (1946), complete release of overstory by clearcutting is an unsatisfactory method of releasing shortleaf pine one or more growing seasons after planting.

Results from our study further suggest that shortleaf pine seedlings in clearcuts developed more rapidly than those planted in other treatments. This is expected because there was less shading in clearcuts. Our results are consistent with reports by Brinkman and Liming (1961) and Guldin and Heath (2001) who reported that growth of underplanted shortleaf pine seedlings in clearcuts was superior to those where partial overstory was retained.

Because midstory competition was highest and growth was best in the clearcut treatments our study suggests that overstory competition is the main factor affecting stocking and growth of underplanted seedlings. Overstory vegetation has a substantial influence on underplanted seedlings by reducing light intensity, intercepting a significant proportion of precipitation and increasing competition for soil moisture and nutrients by roots (Anderson et al. 1969). Underplanted shortleaf pine seedling growth was found to be inversely related to increasing overstory retention after seven growing seasons (Guldin and Heath 2001).

Our study and previous studies indicate that clearcutting is the best for regenerating shortleaf pine. Brinkman and Liming (1961) further observed that delaying complete overstory removal by one year after planting reduced survival of planted shortleaf pine substantially. Liming (1946) recommended spring planting of pine and clearcutting the overstory the following dormant season. Certainly, early removal of the overstory appears to match the silvics of the species because shortleaf pine is generally considered a shade-intolerant species (Lawson 1990). Group openings (small clearcuts) established in uneven-aged management treatments appear to work, but our results suggest that they should be much larger to allow successful establishment and development of planted shortleaf pine seedlings for more than 7 years. Underplanted seedlings in the clearcut treatment had a similar growth response to advanced regeneration in unplanted clearcut treatment, 7 years after planting. This suggests that underplanting was effective in allowing planted pine seedlings time to become established and, therefore, capable of responding once released.

Possible future studies utilizing existing underplanted stands include determining the response of underplanted shortleaf pine seedlings to canopy removal and determining the more effective recruitment method for planted shortleaf pine seedlings in clearcuts. The first study should provide information about whether the underplanted seedlings in partial overstory retention treatments, particularly those in B-level and C-level treatments, will respond to release after seven or more years after planting. Some studies in Missouri carried out from the 1930s to 1960s indicated that underplanted shortleaf pine seedlings respond well to release even at a late stage such as 30 years (Brinkman and Smith 1968). The new studies will provide up-to-date information to supplement or confirm the historical studies. The second study may determine if there are any differences in stocking and growth of shortleaf pine trees in clearcuts released using different methods—mechanical, chemicals and fire—providing important information to resource managers on which method is best at recruiting shortleaf pine trees.

LITERATURE CITED

Anderson, R.C.; Loucks, O.L.; Swain, A.M. 1969. Herbaceous response to canopy cover, light intensity, and throughfall precipitation in coniferous forests. Ecology. 50: 255-263.

Becton, W.R. 1936. Effects of varying densities of hardwood cover on growth and survival of shortleaf pine reproduction. Journal of Forestry. 34: 160-164.

Brinkman, K.A.; Liming, F.G. 1961. Oak and pine reproduction to over head release. Journal of Forestry. 59: 341-346.

Brinkman, K.A.; Smith, R.C. 1968. Managing shortleaf pine in Missouri. Stn. Bull. 875. Columbia, MO: University of Missouri Agricultural Experiment Station. 33 p.

Gingrich, S.F. 1967. Measuring and evaluating stand density in upland hardwood forests in Central States. Forest Science. 13: 38-53.

Guldin, J.M.; Heath, G. 2001. Underplanting shortleaf pine seedlings beneath a residual hardwood stand in the Ouachita Mountains: Results after seven growing seasons. Res. Note. SRS-09. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 8 p.

Johnson, P. 1993. Sources of oak reproduction. In: Loftis, D.L.; McGee, C.E., eds. Proceedings, oak regeneration: serious problems, practical recommendations; 1992 September 8-10; Knoxville, TN. Gen. Tech. Rep. SE-84. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 112-131.

Law, J.R.; Melick, R.; Studyvin, C.; Steinman, J.R. 2004. Oak decline in Missouri: History revisited. In: Spetich, M.A., ed. Upland oak ecology symposium: history, current conditions, and sustainability. Gen. Tech. Rep. SRS-73. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station: 257-258.

Lawson, E.R. 1990. *Pinus echinata* Mill. shortleaf pine. In: Burns, R.M.; Honkala, B.H., tech. coords. Silvics of North America. Volume 1, Conifers. Agric. Hndbk. 654. Washington, DC: U.S. Department of Agriculture, Forest Service.

Liming, F.G. 1945. Natural regeneration of shortleaf pine in the Missouri Ozarks. Journal of Forestry. 43(5): 339-345.

Liming, F.G. 1946. Response of planted shortleaf pine to overhead release. Tech. Pap. No. 105. Columbus, OH: U.S. Department of Agriculture, Forest Service, Central State Experiment Station. 20 p.

Missouri Department of Conservation. 1986. Forest land management guidelines. Jefferson City, MO: Missouri Department of Conservation. 86 p.

Nigh, T.A.; Schroeder, W. A. 2002. Atlas of Missouri ecoregions. Jefferson City, MO: Missouri Department of Conservation. 212 p.