A COMPARISON OF NUTTALL OAK ESTABLISHMENT METHODS USING IMPROVED AND UNIMPROVED SEEDLINGS, SEEDLING TREATMENTS, AND SITE PREPARATION INTENSITY IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY

Kutcher Kyle Cunningham and H. Christoph Stuhlinger

Abstract—Restoration of bottomland hardwoods in the Lower Mississippi Alluvial Valley (LMAV) has increased over the past 3 decades to restore the resource, increase wildlife habitat, improve water quality, and enhance forest health and production. However, establishment successes of afforestation efforts in this region have been highly variable. This study attempted to employ proven establishment operations with new concepts to further supplement our understanding of oak establishment on bottomland sites. Two locations were established using minimum site preparation and intensive site preparation methods. Cultural factors included varying combinations of subsoiling, chemical site preparation, herbaceous release, and clipping and sheltering treatments to planted 1-0 bare-root seedling stock. An additional opportunity arose to evaluate the impacts on improved and unimproved seedling stock. Significant differences were identified between minimum and intensive site preparation treatments in regard to survival and growth variables. Additional differences were observed in seedling and planting stock treatments at each study site.

INTRODUCTION

Hardwood restoration of bottomland tree species in retired agricultural fields has been a significant practice of varying, but steady, intensity for the past 3 decades. A majority of these hardwood plantations were established in the Lower Mississippi Alluvial Valley (LMAV). The driving force for these efforts has been the soil and water conservation cost-share programs (e.g., Wetland Reserve Program, WRP) initiated in the 1980s, resulting in hundreds of thousands of reforested acres in the LMAV (Lockhart 2008, Schoenholtz and others 2001). High variability in seedling establishment success resulted in a need for improved establishment methods for existing cost-share programs. Ultimately, improvement in our understanding of site factors including species/site relationships, compacted soil layers, and competition control resulted in significantly higher planting success rates (Ezell and others 2007, Ezell and Shankle 2004). This study attempted to further supplement our understanding of site preparation methods through soil amelioration and competition control operations, while developing new ideas about necessity and timing of operations.

Genetic improvement efforts have been conducted on a limited basis for oak species. However, selection of seed from parent trees with desirable traits and ensuring genetic diversity through seed selection methodology are potentially important to successful plantings of oak species (Dey and others 2008). Oak seedling improvement efforts have been successfully conducted by the Arkansas Forestry Commission (AFC). The improved selections were generated from rogued seed orchards for Nuttall oak (*Quercus texana*) and cherrybark oak (*Q. pagoda*). The trees in the orchards were open-pollinated. While total genetic gain is not measurable with such a method, the seedlings are still potentially improved over standard nursery seedlings or “unimproved” seedlings. The largest potential differences stem from the fact that large amounts of acorns may be selected from one single tree of unknown genetic traits for unimproved seedlings. Our study incorporated improved and unimproved seedlings into the design. The goal was to evaluate, in an operational field setting, improved selections against unimproved seedlings. Additionally, we desired to explore the impact cultural treatments could have on the different seedling stock types.

Author information: Kutcher Kyle Cunningham, Assistant Professor of Forestry, University of Arkansas Division of Agriculture, Arkansas Forest Resources Center, Little Rock, AR 72204; and Hans Christoph Stuhlinger, University Forester, University of Arkansas Division of Agriculture, Arkansas Forest Resources Center, Monticello, AR 71656.

Kirschman, Julia E., comp. 2018. Proceedings of the 19th biennial southern silvicultural research conference. e-Gen. Tech. Rep. SRS-234. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 444 p.

Finally, individual seedling treatments to promote survival and growth of hardwood seedlings have not been fully explored. Some of these treatments have included top-clipping and the application of tree shelters as independent measures, but few studies have considered both treatments simultaneously. Significant work was conducted evaluating the impact of top-clipping with red oak species such as northern red oak (*Q. rubra*). Top-clipping has been employed at a lesser extent in other oak species, but has proven beneficial in some studies (Dey and others 2008). Some studies have demonstrated the benefits and problems (e.g., cost and maintenance) associated with the use of tree shelters in seedling establishment of bottomland hardwoods (Stuhlinger 2013). Our study was designed to test new methods incorporating top-clipping with short tree shelters to potentially address prior concerns with these treatments.

METHODS

Study Site

Two study sites in the LMAV were selected for use at the University of Arkansas Division of Agriculture Pine Tree Research Station near Forrest City, AR. The retired agricultural sites were located on terrace slope positions along tributaries of the Le'Anguille River. Soil types at both sites were Loftis somewhat poorly drained silt loams. The sites had a potential to be wet during the dormant season, but did not flood regularly. Site analysis suggested Nuttall oak would be a good fit for these site types. Therefore, improved and unimproved Nuttall oak seedlings from the AFC were used in the study.

Vegetative cover at site 1 primarily consisted of native warm season grasses, with lesser components of broadleaf weeds, vines, and woody species. Vegetative cover at site 2 consisted of a mix of competition types including grasses, broadleaf weeds, vines, and woody species. Both sites were assumed to contain compacted soil layers present near the surface, evident by soil probing.

Treatments

Minimum site preparation (MSP) (site factor) – Site 1 was assigned the MSP treatment group. The MSP treatment included mowing in July 2014, followed by an herbicide application in September 2014. Glyphosate (Accord® XRT II) was applied at 2 quarts per acre for the September site preparation treatment. Seedlings were hand-planted in 20-tree row replicates during February 2015.

Intensive site preparation (ISP) (site factor) – Site 2 was assigned the ISP treatment group. The ISP treatment included mowing in July 2014, followed by an herbicide application in September 2014. An attempt was made in November 2014 to subsoil the site; however, excess moisture precluded this treatment. Instead, each planting location was drilled by auger prior to planting to address subsoil compaction. Seedlings were hand-planted in 20-tree row replicates during February 2015, followed by an herbaceous release using 2 ounces sulfometuron methyl (Oust® XP) per acre 2 weeks after planting.

Seedling Treatments (blocking factor) – At both locations, three seedling treatment factors were applied immediately following planting and herbicide treatment applications. Seedling treatment 1 (CL) included top-clipping seedlings to 3 inches above ground. Seedling treatment 2 (CL+S) included top-clipping seedlings to 3 inches above ground, plus adding a 2-foot tree shelter (Tubex™). Seedling treatment 3 (UNC) included simply planting 1-0 bare-root seedlings in a traditional method.

Planting Stock Treatment (split plot factor) – At both site location and for each blocking factor, 20-tree row plots were established for improved planting stock and unimproved planting stock. At the ISP location, an additional three rows were established with unaltered improved and unimproved stock. The extra rows provided 120 1-0 bare-root improved and 120 1-0 bare-root unimproved seedlings for comparison with reduced soil and competition concerns.

Statistical Analysis

Sample size for analysis varied by treatment factor. Replication in rows was 18 for site factor, 3 or 6 for seedling treatment factor (depending on whether split plot factor was employed), and 9 for the split plot analyses. Each tree was measured for survival, groundline diameter (GLD; inches), and height (feet). Statistical analyses between site locations were performed using paired t-tests for comparisons of survival and growth variables. Paired t-tests were also used for planting stock comparisons. Seedling treatment factors were analyzed using a one-way analysis of variance (ANOVA). Means separation was conducted using a Student-Newman-Keuls (SNK) method. All statistics were performed in SigmaPlot 11.0 and conducted at an alpha 0.05 level.

RESULTS

Site Preparation Intensity

Figure 1 illustrates seedling survival for MSP and ISP. A paired t-test detected a significant difference in overall survival between the two sites ($p = 0.01$). Mean ISP site survival was 6 percent higher than survival on the MSP location.

A paired t-test did not identify a significant difference in height between the two locations ($p = 0.10$). Mean overall height growth at the ISP location was 0.4 feet greater than the MSP location. However, average year

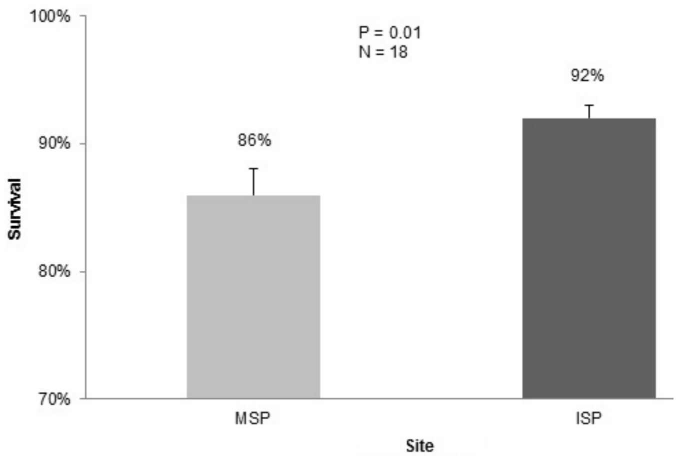

Figure 1—Overall mean survival of Nuttall oak seedlings on the MSP and ISP locations.

2 seedling height was 2.5 feet at both the MSP and ISP sites. A paired t-test identified a significant difference between the two locations in GLD growth (p = 0.007). Mean overall GLD growth was 0.04 inches larger on the ISP location versus the MSP location. Mean year 2 GLD was 0.35 inches at the MSP location and 0.45 inches at the ISP location.

Seedling Treatment Factors

ISP location – No significant differences were detected in survival across seedling treatment factors at the ISP location. Year 2 mean survival was 95, 91, and 91 percent, respectively, for CL+S, CL, and UNC seedling treatments at this location.

Figure 2 illustrates mean height data for seedling factors at the ISP site. A one-way ANOVA did not detect a significant difference in year 2 height growth across seedling treatment factors (p = 0.06). Mean year 2 total seedling heights were 3.1, 2.5, and 1.3 feet, respectively, for CL+S, CL, and UNC seedling treatments at this location. Furthermore, a one-way ANOVA did not detect a significant difference in year 2 GLD growth across seedling treatment factors. Mean GLD growth was 0.17, 0.19, and 0.20 inches, respectively, for CL+S, CL, and UNC seedling treatments at the ISP location.

MSP location – No significant differences were detected in survival across seedling treatment factors at the MSP location. Year 2 mean survival was 86, 89, and 86 percent, respectively, for CL+S, CL, and UNC seedling treatments at this location.

Figure 3 illustrates mean height data for seedling factors at the MSP site. A one-way ANOVA did not detect a significant difference in year 2 height growth across seedling treatment factors (p = 0.06). Mean year 2 total seedling heights were 2.6, 2.3, and 2.6 feet, respectively, for CL+S, CL, and UNC seedling treatments at this location. Furthermore, a one-way ANOVA did not distinguish a significant difference in year 2 GLD growth across seedling treatment factors. Mean GLD growth was 0.15, 0.12, and 0.16 inches, respectively, for CL+S, CL, and UNC seedling treatments at the MSP location.

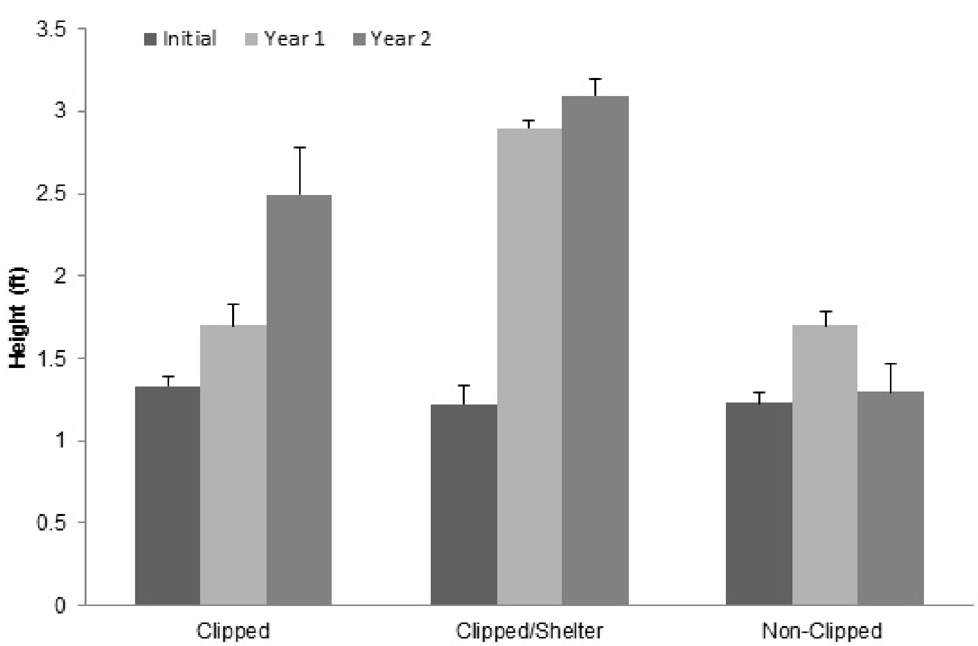

Figure 2—Overall mean heights for seedling treatment factors for Nuttall oak seedlings at the ISP location.

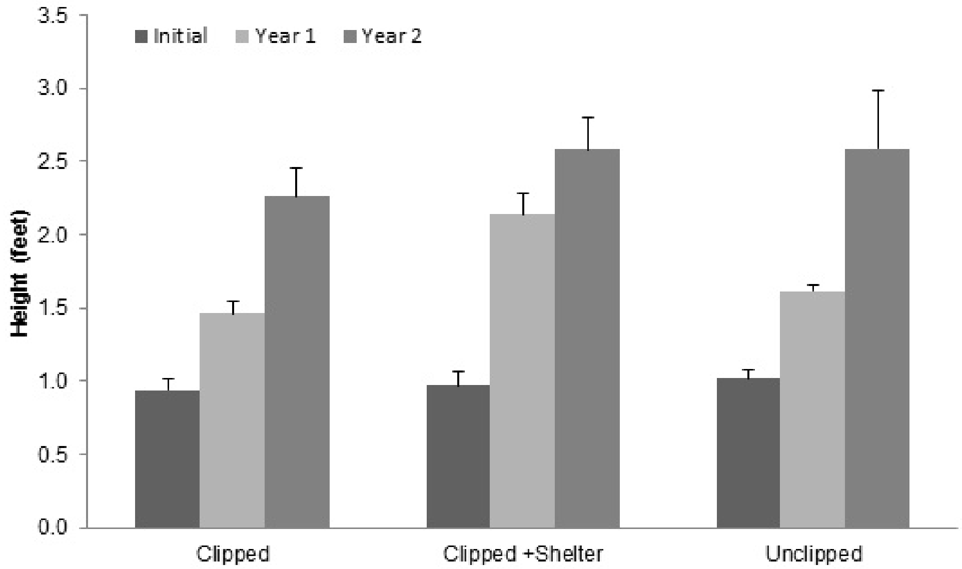

Figure 3—Overall mean heights for seedling treatment factors for Nuttall oak seedlings at the MSP location.

Planting Stock Factors

Figure 4 illustrates mean survival data for seedling factors at the MSP and ISP sites. A paired t-test detected a significant difference between planting stock factors of improved and unimproved at the ISP location. At this location, survival was 94 percent for improved and 89 percent for unimproved. A paired t-test did not detect a significant difference between planting stock factors of improved and unimproved at the MSP location. At the MSP site, survival was 87 percent for improved and 85 percent for unimproved. Seedling growth analyses between improved and unimproved are not presented.

DISCUSSION

The bulk of statistical significance occurred in the survival and growth analyses across sites. Statistical comparisons for planting stock growth data, improved versus unimproved, were not presented. Differences from genetic factors impacting growth often require several growing seasons to develop. However, some notable differences were beginning to manifest between improved and unimproved seedlings.

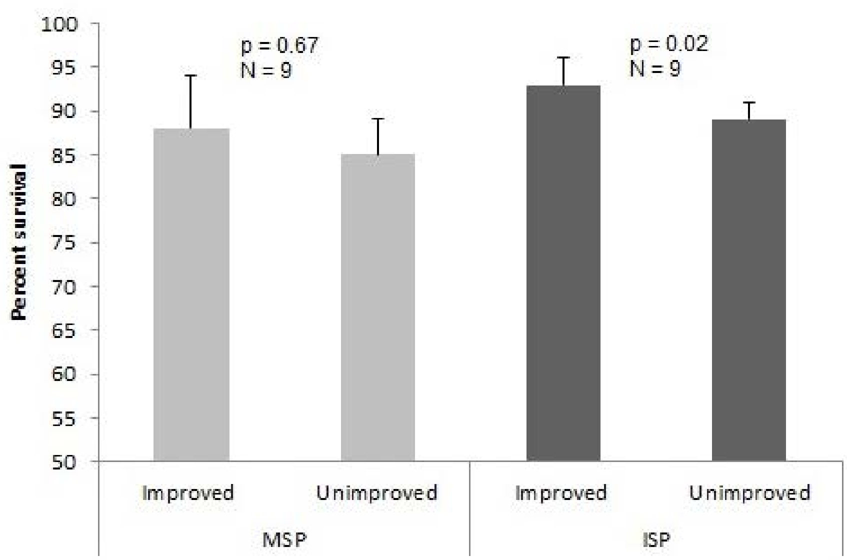

Figure 4—Overall survival between planting stock types at each treatment location.

Survival and growth were significantly better in the ISP treatments compared to the minimal site preparation treatments. While not unexpected and a result demonstrated in previous studies, the results between treatment intensities further validated the more pressing questions regarding the necessity of chemical site preparation treatments in old field scenarios. In this case, the sole application of a foliar active-only herbicide, glyphosate, actually resulted in the release of the herbaceous seed bank in the following season. Survival and growth would have potentially been higher if no site preparation had been conducted and the site would have remained in native warm season grasses. The combination of subsoiling and herbaceous release proved to be a significantly more effective treatment than site preparation alone in this instance.

The analysis between seedling treatment factors provided meaningful and insightful information regarding early growth of planted seedlings. The CL+S treatment demonstrated that first season growth can be greatly increased by its application compared to planting unaltered 1-0 bare-root seedlings. While the CL seedlings closed the gap with the CL+S seedlings in year 2, the greatest benefit and ultimate application of using shelters is the rapid height growth flush initiated in year 1. Furthermore, this effect was primarily present where the intensive cultural treatments were employed. This effect was greatly reduced with MSP inputs. Low predation levels were observed at both locations.

Height growth of 1-0 bare-root Nuttall oak seedlings responded differently at the two sites. At the ISP location, this set of seedlings demonstrated a reduction in height growth over the 2-year period. This dieback pattern is not uncommon in Nuttall oak (Gardiner and others 2010). However, at the MSP location, planted seedlings exhibited substantial 2-year height growth. This could be a microsite effect or potentially an effect of competition intensity, resulting in a height growth response. The rapid growth generated by the combination of intensive site preparation, top-clipping, and addition of a 2-foot tree shelter could prove useful as a method for initiating height growth, a growth response considered atypical of Nuttall oak after transplanting.

Figures 5 and 6 demonstrate the potential effects adequate and inadequate site preparation methods have on seedling survival over time. Survival remained steady at the ISP location from year 1 to year 2. However, survival continued to decrease in year 2 when minimum site preparation occurred. The authors expect this pattern to continue in years 3 through 5 of stand establishment.

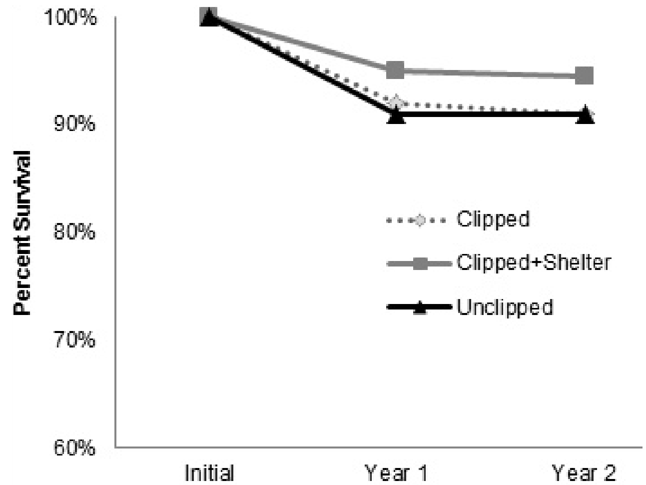

Figure 5—Percent survival by seedling factor at the ISP site.

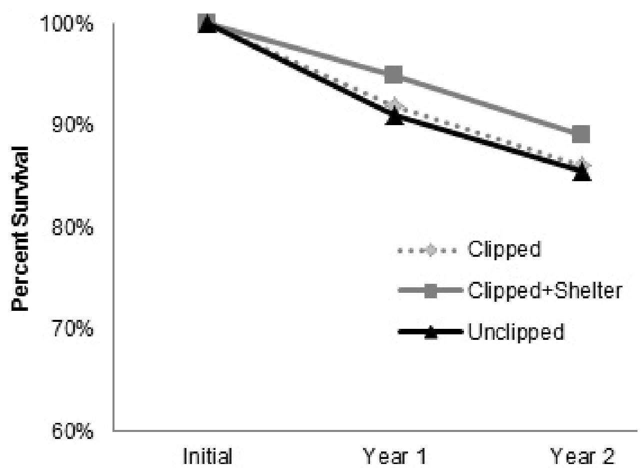

Figure 6—Percent survival by seedling factor at the MSP site.

A question that arose in the course of the study was whether CL+S seedlings were trading off stem diameter and root growth to allocate resources to height growth. The induced rapid height growth pattern was the inverse of the typical allocation of oak seedlings, creating a potential concern for seedling resiliency to adverse environmental conditions. However, an evaluation of GLD did not support this concern. Groundline diameters of CL+S seedlings were equal to or larger than alternative seedling treatment factors. Thus, we concluded that root growth remained adequate for sheltered seedlings (table 1).

Table1—Mean groundline diameter (GLD) growth for minimum site preparation (MSP) and intensive site preparation (ISP) locations by seedling treatment factor

Treatment	GLD growth *(inches)*	Standard error
MSP location		
CL (unimproved seedlings)	0.16	0.04
CL+S (unimproved seedlings)	0.13	0.03
UNC (unimproved seedlings)	0.17	0.03
CL (improved seedlings)	0.14	0.02
CL+S (improved seedlings)	0.10	0.02
UNC (improved seedlings)	0.15	0.02
ISP location		
CL (unimproved seedlings)	0.14	0.03
CL+S (unimproved seedlings)	0.17	0.03
UNC (unimproved seedlings)	0.21	0.04
CL (improved seedlings)	0.20	0.02
CL+S (improved seedlings)	0.21	0.03
UNC (improved seedlings)	0.18	0.03

CL = seedlings top-clipped to 3 inches above ground;
CL+S = top-clipped seedlings with 2-foot tree shelter;
UNC = unclipped seedlings.

Survival differences between planting stock types were greatest on the ISP location. Improved seedlings had significantly higher survival rates compared to unimproved seedlings. This effect was not observed on the MSP location, with similar survival observed between improved and unimproved seedling stock. A possible explanation is that ameliorating soil and competition concerns adequately allowed for any genetic differences to better express themselves. The authors believe the higher level of competition present and potential soil compaction issues reduced the ability of improved seedlings to express any potential gain in growth traits. Again, growth data comparing planting stock type were not included in this study, since growth traits could take several years to fully express.

CONCLUSIONS

Addressing soil factors and competition control remain the focus of cultural treatments aimed at increasing survival of planted Nuttall oak seedlings through facilitating root development in the first few growing seasons. The greatest impact from applying the CL+S method was in first year height growth. This rapid growth flush could prove useful in scenarios including areas under heavy predation or at potential risk for growing season flooding. Ultimately, this method could be included in existing methods (cover crops and underplanting) for addressing early height growth concerns of afforestation efforts with Nuttall oak. The ability to utilize 2-foot shelters for one growing season further impacts their use in that they can be reutilized in subsequent plantings, reducing operational costs (a limiting factor for tree shelters).

The improved seedlings in this study performed well in the operational planting. The potential gain in genetic diversity, combined with the ability to obtain at least a mid-parent gain value, help to establish a basis for utilizing improved Nuttall oak in hardwood plantings in the LMAV.

LITERATURE CITED

Dey, D.C.; Jacobs, D.; McNabb, K. [and others]. 2008. Artificial regeneration of major oak (*Quercus*) species in the eastern United States—a review of the literature. Forest Science. 54(1): 77–106.

Ezell, A.W.; Shankle, M.W. 2004. Effects of subsoiling and competition control on first year survival and growth of four hardwood species. Gen. Tech. Rep. SRS-71. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station. 571–573.

Ezell, A.W.; Yeiser, J.L.; Nelson, L.R. 2007. Survival of planted oak seedlings is improved by herbaceous weed control. Weed Technology. 21(1): 175–178.

Gardiner, E.S.; Dey, D.C.; Stanturf, J.A.; Lockhart, B.R. 2010. Approaches to restoration of oak forests on farmed lowlands of the Mississippi River and its tributaries. Colombia Forestal. 13(2): 223–236.

Lockhart, B.R.; Gardiner, E.; Leininger, T.; Stanturf, J. 2008. A stand-development approach to oak afforestation in the Lower Mississippi Alluvial Valley. Southern Journal of Applied Forestry. 32(3): 120–129.

Schoenholtz, S.H.; James, J.P.; Kaminski, R.M. [and others]. 2001. Afforestation of bottomland hardwoods in the Lower Mississippi Alluvial Valley: status and trends. Wetlands. 21(4): 602–613.

Stuhlinger, H.C. 2013. A comparison of tree shelters installed on green ash and cherrybark oak seedlings in Arkansas. In: Guldin, J.M., ed. 2013. Proceedings of the 15th biennial southern silvicultural research conference. e-Gen. Tech. Rep. SRS- 175. Asheville, NC: U.S. Department of Agriculture Forest Service, Southern Research Station: 307–313.