THE CASE FOR DELAYING PLANTING OF BOTTOMLAND OAKS: AN EXAMPLE INVOLVING NUTTALL OAKS

David C. Mercker, David S. Buckley, and John P. Conn[1]

Abstract.—A prominent difficulty during bottomland hardwood afforestation in the southeastern United States is that sites are often flooded during the preferred months of planting (January - March), which results in delayed planting (April - June) and reduced survival. We monitored growth and survival of Nuttall oak (*Quercus texana* Buckley) seedlings planted in 11 months (February through December) after varying periods of humidified cold storage to investigate the hypothesis that seedlings held over the summer months in humidified cold storage and planted in autumn months would fare better than seedlings planted in late spring and summer. Results generally agreed with this hypothesis. A trade-off is that height growth decreased with increased periods of time in cold storage. These results suggest that although reduced height growth can initially be expected, long-term storage over the summer months and subsequent planting in autumn need not result in substantial mortality of Nuttall oak. Differences in height may become less significant with each successive growing season.

INTRODUCTION

Over the past century, a considerable amount of bottomland forest has been deforested and drained for row crop farming throughout the southeastern United States (MacDonald et al. 1979, Turner et al. 1981). Since the 1980s, natural resource professionals and federal and state agencies have focused on restoring portions of these cleared areas to native hardwood trees through various conservation programs (Stanturf et al. 2001). Restoration of bottomland hardwoods has been a recent focus in the management of agricultural wetlands in Tennessee (Johnson 2007).

Professional foresters and contractors often follow conventional tree planting procedures that are well established for upland sites, but prove problematic in bottomlands. High water tables, poor soil drainage, overland flooding, and diverse soil properties make tree planting difficult during the commonly accepted optimum planting period between mid-winter and mid-spring (January through April). These hydrologic obstacles often cause seedlings to be planted in late spring and summer (from May on). Late planting results in poor survival. In some cases the sites may go unplanted, leading to disposal of seedlings and a follow-up attempt to plant the next year.

A previous investigation involving upland hardwood seedlings suggested that increasing the length of time in cold storage decreases post-planting root growth and percent bud break, and increases stem dieback and mortality (Englert et al. 1993). We investigated whether results would be similar with bottomland species on a bottomland site. Our hypothesis was that seedlings held over the summer months in cold storage and planted in autumn months would fare better than seedlings planted in late spring and summer.

[1]Extension Forester (DCM), University of Tennessee, 605 Airways Blvd., Jackson, TN 38301; Professor (DSB), University of Tennessee, Department of Forestry, Wildlife and Fisheries; and Forest Management Administrator (JPC), Tennessee Nursery and Tree Improvement. DCM is corresponding author: to contact, call 731-425-4703 or email at dcmercker@utk.edu.

STUDY AREA

The study was conducted on the University of Tennessee's West Tennessee Research and Education Center (WTREC), located in Jackson, Tennessee. The site is located adjacent to the South Fork of the Forked Deer River (35º 37'34" N, 88º51'22" W, 120 m mean elevation). It includes a 122 m by 122 m section nested within a larger 49-ha bottomland area that underwent afforestation in winter 2004. The predominant soil type is Waverly silt loam (0- to 2-percent slope), which is deep and poorly drained (Sease and Springer 1957). Flooding of the site occurs five to six times per year and inundation often lasts several days. The site was used for row crop farming until 2004, when it was enrolled into the Conservation Reserve Program.

METHODS

Nuttall oak (*Quercus texana* Buckley) was selected because this species was previously found to be tolerant of extended inundation on the site available for this study (McCurry 2006). All seedlings planted were 1-0 stock and were grown at the Tennessee Department of Agriculture, Forestry Division, East Tennessee Nursery in Delano, Tennessee.

Seedlings were lifted during the first week of January and shipped on January 5, 2007. They were picked up on January 8, 2007. Prior to shipping from the nursery, seedlings were graded so that all had root collars greater than 0.6 cm caliper. The roots were dipped in Viterra root dip (potassium propenoate propenamide copolymers, Amereq, Inc., New City, NY) to conserve moisture. The Viterra root dip was mixed at a rate of 3.75 g per L of water. After dipping, seedlings were packaged (without mulch) into 4-mil plastic bags, then placed into triple-ply craft paper with a poly-coated inner lining. Each ply was 50-lb. craft paper. After arrival, the seedlings were stored in a humidified cold room with temperature and relative humidity set at 2.2 ºC and 94 percent, respectively. A 30-hour power outage occurred unexpectedly on August 24-25, 2007. The maximum temperature in the cold room during the outage reached 25.2 ºC with an average of 19.6 ºC. The relative humidity dropped to a low of 82 percent.

Initial height measurements were taken to the nearest cm using a custom-made polyvinyl chloride pipe with markings graduated in centimeters. The average aboveground height at the time of planting, measured from ground to terminal bud, was 51 cm (S.E. = 0.5). Initial stem caliper was also measured with a Plasti-cal Digital Caliper (Mitutoyo, Kawasaki, Japan) to the nearest 1 mm at ground level. The average caliper was 8 mm (S.E. = 0.1).

The study was established as a randomized complete block design with all treatments appearing once in each of three blocks established in relation to elevation of the site. No attempt was made to select uniform stock from within the bundles, nor was there any culling of very small or very large seedlings (other than what occurred at the nursery). Twelve treatments, corresponding to plantings in every month of the year, were assigned at random to 12 plots within each block, resulting in 36 plots with 720 seedlings for the entire study (Fig. 1). A single row containing 20 Nuttall oak seedlings on 1-m spacing was established in each plot. With a total of three replications, 60 Nuttall oak seedlings were planted per month. Seedlings for each month were planted successively between 7:00 a.m. and 10:00 a.m. and between the 10th and 20th day of any given month. No seedlings could be planted during January at the outset of the study in 2007 because the site was flooded. As a result, the January treatment was dropped from the study.

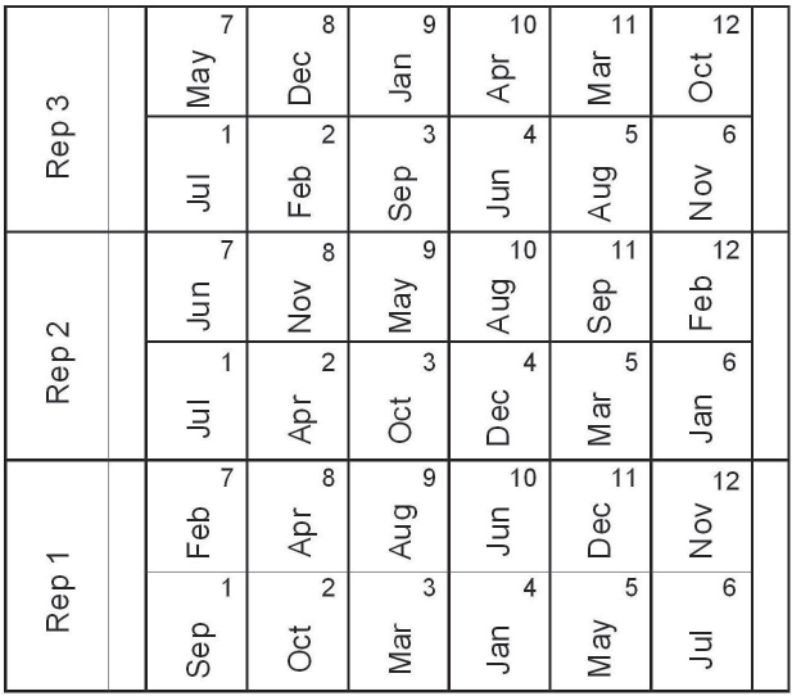

Figure 1.—Study design.

Site preparation, conducted in August 2006, consisted of a single application of a 2 percent solution of active ingredient (glyphosate) of Roundup® (Monsanto, St. Louis, MO) in 76-cm bands applied directly over the designated rows. In addition, during the year of planting (2007) and the next 2 years, planted rows were side-dressed with the same herbicide at the same rate, once per month (April through September). The band width was 38 cm on both sides of every row. Weeds were controlled carefully throughout the entire study to minimize effects of differences in the abundance of competing vegetation over the time period of the study. Mowing between the rows occurred each month during the growing seasons. Survival and seedling heights were recorded in September of 2008 and 2009, and in October 2010. Seedlings were considered dead if there was no indication of living tissue above ground. Scratch testing to reveal green cambium was conducted on questionable seedlings.

Data were analyzed through one-way analysis of variance (ANOVA) and analysis of covariance (ANCOVA) with models appropriate for a randomized complete block design. The general linear models procedure (SAS Institute, Cary, NC) was used. Pairwise comparisons were conducted between months with Tukey's honestly significant difference ($\alpha = 0.05$). The degree to which assumptions underlying ANOVA and ANCOVA were met was investigated using the univariate procedure (SAS Institute). The normal probability plot and Shapiro-Wilk statistic and associated p-value yielded by the univariate procedure suggested that it was reasonable to assume that the survival percentage data came from a population with a normal distribution ($W = 0.94$ and $Pr < W = 0.0657$). As a result, survival percentage data were not transformed before analysis. Similarly, results yielded by the univariate procedure for the height data suggested that no transformations of these data were necessary ($W = 0.99$ and $Pr < W = 0.0743$). Analyses of height data for 2010 were conducted with and without 2007 heights and 2007 caliper measurements as covariates. Patterns in significant differences among months were identical between both types of analysis. All analyses were conducted using SAS, Version 9.2 (SAS Institute, Inc., Cary NC).

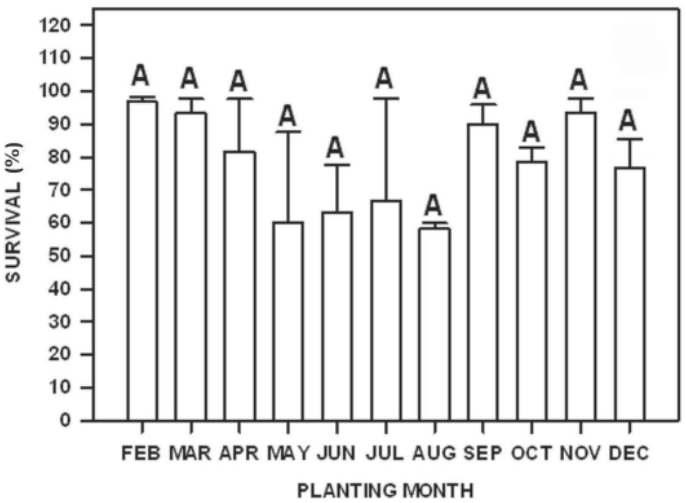

Figure 2.—Mean percent survival of Nuttall oak as of September 2010 by planting month treatment. Bars with the same letters are not significantly different at the alpha=0.05 level. Error bars represent 1 standard error.

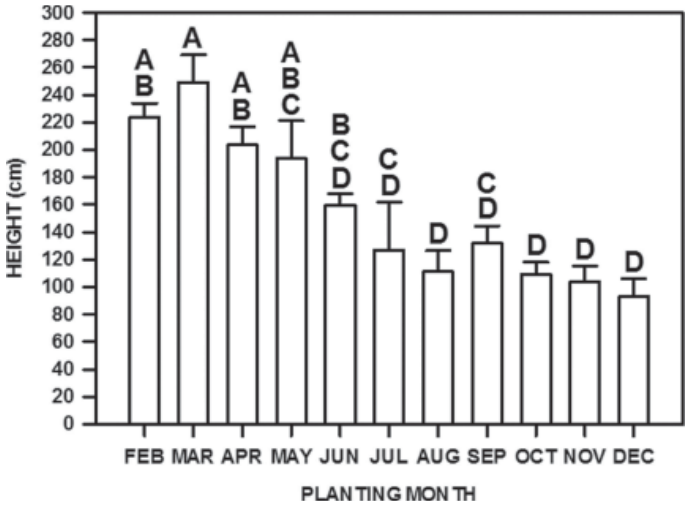

Figure 3.—Mean height of Nuttall oak as of October 2010 by planting month treatment. Bars with the same letters are not significantly different at the alpha=0.05 level. Error bars represent 1 standard error.

RESULTS

As of September 2010, mean survival rate calculated across all treatments and sample periods was 78 percent (Fig. 2). Analysis of variance suggested significant differences in mean survival rate among months ($p = 0.0164$), but Tukey's honestly significant difference did not. It should be noted, however, that Tukey's honestly significant difference indicated that February survival was significantly different from August survival when the highly variable May and July survival data were omitted from the analysis. Based on the magnitudes of the means, survival was favorable in the February through April planting treatments, averaging 91 percent. Survival was less favorable during the late spring and summer period (May through August), averaging 62 percent. Survival rate for the final planting period (September through December) rebounded, averaging 85 percent.

Mean seedling height differed among planting months ($p < 0.0001$) and decreased from early to late planting dates (Fig. 3, Table 1). However, the year-over-year percentage difference in height narrowed with each successive year. For instance, when observing height measurements over the duration of the project, we found in 2008 that February- through April-planted seedlings were 233 percent taller than September- through December-planted seedlings in 2008, 226 percent taller in 2009, and 204 percent taller in 2010. Although data on resprouting were not formally collected, resprouting of late-planted seedlings was observed to be more prevalent than early-planted seedlings and likely explains the decrease in height from 2007 to 2008 in the later months. This trend reversed in 2009.

Table 1.—Height (cm) of Nuttall oak (2007 - 2010)

Month	2007	2008	2009	2010
Jan	n/a	n/a	n/a	n/a
Feb	48	82	167	224
Mar	58	110	200	251
Apr	50	78	149	206
May	49	82	155	209
Jun	51	55	110	163
Jul	46	53	113	159
Aug	51	34	81	112
Sep	55	51	100	132
Oct	54	41	77	110
Nov	48	34	63	105
Dec	49	29	66	97

DISCUSSION

This study is not a definitive test of the hypothesis that holding seedlings in a humidified cold room over the summer months, and then planting them during the autumn months, is a viable solution to the problem of early season flooding of bottomland restoration sites. The findings do suggest, however, that in the case of Nuttall oak, it is at least possible to have acceptable survival rates (80 percent or better) with seedlings planted in September through December.

The potential effects of two occurrences during the study should be noted. First, during the year of implementation (2007), the west Tennessee region experienced an extreme drought. Eight months received below-normal precipitation in 2007, and year-end total precipitation was 33.4 cm below normal. During the growing season, May through August, the precipitation deficit was 31.3 cm (National Oceanic and Atmospheric Administration 2009). The drought could have increased mortality overall, particularly in the summer months. Secondly, the power outage that occurred for 30 hours in August, allowing the temperature in the cold room to climb to 25.2 ^{o}C, may have influenced seedling viability. If these events had not taken place during the study, survival could have been greater for all planting dates.

Survival was greatest in the early spring planting period, was less favorable in the late spring/summer period, but then rebounded in the autumn period. Results confirm that, at least within the first four growing seasons, height growth is suppressed by delayed planting. However, the percentage difference in height between these two groups declined with each successive year. This result suggests that early height differences could become less substantial over the duration of the rotation. Initial growth can be important, however, in influencing the competitive status of planted seedlings relative to other vegetation.

The promising results obtained for Nuttall oak in this study suggest that additional research involving the performance of delayed plantings of other species used in bottomland hardwood restoration is warranted. Examination of the viability of a range of seedling size classes for an expanded set of species stored for various periods of time in a cold room is planned.

ACKNOWLEDGMENTS

Our study was funded by the Department of Forestry, Wildlife and Fisheries; the University of Tennessee Extension; and the West Tennessee Research and Education Center (WTREC) of the University of Tennessee Institute of Agriculture. Seedlings were supplied by the Tennessee Division of Forestry, East Tennessee Nursery. The restoration project was made possible by the Natural Resources Conservation Service through a Conservation Reserve Program agreement under the Forested Riparian Buffer Practice. We especially thank R. Hayes, G. Percell, and R. Staggs at WTREC for assistance with study implementation.

LITERATURE CITED

Englert, J.M.; Fuchigami, L.H.; Chen, T.H. 1993. **Effects of storage temperatures and duration on the performance of bareroot deciduous hardwood trees.** Journal of Arboriculture. 19(2): 106-112.

Johnson, J.W. 2007. **Rivers under siege: the troubled saga of West Tennessee's wetlands.** Knoxville, TN: University of Tennessee. 239 p.

MacDonald, P.O.; Frayer, W.E.; Clauser, J.K. 1979. **Documentation, chronology, and future projections of bottomland hardwood habitat losses in the Lower Mississippi Alluvial Plain.** Vol. I, basic report. Vicksburg, MS: U.S. Department of the Interior, Fish and Wildlife Service, Ecological Services. 133 p.

McCurry, J.R. 2006. **Flood tolerance of hardwood bottomland oak seedlings.** Knoxville, TN: University of Tennessee. 73 p. M.S. thesis.

National Oceanic and Atmospheric Administration. 2009. **Annual climatological summary (2007).** Available at http//www.ncdc.noaa.gov/mpp.html. (Accessed 2009).

Sease, C.S.; Springer, M.E. 1957. **Soil map of the west Tennessee Experiment Station, Jackson, Tennessee.** Washington, DC: U.S. Department of Agriculture, Soil Conservation Service.

Stanturf, J.A.; Schoenholtz, S.H.; Schweitzer, C.J.; Shepard, J.P. 2001. **Achieving restoration success: myths in bottomland hardwood forests.** Restoration Ecology. 9: 189-200.

Turner, R.E.; Forsythe, S.W.; Craig, N.J. 1981. **Bottomland hardwood forests of the southeastern United States.** In: Clark, J.R.; Benforado, J., eds. Wetlands of bottomland hardwood forests. Amsterdam, the Netherlands: 13-28.