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# Extension Efforts to Restore Bottomland Oaks Requires Knowledge of Both Trees and Soil

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***Abstract:*** *Bottomland oak restoration projects have been marginally successful because professionals often recommend conventional tree planting procedures that prove problematic in saturated soils. A reliable method of matching oak species to bottomland sites is needed prior to planting. In the study reported here, bottomland oaks were matched to hydric soils based on soil mottling. The findings suggest that as soil drainage improves, species diversity expands. Natural Resource Extension professionals should consider "active" methods of direct technical assistance and field demonstrations and "passive" methods of newsletters, publications, and pamphlets, as delivery methods to educate both landowners and professionals about this subject.*

## Introduction

Over the past several decades, federal incentive programs have encouraged the restoration of bottomland oaks throughout the United States. Private forest landowners are involved in these programs that are designed to protect water and soil resources and play a major role in sequestering atmospheric carbon (Cason, Grebner, Londo, & Grabo, 2006). Extension personnel involved in natural resource issues should be knowledgeable about these programs and be effective communicators to increase their adoption.

Programs such as the Conservation Reserve (CRP) and Wetlands Reserve (WRP) have been marginally successful (Stanturf, Schoenholtz, & Schweitzer, 2001). Natural Resource Extension Professionals have been engaged in many of these projects and make general recommendations on bottomland restoration. These recommendations often follow conventional tree planting procedures that are well established for upland sites, but prove problematic in bottomlands. High water tables, soil drainage and compaction, overland flooding, and diverse soil properties make species selection difficult. Slight changes in topography and soil structure often have a dramatic effect on survival and growth of planted oak seedlings (Hodges & Schweitzer, 1979). The project reported here documented the survival and growth of 6-year old seedlings that were established on a bottomland site in 2004, located at the University of Tennessee West Tennessee Research and Extension Center (WTREC), Jackson, Tennessee. This site is adjacent to the South Fork of the Forked Deer River and periodically floods.

The purpose of the project was to determine how soil drainage as indicated by mottling (specifically, the point of >50% gray color throughout the soil profile) affects the survival and growth of bottomland oaks. Secondarily, a review of Extension's efforts in educating forest landowners about natural resource issues is made, so that the results of this work will lead to more successful plantings, increased adoption and better use of financial resources.

### Species Examined

A variety of species can be planted in bottomlands. However, due to their economic and ecological values, this project focused only on bottomland oaks. The natural range of 10 species of bottomland oaks overlaps (or slightly extends into) the study region in West Tennessee (Burns & Honkala, 1990; Fowells 1965; Mercker, Buckley, & Ostby, 2006). Only eight species were available from the nursery at the time of establishment. Those eight included:

**Red Oak Group**

Water oak (*Quercus nigra*)

Willow oak (*Quercus phellos*)

Pin oak (*Quercus palustris*)

Nuttall oak (*Quercus texana*)

Shumard oak (*Quercus shumardii*)

**White Oak Group**

Overcup oak (*Quercus lyrata*)

Swamp chestnut oak (*Quercus michauxii*)

Swamp white oak (*Quercus bicolor*)

The two other oak species that are prevalent in bottomland systems but were not available for this work include:

Cherrybark oak (*Quercus pagoda*)

Bur oak (*Quercus macrocarpa*).

### Soil Mottling and Gleyed Matrix Explained

Properly matching oak species to bottomland planting sites requires an understanding of soil drainage. Highest groundwater levels and water table fluctuations are routinely estimated by Extension specialists and agents using the soil color. Gray colors are associated with saturated soil environments. *Soil mottling* and the presence of a *gleyed matrix* are important determinants when predicting high groundwater conditions and the resulting survival and growth of bottomland oaks. Further explanation of these terms follows.

**Soil mottling** - occurs when gray or black colors become mixed with the normal red, brown or yellow soil colors; gray and black colors indicate that periods of soil saturation are frequent.

**Gleyed matrix** - occurs when water is removed very slowly and the soil is saturated for three or more months of the year; the gleyed matrix is the point where gray mottling becomes so excessive that gray colors exceed 50% of the soil profile.

The color of a soil and its location within the soil profile can indicate the conditions under which the soil developed. A gray soil color, for example, occurs after prolonged saturation. The colors present within a soil horizon are described by comparison with color charts. The color chart standardly used by Extension personnel to describe soil color is a segment of the Munsell Soil Color Chart (Munsell, 2000) that consists of systematically arranged pages of colored squares, or chips. The color chips are arranged by color hue, value, and chroma. *Hue* refers to principle spectral colors such as yellow (Y), red (R), and their intermediate midpoints, such as yellow-red (YR). *Value* describes the lightness or darkness of a color from black (0) to white (10). *Chroma* refers to the relative purity or dullness of a color, ranging from the purest colors (8) to the most neutral colors (0). Color hue, value, and chroma are combined in a numerical expression to form a designation for each color chip. For example, a color chip having a designation of 10 YR 4/2 has a hue of 10 YR, a value of 4, and a chroma of 2. The dominant color in a soil horizon is referred to as the soil matrix color and the contrasting colors, or areas marked with spots of color, are referred to as mottles.

Hydric soils, such as those located on the study site (USDA, 2010), are periodically saturated for sufficient duration to produce chemical and physical soil properties associated with low oxygen. Under conditions of a fluctuating water table, soils may exhibit a variety of contrasting colors within the soil profile. Low oxygen soils are usually gray and/or mottled immediately below the surface horizon. The study reported here sought to determine if these gray soils can be used as an indicator of successful establishment of bottomland oaks, so that Extension personnel can use such information as an indicator when making recommendations on bottomland restoration projects.

## Methods

The project location is in a floodplain of the South Fork of the Forked Deer River located on the West Tennessee Research and Extension Center in Jackson, Tennessee. The soils in the floodplain are:

- Vicksburg silt loam (well-drained), coarse-silty, mixed, active, acid, thermic typic Udifluvents,
- Collins silt loam (moderately well-drained), coarse-silty, mixed, active acid, thermic aquic Udifluvents,
- Falaya silt loam (somewhat poorly-drained), coarse-silty, mixed, active, acid, thermic aeric Fluvaquents, and
- Waverly silt loam (poorly-drained), coarse-silty, mixed, active, acid, thermic fluvaquentic Endoaquepts.

The predominant soils in the study location in the floodplain are Falaya and Waverly. The site has a gradual gradient in elevation that allowed blocks of seedlings to be established from higher to slightly lower elevation along the gradient.

This site was originally forested, then cleared in the 1930's, channelized, tiled, and then placed into agricultural production. With marginal row crop success, in 2003 the land was enrolled into the CRP and WRP programs.

The project was designed with solid blocks of oak species, each block 2,680 feet long and ranging from four-to-eight rows wide. Trees were spaced 10 ft. x 10 ft. apart (435 trees per acre). Seedlings were grown at the Tennessee Department of Agriculture Division of Forestry Nursery, Delano, TN. In the fall of 2003, the site was sub-soiled using an 18-inch single-shank sub-soiler to loosen compacted soil and improve root growth. Seedlings were planted during February and March 2004, using a Whitfield® Tree planter (R. A. Whitfield Manufacturing, Mableton, Georgia), which is designed specifically for planting hardwood seedlings. Initial above-ground height at planting were (in descending order): swamp chestnut oak (25.5 in.), overcup oak (20.8 in.), water oak (18.3 in.), Shumard oak (16.5 in.), Nuttall oak (15.8 in.), pin oak (14.3 in.), willow oak (13.1 in.), and swamp white oak (initial height not available). To limit the potential effects of herbaceous vegetation on seedling responses, initial and second year herbicide application were applied. This consisted of Oust® XP (sulfometuron methyl, DuPont, Wilmington, Delaware) sprayed in early spring before bud break at a concentration of 1.5 oz/acre (as an 18-in. side-dressing).

In early 2010, 272 permanent plots were established within the area, 34 plots per species. Plots were located between the center rows of each block and spaced 80 feet apart. In March 2010, following six growing seasons, the plots were visited to record survival, height (ft.) and diameter at breast height (dbh - in.) of the four trees nearest (diagonal to) the plot center.

During June of 2010, soil samples were taken at each plot and used to represent an area of 100 ft2. The purpose was to determine the depth at which the >50% gray matrix occurs. At the center point of each plot, a soil probe was used to extract a soil core. The soil was examined in 3-inch increments to determine moist soil color and abundance or absence of gray colors. A Munsell Soil Color Chart was used to determine the hue, value, and chroma of each sample. Sampling stopped at a depth where chroma 2 or less was determined to be 50% or greater. Depth to gray matrix was then compared with survival and growth of the oak species under study.

Mean height, dbh, and survival were calculated for each plot and analyzed using a complete random factorial design, with species and soil classification factors. A spatial variance structure was used, because it improved the residual log likelihood of the model. Degrees of freedom adjustment for the spatial component was done by Kenward-Roger, which correlates degrees of freedom for spatial correlations among the observations (Schaalje, McBride, & Fellingham, 2001). Least squares means were separated with pairwise t-tests at the 5% significance level.

## Results

### Soil Mottling

In order to simplify characterizing soil conditions, soil results were placed into three broad classes. These separations were based on the depth at which the > 50% gray matrix occurred. Such broad classes are easier for field practitioners to observe, characterize, and then match with appropriate species. The classes included:

1. Poorly drained—soil reached the >50% gray matrix within the first 0 to 3 inches,

2. Somewhat poorly drained—soil reached the >50% gray matrix at 3 to 9 inches, and

3. Moderately well drained—soil reached the >50% gray matrix at 9 to 18 inches.

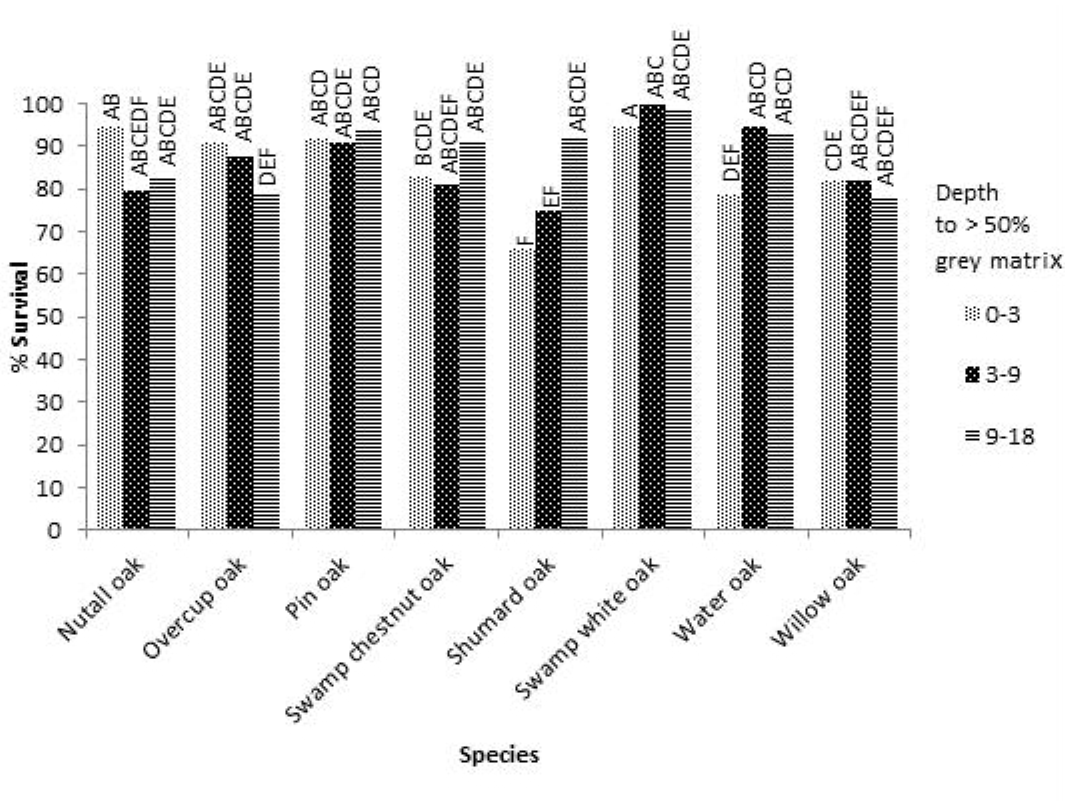
In the study, of the 272 soil samples, 207 plots (76%) reached the > 50% gray matrix within the first two classes (0 to 9 in.), indicating the majority of the site was somewhat-to-poorly-drained.

### Survival and Growth

Overall, the survival across all eight species and all soil classes was acceptable, exceeding 70% (Figure 1). The one exception was with Shumard oak on areas where the 50% gray matrix was present in the top 3 inches (0-3 inch depth class).

**Figure 1.**

Survival Rate Across Eight Species of Bottomland Oak Following Six Growing seasons

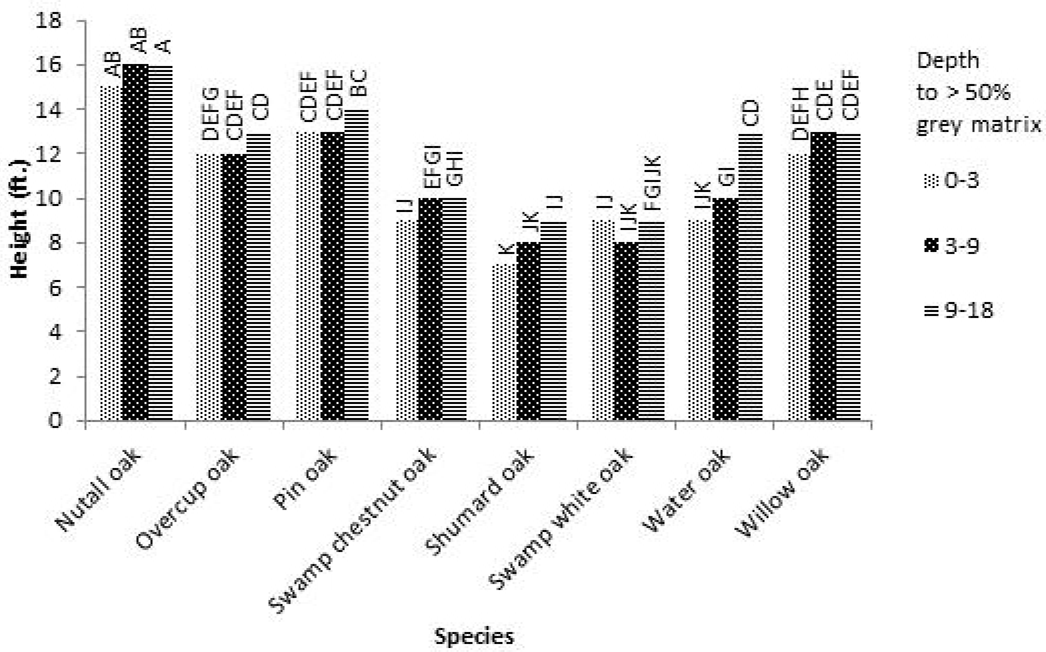



(Among columns, values having the same letter are not significantly different (P≤ 0.05)).

Survival rate represents one diagnostic indicator of the future success of a bottomland stand. However, survival does not necessarily reflect vigor. After six growing seasons, variables such as height and dbh may be better predictors of long-term success. In examining height (Figure 2), Nutall oak was significantly taller than other species across all depth classes to grey matrix except pin oak at the 9-18 inch depth class. Overcup, pin, and willow oaks were similar in height across the three grey matrix depth classes. Water and swamp chestnut oaks were intermediate in height, while Shumard and swamp white oaks were usually shortest across the grey matrix depth classes.

**Figure 2.**

Height (ft.) Across Eight Species of Bottomland Oak Following Six Growing Seasons

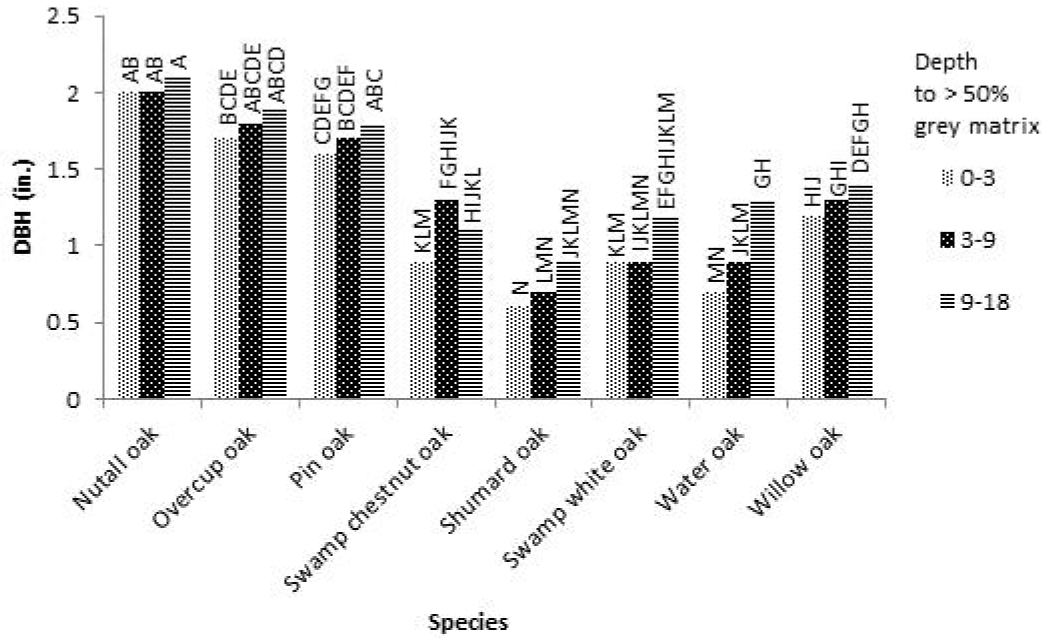



(Among columns, values having the same letter are not significantly different ($P \leq 0.05$)).

Diameter at breast height (dbh) measurements generally showed similar trends by species. In the best drained 9-18 inch class, Nutall, overcup, and pin oaks were statistically the same (Figure 3). In the two other classes Nutall, overcup, and pin oaks were not significantly different except that pin oak was significantly different in the poorest-drained 0-3 inch class. For willow oak in the 9-18 depth class, dbh was not significantly different from water oak and swamp white oaks. In the 0-3 and 3-9 classes, water, Shumard, and swamp white oaks usually had a smaller diameter than willow oak. Overall, Nutall had the greatest diameter with overcup and pin oaks as second and third respectively. On most of the sites, especially the 0-3 and 3-9 inch classes, all other species had significantly lower dbh than the top three.

**Figure 3.**

Diameter at Breast Height (in.) Across Eight Species of Bottomland Oak Following Six Growing Seasons




(Among columns, values having the same letter are not significantly different ($P \leq 0.05$)).

Finally, initial seedling height difference between species is not a good predictor of height at 6 years. Although the initial height rank of Nuttall and pin oaks were fifth and sixth respectively, their rank had improved to first and second by year six. In contrast, swamp chestnut oak, initially the tallest seedlings, fell to fifth in rank by year six (for initial height, refer to Methods section).

## Extension Delivery

A number of studies have been conducted that address landowner willingness to adopt new practices, how they wish to be educated on those practices, and how demographic characteristics correlate to willingness to adopt them. Because the study reported here offers a new approach to evaluating how oaks are established on bottomland sites, Extension delivery is paramount to adoption.

Reaching target landowners can be a challenge because the majority of landowners have not participated in past Extension programs, are not aware of them, or are not taking full advantage of them (Measells, Grado, Hughes, Dunn, & Idassi, 2006). Landowners who are typically well educated, new at ownership, and have received professional advice about their forestland are more likely to be early adopters (Mercker & Hodges, 2007a). Perhaps this same profile of landowners would be receptive to the results of the study reported here and should be targeted first. The first of these characteristics (well-educated) would be difficult to isolate for educational programs. The latter two would not. The names of new landowners can be obtained through county tax assessment records, and lists of landowners having received professional advice could be found through solicitation of state forestry agencies.

Landowners who have previously received professional advice about a specific forestry practices are more likely to implement these practices. Such landowners typically indicate that technical assistance is a preferred method of "active" education (Magill, McGill, & Fraser, 2004; Mercker & Hodges, 2007b). Field demonstrations are also favored as a forum for addressing controversial or new issues (Harmon & Jones, 1997). Whereas preferred "passive" methods of education include newsletters, publications, and pamphlets (Radhakrishna, Nelson, Franklin, & Kessler, 2003; Measells et al., 2006; Mercker & Hodges, 2007b). All the above delivery methods fall within the expertise of Extension educators, so it is logical that Extension could take the lead. Prior to reaching landowners, however, it is important to first convey the findings to those who may be in position to offer field expertise. Therefore, to date, these results have already been delivered to regional county Extension personnel via in-service trainings, and to professional foresters through two regional and one national conference.

## Conclusion

The results of this work concur with the findings of others that Nuttall (Filer, 1990; Ozalp, Schoenholtz, Hodges, & Miwa, 1997; Stanturf et al., 1998) and overcup oaks (Stanturf, Schweitzer, & Gardiner, 1998; McCurry, Gray, & Mercker, 2010) outperform other bottomland oaks on poorly drained sites. Based on data from the study reported here, pin oak should be added to this list because of its tolerance to hydric soil. Although not preferred for its lumber quality, pin oak is a favorable food source for waterfowl (Allen, Keeland, Stanturf, Clewell, & Kennedy, 2001).

For most land objectives and under normally accepted practices, species diversity is desired for bottomland restoration. Some oaks can tolerate poorly drained soils; others cannot. Species diversity is easiest achieved on soils lacking a high water table and where the soil >50% gray matrix exceeds 18 inches in depth. However, as the water table rises and the > 50% gray matrix follows it toward the surface, the diversity of oak species tolerant of such sites narrows.

When natural resource Extension professionals make recommendations for the establishment of oaks on bottomland sites, they should evaluate the soil to determine at what depth the >50% gray matrix occurs. Because internal drainage so greatly affects tree survival and growth, the importance of matching species-to-site in bottomlands is paramount. On sites and in physiographic regions similar to those in this study, practitioners should plant Nuttall, pin and overcup oaks in poorly drained soils. As the drainage improves, begin mixing in willow oak. In the best-drained soils (if they exist), finish by including water, swamp chestnut, swamp white, Shumard, cherrybark and bur oaks. Tree species diversity can expand as the soil drainage improves. Extension professionals should seek localized knowledge of the silvics of each species before incorporation into bottomland restoration regimes.

Finally, Extension professionals should consider active methods of direct technical assistance and field demonstrations, and indirect methods of newsletters, publications and pamphlets as delivery methods to educate both landowners and professionals about this subject.

## References

Allen, J., Keeland, B., Stanturf, J., Clewell, A., & Kennedy, H. (2001). *A guide to bottomland hardwood restoration*. U.S. Geological Survey, Reston, Virginia. Gen. Tech. Report SRS-40.

Burns, R., & Honkala, B. (eds.). (1990). *Silvics of North America: volume 2, hardwoods*. U.S. Department of Agriculture, Forest Service, Washington, DC.

Cason, J. D., Grebner, D. L., Londo, A. J., & Grabo, S. C. (2006). Potential for carbon storage and technology transfer in the southeastern United States. *Journal of Extension* [On-line], 44(4) Article 4FEA6. Available at: http://www.joe.org/joe/2006august/a6.php

Filer, T. (1990). Nutall oak. *Silvics of North America. volume 2: hardwoods*. U.S. Department of Agriculture, Forest Service: 704-708. Washington, DC.

Fowells, H. (1965). *Silvics of forest trees of the United States*. U. S. Department of Agriculture, Forest Service. Agriculture Handbook No. 271. Washington, DC.

Harmon, A. H., & Jones, S. B. (1997). Forestry demonstrations: What good is a walk in the woods? *Journal of Extension* [On-line], 35(1) Article 1RIB3. Available at: http://www.joe.org/joe/1997february/rb3.php

Hodges, J., & Switzer., G. (1979). *Some aspects of the ecology of southern bottomland hardwoods*. Pages 22-25 in proceedings of the Society of American Foresters Annual Meeting, St. Louis, Missouri, 1978. Society of American Foresters, Bethesda, Maryland.

Magill, D. J., McGill, D. W., & Fraser, R. F. (2004). Refining outreach to woodland owners in West Virginia—preferred topics and assistance methods. *Journal of Extension* [On-line], 42(4) Article 4RIB5. Available at: http://www.joe.org/joe/2004august/rb5.php

Measells, M. K., Grado, S. C., Hughes, H. G., Dunn, M. A., & Idassi, J. O. (2006). Educational needs of southern forest landowners. *Journal of Extension* [On-line], 44(5) Article 5RIB4. Available at: http://www.joe.org/joe/2006october/rb4.php

Mercker, D., Buckley, D., & Ostby, B. (2006). *Identifying oak trees native to Tennessee*. University of Tennessee Extension. PB1731.

Mercker, D. C., & Hodges, D. G. (2007a). Forest certification and nonindustrial private forest landowners: who will consider certifying and why? *Journal of Extension* [On-line], 45(4) Article 4RIB6. Available at: http://www.joe.org/joe/2007august/rb6.php

Mercker, D. C., & Hodges, D. G. (2007b). How do forest landowners desire to learn about forest certification? *Journal of Extension* [On-line], 45(5) Article 5RIB4. Available at: http://www.joe.org/joe/2007october/rb4.php

McCurry, J. R., Gray, M. J., & Mercker, D. C. (2010). Early season flooding influence on seedlings of three common bottomland hardwood species in Western Tennessee. *Journal of Fish and Wildlife Management* 1(1):11-18.

Munsell Color. (2000), Munsell soil color chart: Baltimore, Maryland.

Ozalp, M., Schoenholtz, S., Hodges J., & Miwa, M. (1997). Influence of soil series and planting methods on fifth-year survival and growth of bottomland oak re-establishment in a farmed wetland. *Proceedings of the Ninth Biennial Southern Silvicultural Research Conference*. Clemson, South Carolina. USDA US Forest Service. Southern Research Station. Gen. Tech. Report SRS-20. Feb. 25-27, 1997.

Radhakrishna, R. B., Nelson, L., Franklin, R., & Kessler, G. (2003). Information sources and Extension delivery methods used by private longleaf pine landowners. *Journal of Extension* [On-line], 41(4). Article 4RIB3. Available at: http://www.joe.org/joe/2003august/rb3.php

Schaalje, G. B., McBride, J. B., & Fellingham G. W. (2001). Approximations to distributions of test statistics in complex mixed linear models using SAS proc MIXED. *SAS Users Group International Proceedings*, Paper 262-26. Retrieved from: http://www2sas.com/proceedings/sugi26/p262-26.pdf

Stanturf, J., Schweitzer, C., & Gardiner., E. (1998). Afforestation of marginal agricultural land in the Lower Mississippi River Alluvial Valley, U.S.A. *Silva Fennica* 32(3): 281-297.

Stanturf, J., Schoenholtz, S., Schweitzer C., & Shepard, J. (2001). Achieving restoration success: myths in bottomland hardwood forests. *Restoration Ecology* 9(2): 189-200.

US Department of Agriculture. (2010). *Field indicators of hydric soils in the United States: a guide for identifying and delineating hydric soils.* Natural Resource Conservation Service, Washington, DC. Version 7.0.

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