EVALUATION OF NUTTALL OAK AND CHERRYBARK OAK SURVIVAL BY PLANTING STOCK AND SITE PREPARATION TREATMENT TYPE IN A WRP PLANTING ON A RETIRED AGRICULTURAL SITE

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Abstract—Oaks are an ecologically and economically important component of the southern landscape, and many landowners are opting to regenerate their lands with these species. Federal cost share programs, such as the Wetland Reserve Program (WRP), have increased public interest in afforestation of retired agricultural sites in the Lower Mississippi Alluvial Valley (LMAV). Acorns, bare-root, container, and potted seedlings of Nuttall oak (*Quercus texana* Buckl.) and cherrybark oak (*Quercus pagoda* Raf.) were tested in a WRP planting near Port Barre, LA to evaluate survival following four mechanical/chemical site preparation combinations. These acorns/seedlings were planted using a 16 by 36 foot spacing with soft mast tree species interplanted on 16 by 9 foot intervals to meet WRP compliance specifications. The entire research site was subsoiled on 16 foot centers with acorn/seedlings planted in the subsoil trench. Control (no mechanical/chemical treatment), subsoil only, subsoil/Chopper EC®, subsoil/Arsenal AC®, and subsoil/OneStep® site preparation treatments were applied in an attempt to evaluate which treatment combination provided the greatest overall survival. Survival and herbaceous coverage estimates were recorded monthly in order to chronologically observe site preparation efficacy and the relationship between herbaceous competition and oak survival. Acorns did not germinate and bare-root seedlings exhibited very low survival. Containerized seedlings exhibited midrange survival and potted seedlings had the greatest overall survival. Early season flooding and a summer drought probably decreased survival of all planting stocks. Increased broadleaf competition in areas that received chemical treatments resulted in less survival compared to areas that received subsoiling only.

INTRODUCTION

Oaks (*Quercus* spp.) are an ecologically and economically important component of the southern landscape, and many landowners are opting to regenerate their lands with these species. Federal cost share programs, such as the Wetland Reserve Program (WRP) and the Conservation Reserve Program (CRP), have increased public interest in afforestation of retired agricultural sites in the Lower Mississippi Alluvial Valley (LMAV). These programs offer financial incentives to aid in recovery of costs incurred by artificially regenerating oaks (Schweitzer and Stanturf 1999).

According to Schoenholtz and others (2001), survival of planted seedlings and acorns has been low in these areas, resulting in a low percentage of oaks in established stands. This is possibly a corollary of poor soil conditions, poor planting techniques, poor seedling quality, and problems with competing vegetation. These problems can be alleviated through proper planting of high quality seedlings and through the application of proper silvicultural treatments needed to achieve enhanced survival and growth.

Survival and growth of seedlings could potentially be improved by using both mechanical and chemical site preparation treatments. Many retired fields have substantial levels of compaction due to past land use practices (Allen and others 2001). Subsoiling can correct some of the problems associated with these sites. Subsoiling can increase growth and possibly survival (Ezell and Shankle 2004). Potential increases in survival and growth from subsoiling can be the result of improved moisture and nutrient uptake, as well as enhanced root formation. These advantages could be critical on more xeric sites. Possibly the most influential agent in the failure of oak plantings is competing vegetation, and an increase in first-year growth of oaks receiving herbicide treatments for competition control has been documented (Russell and others 1997). Both herbaceous and woody competition may pose a threat to the survival of planted oak seedlings, with herbaceous competition posing the greatest threat in the first years of establishment (Smith and others 1997). Improved oak survival as a response to herbicide applications has been noted in several studies (Ezell and Catchot 1997, Ezell and Hodges 2002).

OBJECTIVES

The objectives of the study were:

1. To evaluate effects of subsoiling on first-year survival in oaks.
2. To evaluate effects of competition control on first-year survival of oaks.
3. To evaluate first-year survival of different planting stock types.

MATERIALS AND METHODS

Site Description

The tract selected for this study was formerly in row-crop production and is located approximately five miles northeast of Port Barre, LA in St. Landry Parish. Watercourses border the site on all sides. The study area encompasses approximately 78 acres within a 250-acre retired agricultural field. Soil series are Sharkey clays, and the average yearly precipitation is 53.56 inches. Soil saturation was observed on much of the study area through early June 2005, but by October, cumulative precipitation was 16.58 inches lower than average for the area.

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Citation for proceedings: Stanturf, John A., ed. 2010. Proceedings of the 14th biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-121. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southern Research Station. 614 p.

There was a well established herbaceous groundcover with a scattered woody component at the time of site selection. The dominant herbaceous species onsite included: vaseygrass (*Paspalum urvillei* Steud.), sumpweed (*Iva annua* L.), bermudagrass (*Cynodon dactylon* L.), beaked rush (*Rhynchospora corniculata* Lam.), soft rush (*Juncus effusus* L.), curly dock (*Rumex crispus* L.), and Pennsylvania smartweed (*Polygonum pensylvanicum* L.). Other herbaceous species were present in small quantities. The dominant woody species on the site was tallowtree (*Sapium sebiferum* L.). There were also small components of green ash (*Fraxinus pennsylvanica* Marsh.), black willow (*Salix nigra* Marsh.), sugarberry (*Celtis laevigata* Willd.), eastern baccharis (*Baccharis halimifolia* L.), honeylocust (*Gleditsia triacanthos* L.), and sweetgum (*Liquidambar styraciflua* L.).

Study Design and Plot Establishment

Operational constraints strongly influenced the design of this study. Herbicide treatments, planting stocks, and species could not be randomly allocated for reasons of equipment and personnel efficiency. A split, split strip-plot design was utilized in this experiment. The research was conducted on a rectangular area of approximately 72 acres. This area was divided in a vertical (north/south) direction into four, 18-acre blocks. These blocks were established for the purpose of applying site preparation treatments. For replication purposes, the site was divided horizontally (east/west) into three, 24-acre blocks. A total of 48 data cells comprising 1.5 acres each, were established on the research site. Six control (no site preparation, no herbicide application) data cells were established immediately adjacent to study area boundaries. These data cells were used to determine survival of seedlings in areas without chemical or mechanical silvicultural treatment. All exterior and interior boundary lines were delineated using a transit and a 300-foot surveyor's tape.

Data cell corners were marked with five foot sections of one inch PVC pipe. Individual tree rows were marked with two foot sections of one inch PVC pipe. Tree row pipes were also marked with 36-inch pin flags color specific to species. Individual tree/acorn planting locations were determined and marked with 36-inch pin flags color specific to species.

Site Preparation Treatments

Both mechanical and chemical treatments were used in initial site preparation efforts. Mechanical site preparation consisted of subsoiling the entire area using 16-foot spacing across the site. This subsoiling treatment was performed to reduce "restriction layers" or compaction commonly found in retired agricultural fields. Subsoiling was also utilized to evaluate its effect on survival in oak establishment attempts. The subsoil treatment was performed using a three-inch-wide single shank subsoil plow pulled by a skidder. The subsoil plow was tipped with an eight-inch tiger wing tip followed by two sixteen-inch closing wheels attached to the rear. Subsoil trenches were installed on December 1 and 2, 2004.

There were four chemical site preparation treatments used in this study: a no herbicide application, a 32-ounce Chopper EC® per acre + one percent volume/volume (v/v) Timbersurf 90®, a 16-ounce Arsenal AC® per acre + one percent (v/v) Timbersurf 90®, and a 16-ounce OneStep® per acre + one percent (v/v) Timbersurf 90®. All chemical treatments were applied to the areas which had received the mechanical subsoiling treatment. Chemical site preparation was deemed necessary for the site due to complete herbaceous coverage. Site preparation herbicides were applied using 20 gallons per acre (g.p.a.) total spray volume. Applications were completed using a cluster nozzle sprayer with a radiarc nozzle system and 0.048 tips. This sprayer was mounted on an agricultural tractor and the spray rate was regulated by speed. All chemical site preparation treatments were applied on July 26 and 27, 2004 during morning and evening hours to avoid wind drift.

Seedling Establishment

There were 14 subsoil trenches in each data cell. These served as planting rows with the two outside rows being used as buffers (no measurements). The 12 internal rows were specified as evaluation rows. Individual oak seedling/acorn planting sites were spaced using a 36-foot interval along the subsoiled row. Nuttall oak and cherrybark oak seedlings/acorns were planted. Four planting stock types were used: acorns, bare-root seedlings, containerized seedlings, and potted seedlings. A total of 5,616 seedlings/acorns were planted. Twelve-inch-diameter holes were augered for seedlings planted on potted or bare-root stock rows. The purpose of this augering treatment was to facilitate planting of the large root systems of the potted and large caliper bare-root seedlings. These holes were backfilled to a depth that placed individual seedling root collars at or slightly below ground level. Seedlings were then placed in their respective holes and the holes were refilled with soil being packed around the root systems. Containerized seedlings were planted at or slightly below root collar depth using planting shovels. Acorns were planted approximately one half to one inch deep using a piece of PVC pipe to open a hole, placing the acorn in the hole, and then packing soil over the acorn.

Potted and containerized seedlings were purchased from Five Oaks Tree Nursery in Dewitt, AR and were lifted December 16, 2004. These seedlings were planted on December 18 through 20, 2004. Bare-root seedlings were purchased from Delta Wildlife Consulting, Inc. in Winnesboro, LA and were lifted December 27, 2004. These seedlings were planted on December 28 and 29, 2004. Acorns were purchased form the Louisiana Forest Seed Company, and were collected from sources within LA. The acorns were float tested and guaranteed 95 percent sound. Acorns were planted April 8, 2005. Bare-root green ash, winged elm (*Ulmus alata* Michx.), red maple (*Acer rubrum* L.), hackberry (*Celtis occidentalis* L.), common persimmon (*Diospyros virginiana* L.), and sweetgum seedlings were interplanted between oak seedlings/acorns on nine foot intervals to achieve WRP tree number specifications. These seedlings were not measured, nor assessed for this study.

Survival Observations

Survival checks and herbaceous coverage percentages were recorded monthly from May 2005 through August 2005. A survival check was not completed during the month of September due to complications arising from Hurricane

Katrina. No observable onsite damage resulted from Hurricane Katrina. One half of the treatment and control plots were observed in the monthly evaluations in a checker-board pattern for a total of 27 data cells and 2,808 planting sites evaluated. Seedling survival was based on ocular evaluation. If a seedling was not present it was considered dead. If it was observed as a resprout in later observations, it was included in earlier survival estimations. The cambium was nicked on seedlings which appeared dead to ensure survival status. Acorn germinants were sought, but not found throughout the growing season. Herbaceous ground coverage was estimated ocularly and recorded as a percentage. Herbaceous components were separated into grass or broadleaf categories and then further delineated into major species. Final observations were taken October 8 through 18, 2005 on surviving seedlings.

Data Analysis

Survival averages were calculated using Statistical Analysis System (SAS) software version 9.1®. All survival data were averaged among chemical site preparation treatments, species, and planting stock types. When significant differences were noted among combinations, seedlings were pooled within their respective site preparation treatment, species, and planting stock categories for calculating averages.

RESULTS

Survival/Planting Stock

No acorn germinants were found across the site. Willoughby and others (1996) state that growing season flooding can result in failure of direct seeding attempts. Saturated soil conditions observed onsite from April through June 2005 probably resulted in the failure of acorn germination. Potted seedlings exhibited the best survival, followed by containerized seedlings and bare-root seedlings (table 1). Overall survival of potted seedlings was 31.8 percent greater than containerized seedlings (82.0 percent and 50.2 percent, respectively). Bare-root survival (24.7 percent) was approximately one half that of containerized stock and one third that of potted stock. This pattern in survival was observed in both species as well (table 2). Potted seedlings exhibited greatest survival, followed by containerized seedlings, followed by bare-root seedlings with the lowest survival.

Table 1—Overall survival for planting stock types (all treatments)

Planting stock	Survival
	-- *percent* --
Containerized	50.2b[a]
Potted	82.0a
Bare-root	24.7c

[a]values within a column followed by different letters are significantly different at $\alpha = 0.05$ (Duncan's Multiple Range Test).

Table 2—Overall survival for Nuttall oak and cherrybark oak by planting stock type (all treatments)

Planting stock	Nuttall oak	Cherry-bark oak
	---------- *percent* -----------	
Containerized	53.3b[a]A[b]	47.0bA
Potted	95.3aA	68.7aB
Bare-root	36.6cA	12.7cB

[a]values followed by different lower case letters within a column are significantly different at $\alpha = 0.05$ (Duncan's Multiple Range Test).
[b]values followed by different upper case letters within a row are significantly different at $\alpha = 0.05$ (Duncan's Multiple Range Test).

On a species basis, Nuttall oak exhibited greater overall survival than cherrybark oak (61.7 percent and 42.8 percent, respectively). Greater survival of Nuttall oak was also observed for comparable planting stock types in cherrybark oak (table 2). Early growing season saturated soil conditions are thought to have influenced the low survival observed for cherrybark oak. Subsequently, summer drought conditions are thought to also have contributed to much of the mortality observed across all species/planting stock combinations.

Survival/Site Preparation

Chemical site preparation worked well in controlling existing vegetation at the time of application. However, chemical site preparation did not control growing season herbaceous competition, nor was it expected to. The lowest survival was observed in areas receiving the Subsoil Only and Subsoil/OneStep® treatment combinations (47.2 percent and 41.1 percent, respectively) (table 3). Subsoil/Chopper EC® and Subsoil/Arsenal AC® treatment areas exhibited 57.7 percent and 50.9 percent survival. The discrepancy between areas that received a chemical application as a part of site preparation was likely the result of site condition differences and not the herbicide treatment. Areas on which the Subsoil/OneStep® treatment was applied were at the lowest elevations. These areas were inundated during much of the early growing season and remained saturated through June. The greatest overall survival (68.8 percent) was observed in Subsoil Only treatment areas. Lower survival in areas receiving a chemical component to site preparation was thought to be a result of recolonization of an aggressive broadleaf weed complex.

SUMMARY

Greater survival was observed for Nuttall oak than for cherrybark oak both on a species basis and on an individual planting stock basis. The much lower overall survival exhibited by cherrybark oak indicates that the species was probably not suited for saturated soil conditions found onsite during the early part of the growing season. Nuttall oak is considered more water tolerant than cherrybark oak (Burns and Honkala 1990, Day III and others 1997, Miwa and others 1992, Williams and others 1992). Findings of these

Table 3—Overall survival by site preparation treatment (all planting stocks)

Site preparation	Survival
	----- *percent* -----
Control	47.2c[a]
Subsoil Only	68.8a
Subsoil/Chopper EC®	57.7b
Subsoil/Arsenal AC®	50.9b
Subsoil/OneStep®	41.1c

[a]values within a column followed by different letters are significantly different at $\alpha = 0.05$ (Duncan's Multiple Range Test).

studies seem to be supported by the fact that cherrybark oak survived best on drier portions of the research site in this study.

Generally, greater survival is expected in potted stock, followed by containerized and bare-root planting stocks (Allen and others 2001, Burkett 1996, Howell 2002, Rathfon and others 1995, Williams and Craft 1997). As expected, potted stock exhibited the greatest survival, containerized second greatest, and bare-root stock exhibited the worst survival in this study. Bare-root survival can be excellent, but competition has to be controlled and uncontrollable natural site conditions have to be conducive to the desired outcome.

An interesting result was that the greatest overall survival observed (68.8 percent) was in areas receiving only subsoiling as a site preparation treatment. Survival in these areas was significantly greater than in areas receiving an additional chemical component to the site preparation treatment combination. This indicates if adequate competition control is not achieved with chemical site preparation, greater survival can be achieved through the use of subsoiling only. In this case aggressive broadleaf competition, which invaded areas "cleared" by the chemical site preparation, encroached at levels sufficient to negatively impact seedling survival. Subsoil Only treatment areas did not experience the increased broadleaf competition levels that other site preparation treatment areas did, resulting in significantly greater survival.

Subsoiling probably alleviated preexisting site condition problems as well. Earlier studies substantiate that seedlings benefit from subsoiling in former agricultural fields (Allen and others 2001, Ezell and Shankle 2004, Johnson and others 2002, Lockhart and others 2003). The biggest concern in regenerating retired agricultural fields is that of compacted soils (Allen and others 2001). Subsoiling fractures restrictive layers found in retired fields and can increase survival of planted seedlings. Subsoiling can also result in greater survival from increased nutrient and water uptake, deep root development, and higher levels of soil exploitation by developing root systems. These benefits are probably responsible for some of the survival observed in Subsoil Only areas.

It should be noted that the chemical site preparation treatments used in this study can provide excellent short term control of competing vegetation. Chemical site preparation should be used only to control species which cannot be eliminated by growing season herbaceous weed control efforts. It is these herbaceous release applications that typically provide longer term control of competition if the proper herbicide is used. Chemical site preparation is of little value if it does not control vegetation throughout the growing season. Thus, when chemical control is deemed necessary to control existing onsite vegetation, it should be followed by growing season herbaceous control. This is evidenced through survival observed in Subsoil Only areas. Greater overall survival would generally be expected in areas receiving both mechanical and chemical site preparation, but areas receiving the Subsoil Only treatment exhibited significantly greater survival. Areas treated with chemical site preparation did not receive growing season competition control and subsequently, survival in these areas suffered.

CONCLUSION

Generally, best survival results would be expected in areas receiving both subsoiling and effective competition control. However, if an aggressive broadleaf competitor exists onsite and growing season herbaceous control is not an option, the best option might be to not perform any chemical applications. If adequate growing season control cannot be achieved, subsoiling can provide improved results when planting hardwoods on retired agricultural areas. Subsoiling is also beneficial as a site preparation treatment in its own right, with a proven track record in influencing increased survival.

Bare-root and containerized stock survival was considered unacceptably low in this study. Potted seedlings survived the best, but the cost of using such seedlings ($1,216.00 per acre) would be prohibitive in most afforestation efforts. Containerized seedlings exhibited survival approximately one-half that of potted seedlings, but much greater than bare-root seedlings. In this case, containerized seedlings were less expensive than bare-root or potted seedlings due to bare-root and potted seedling size and associated planting costs. Containerized stock could be planted at higher densities to achieve survival equal to or exceeding potted stock survival at a fraction of the cost.

Hardwood plantings are never guaranteed, but greater survival should be expected than observed in this study. As land managers we can control species selection, seedling and planting quality, pre-plant seedling treatments, site preparation treatments, and post-plant herbicide treatments in the attempt to establish successful hardwood plantings. Natural factors such as droughty conditions or flooding cannot be prevented. The only thing we can do to counter effects of adverse natural conditions and increase the chance of planting success is to make the best silvicultural choices possible to promote planting survival.

LITERATURE CITED

Allen, J.A.; Keeland, B.D.; Stanturf, J.A. [and others]. 2001. A guide to bottomland hardwood restoration. Gen. Tech. Rep. SRS-40. U.S. Forest Service, Southern Research Station, Asheville, NC: 132 p.

Burkett, V. 1996. Effects of flooding regime, mycorrhizal inoculation and seedling treatment type on the establishment of Nuttall oak (*Quercus nuttallii* Palmer). Ph.D. dissertation, Stephen F. Austin State University, Nacogdoches, TX: 140 p.

Burns, R.M.; Honkala, B.H. 1990. Silvics of North America: 2. Hardwoods. Agriculture Handbook 654. U.S. Forest Service, Washington, DC: 877 p.

Day, C.P. III.; Hodges, J.D.; Schoenholtz, S.H. [and others]. 1997. Influence of hydrology on artificial regeneration of oaks in the Mississippi delta. In: Proceedings ninth biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-20. U.S. Forest Service, Southern Research Station, Asheville, NC: 295-299.

Ezell, A.W.; Catchot, A.L. Jr. 1997. Competition control for hardwood plantation establishment. In: Proceedings ninth biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-20. U.S. Forest Service, Southern Research Station, Asheville, NC: 42-43.

Ezell, A.W.; Hodges, J.D. 2002. Herbaceous weed control improves survival of planted Shumard oak seedlings. In: Proceedings eleventh biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-48. U.S. Forest Service, Southern Research Station, Asheville, NC: 273-275.

Ezell, A.W.; Shankle, M.W. 2004. Effects of subsoiling and competition control on first year survival and growth of four hardwood species. In: Proceedings twelfth biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-71. U.S. Forest Service, Southern Research Station, Asheville, NC: 571-573.

Howell, K.D. 2002. Cherrybark oaks from perforated containers planted as bareroots with open-grown bareroots. In: Proceedings eleventh biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-48. U.S. Forest Service, Southern Research Station, Asheville, NC: 342-345.

Johnson, J.E.; Mitchem, D.O.; Kreh, R.E. 2002. The relationship between soils and foliar nutrition for planted royal paulownia. In: Proceedings eleventh biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-48. U.S. Forest Service, Southern Research Station, Asheville, NC: 239-244.

Lockhart, B.R.; Keeland, B.; McCoy, J. [and others]. 2003. Comparing regeneration techniques for afforesting previously farmed bottomland hardwood sites in the Lower Mississippi Alluvial Valley, USA. Forestry. 76: 169-180.

Miwa, M.; Schoenholtz, S.H.; Hodges, J.D. [and others]. 1992. First-year results of bottomland oak reestablishment in alluvial soils of the lower Mississippi valley. In: Proceedings seventh biennial southern silvicultural research conference. Gen. Tech. Rep. SO-93. U.S. Forest Service, Southern Forest Experiment Station, New Orleans, LA: 73-79.

Rathfon, R.A.; Kaczmarek, D.J.; Pope P.E. 1995. Site preparation for red oak plantation establishment on old field sites in southern Indiana. In: Proceedings tenth central hardwood forest conference. Gen. Tech. Rep. NE-197. U.S. Forest Service, Northeastern Forest Experiment Station, Broomall, PA: 349-362.

Russell, D.R., Jr.; Hodges, J.D.; Ezell A.W. 1997. An evaluation of hardwood reforestation methods on previously farmed lands in central Alabama. In: Proceedings ninth biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-20. U.S. Forest Service, Southern Research Station, Asheville, NC: 272-276.

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. 21:602-613.

Schweitzer, C.J.; Stanturf, J.A. 1999. A comparison of large-scale reforestation techniques commonly used on abandoned fields in the lower Mississippi alluvial valley. In: Proceedings tenth biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-30. U.S. Forest Service, Southern Research Station, Asheville, NC: 136-141.

Smith, D.M.; Larson, B.C.; Kelty, M.J. [and others]. 1997. The Practice of Silviculture: Applied Forest Ecology. 9th ed. John Wiley & Sons, Inc., New York.

Williams, H.M.; Craft, M.N. 1997. First-year survival and growth of bare-root, container, and direct-seeded Nuttall oak planted on flood-prone agricultural fields. In: Proceedings ninth biennial southern silvicultural research conference. Gen. Tech. Rep. SRS-20. U.S. Forest Service, Southern Research Station, Asheville, NC: 300-303.

Willoughby, I.; Derr, G.; Jinks, R. [and others]. 1996. Establishing new woodlands by direct sowing. For. Comm. Res. Inf. Note-285. Forestry Authority Research Division. Edinburgh, UK: 7 p.