SURVIVAL AND GROWTH OF PLANTED AND DIRECT-SEEDED CHERRYBARK OAK IN THE SANTEE RIVER FLOODPLAIN AFTER 11 YEARS[1]

John A. Stanturf[2]

Abstract—Five treatments were used to evaluate the survival and growth of planted and direct-seeded 2-0 cherrybark oak (*Quercus falcata* var. *pagodifolia* Ell.). Treatments included planting at two depths and top-pruning seedlings; and direct-seeding acorns. Survival averaged 64% after 11 years and treatment had no significant affect. Planting depth and pruning did not affect survival of planted seedlings. Stems from the direct-seeded acorns were 16 ft tall, on average, and significantly smaller after 11 years than planted stems (23 ft tall). There were no differences in the size of stems in the planting treatments.

INTRODUCTION

Oaks have been the backbone of the hardwood lumber industry in the South. Oaks are also preferred for wildlife. Public and private programs to reforest former agricultural land have stimulated interest in artificial regeneration of bottomland hardwoods. Intensively cultured plantations, however, are expensive to establish (Bullard et al. 1991). Two alternatives are direct-seed acorns (Johnson and Krinard 1987; Kennedy 1993) or plant fewer, large seedlings that may require less intensive weed control treatments.

This paper presents results after 11 years of a study designed to compare planting large 2-0 cherrybark oak, *Quercus falcata* var. *pagodifolia* Ell., seedlings with direct-seeding cherrybark oak acorns. Seedlings were planted at two depths, with and without top-pruning, and survival and growth compared to seedlings that developed from direct-seeded acorns.

METHODS

Study Site

This study was established in the floodplain of the Santee River, about 20 miles southeast of Manning, SC, on private land. Harvesting began in late 1982, and the site prepared by shearing residual trees, removing debris, and root-raking. Planting and direct-seeding took place in March, 1983. Soils are of the Tawcaw series of fine, kaolinitic, thermic Fluvaquentic Dystrochepts. These soils have dark brown silty clay A horizons over brownish clayey and loamy B horizons. Drainage is poor, and runoff and permeability are slow. Many areas are frequently flooded, and the water table ranges between 20 and 48 inches during winter and early spring. Site index is 90 to 100 ft at base age 50 for water oak, *Q. nigra* L., cherrybark oak, and willow oak, *Q. phellos* L.

Design and Treatments

The study was designed as a randomized complete block with five replications of five treatments. Blocks were approximately 60 ft by 100 ft in size. Each block contained six rows laid out 10 ft apart. One of five treatments was randomly assigned to each row in each block. Planting spots within rows were 5 ft apart, thus a spacing of 5 ft by 10 ft.

Treatments were as follows:

1. 2-0 cherrybark oak, deep-planted, not top-pruned (D_{NP})
2. 2-0 cherrybark oak, deep-planted, top-pruned (D_P)
3. 2-0 cherrybark oak, shallow-planted, not top-pruned (S_{NP})
4. 2-0 cherrybark oak, shallow-planted, top-pruned (S_P)
5. Cherrybark oak acorns, direct-seeded (DS).

Seedlings for all treatments were collected near Stoneville, MS. Seedlings were grown in the nursery at the Southern Hardwoods Laboratory at Stoneville, MS.

Planting and Pruning

Seedlings were planted in 9-inch-diameter holes dug with a gasoline-powered post-hole digger. Holes for deep-planted seedlings were approximately 2 ft deep, and those for shallow-planted seedlings were approximately 1 ft deep. The root systems of seedlings were pruned to about 9 inches in diameter and 1 ft in length before planting. Root collars for deep-planted seedlings were placed about 1 ft below the groundline. Top-pruned seedlings were pruned 1 ft above the groundline at planting. Unpruned seedlings averaged 2

[1]Paper presented at the Eighth Biennial Southern Silvicultural Research Conference, Auburn, AL, Nov. 1-3, 1994.

[2]Project Leader, USDA, Forest Service, Southern Forest Experiment Station, Stoneville, MS.

to 2.5 ft tall at planting. Soil was replaced and tamped firmly around the roots. Four acorns per spot in direct-seeded rows were sown 1 to 2 inches deep. There were 20 seedlings or direct-seeded spots in each row. No weed control was done after planting.

Soil Sampling and Analyses

Soils were sampled at four points systematically located along each of two transects across the study area. Samples were taken from four depths at each point: 0 to 6 inches, and 1, 2, and 3 ft. Samples were composited by depth along each transect; thus, a total of eight samples, two from each depth, represented the study area. Soil was air-dried and ground to pass through a 2-mm sieve for analyses. Results are reported as the average of the two composite samples for each depth.

Soil N was determined by the Kjeldahl method. Phosphorus was determined colorimetrically (Donohue 1992). Concentrations of K, Ca, and Mg were measured by atomic absorption spectrophotometry after extraction in 1 N NH_4OAc. Soil pH was measured with a glass electrode in a 1:1 soil/water mixture. Oxidizable OM was determined by chromic acid oxidation and titration with $Fe(NH_4)_2(SO_4)_2$.

Measurements

Height, diameter at breast height (dbh), and survival were measured after the first, fifth, and eleventh growing seasons. Diameter was measured to the nearest 0.1 inch at 4.5 ft aboveground (dbh). Height was measured with a graduated aluminum pole to the nearest 0.1 ft. The four acorns planted at each direct-seeded spot were considered as one planting spot. If more than one acorn germinated, the height and diameter of the largest seedling was used in statistical analysis.

Statistical Analyses

The mean of each block by treatment combination was considered the experimental unit. Mean survival (arcsine transformed), dbh, and total height of the seedlings in each treatment after the first, fifth and eleventh growing seasons were the variables tested. Variables were tested at the 0.05 level of confidence. Means were compared by orthogonal linear contrasts using the GLM program in SAS (SAS Institute 1989).

RESULTS

Nutrient levels in these soils are lower (Table 1) than are found on the best sites (Broadfoot 1976). Organic matter and phosphorous levels in the surface soil (0-6 inches) are higher than typically found on drier sites planted to pines (McKee and Wilhite 1986).

Survival of planted and direct-seeded cherrybark oak was not significantly different in any year. Small initial differences after the first and fifth growing seasons (Figure 1) had disappeared by age 11. Survival of planted seedlings declined from near 80% after one growing season to 63% at age 11.

Table 1–Soil characteristics of the study area.

	Soil depth (inches)			
Component	0 to 6	12	24	36
pH	5.0	5.0	4.8	4.8
Organic matter (pct)	3.29	1.01	0.49	0.47
Nitrogen (pct)	0.164	0.053	0.035	0.045
Phosphorus (ppm)	8	12	8	4
Potassium (ppm)	72	30	30	30
Calcium (ppm)	455	181	136	168
Magnesium (ppm)	89	42	36	36

Cumulative height of direct-seeded stems was significantly less than planted seedlings on all dates. Initially taller, the planted seedlings not only maintained their height advantage, but appear to be growing faster (Figure 2). At age 11, planted stems averaged 23 ft tall, while the average height of stems in the direct-seeded treatment was 16 ft. The same patterns were evident in diameter growth (Figure 3). DBH of planted stems averaged 2.6 inches at age 11, as compared to 1.4 inches for direct seeded stems.

Deep planting and top pruning did not significantly affect survival of planted seedlings after the first 11 years (Table 2). Survival ranged from 50% to 73%. The lowest survival was in the most severe treatment, deep-planting and top-pruning, but was not significantly different from the other treatments. At the spacing of this study, stocking would be 436 to 636 stems per acre.

Both deep-planting and top-pruning reduced the initial height of planted seedlings. Planting stock in this study ranged from 1.9 ft to 3.6 ft tall, above the root collar. Prior to pruning, deep-planted seedlings averaged 1.8 ft tall above groundline; shallow-planted seedlings averaged 2.3 ft. Pruning removed as much as 2.5 ft of stem material. Nevertheless, neither treatment significantly reduced height or diameter of planted stems after 11 years (Table 3). The largest trees were in the shallow-planted and pruned treatment.

Cumulative height of planted trees is shown in Figure 4. Pruning to 1 ft above groundline at planting gave the unpruned seedlings an average 0.7 ft to 1.3 ft height advantage, depending upon planting depth. At the end of the first growing season, pruned seedlings were almost as tall as unpruned. By age 5, pruned stems were slightly taller, on average. By age 11, trees that had been pruned at planting averaged 0.5 ft taller than unpruned (23.8 ft vs. 23.3 ft, respectively).

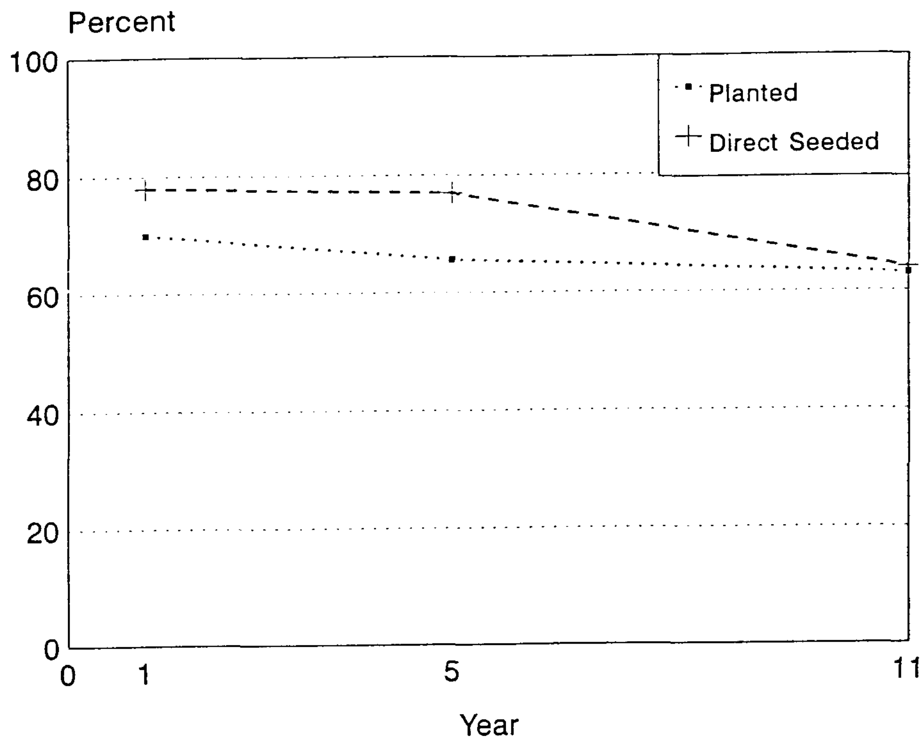

Figure 1. Survival at age 1, 5, and 11 years of direct-seeded and planted cherrybark oak.

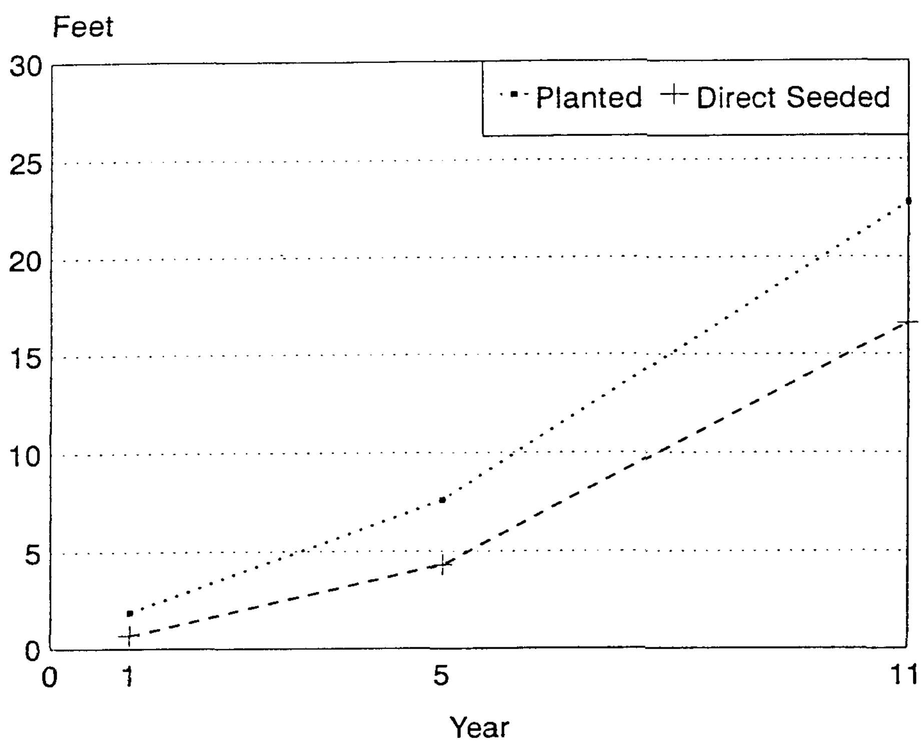

Figure 2. Cumulative height growth of direct-seeded and planted cherrybark oak at age 1, 5, and 11 years.

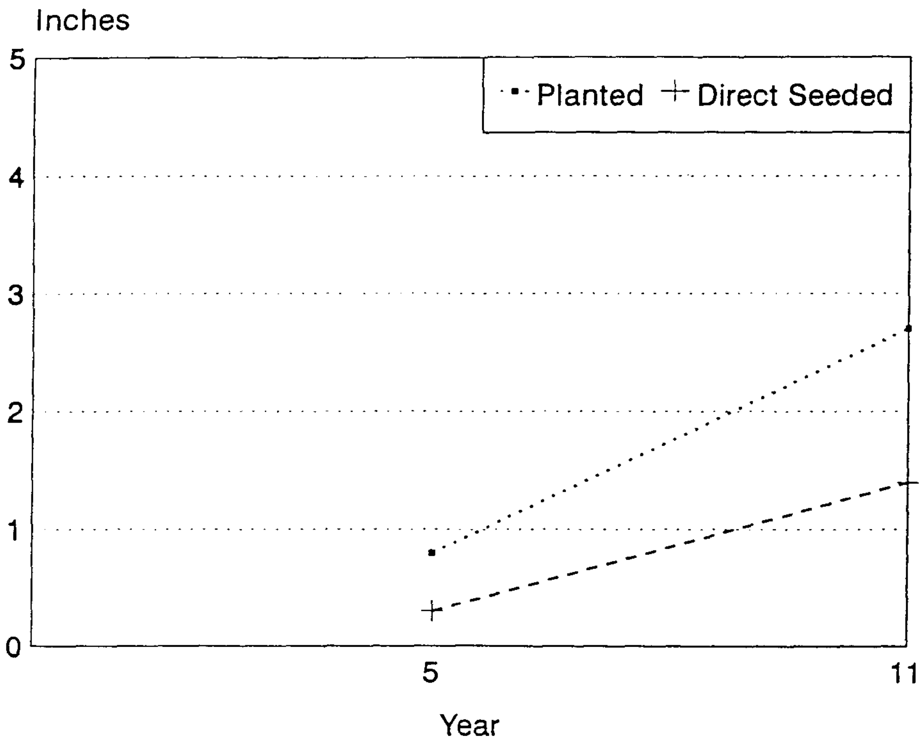

Figure 3. Cumulative diameter growth of direct-seeded and planted cherrybark oak at age 5, and 11 years.

Table 2. Percent survival at age 1, 5, and 11 years of cherrybark oak seedlings planted at two depths, with and without top pruning.

Treatment	——Year One——		——Year Five——		——Year Eleven——	
	Mean	Range	Mean	Range	Mean	Range
Deep Plant, Prune	60	10-80	55	15-75	50	15-65
Deep Plant, No Prune	83	75-90	76	70-85	73	60-85
Shallow Plant, Prune	69	15-100	69	20-100	68	20-100
Shallow Plant, No Prune	72	30-100	64	20-90	61	10-85

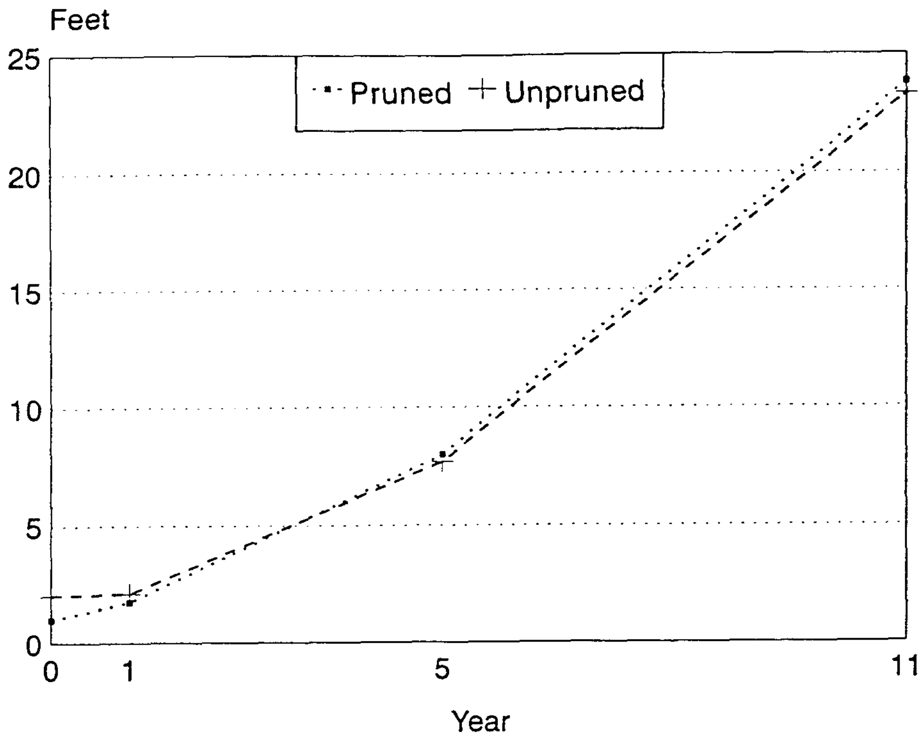

Figure 4. Cumulative height growth of pruned and unpruned cherrybark oak seedlings at age 1, 5, and 11 years.

Table 3. Mean height (cumulative) and d.b.h. of planted 2.0 cherrybark oak at age 11.

Treatment	Height, ft	DBH, inches
Deep Plant, Prune	23.2	2.55
Deep Plant, No Prune	23.0	2.75
Shallow Plant, Prune	24.4	2.92
Shallow Plant, No Prune	23.6	2.61

DISCUSSION

The 63% survival rate of direct-seeded cherrybark oak in this study was similar to that found in other studies (Johnson and Krinard 1987) but greater than is achieved operationally (Kennedy 1993). The relatively intense site preparation removed or setback woody and herbaceous competitors and reduced habitat for small mammals that pilfer acorns (Kennedy 1993). The slower height growth rates of direct-seeded trees (Figure 1) may be due to competition from other oak stems that survived at the same planting spot.

Top pruning and deep planting had no significant effect on survival or growth of planted cherrybark oak. Large seedlings can be top-pruned without reducing survival, and will actually grow more vigorously than unpruned seedlings. Thus the advantage in top-pruning to reduce shipping and handling expense may be obtainable (Johnson et al. 1986). In this study, however, top pruning occurred after the seedling was planted. Pruning before outplanting may affect vigor in ways not tested in this study. Recommended planting depth is with the root collar at groundline for best survival (Kennedy 1993). Results from this study indicate that 2-0 seedlings can be planted with the root collar as deep as 1 ft below groundline without a reduction in survival or growth, as long as the planting hole is adequate for the root system. This eases the operational requirements for planting large seedlings, as a standard hole size can be used rather than "custom digging" a hole for each seedling.

Application of the results of this study to reforestation of bottomland hardwood and wetland forests depends upon the objectives of the landowner. While direct-seeding has the lowest initial cost of any artificial regeneration method (Bullard et al. 1991), the landowner will have to accept smaller trees early in the rotation. Planting larger seedlings may have considerable merit on rougher sites without competition control. If expensive site preparation and vegetation management treatments can be avoided, those savings may offset the greater expenses associated with producing and planting larger seedlings. Further research, however, is needed to test this hypothesis.

ACKNOWLEDGEMENTS
This research was done in cooperation with the Mississippi Agricultural and Forestry Experiment Station and the Southern Hardwood Forest Research Group.

LITERATURE CITED
Allen, J.A. 1990. Establishment of bottomland oak plantations on the Yazoo National Wildlife Refuge Complex. Southern Journal of Applied Forestry. 14(4):206-210.

Broadfoot, W.M. 1976. Hardwood suitability for and properties of important midsouth soils. Res. Pap. SO-127. New Orleans, LA: U.S. Department of Agriculture, Forest Service, Southern Forest Experiment Station. 84 pp.

Bullard, S.; Hodges, J.D.; Johnson, R.L.; Straka, T.J. 1991. Economics of direct seeding and planting for establishing oak stands on old-field sites in the South. Southern Journal of Applied Forestry. 16(1):34-40.

Donohue, S.J., editor. 1992. Reference soil and media diagnostic procedures for the southern region of the United States. Southern Cooperative Series Bulletin No. 374. Virginia Agricultural Experiment STation, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and STate U

Kennedy, H.E., Jr. 1993. Artificial regeneration of bottomland oaks. In: Loftis, D.L.; McGee, C.E. (Editors), Oak Regeneration: Serious Problems, practical recommendations. Symposium proceedings; 1992 September 8-10; Knoxville, TN. Gen. Tech. Rep. SE-84. Asheville, NC: U.S. Department of Agriculture, Forest Service, Southeastern Forest Experiment Station: 241-249.

Johnson, P.S. 1993. Perspectives on the ecology and silviculture of oak-dominated forests in the Central and Eastern States. Gen. Tech. Report NC-153. Minneapolis, MN: U.S. Department of Agriculture, Forest Service, Northcentral Forest Experiment Station. 28 pp.

Johnson, R.L.; Krinard, R.M. 1987. Direct-seeding of southern oaks--a progress report. In: Proceedings of the 15th annual hardwood symposium of the Hardwood Research Council; 1987 May 10-12; Memphis, TN. Memphis, TN: Hardwood Research Council: 10-16.

McKee, W.H., Jr.; Wilhite, L.P. 1986. Loblolly pine response to bedding and fertilization varies by drainage class on Lower Atlantic Plain Sites. South. J. Appl. For. 10(1):16-21.

SAS Institute. 1989. SAS/STAT user's guide, version 6, fourth edition, volume 2. Cary, NC: SAS Institute, Inc. 846 pp.

Wittwer, R.F. 1991. Direct-seeding of bottomland oaks in Oklahoma. Southern Journal of Applied Forestry. 15(1):17-22.