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First-year survival and growth of bareroot, container, and direct-seeded Nuttall oak planted on flood-prone agricultural fields

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FIRST-YEAR SURVIVAL AND GROWTH OF BAREROOT, CONTAINER, AND DIRECT-SEEDED NUTTALL OAK PLANTED ON FLOOD-PRONE AGRICULTURAL FIELDS

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Abstract—Container and 1-0 bareroot Nuttall oak (*Quercus nuttallii*, Palmer) seedlings were hand-planted, and acorns were direct- seeded, in a Sharkey soil (very fine, montmorillonitic, nonacid, thermic, Vertic Haplaquepts). The seedlings and seed were planted in January, February, March, and June, 1993. Flooding, to a depth of 2 meters, occurred on the study site from late March to late May. Seedlings planted in June were not flooded. Regardless of planting date, mean first-year survival for container seedlings was greater than 80 percent. Overall mean survival for bareroot seedlings was about 40 percent and direct-seeding survival was 30 percent. Bareroot seedling survival was about 60 percent when seedlings were planted in January or February, but fell below 25 percent when seedlings were planted in March and June. The reduction in bareroot survival was attributed to long-term cold storage. Mean first-year total height of container, bareroot, and direct-seeded seedlings was 46 centimeters, 34 centimeters, and 15 centimeters, respectively. However, stem dieback resulted in shorter seedlings after the first year in the field. Container seedlings were slightly shorter than when planted, but bareroot seedlings averaged 22 centimeters shorter. Greater survival and flexibility with regard to planting schedules may justify the use of container seedlings on flood-prone sites.

INTRODUCTION

Federal programs such as the Wetlands Reserve Program administered by the Natural Resource Conservation Service, and mitigation for wetland loss required by the U.S. Clean Water Act have initiated the increase in bottomland hardwood wetlands restoration in the Southeastern United States. Usually, the objective is to restore the wildlife and water quality wetland functions. Timber production, while enhancing the value of these reforested sites, is a secondary objective. Agricultural fields that flood in most years are ideal restoration sites because the presence of hydrology increases the opportunity for many wetland functions to occur. In addition, restoration costs may be reduced because little site preparation is needed prior to planting.

Flooding usually occurs in the Southeastern United States during the winter and early spring, which coincides with the conventional planting season. Consequently, this desirable flooding can cause significant problems during reforestation. Flood timing can disrupt seedling delivery and planting schedules, prolong cold storage of seedlings, or create difficult planting conditions. The long-term, complete inundation of newly planted flood-tolerant bottomland hardwood seedlings may reduce survival (Kozlowski and others 1991).

In 1991, the U.S. Army Corps of Engineers, Vicksburg District, began the reforestation of 3600 hectares of agricultural land located in Yazoo County, MS. The Lake George Wildlife/Wetland Restoration Project was initiated as mitigation for the Yazoo and Satartia Area Backwater Levee Project completed in 1987. The primary objective was to improve wetland and terrestrial wildlife habitat by planting a suite of mast-producing bottomland hardwood tree species. Reforestation was to be accomplished by using 1-0 bareroot seedlings. Except for some ponding, about 2650 hectares of the Lake George site is protected from flooding by an existing levee system. However, 40[illegible] hectares are unprotected and subject to backwater floo[illegible] from the Big Sunflower and Yazoo Rivers. Early survival planted seedlings was high on areas that did not flood. However, survival was poor on sites where backwater flooding occurred after planting. Many of these areas ha[illegible] to be replanted, resulting in increased restoration costs [illegible] changes in the long-term planting schedule. The study objective was to observe the early survival and growth o[illegible] seedlings planted on flood-prone sites on different dates and using different stocktypes.

METHODS

Container seedlings, 1-0 bareroot seedlings and acorns Nuttall oak (*Quercus nuttallii*, Palmer) were hand-plante[illegible] on January 22, February 16, March 18, and June 8, 199[illegible] The seedlings were planted on a Sharkey soil series (ve[illegible] fine, montmorillonitic, nonacid, thermic, Vertic Haplaque[illegible] located at the Lake George site (U.S. Department of Agriculture 1975). The exact study location was chosen because the site was known to experience backwater flooding almost every year. The bareroot seedlings were purchased from a local forest tree nursery. All the barer[illegible] seedlings used in the study were delivered in January a[illegible] placed in cold storage at 5 °C until planting. The barero[illegible] seedlings were packed in Kraft paper bag bundles of 10[illegible] to 250 seedlings. The roots were kept moist by a synthe[illegible] mulch.

The container seedlings were grown at facilities located the U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS. In May 1992, artificially stratified Nuttall [illegible] seeds were sown into 164 cubic centimeter plastic cone containers filled with a 1:1 ratio of sphagnum peat moss and vermiculite. The acorns were purchased from a loca[illegible] seed vendor. Seed stratification was consistent with methods as described by Olson (1974). Container seedl[illegible] density was 258 per square meter. Seedlings were

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established in the greenhouse; then, for the remainder of the growing season, they were placed in a shadehouse covered with a 50 percent shade cloth. Seedlings were watered daily and fertilized weekly with a complete fertilizer (20-20-20 or 15-45-15). Watering and mineral fertilization were reduced in September. Seedlings remained outside and in the containers until planted.

In fall 1992, Nuttall oak acorns for the direct-seeding treatment were purchased from the same local seed vendor as the container seedlings. The seeds were artificially stratified prior to sowing at the study site.

Experimental Design

The study was conducted as a randomized, complete block, split-plot design with four replications. The whole plots were the planting dates and the subplots were the stocktypes. Each subplot contained 25 planting positions. The seedlings and seed positions were on a 3-meter by 3-meter spacing. Seedlings were planted with a shovel and acorns were sown by hand to a depth of 5 centimeters. Two acorns were sown at each position. First-year survival and height measurements were taken in September, 1993. Analysis of variance was conducted using Statistical Analysis System Procedures (SAS Institute Inc. 1989). Results are discussed as significant at the 5 percent probability level.

RESULTS AND DISCUSSION

The bareroot seedlings were taller and had greater shoot and root mass than the container seedlings (table 1). Morphology recommendations for bareroot seedlings include heights greater than 46 centimeters, minimum root-collar diameters of 10 millimeters, and a well-developed root system (Kennedy 1993). An important distinction between stocktypes may be in their root characteristics. The bareroot seedling roots consisted primarily of a large tap root and a few primary and secondary laterals. The container seedling roots were fibrous, consisting of a tap root and many higher-order lateral roots. Container seedling production typically promotes fibrous root system development and protects these roots until planting (Landis and others 1990). Container hardwood seedlings, which experience lower handling stresses prior to planting, may have a better survival rate than bareroot seedlings on poor sites (White and others 1970). While bareroot production may also promote a fibrous root system, many of these roots can be lost during seedling removal from the nursery bed.

Table 1—Morphological comparison between 1-0 bareroot and 9-month-old container Nuttall oak seedlings prior to planting

Variable	Bareroot	Container
Height (cm)	56	46
Diameter (mm)	7.0	6.2
Root dry weight (g)	5.7	3.8
Shoot dry weight (g)	6.7	4.9

Soil moisture content (oven-dry basis) was about 40 percent for the January, February, and March plantings. Small portions of the site were ponded with rainwater, and the remainder of the soil on the site appeared to be near saturation. The original experimental design called for plantings to occur in April and May. However, above-average rainfall combined with high Mississippi River stages caused backwater flooding to occur at the study site. The seedlings planted in January, February, and March experienced flooding to a depth of 2 meters from late March to late May. For the June planting, soil moisture content in the root zone was about 28 percent. The soil was dry and cracked at the surface, typical for a montmorillonitic clay. Pettry and Switzer (1996) reported moisture contents in the root zone of forested Sharkey soils of about 51 percent and 41 percent for field capacity (.03 MPa tension) and permanent wilting percentage (1.5 MPa tension), respectively. Perhaps the discrepancies in soil moisture retention can be explained by the higher organic matter content that could be expected in a forest soil.

Survival was highest if the seedlings and seeds were planted in January and February (table 2). Survival was reduced significantly if the planting occurred in March or

Table 2—First-year height and survival of 1-0 bareroot, 9-month-old container and direct-seeded Nuttall oak seedlings planted on four different dates on a Sharkey clay soil series, Yazoo County, MS

Treatment	Total height	Height growth	Survival rate
	- - - *Centimeters* - - -		*Percent*
Planting date			
January 1993	31	2	62***
February 1993	33	1	58
March 1993	34	0	45
June 1993	32	-5	36
Stocktypes			
Bareroot	34***	-19**	38***
Container	46	3	84
Seed	15	15	30
Date and stocktype			
Jan-bareroot	35	-12	59
Jan-container	44	4	84
Jan-seed	14	14	44
Feb-bareroot	39	-14	56
Feb-container	46	3	80
Feb-seed	14	14	39
Mar-bareroot	37	-21	32
Mar-container	48	4	75
Mar-seed	16	16	28
Jun-bareroot	22	-31	4
Jun-container	48	3	95
Jun-seed	17	17	9

,* = Significant at the 1 percent and 0.1 percent probability level, respectively.

June. Overall, container seedlings had the best first-year survival, while direct seeding of had the worst. Direct seeding of bottomland oak species can be a low-cost and effective means of reforesting agricultural lands (Wittwer 1991, Bullard and others 1992, Stanturf and Kennedy 1996). However, adequate stocking by direct seeding may not be achieved because of seed predation, flooding, or drought (Johnson and Krinard 1987). Considering a recommended sowing rate of 3,600 seeds per hectare (Bullard and others 1992), stocking by direct seeding for the study site was about 1,100 seedlings per hectare after the first year. This is twice the minimum 550 seedlings per hectare usually recommended when planting bareroot seedlings for wildlife objectives. Seedling stocking could have been higher; however, many of our acorns sown prior to the flood were found on the soil surface or exposed in the soil cracks in June. Also, the small direct-seeded seedlings will be exposed to future floods and herbivory, probably further reducing the stocking. For reforestation projects initiated by Federal programs or regulation, adequate seedling survival usually must be guaranteed. The required seedling survival can range from 50 to 90 percent. Consequently, direct seeding, although relatively inexpensive, may be too risky for many bottomland hardwood wetland restoration projects.

Excellent survival can be achieved by planting bareroot seedlings, especially when environmental conditions are optimum (Allen 1990, Miwa 1995). For this study, the reduced survival rate for bareroot seedlings planted in March and June may be partially explained by the reduction in seedling viability during long-term cold storage. The long-term cold storage of hardwood seedlings should be avoided. Because of the height of hardwood seedlings, storage bags usually cannot be completely sealed. Long-term cold storage could result in the drying of the roots. Ideally, only the number of seedlings that can be planted in 1 day should be delivered from the nursery to the site (Kennedy 1993). However, nursery location, the size of the reforestation project, and delivery schedules may necessitate receiving all of the seedlings at one time. For large projects, the inability to plant all of the seedlings in a short time period will increase seedling storage time. In addition, planting delays caused by flooding may further keep the seedlings in cold storage. For the Lake George Project, delivery schedules, nursery location, and flooding kept large numbers of seedlings in cold storage for weeks prior to planting.

Flooding appeared to have less adverse effect on container seedling survival. Container seedling survival was higher than bareroot seedling survival when the planting occurred in January or February. In addition, the high June survival for container seedlings suggests that they can be kept in the containers and successfully established after the flood waters recede. The successful establishment of the June-planted container seedlings was achieved even though the seedlings were growing and evapo-transpirational demand on the site was high.

It was anticipated that the direct-seeded seedlings would be smaller than container or bareroot seedlings. However, the amount of stem dieback observed for the container and bareroot seedlings was disturbing. Bareroot seedlings were shorter after the first year in the field than when planted. Container seedlings were about as tall as when they were planted. Adequate survival is usually more important than rapid height and diameter growth for most bottomland hardwood restoration projects. However, the detrimental effects of complete inundation on seedling survival suggests that rapid height growth after planting is desirable.

CONCLUSIONS

First-year survival was highest when seedlings were planted during the conventional planting season. Container seedlings had the best survival regardless of planting date. Their apparent greater tolerance to flooding and handling stress, combined with better planting-time flexibility, may make container bottomland hardwood seedlings the best choice for the reforestation of sites prone to winter/early spring flooding.

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