LARGE-SCALE COMPARISON OF REFORESTATION TECHNIQUES COMMONLY USED IN THE LOWER MISSISSIPPI ALLUVIAL VALLEY: FIRST YEAR RESULTS

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Abstract: In the Lower Mississippi Alluvial Valley (LMAV), restoring bottomland hardwood forests has attracted heightened interest. The impetus involves not only environmental and aesthetic benefits, but also sound economics. Financial incentives to restore forested wetlands in the LMAV can come from federal cost share programs such as the Conservation Reserve Program and the Wetlands Reserve Program (WRP), which provide easements and funding to cover planting costs. Forestry led Mississippi agriculture production in 1995, testimony to the importance of timber. This project is designed to test four restoration techniques and includes methods outlined by both federal program guidelines and by industry. The four techniques being tested are: (1) Eastern cottonwood (*Populus deltoides* Marsh.) as a nurse crop for Nuttall oak (*Quercus nuttallii* Palmer), (2) planting bareroot Nuttall oak seedlings, (3) direct seeding Nuttall oak acorns and, (4) natural, old field succession. A former farmland in Sharkey County, MS, was chosen as the study area because it represents edaphic and hydrologic conditions frequently encountered in economically marginal cropland in the LMAV. A randomized complete block design was used with three replications. Block size was 32 hectares, allowing for four 8 ha treatment plots. All planting was completed by March 1995, except for the interplanting of oak in the cottonwood, which will occur in year 3. Acorns were sown in May 1995. Sample plots were measured in fall 1995. Survival after one growing season averaged 92% for cottonwood, 63% for planted oak seedlings, and 11% for oak germinants. No trees were found in the natural succession plots. Number of stems per ha averaged 793 for cottonwood, 467 for seedlings and 284 for germinants. Average height of cottonwood after the first growing season was 2.1 meters, seedling height was 0.4 m, and germinant height was 0.1 m. There was variability between blocks, and seedling damage by rodents was prominent. Tree planting on land enrolled in the WRP is considered successful for wetland restoration purposes if 309 live trees per ha are present after three growing seasons. After 1 year, both the cottonwood and oak plantings resulted in stocking that could meet these standards. Although the stocking mandated by WRP was not met for the direct seeded oak after one growing season, delayed germination may increase stocking. In addition to providing wildlife habitat, the high survival rate and rapid growth of the cottonwood will enable harvest in 10 years, generating income in a relatively short time period. Further evaluation of tree growth and survival under these restoration techniques will allow for a more definitive conclusion on their feasibility and attractiveness to landowners.

INTRODUCTION

The Federal Agriculture and Reform Act of 1996, commonly called the Farm Bill, was recently passed by Congress and contains some provisions to promote afforestation in the lower Mississippi alluvial valley. Both the Conservation Reserve and Wetland Reserve Programs were reauthorized; these programs are instrumental in providing landowner incentives to plant trees. In addition, the Farm Bill authorized $50 million to the Wildlife Habitat Incentives Program for cost-share payments to landowners to develop wildlife habitat, and tree planting is included. Nevertheless, the potential exists for thousands of hectares of additional land to be planted to trees beyond that included in federal programs. One way to realize the potential is to develop alternative reforestation techniques that

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offer more immediate financial returns to landowners than is provided by conventional sawlog rotations or by wildlife habitat/wetland restoration techniques.

The most commonly used reforestation approach has been to plant one to three overstory tree species, usually oaks (*Quercus* spp.). Artificial regeneration is accomplished by either sowing acorns or other hard mast species, or by planting bareroot seedlings. On former agricultural lands, machine planting of seedlings or sowing of acorns or other hard mast is common. This project was designed to test one alternative reforestation technique that combines a faster growing species, cottonwood (*Populus deltoides* Marsh.) and a slower growing species, Nuttall oak (*Quercus nuttallii* Palmer), and contrast this technique with more traditional approaches of planting bareroot seedlings or direct seeding of acorns of Nuttall oak. The control treatment for this study is "do nothing" and allow natural, old field succession to occur.

Compared to other reforestation techniques, one advantage of using the cottonwood nurse crop may be the creation of a more favorable microclimate for oak growth and survival. Obviously, we cannot test this until later in the study. The early growth of cottonwood allows for the rapid establishment of a forest canopy. The advantage of this canopy is that it may lend itself to accelerating natural succession by attracting birds and small mammals that are vectors for dispersal of heavy seeds.

The major disadvantage of pure cottonwood plantations to wildlife may be the paucity of hard mast. Although some may also feel that cultivation works against restoration goals, it has been found that wildlife importance values for all wildlife food plants in several cottonwood plantations studied peaked in the fourth, fifth and sixth growing seasons (Wesley and others 1981). The planting scheme under study here will provide for hard mast, and cultivation cessation after establishment will hopefully serve to promote plant establishment which would benefit wildlife and restoration in the later growing seasons.

In addition to providing wildlife habitat, the high survival rates and rapid growth of cottonwood will enable harvest in 10 years, generating income in a relatively short time period. Stanturf and others (in review) conducted, as an example, a financial analysis for a private landowner of a cottonwood plantation and found that the cottonwood provided a cash flow over the rotation, and a positive internal rate of return. Data collected from this study will allow for future cost analysis with the additional returns of the oak together with the cottonwood.

METHODS

The study is located on a tract of abandoned farmed wetland in Sharkey County, MS, 2.5 km east of the community of Anguilla, approximately 1 km south of State Highway 14, and immediately north of the Delta National Forest. This land was transferred to the USDI Fish and Wildlife Service from the Farmers Home Administration in 1993, and is administered by personnel at the Yazoo National Wildlife Refuge Complex.

A recent soil survey of the tract conducted by the Natural Resources Conservation Service indicates that the soil is of the Sharkey series, a heavy clay with shrink-swell properties (very fine, montmorillonitic, nonacid, thermic Vertic Haplaquepts; Floyd Wood, NRCS, Jackson, MS, pers. comm. Dec. 1995). The Sharkey series consists of poorly drained, clayey soils formed in fine textured sediment in slack water areas along the Mississippi River. The shrink-swell nature typical of clays with montmorillinitic mineralogies results in 2-10 cm wide cracks up to 1.5 m deep that form under dry conditions, and close upon wetting. The hydrologic and edaphic conditions of our study site typify most of the adandoned agricultural land available for, and undergoing, reforestation in this region.

The experimental design follows a randomized complete block with three replicates located in different portions of the tract. Treatment plots are approximately rectangular and 8.1 hectares in size. Treatment plots were established in October, 1994 (Blocks II and III) and February, 1995 (Block I). Azimuths were measured with a transit and distances with a 30.5 meter tape. Plot corners were permanently marked with steel fence posts. The assignment of treatment to plots was done using a random numbers table, and is summarized in Table 1. The cottonwood/oak plots have a 9 meter buffer around them for machine turn rows, as they will be cultivated for 2 years. All other plots share borders.

Table 1. Treatment plot assignment in each block

TREATMENT PLOT	BLOCK I	II	III
1	PLN	SOW	NUR
2	NAT	NAT	SOW
3	NUR	PLN	NAT
4	SOW	NUR	PLN

PLN = Plant bare-root Nuttall oak seedlings (1-0 stock)
NAT = Natural old field succession
NUR = Cottonwood/Nuttall oak intercrop
SOW = Direct seeded Nuttall oak acorns

Agricultural production on the study site ended in September, 1994. Site preparation consisted of double disking all treatment plots (including the natural succession treatment) in October, 1994. Acorns were collected on the Delta National Forest, placed in water and non-viable acorns that floated were discarded. Acorns were then stored in ventilated polyethylene bags at 1.7° C. The Fish and Wildlife Service conducted the planting/sowing using their standard equipment and techniques. In May 1995, acorns were machine sown at 1.1 m X 3.7 m spacing, with one acorn placed at each planting spot. Oak seedlings (1-0 stock) were obtained from Fratesi Nursery, Leland, MS, (seed source was the Delta National Forest). Seedlings were machine planted in March 1995 at 3.7 m X 3.7 m spacing.

Cottonwood was chosen as a nurse crop to establish Nuttall oak because of its economic value and its suitability, under cultivation, to Sharkey soils (Stanturf and others, in review, Stanturf and Shepard 1995). Cottonwood cuttings were planted by Crown Vantage Inc., following their operational procedures (Table 2). Four cottonwood clones, ST66, ST72, ST75 and S7C1 were hand planted in pure blocks at 3.7 m X 3.7 m spacing in March 1995. Cultivation will keep the cottonwood practically weed-free for two growing seasons. In March 1997, Nuttall oak seedlings will be interplanted at 3.7 m X 7.3 m spacing (i.e., between every other cottonwood row). Pulpwood harvests will remove most of the cottonwood at year 10 and coppice regrowth at year 20; at year 20 the oaks will be fully released, although some cottonwood stems will be retained beyond year 20 to increase diversity.

Table 2. Schedule of operations for cottonwood/nuttall treatment

October 1994	Two-pass site preparation disking Row establishment and liquid nitrogen applied in trenches at 112 kg N ha^{-1}
March 1995	Plant cottonwood
March 1995	Spray herbicide in bands over dormant cuttings (oxyfuorfen @ 0.26 kg ha^{-1} + glyphosate @ 1.4 kg ha^{-1})
May 1995	One pass disking, followed 2 weeks later by second pass at right angle to first
June and July 1995	Basal application of oxyfluorofen @ 0.7 kg ha^{-1}
August 1995	One pass disking, followed 2 weeks later by second pass at right angle to first
Summer 1995	Insect control for cottonwood leaf beetles (carbaryl @ 0.92 kg ha^{-1})
June 1996	Insect control for cottonwood leaf beetles (carbaryl @ 0.92 kg ha^{-1})
June and July 1996	One pass disking
March 1997	Plant Nuttall oak seedlings at offset position from cottonwood
Winter 2004	Cottonwood pulpwood harvest

Four permanent measurement plots were installed in each treatment plot in fall 1995. Measurement plots are rectangular, approximately 0.2 hectare in size for the cottonwood and planted treatments, and 0.06 hectare for the sown treatments. Plot corners were marked with PVC pipe. Measurements for every stem found in each measurement plot included height (from root collar to terminal of main leader), diameter at 15 cm and dbh (for cottonwood only). Height was measured to the nearest cm using a meter tape, and diameters were measured to the nearest 0.01 cm using a 15 cm dial caliper.

Statistical analysis followed a Model I three-treatment ANOVA. The SAS statistical package (SAS Institute, Inc. 1990) was used for data analysis, incorporating Duncan's New Multiple range test for mean comparisons. All significant differences are reported at $\alpha \leq 0.05$.

RESULTS

Survival after one growing season was significantly different among treatments, and averaged 92% for cottonwood, 63% for planted Nuttall oak seedlings, and 11% for Nuttall oak germinants (Figure 1). No data were collected from the natural succession areas, as a preliminary survey revealed no woody stems present. Number of stems per hectare was significantly different among treatments, with an average of 794 ha^{-1} for the cottonwood, 484 ha^{-1} for the planted seedlings, and 296 ha^{-1} for the germinants (Figure 2). The average total height was significantly greater for the cottonwood (2.1 m) compared to the oak; planted oak seedlings (0.4 m) were taller than germinants (0.1 m), but this difference was not significant (Figure 3). The total average diameter at 15 cm was significantly different among all three treatments, with cottonwood have the largest average diameter, 2.9 cm, followed by the planted seedlings, 0.32 cm, and the germinants, 0.25 cm (Figure 4).

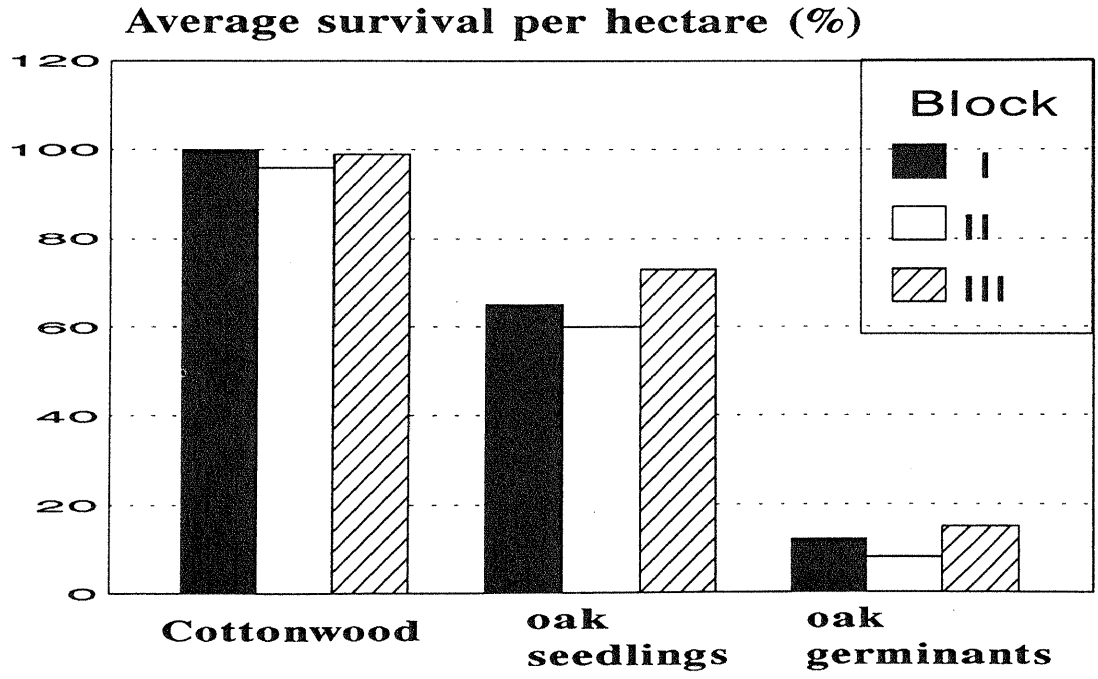

Figure 1. Average survival per hectare, by block, after the first year. Treatments were significantly different at $\alpha \leq 0.05$.

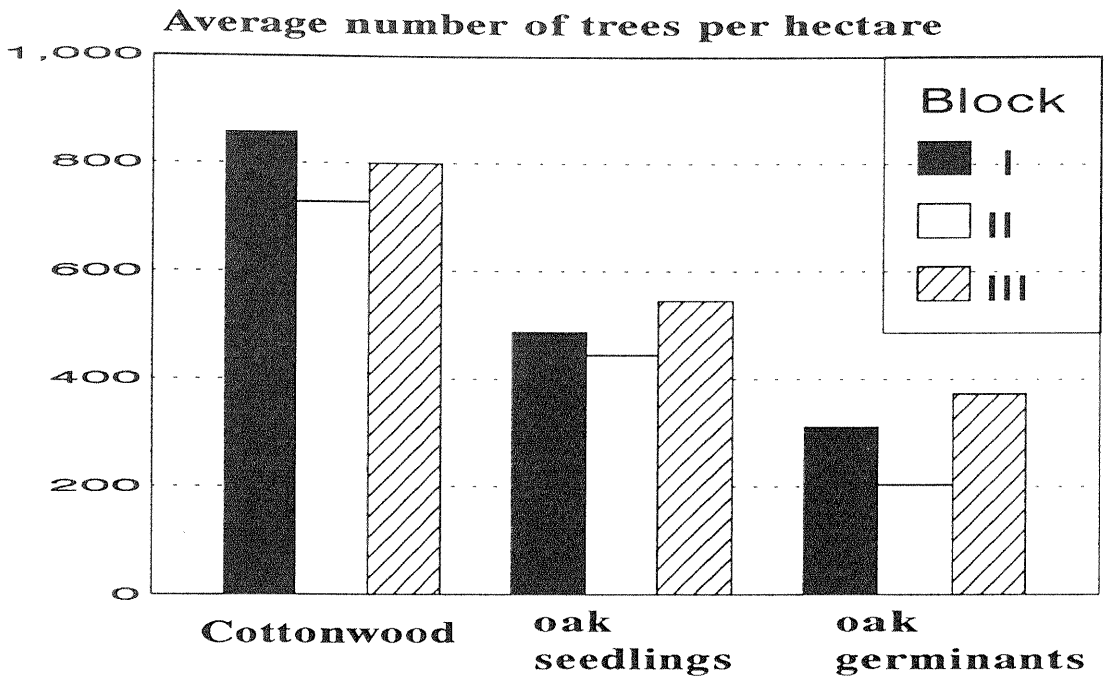

Figure 2. Number of trees per hectare, by block, after the first year. Treatments were significantly different at $\alpha \leq 0.05$.

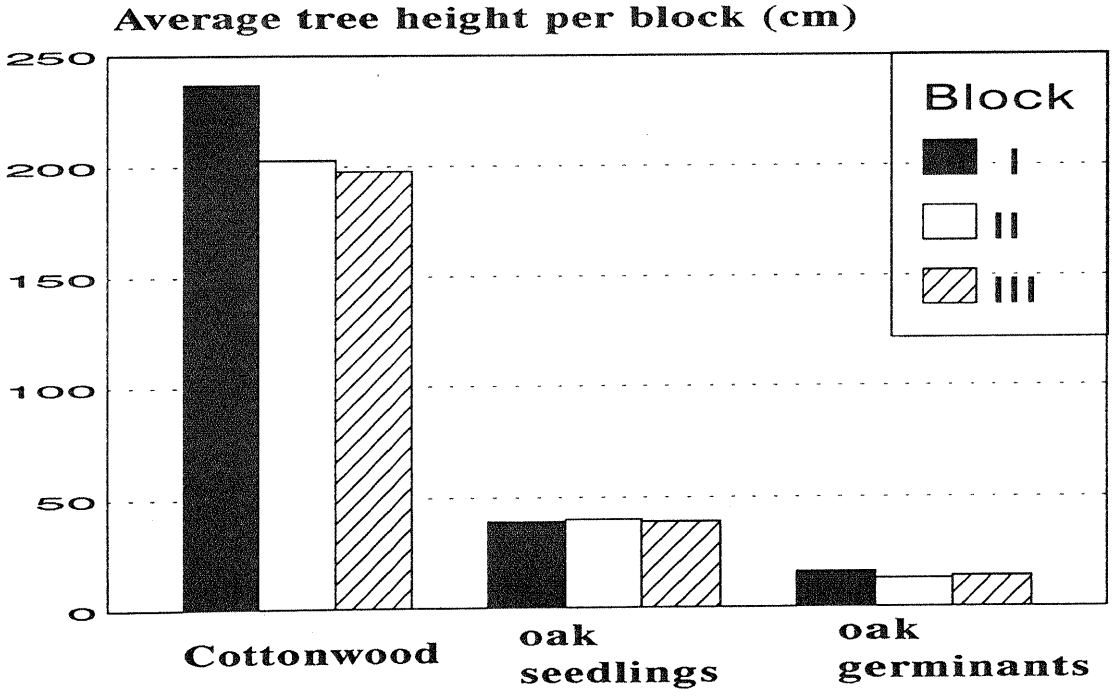

Figure 3. First year average total height per block; cottonwood height was significantly greater than oak seedlings and oak germinants at $\alpha \leq 0.05$.

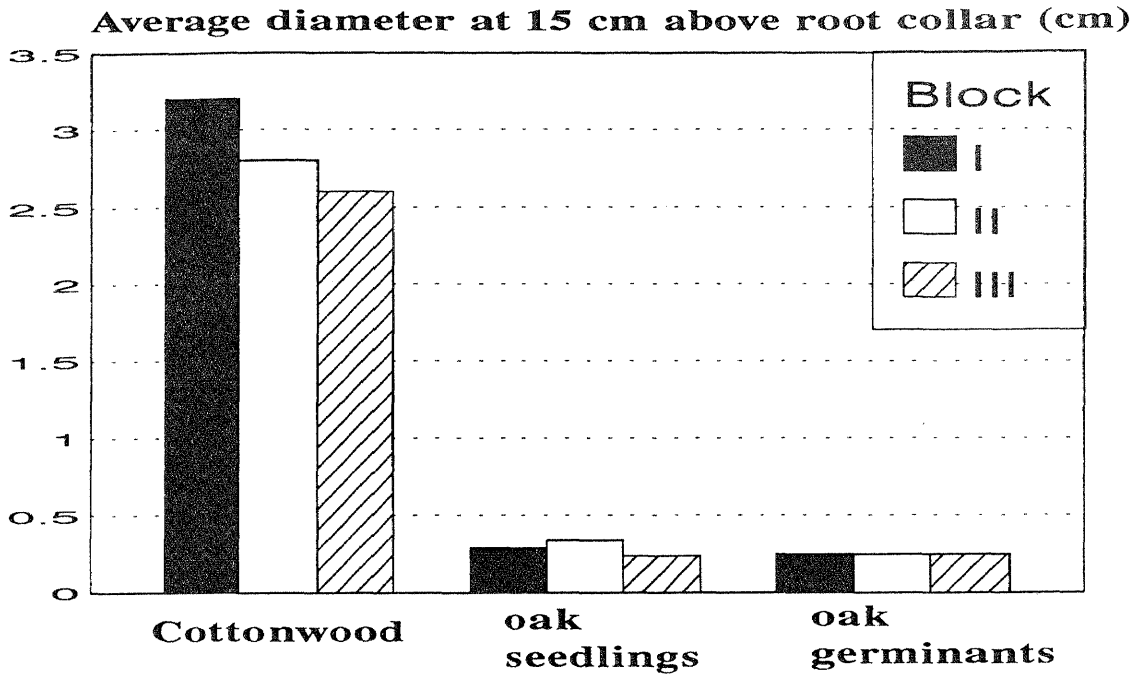

Figure 4. First year total average diameter at 15 cm; treatments were significantly different at $\alpha \leq 0.05$.

DISCUSSION

Selected tree species were established on an abandoned agricultural field using three different techniques. Results for the first growing season were as expected, although stocking levels in the direct seeded treatment were lower than anticipated. These results support other work over the last 25 years that has shown that bottomland oaks can be established using 1-0 bareroot nursery stock or by direct seeding acorns on sites typical of the lower Mississippi alluvial valley (Allen 1990; Baker and Blackmon 1973; Johnson and Krinard 1985, 1987; Krinard and Kennedy 1987a; Miwa and others 1992). That reforestation can work with little site preparation and no weed control is especially attractive to public agencies, as it allows for the re-establishment of a particular habitat with a minimal commitment of funds and manpower.

Few studies exist, however, where planted seedlings and direct seeding are concurrently compared on the same site. Variability among blocks existed, but the above ground growth performance of planted seedlings and of direct seeded germinants in the establishment year was similar. Direct seeded oaks develop natural root systems on site, thus eliminating the root injury associated with planting bareroot stock. It appears as if the bareroot seedlings in this study spent the establishment year restoring a balance between roots and shoots; however, no root measurements were made. Others have found that the height growth of direct seeded red oak may equal that of 1-0 bareroot seedlings several years after planting (Zaczek and others 1993). Subsequent growth measurements will allow for more definitive results on growth characteristics of seedlings versus germinants.

Survival and stocking levels must be viewed in the context of a landowner's objectives. It should be noted that the extremely high cottonwood survival percentage was enhanced by ideal planting conditions and the experience of Crown Vantage's planting crew. For the cottonwood plantation, the primary objective is fiber production, and the high survival and increases in growth justify weed control costs necessary to achieve full stocking. In a short time period, these cottonwood plantations create a visual habitat that is also desired by many landowners. If enhancement of the hard mast component in stands established to create wildlife habitat is the objective, weed control may not be needed.

Stocking levels obtained by planting seedlings were generally higher than those obtained by direct seeding, but these data reflect only one growing season and may change because of delayed germination of the acorns. Delayed germination over the 2 years following planting may increase the stocking rates. Miwa and others (1993) found a slow, steady germination of Nuttall oak throughout the growing season on similar soils. We have observed delayed germination for oak acorns on nearby reforested land under the management of the Fish & Wildlife Service. The expected survival of operationally direct seeded acorns has been reported at 35% (Kennedy 1993, Krinard and Johnson 1985). The greater number of planting spots per ha for direct seeding (3073 ha^{-1} as compared to 714 ha^{-1} for bare-root seedlings) is designed to compensate for expected differences in survival. When hardwoods are planted without weed control on cleared clay soils, some species are better able to survive and compete than others. It has been noted that the slow growth of oaks in the first 5 years may be discouraging because of competition outgrowing the oaks. However, Wittwer (1991) found that competition control did not improve regeneration success of direct seeded oaks on a bottomland site in southeastern Oklahoma, and Krinard and Kennedy (1987b) found that Nuttall oak survival, without weed control, was 80% after 16 years. Research by Johnson (1981) showed that Nuttall oak in particular is a late grower that becomes increasingly more competitive as it persists and develops in the reproductive stand.

Tree planting on land enrolled in the Wetland Reserve Program (WRP) must produce 309 desirable woody stems per hectare after three growing seasons. According to these guidelines, stocking of cottonwood and planted oak seedlings is acceptable in this study. Unless delayed germination occurs, stocking in the direct seeded treatment does not meet WRP minimal stocking levels. Variable success with direct seeding has caused some states to require seedling planting.

Allen (1990) suggested several reasons why stocking and survival of direct seeded stands might be lower than those planted with seedlings, including use of unsuitable genetic stock or lower viability, rodent predation, and inability of very small seedlings to withstand drought and/or weed competition. Local seed collection and float testing of acorns ensured that quality, viable seed was used in this study. A pilot small mammal trapping study (600 trap-nights) conducted on a single plot of the direct seeded and the cottonwood treatments in October 1995 indicated that very dense small mammal populations were present on the direct seeded treatment (202 animals captured 216 times) compared to the cottonwood (2 animals captured 2 times). *Sigmodon hispidus* was the most abundant of five species captured. (Hamel and others, in review). Therefore, rodent predation of acorns may have contributed to the lower survival rates and stocking in the direct seeded treatments, which had extensive weed cover compared to the bare soil conditions in the cottonwood treatments. Alternatively, soil cracking may have exposed new germinants to desiccation.

Cottonwood height and diameter growth greatly exceeded that of the oak (as would be expected by the fastest growing tree native to North America) (Capel and Coffman 1966). Growth was better for the planted oak seedlings compared to the germinants, with planted seedling height being four times greater than germinant height. Although there was much variability in height growth, the difference between planted and sown oaks was not statistically significant.

SUMMARY AND CONCLUSION

Planting oak seedlings and direct seeding acorns were used to establish an oak component on an abandoned agricultural field. First year performance results indicated better survival rates and stocking for planted seedlings compared to oak germinants. However, height growth of surviving oaks did not differ between seedlings and germinants. The intense cultivation involved in establishing cottonwood was manifested by high survival rates and stocking.

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