The paper is two pages down. The two pages here could not be be removed.

using containers to grow conifers also apply to hardwoods. Containerized seedlings can be planted almost any time of year depending on soil moisture at the site and prevalent weather patterns. The root system is protected by the container, which helps to reduce seedling damage associated with lifting, storing and planting bareroot seedlings. Containerized seedlings can be grown to transplant size more quickly to meet unforeseen demands, giving containers a versatility that bareroot seedlings do not have. Experience at Monticello Mine also indicates that more hardwood species are available as containers. Disadvantages of containers include higher cost, difficulty with handling, storing and transporting, and their smaller size.

Once a container-grown seedling is ready for transplant, the root system is extracted from the container resulting in a plug of potting mix and intact roots. Seedlings may be shipped and stored on-site in containers or extracted prior to shipment. Container-grown coniferous seedlings have been used successfully in the Pacific Northwest, with increased survival and growth reported in many studies (McDonald 1991). Hardwood research in the South has not shown a consistent advantage of containerized over bareroot seedlings (Kerr 1994).

Tinus (1979) suggests that varied results from studies comparing container-grown and bareroot seedlings can be understood in terms of the relation between site stress and first year survival of different qualities of stock. On highly favorable sites, most planting stocks survive well regardless of quality. However, on poor sites the best stock survives poorly and lesser stocks will not survive. Stated in these terms, does the advantage container seedlings have of possessing all their roots, mostly oriented downward, in a plug of potting mix (McDonald 1991) necessarily result in higher quality planting stock as reflected in higher first year survival relative to bareroot seedlings?

Reclaimed mine spoil has been shown to have higher surface temperatures, greater surface air movement and lower relative humidity than undisturbed areas (Jenkins 1980). These microclimatic conditions combine to create severe moisture stress for tree seedlings, particularly during the months of July and August. Bilan (1980) and Bryson (1980) have concluded that most seedling mortality on reclaimed areas can be attributed to moisture stress.

This applied study was designed to assist reclamation personnel at the Monticello Mine select appropriate commercially available stock and the best season for planting. As such, the techniques and procedures for growing, shipping, storing, handling and planting were limited to those in use by Weyerhaeuser and TUMCO. The objective was to determine if seedling stock type (containers versus bareroot) influenced first year survival.

Methods

Seedlings were grown in 1994 at Weyerhaeuser's Ft. Towson forest tree nursery located in southeast Oklahoma. Seed for each species were randomly selected from a common seed lot and used for both bareroot and containerized seedlings. Bareroot seedlings were grown in the outdoor nursery beds at Ft. Towson while containerized stock was grown in a greenhouse at the same location. Containers used were Leech tubes, made of plastic approximately 165 cm^3 (10 in^3) in size with a ribbed cone shaped tip containing five drain holes. Individual containers rested in trays with 98 seedlings grown in each tray. Cultural practices were applied to both seedling types including the use of fertilizer, herbicides, and fungicides according to Weyerhaeuser standard procedures for producing hardwood seedlings.

The field layout included three sites (bottomland, slope and upland) planted with three species as follows:

Bottomland: Water oak (*Quercus nigra L.)*
Willow oak (*Q. phellos L.*)
Green ash (*Fraxinus pennsylvanica* Marsh.)

Slope: Cherrybark oak *(Q. falcata* var. *pagodaefolia* Ell.)
Willow oak (*Q. phellos* L.)
Sawtooth oak (*Q. acutissima* Carruthers)

Upland: Southern red oak (*Q. falcata* Michx.)
Shumard oak (*Q. shumardii* Buckl.)
Sawtooth oak (*Q. acutissima* Carruthers)

Within each site, the following seedling types for each species were planted:

Fall planting: containerized seedlings
Winter planting: containerized seedlings
bareroot seedlings

Each species/seedling type combination consisted of a row of 36 seedlings. Rows were randomized within each replication. Three replications were used for each site. Seedlings were planted on a 3.0m x 4.6m (10' x 15') grid. Each replication for each site was 45.7m x 118.9m (150' x 390') and consisted of 9 (3 species x 3 seedling types) randomly placed rows of 36 seedlings. A total of 2916 seedlings were planted (3 sites x 3 replications x 3 species x 3 seedling types x 36 seedlings). The number of seedlings planted for each species was 324 (3 replications x 3 seedling types x 36 seedlings), although 648 seedlings of willow oak and sawtooth oak were planted, since these species were used on two sites.

Reclaimed soils in the study area consisted of a topsoil substitute created by selective handling of the overburden based upon physical and chemical characterizations of geologic strata prior to mining. Minesoil was sampled on one 9.3 ha (23 ac) grid and analyzed following procedures required by the mining regulatory authority (Railroad Commission of Texas 1989). The soil sample for the grid was a composite of 24 sub-samples taken at one depth increment: 0 - 0.3m (0 - 1'). Soil parameters of interest in this study included pH, texture and plant available nitrogen, P_2O_5, K_2O, calcium and magnesium.

The study plots were seeded with winter wheat (*Triticum aestivum*) and mulched with hay in September 1994, prior to planting trees. Since the wheat became dormant as the tree seedlings began to grow, there was sparse actively growing groundcover during the first growing season. Vegetation control was not required.

Fall containerized seedlings were planted on October 13-14, 1994. Winter containerized and bareroot seedlings were planted on February 20-22, 1995. After shipment and prior to planting, fall- and winter-planted containerized seedlings were stored in trays indoors and misted with tap water as necessary. Temperature was controlled only to the extent necessary to prevent the seedlings from freezing. Sunlight was provided through windows. Bareroot seedlings were stored at 2°C (35°F). All seedlings were planted within two weeks of receipt using a single furrow, two person mechanical tree planter. Containerized seedlings were extracted from the containers immediately prior to planting. Each seedling, regardless of stock type, was fertilized with a 21-gram Agriform™(20-10-5 plus minors) two year tablet dropped from the tree planter within 5.1 cm (2") of its root mass as the seedling was placed in the furrow. Care was taken during planting to insure plugs were not exposed above ground, which can result in desiccation shortly after planting. All seedlings were inspected after planting to insure correct planting depth and proper sealing of the furrow.

Rainfall records were kept daily at the reclamation office five miles east of the study area.

Survival was determined in October, 1995. Differences in the mean number of surviving seedlings were analyzed using the General Linear Models Procedure of the Statistical Analysis System (SAS) and converted to percentages for reporting here.

Results and Discussion

Soils

The minesoils in the study area were conducive to hardwood seedling survival. Texture was sandy clay loam with a pH of 5.5. Plant available nitrogen and phosphorus were low but other sampled major nutrients were present in adequate amounts (Table 1). These results are similar to analyses of minesoils reported for Freestone (Angel 1973, Hons et al. 1978), Harrison (MacBeth 1980) and Panola (Bryson 1980) Counties (Texas) that indicate although nitrogen and phosphorus may be growth limiting, other major nutrients are available in adequate amounts. Fertilization with Agriform™ tablets helped insure adequate amounts of nitrogen, phosphorus and minor nutrients. Once established, seedlings looked vigorous and healthy. Based on the soil analyses available, the minesoils did not appear to have a major impact on survival in this study, particularly since each seedling was individually fertilized at the time of planting.

Rainfall

Above average rainfall was recorded during most months of the study (Table 2). During October 1994, 11.28 cm (4.44 in.) of rain fell before containerized seedlings were planted. Three days after planting, 3.78 cm (1.49 in.) of rain occurred. In February 1995, rainfall was close to half the expected norm. Prior to planting containerized and bareroot seedlings, 1.90 cm (0.75 in.) of rain fell. Five days after planting, there was a two day rainfall event of 3.17 cm (1.25 in.)

Although the fall planting received more total rainfall immediately prior and after planting, the winter planting had the advantage of above average rainfall during the months prior to planting. The timing and amount of rainfall was adequate for encouraging seedling establishment during both the fall and winter plantings. None of the months during the study had rainfall equal to or less than the "2 year in 10 less than"

FIRST YEAR SURVIVAL OF BAREROOT AND CONTAINERIZED HARDWOOD TREE SEEDLINGS PLANTED IN NORTHEAST TEXAS LIGNITE MINESOILS[1]

by

Jerry Wood, Mike Waxler, Dudley A. Huber and John Denman[2]

Abstract: Successful regeneration of hardwood tree seedlings is critical to the reclamation of quality wildlife habitat and commercial forests on lignite mines in northeast Texas. Because bareroot hardwood seedling survival rates have often been lower than desired, the survival of containerized and bareroot hardwood tree seedlings was compared. Seven hardwood species, including six species of oaks, were planted in lignite minesoils on sites classified as bottomland, slope and upland. Three species were planted per site. Containerized seedlings were planted during the fall and winter, whereas bareroot seedlings were planted in the winter only. Survival was determined at the end of the first growing season. Results across all sites indicate that winter-planted containerized seedlings (64% survival) had significantly lower survival than either fall-planted containerized seedlings (74%) or bareroot seedlings (76%). Within the sites, the only significant difference was on upland sites where survival of winter-planted containerized seedlings (60%) was lower than bareroot seedlings (77%). Survival among species was not significantly different. There was no significant survival benefit from using more expensive containerized hardwood seedlings. The results also question the practice of planting containerized hardwood seedlings during the typical winter planting season for optimum survival.

Additional Key Words: reforestation, *Fraxinus pennsylvanica* Marsh., *Quercus acutissima* Carruthers, *Quercus falcata* Michx., *Quercus falcata* var. *pagodaefolia* Ell., *Quercus nigra* L., *Quercus phellos* L., *Quercus shumardii* Buckl..

Introduction

Successful regeneration of hardwood tree seedlings is critical to reclamation of quality wildlife habitat and commercial forests on lignite mines in northeast Texas. Texas Utilities Mining Company (TUMCO) has a long-term, hardwood survival rate of about 70% at its Monticello Mine in Titus, Franklin and Hopkins Counties, Texas. Generally, about 50% survival is acceptable for the East Texas forest industry. While TUMCO's rate compares very favorably to industry standards, improvements in survival percentages would result in more complete site utilization and fewer trees per acre being planted to achieve management objectives.

Selection of quality planting stock and proper care of seedlings before and during planting have been recognized as key elements for successful stand establishment (Allen and Kennedy 1989). This study focuses on selection of planting stock, comparing the survival of containerized hardwood seedlings to bareroot seedlings. Much interest has been centered on the use of greenhouse-grown containerized hardwood seedlings, as opposed to bareroot seedlings grown in outdoor nursery beds, for reforestation of lignite mine sites. With bareroot nurseries now devoting more resources to the production of hardwood seedlings than in the past, this study was established to better understand the potential benefits, if any, of using more expensive containerized seedlings.

Southern pine containerized seedlings are known to have several advantages over bareroot seedlings (USDA Forest Service 1989). Early planting of containerized seedlings in the South can begin in October, allowing seedlings to become established before the first freeze. Although bareroot seedlings can also be planted in the fall, seedlings must be planted as they are lifted from nursery beds and cannot be stored. From a practical standpoint, the logistics involved prevent fall planting of bareroot seedlings on a large scale. Tinus (1979) states that the same advantages for

[1]Paper presented at the 1997 National Meeting of the American Society for Surface Mining and Reclamation, Austin, Texas, May 10-16, 1997.

[2]Jerry Wood, Reclamation Technician, and John Denman, Environmental Supervisor, Texas Utilities Mining Company, Mt. Pleasant, Texas 75455. Mike Waxler, Southwest Sales and Distribution Manager, and Dudley A. Huber, Tree Improvement Geneticist, Weyerhaeuser, Hot Springs, Arkansas 71902.

Proceedings America Society of Mining and Reclamation, 1997 pp 265-271
DOI: 10.21000/JASMR97010265

https://doi.org/10.21000/JASMR98010265

Table 1. Major nutrient concentrations in the 0 - 0.3m (0 - 1') depth of the minesoil based on one composite sample (24 subsamples) taken from a 9.3ha (23 acre) grid in the study area at Monticello Mine.[1]

Plant Available Nutrient	Concentration		Soil Test Rating	Recommendations	
	kg/ha	lb/ac		kg/ha	lb/ac
Nitrogen	0	0	Very Low	67	60
P_2O_5	25	22	Low	11	10
K_2O	220	196	Very Low	0	0
Calcium	3321	2963	High	0	0
Magnesium	1245	1111	High	0	0

[1]Fertilizer recommendations for shade trees and soil test ratings from Soil Testing Laboratory, Texas Agricultural Extension Service, Texas A&M University System, College Station, Texas.

Table 2. Precipitation by month from September 1994 to October 1995 for the study area at Monticello Mine.[1]

Month	Precipitation							
	Centimeters				Inches			
	1994-1995	Average	2 years in 10 will have		1994-1995	Average	2 years in 10 will have	
			Less Than	More Than			Less than	More than
September	0.86	11.48	3.10	18.19	0.34	4.52	1.22	7.16
October	21.56	9.50	2.54	15.04	8.49	3.74	1.00	5.92
November	24.97	9.96	3.86	15.06	9.83	3.92	1.52	5.93
December	18.49	8.74	3.30	13.23	7.28	3.44	1.30	5.21
January	17.20	7.72	3.81	11.07	6.77	3.04	1.50	4.36
February	5.08	8.51	3.78	12.50	2.00	3.35	1.49	4.92
March	7.06	9.78	4.75	14.10	2.78	3.85	1.87	5.55
April	22.61	12.88	5.31	19.25	8.90	5.07	2.09	7.58
May	18.21	12.62	6.27	18.11	7.17	4.97	2.47	7.13
June	7.82	9.63	3.25	14.83	3.08	3.79	1.28	5.84
July	12.90	8.48	3.12	12.93	5.08	3.34	1.23	5.09
August	6.04	6.73	2.26	10.36	2.38	2.65	0.89	4.08
September	7.57	11.48	3.10	18.19	2.98	4.52	1.22	7.16
October	2.41	9.50	2.54	15.04	0.95	3.74	1.00	5.92

[1]Monthly precipitation averages and 2 year in 10 data are for the period 1950 - 1981 as recorded at Mt. Pleasant, Texas (USDA Soil Conservation Service. 1990. Soil Survey of Camp, Franklin, Morris, and Titus Counties, Texas. p.2,120).

levels, except September 1994 and October 1995.

During August and September 1995, rainfall was close to normal. Normal rainfall during summers in northeast Texas, however, does result in moisture stress, particularly for first year plantings. Most of the mortality in this study was probably the result of this moisture stress.

Survival

Overall, hardwood seedlings survived at 71%, ranging from 59% to 79% among treatments (Table 3).

Seedling Types. Across all sites the survival of winter-planted containerized seedlings (64%) was significantly lower than fall-planted containerized seedlings (74%) and winter-planted bareroot seedlings (76%). Within the sites, the upland category showed similar significant statistical results. Although not statistically significant, the same trend occurred in the bottomland and slope categories as well. There were no significant differences between fall-planted containerized and winter-planted bareroot stock.

It is not clear why this difference in survival between winter and fall-planted containerized seedlings occurred. Although every precaution was taken to insure similar handling and storage of the containerized seedlings, different storage conditions invariably result from two planting dates. Cold storage (2°c) for winter-planted containerized seedlings is an option not studied here, although Kerr (1994) reported that cold storage had no significant effect on survival of cell (container) grown oak and beech seedlings one year following outplanting. The most plausible explanation for the survival differences is that fall-planted seedlings are able to initiate root growth sooner and are better positioned to become well established prior to the time moisture becomes a limiting factor.

Species. There were no statistical differences in survival between species (Table 4). However, the survival rate for sawtooth oak on slope sites (57%) was very close to being significant (alpha=0.0525). Survival of sawtooth oak on upland sites (67%) was not significant. Further trials with sawtooth oak are warranted to determine if it has inherently lower first year survival rates than the other species studied.

Conclusions

There was no survival benefit from using the more expensive containerized hardwood seedlings. This was somewhat surprising since it was thought that the containerized stock, with their intact root systems and reduced handling stress, might establish themselves quicker and be in better position to withstand environmental extremes. In fact the results question the practice of planting containerized stock during the typical winter-planting season, given the storage and handling practices used in this study.

Since bareroot hardwood seedlings are cheaper, the results suggest that bareroot seedlings should be selected over containerized seedlings. However, depending on other circumstances at individual mine sites, it may also be cost effective to fall-plant containerized hardwoods. At Monticello Mine, due to the ability to optimize the use of available experienced labor and equipment, we feel the combination of fall-planted containerized hardwoods and winter-planted bareroot hardwoods best meet our reclamation objectives at this time.

Literature Cited

Allen, J. A. and H. E. Kennedy, Jr. 1989. Bottomland Hardwood Reforestation in the Lower Mississippi Valley. USDI Fish and Wildlife Service, National Wetlands Research Center, Slidell, Louisiana and USDA Forest Service, Southern Forest Equipment Station, Stoneville, Mississippi. 28p.

Angel, P.N. 1973. A soil analysis of the strip mine spoil bank at Fairfield, Texas. MSF Thesis, Stephen F. Austin State University, Nacogdoches, Texas. 72 p.

Bilan, M.V. 1980. Growth of loblolly pine (*Pinus taeda* L.) on lignite-mined and undisturbed land in Harrison County, East Texas. *In:* Proceedings of Reforestation of Disturbed Sites (M.J. Walterscheidt, editor). Texas Agricultural Extension Service, Texas A&M University, College Station, Texas. Pages not numbered.

Bryson, H.L. 1980. *Pisolithus tinctorius* mycobiont inoculations as a factor in performance of containerized and bareroot shortleaf pine seedlings on lignite minesoils in Panola County, Texas. DF Dissertation, Stephen F. Austin State University, Nacogdoches, Texas. 418 p.

Hons, F.M., P.E. Askenasy, L.R. Hossner, and E.L.

Table 3. First year survival percentages of containerized and bareroot hardwood seedlings by site at Monticello Mine, 1994.[1]

Site	Containerized		Bareroot (%)	Mean (%)
	Fall-Planted (%)	Winter-Planted (%)		
Bottomland	79a	69a	78a	75z
Slope	73a	63a	73a	70z
Upland	71a	59b	78a	69z
Mean	74a	64b	76a	71

[1]For each row seedling types followed by the same letter do not differ statistically (alpha=.05). In the mean column sites followed by the same letter do not differ statistically (alpha=.05).

Table 4. First year survival percentages of hardwood seedlings by species and site at Monticello Mine, 1994.[1]

Species	Site		
	Bottomland (%)	Slope (%)	Upland (%)
Water oak	74a	-	-
Willow Oak	78a	76a	-
Green ash	73a	-	-
Cherrybark oak	-	76a	-
Sawtooth oak	-	57a	67a
So. red oak	-	-	70a
Shumard oak	-	-	71a

[1]For each column (site) species followed by the same letter do not differ statistically (alpha=0.05).

Whitely. 1978. Physical and chemical properties of lignite spoil material as it influences successful revegetation. *In:* Proceedings of the Gulf Coast Lignite Conference: Geology, Utilization, and Environmental Aspects (W.R. Kaiser, editor), p. 209-217. University of Texas Bureau of Economic Geology Report of Investigation 90. 276 p.

Jenkins, K. 1980. Soil environmental factors affecting reforestation. *In:* Proceedings of Reforestation of Disturbed Sites (M.J. Walterscheidt, editor). Texas Agricultural Extension Service, Texas A&M University, College Station, Texas. Pages not numbered.

Kerr, G. 1994. A comparison of cell grown and bare-rooted oak and beech seedlings one season after outplanting. Forestry 67(4): 297-312.
https://doi.org/10.1093/forestry/67.4.297

MacBeth, R.M. 1980. The effect of Agrispon on loblolly pine seedlings growing on lignite minesoil, Harrison County, Texas. MSF Thesis, Stephen F. Austin State University, Nacogdoches, Texas.

MacDonald, P. M. 1991. Container seedlings out perform bareroot stock: Survival and growth after 10 years. New Forests 5(2): 147-156.
https://doi.org/10.1007/BF00029305

Railroad Commission of Texas. 1989. Overburden Parameters and Procedures. Surface Mining and Reclamation Division. Austin, Texas. 6 p.

USDA Forest Service Southern Region. 1989. A Guide to the Care and Planting of Southern Pine Seedlings. Management Bulletin R8-MB39. p. 4-5.

Tinus, R W. 1979. Use of container-grown hardwoods for reforestation. *In*: Proceedings of 1979 John S. Wright Forestry Conference: Regenerating Oaks in Upland Hardwood Forests (H.A. Holt and B.C. Fischer, editors). Purdue University, February 22-23, 1979. p. 120-125.