

EARLY DEVELOPMENT OF A SPECIES TEST ESTABLISHED ON SURFACE MINES THIRTY YEARS POST-RECLAMATION¹

David W. McGill², Victor L. Ford, and Joseph F. McNeel

Abstract. Three reclaimed surface mine sites are part of a surface mine reforestation species test to assess opportunities for planting previously-mined and recontoured lands. Located in southeastern West Virginia on MeadWestvaco property, these sites were mined just over 30 years ago. In 2001, a reforestation species test was established on one site per year through 2003. Site preparation consisted of a fall, aerial application of 9.4 liters ha⁻¹ of Accord (glyphosate) to control the thick herbaceous cover of crown vetch and panicum grass and a “bedding” treatment for the planting rows. Species tests in the research areas included plantings of black cherry (*Prunus serotina*), white ash (*Fraxinus americana*), hybrid aspens, hybrid poplars, pitch×loblolly hybrid pine (*Pinus rigida*×*taeda*), white pine (*P. strobus*), and Norway spruce (*Picea abies*).

First year survival values varied by species and year of planting. At the end of the second growing season, *P. trichocarpa*×*deltoides* (TD) clones were statistically taller than all other species in the test. The clone TD184 averaged 2.9 m and 2.1 cm diameter at breast height (dbh) at the site planted prior to the harsh environmental conditions experienced in the second year of this project. However, TD52 appears to be more sensitive to environmental conditions during the initial year of establishment as its first year survival was only 43% when established in the difficult 2002 planting season, whereas its survival was high in the 2001 (97%) and 2003 (98%) planting seasons.

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² David W. McGill is Associate Professor of Forestry and Forest Resources Extension Specialist, West Virginia University, Morgantown WV 26506. Victor L. Ford is Research Center Leader, MeadWestvaco Corp., Rupert WV 25984. Joseph F. McNeel is Director, Division of Forestry, WVU, Morgantown WV 26506.

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Introduction

Until the late 1990's, hardwood plantation silviculture on the former Westvaco Appalachian Region properties had been largely unsuccessful (Brenneman et al. 1996). During the mid- to late- 90's, a Hardwood Research Initiative led to the establishment of several research and operational plantings that resulted in both good survival and growth. With the large acreages of treeless or unproductive surface mines present in the Appalachian Region and given these relatively new successes in hardwood plantation silviculture, the Appalachian Research Center entered into a collaborative effort with West Virginia University and the West Virginia Development Office to reexamine opportunities for establishing hardwood plantations on reclaimed surface mines in the Rupert Area.

Surface-mined property covers approximately 4,290 hectares of the MeadWestvaco area in West Virginia. The Surface Mining Control and Reclamation Act of 1977 (Public Law 95-87) requires reshaping the surface-mined site to resemble the original contour of the land and establishing a vegetative ground cover to stabilize and protect affected areas (Wolf, 1983). While the intent of the law was to stabilize and improve drastically disturbed sites, each of these practices has been shown to be detrimental to tree growth (Ashby, 1982); compaction from heavy equipment restricts tree root growth and herbaceous cover competes with tree seedlings for limited moisture and nutrients on the harsh, reclaimed surface mine sites.

Research focusing on reclamation of surface mines and subsequent establishment of tree cover is abundant (Czapowskyj, 1976; Rafaille and Vogel, 1978; Samuel *et al.*, 1978; Schaller and Sutton, 1978; Vogel, 1981; Hamilton, 1995); however, differences in specific site factors and the varying successes found in these studies make simple generalizations regarding the best species and site preparation treatments difficult.

In collaboration with West Virginia University Division of Forestry and with matched funding from the West Virginia Development Office, the MeadWestvaco Appalachian Research Center developed a project with the objective to investigate survival and growth of hardwood species on reclaimed surface mines. Species selected for experimentation under this project are those that have shown good productivity in plantations established for recent research purposes in old-field and cutover site conditions in the area. This report documents the initial

establishment, early cultural treatment, and early growth of the species tests on the three sites chosen for this project.

Procedures

Study Sites

This project comprises three separate reclaimed surface mine sites and was established over a three-year period. All sites are in Greenbrier County, West Virginia. At each location research plantings were established within approximately 12 hectares of reclaimed surface mine land. Site preparation was initiated with an aerial application of 11.7 liters ha⁻¹ of Accord and 0.04 liter ha⁻¹ of Escort applied by helicopter. The entire 12-ha site was sprayed then subsoiled and cultivated with a D-8 bulldozer pulling coulter blades and a 1-m-long ripper. This soil treatment was done at each site in fall before the plantings were established. An electric deer enclosure fence was built around all the research plantings at each location.

2001 Test Site.

The first planting was a species study done in the spring of 2001 at Briery Knob on Anjean Tract at an elevation of 1100 m. The ripping was done in the fall of 2000 on 2.5 m spacing. Two hybrid aspen, six hybrid poplar, black cherry and pitch x loblolly were planted in the species study (Table 1). We rooted hybrid aspen cuttings for this study but had poor survival at the local greenhouse so we used some of the production planted aspen, rooted cuttings that were purchased from a nursery. The hybrid poplars were planted using 20-25 cm unrooted cuttings. The study was laid out and planted in the spring of 2001 in five replications of ten 49-tree plots. The rows are 2.5 m apart and the trees are 3 m apart within rows. In May of 2001 the plots were sprayed to kill grasshoppers by using the tractor boom sprayer and broadcasting Seven XLR Plus at a rate of 2.3 liters ha⁻¹. In June of 2001 the cultivated areas, where the trees were planted, was sprayed with 0.13 liter ha⁻¹ of Transline (clopyralid) to control the vetch. Areas between the beds were directed sprayed with 2% Accord. In July each tree was fertilized with 10-10-10 fertilizer at a rate of 333 kg ha⁻¹. In August a contract crew backpack sprayed the area with 4% Accord (glyphosate) and then we sprayed what they missed with 3% Accord. In 2002 the planting areas were sprayed in May and again in August with 3% Gly Star. The trees were

fertilized in June of 2002 with 34-0-0 at a rate of 333 kg ha⁻¹. In 2003 no cultural treatment was done to this study.

Table 1. Planting stock used in Reforestation of Reclaimed Surface Mines Project in Greenbrier County, West Virginia. Year indicates whether or not the species/cross was planted in the respective plantings, 2001 (Briery Knob), 2002 (Red Dog), and 2003 (South Fork).

	Species/Cross	-----Year-----		
		2001	2002	2003
Hybrid Poplars:				
DN367	<i>Populus deltoides</i> × <i>nigra</i>	x	x	
DN34	<i>P. deltoides</i> × <i>nigra</i>	x		x
TD184-411	<i>P. trichocarpa</i> × <i>deltoides</i>	x		
TD52	<i>P. trichocarpa</i> × <i>deltoides</i>	x	x	x
NE19	<i>P. nigra</i> var. <i>charkowiensis</i> × <i>nigra</i> var. <i>caudina</i>	x	x	x
NM6	<i>P. nigra</i> × <i>maximowiczii</i>	x	x	x
TN311-93	<i>P. trichocarpa</i> × <i>nigra</i>		x	
DM-E	<i>P. deltoides</i> × <i>maximowiczii</i>		x	
Hybrid Aspens:				
Crandon (CRAN)	<i>P. alba</i> × <i>grandidentata</i>	x		
Armstrong (ARM)	<i>P. alba</i> × <i>grandidentata</i>	x		
Other Species:				
Black Cherry (BC)	<i>Prunus serotina</i>	x	x	x
Pitch × Lob pine (P×L)	<i>Pinus rigida</i> × <i>taeda</i>	x	x	x
White Pine (WP)	<i>Pinus strobus</i>		x	
Norway Spruce (NS)	<i>Picea abies</i>		x	
White Ash (WA)	<i>Fraxinus americana</i>			x

2002 Test Site.

In the spring of 2002 the plantings were established on a reclaimed strip mine site on Red Dog Road, on the Anjean Tract at an elevation of 990 m. This site was ripped on 3 m spacing. All trees were planted on a 3 m by 3 m spacing. The species study has six hybrid poplars, black cherry, Norway spruce, white pine, and pitch x loblolly (Table 1). All of the hybrid poplars were 20-25 cm unrooted cuttings. The study was laid out and planted in the spring of 2002 in five replications of ten 49-tree plots.

The Red Dog Road site was sprayed to control grasshoppers by broadcasting Sevin XLR Plus at a rate of 2.3 liters ha⁻¹ using the tractor sprayer. In July and then again in August of 2002 the cultivated areas around the trees in the Species Study was directed sprayed with 3% Gly Star (glyphosate) to control competition. Also in August the trees were fertilized with 10-20-20 at a rate of 333 kg ha⁻¹. In June of 2003 the cultivated areas were sprayed with 0.26 liter ha⁻¹ of Transline and 4.4 liters ha⁻¹ of Vantage (glyphosate). Most of the spraying was done with the tractor sprayer except on the steep places where the backpack sprayer was used. Between the cultivated areas, the herbaceous competition was mowed with the tractor. In July 2003, the trees were fertilized with 34-0-0 at a rate of 333 kg ha⁻¹ and the cultivated areas were sprayed with 2% Gly Pro.

2003 Test Site.

The third and last location is on the South Fork Tract at an elevation of 1220 m. The 12 hectares of reclaimed strip mine that was site prepared was divided into a 7.3 ha piece and a 4.9 ha piece. The research plots are located within the larger area. These areas were ripped on 3 m spacing. In the spring of 2003 a species study was established on this site. The study consists of three replications of seven 49-tree plots. The trees are planted on 3 m by 3 m spacing. The hybrid poplars NM6, DN34, and NE19 were rooted cuttings 1 m to 2 m tall. The TD 52-225 clones were planted as 20 cm cuttings. The site contains four hybrid poplar clones, black cherry, white ash, and pitch x loblolly pine (Table 1). In July the cultivated areas were directed sprayed with 2% Gly Pro (glyphosate) and then again in September.

Measurements and Numerical Analysis

Plantation measurements were recorded each year. In the 2001 planting at Briery Knob, total heights were recorded annually in years one and two; the 2002 planting at Red Dog was hard hit by harsh environmental conditions during its first growing season and hence only year one survival and year two heights were recorded; and at South Fork, the 2003 planting is one year old at this time of this reporting and data include first-year height and survival.

Comparisons of growth and survival attributes among species planted in this experiment were conducted using the SAS GLM procedure (SAS Institute 1999). Species were evaluated at each site. A volume index computed using diameter squared times total height times the number of surviving stems was used to combine these attributes into a measure to assess overall productivity for the measurements taken at the Briery Knob site. Significance cutoffs for all statistical tests were held at $\alpha=0.05$.

Results and Discussion

First Year Survival

Year-one survival varied by species and year of planting (synonymous with location; Table 2). The problems with the 2002 planting—where a late freeze burned leaves on the test and a midsummer drought further hampered establishment efforts—are reflected in these survival values. Among the five species planted at all three locations, pitch×loblolly pine had the highest survival (94%) during this harsh year. Importantly, NM6 hybrid poplar was close behind with 92 percent survival.

Species Comparison—Three species at Briery Knob and Red Dog

Three species were consistently planted and measured in two of the three plantings. These were the hybrid poplars NM6 and TD52, and the pitch×loblolly pine. TD52 hybrid poplar has shown the best average total height growth during the first two years of growth at Briery Knob and Red Dog (mean=7.1 feet), two feet greater than NM6 (Table 3). However, TD52 appears to be more sensitive to environmental conditions during the initial year of establishment as its first year survival was only 43% when established in the difficult 2002 planting season, whereas its survival was high in the 2001 (97%) and 2003 (98%) planting seasons. Other observations of

NM6 at various MeadWestvaco plantings have noted that NM6 is very resilient to early defoliations from late spring frosts. From this study and a single observation of TD52 following a late spring frost, the clone does not seem to have this same degree of resiliency.

Table 2. First-year survival for various species at the three surface mine plantings—2001 (Briery Knob), 2002 (Red Dog), and 2003 (South Fork). ‘*’ indicates that measurements were not recorded.

Species	Site			Mean
	Briery Knob	Red Dog	South Fork	
WA	*	*	99	99
CRANrup	98	*	*	98
NM6	99	92	99	97
ARM	94	*	*	94
BC	93	86	98	92
DN367	100	84	*	92
NE19	99	77	100	92
P×L	96	94	83	91
TD184	91	*	*	91
DN34	98	*	72	85
TD52	97	43	98	79
NS	*	54	*	54
TN311	*	53	*	53
WP	*	48	*	48
CRAN	44	*	*	44
DM-E	*	30	*	30

Survival, Growth, and Volume Development at Briery Knob

During the first two years following the establishment of this experimental plantation, the T×D hybrids (TD184 and TD52-225) have shown consistently rapid growth and are significantly taller on average than all other species in the test (Table 4). In contrast, the Pitch × Loblolly hybrid pine, planted mostly for relative comparison purposes, grew the least. NM6 hybrid

poplars, that have been the preferred clone used in many of the operational and research plantings during the hardwood plantations research period in Parkersburg, Rupert, and Appomattox Areas of the Appalachian Region ranked fifth in second year height and sixth in dbh at the end of the second growing season.

Table 3. Year one and year two average total heights for hybrid poplars NM6 (*Populus nigra* × *P. maximowiczii*) and TD52 (*P. trichocarpa* × *P. deltoides*), and for pitch × loblolly hybrid pine (*Pinus rigida* × *taeda*) on two reclaimed surface mine sites in Greenbrier County, West Virginia. In year 1, ‘*’ indicates that measurements were not recorded.

Species	Site	-----Total Height (m) -----	
		Year 1	Year 2
NM6	Briery Knob	0.9	1.9
	Black Farm	*	1.1
	<i>Mean</i>	<i>0.9</i>	<i>1.5</i>
PXL	Briery Knob	0.4	0.7
	Black Farm	*	1.0
	<i>Mean</i>	<i>0.4</i>	<i>0.9</i>
TD52	Briery Knob	1.0	2.8
	Black Farm	*	1.5
	<i>Mean</i>	<i>1.0</i>	<i>2.1</i>

Most species had over 90 percent survival by the end of the second growing season (Table 5). The best growers did not show exemplary survival; T×D hybrids ranked fifth (TD52-225) and ninth (TD184) among the other species in the test. Still, the lowest average survival of TD184 was 90 percent which, while not exceptional, will lead to adequate stocking at the 2.7 m by 3 m spacing in the plantation as the trees increase in size.

Statistical differences in both first and second year survival were not present among the seven top-ranking species planted in this test. The top ranking species at the end of the second growing season was NE19, virtually tied with the Crandon clone grown in the Rupert Area clone bank. This clone is one of those collected from the Champion Nursery in South Carolina by the Rupert MeadWestvaco research team beginning in 1996. Enthusiasm for this good survival

should be tempered by the fact that this observation represents a ranking of only one replicate of this species in the 2001 planting.

Despite the relatively low survival of both T×D hybrids, the decent survival combined with the exceptional growth positions both hybrids significantly ahead of the other species with respect to volume index. Volume indices for both T×D hybrids were twice that of the next ranking species, NE19.

Table 4. Average size attributes of species in the 2001 Surface Mine Reforestation site at Briery Knob. Species are ranked from greatest to least value for the specific measurement attributes (height and diameter). Note that pitch × loblolly hybrids had no measurable diameter at breast height (dbh). Average values of total height and diameter followed by similar letters are not statistically different according to Duncan’s Multiple Range Test at the $\alpha=0.05$ significance level. ‘*’ indicates that measurements were not recorded.

Species	-----Year 1-----		-----Year 2-----				
	Tot.Ht (m)		Species	Tot.Ht (m)	Species	Dbh (cm)	
TD52-225	1.02	a	TD184	2.88	a	TD184	2.06 a
TD184	1.02	a	TD52-225	2.79	a	TD52-225	1.87 a
NE19	0.96	a	NE19	2.22	b	NE19	1.22 b
NM6	0.93	a	DN367	2.01	bc	DN367	1.04 bc
CRANrup	0.78	ab	NM6	1.95	bcd	DN34	0.84 bcd
DN367	0.66	bc	CRANrup	1.77	cd	NM6	0.81 bcd
ARM	0.60	bcd	DN34	1.65	cd	CRAN	0.66 cd
DN34	0.60	bcd	CRAN	1.53	de	ARM	0.66 cd
CRAN	0.51	cd	ARM	1.53	de	CRANrup	0.66 cd
BC	0.36	d	BC	1.20	e	BC	0.46 d
P×L	0.36	d	P×L	0.75	f	P×L	*

Table 5. First and second year survival and volume index per replicate by species in the 2001 Surface Mine Reforestation site at Briery Knob. Species are ranked from greatest to least value for the specific measurement parameters. Average values followed by similar letters are not statistically different according to Duncan's Multiple Range Test at the $\alpha=0.05$ significance level. '*' indicates no measurable volume index.

----Year One----		-----Year Two-----			
Species	Surv	Species	Survival	Species	Volume Index (m ³)
N367	100 a	NE19	98 a	TD184	0.066 a
NE19	99 a	CRANrup	98 a	TD52-225	0.063 a
NM6	99 a	NM6	97 a	NE19	0.024 b
CRANrup	98 a	DN367	96 a	DN367	0.013 b
DN34	98 a	TD52-225	95 a	NM6	0.008 b
TD52-225	97 a	DN34	93 a	DN34	0.005 b
P×L	96 a	P×L	93 a	CRANrup	0.004 b
ARM	94 a	ARM	90 a	ARM	0.003 b
BC	93 a	TD184	90 a	CRAN	0.002 b
TD184	91 a	BC	90 a	BC	0.001 b
CRAN	44 b	CRAN	43 b	P×L	* b

Conclusions

1. Acceptable survival combined with exceptional diameter and height growth to produce over twice the volume index measure in both T×D hybrids than in any other species included in the 2001 surface mine plantation.
2. First-year survival was consistently good for many of the species in this test. The Crandon clone, collected from Champion International's South Carolina Nursery by MeadWestvaco research staff ranked second, just below NE19, with 98 percent survival. Caution is warranted regarding inferences for this good survival ranking as only one replicate for this species was included in the test.
3. Sub-optimal environmental conditions impacted the survival and growth of species planted in the second year (2002) of this test. This provided some insight into the resiliency of certain species to late spring frosts and summer droughts. Specifically, TD52 clones

planted at Red Dog (2002) had lower survival and resulting total heights in year two measurements at the site established during these harsh conditions than it did in the plantings established in alternate years.

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