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PERFORMANCE OF PONDEROSA PINE ON BITUMINOUS MINE SPOILS IN PENNSYLVANIA

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ABSTRACT

Seedlings from 40 seed sources of ponderosa pine (*Pinus ponderosa* Laws.) were planted on a strip-mine spoil in central Pennsylvania in 1969. Survival of seedlings from different sources ranged from 23 to 90 percent after six growing seasons. The average height of the seedlings ranged from 67 to 140 cm for the same period. Eight sources produced seedlings that were average or above in both height growth and survival.

Keywords: ponderosa pine, surface mine, reclamation, ecotype, provenance

INTRODUCTION

DIFFICULT PLANTING CONDITIONS and poor survival have encouraged the testing of new species for reclamation of strip-mine spoil banks. Ponderosa pine *(Pinus ponderosa* Laws.) was included in early species trials *(Hart and Byrnes 1960)* but it performed poorly and was not recommended. A chance planting of ponderosa pine in 1955 produced much better results *(Jones 1970).* In light of this contradiction, I welcomed the opportunity to participate in field tests of seedlings from ponderosa pine provenances during a study conducted by the Rocky Mountain Forest and Range Experiment Station. In the spring of 1969, I received 2,780 test seedlings from 49 seed sources. The seedlings were 2-1-1 stock which had been grown at the Bessey Nursery in Halsey, Nebraska.

PLANTING SITE

An old strip mine in Clearfield County, Pennsylvania, was selected as the planting site; it is at 41°N latitude and 78°12′W longitude, and has an elevation of about 1,600 feet. Precipitation at the site averages about 45 inches per year, and about 24 inches during the growing season (April through September). The normal growing season is just over 100 days.

The area had been planted at least twice before the ponderosa pine was planted, but only a few scattered trees had become established. An analysis of a composite soil sample showed these characteristics: pH: 3.4; Me H^+/100 gm: 6.7; M.mhos (cm conductance): 0.44; SO_4: 1,062 ppm; P: 0.4 ppm. Particle size distribution was: greater than 2 inches, 8 percent; ¼ inch to 2 inches, 47 percent; 2 mm to ¼ inch, 19 percent; less than 2 mm, 26 percent.

PLANTATION ESTABLISHMENT AND LAYOUT

The seedlings were shipped by air to the planting site; they were stored for 1 week in an unheated basement before being planted in mid-April, 1969. The seedlings were in excellent condition; they were planted by a two-man crew in 3 consecutive days. Mattocks were used to prepare the planting holes. The stony, compacted soil and the large size of the 2-1-1 seedlings made planting extremely difficult.

The study design was a randomized complete-block; a row of 10 trees from each provenance was in each of six blocks. Seedlings were planted at 6- × 6-foot spacings. All seedlings were planted, but there were only enough seedlings from 40 of the 49 sources for six complete replications; so only the 40 sources were compared (table 1).

Table 1.—Climatological data for sources of ponderosa pine planted on bituminous strip-mine spoils [a]

Ecotype and source	State	Latitude north	Longitude west	Elevation	Annual precipitation	Growing [b] season precipitation	Growing season
				Feet	*Inches*		*Days*
Transition zone							
754	MT	47°05′	110°50′	4,550	13.73	10.64	116
Central Montana							
815	MT	47°04′	109°15′	4,800	16.52	12.02	108
814 [c]	MT	47°03′	108°59′	3,700	16.52	12.02	108
813	MT	47°53′	108°33′	4,700	11.27	8.51	112
812	MT	47°30′	109°30′	3,400	12.85	9.15	131
823 [c]	MT	46°05′	107°23′	2,900	14.44	9.32	135
829	WY	44°48′	107°20′	5,100	15.91	10.57	130
Central Rockies							
830	WY	44°37′	107°05′	7,000	15.91	10.57	130
831 [c]	WY	44°11′	106°50′	5,800	13.07	9.47	117
848	WY	42°35′	105°40′	6,900	13.74	9.76	124
847 [c]	WY	42°13′	105°15′	5,500	12.44	9.61	141
845	NE	41°30′	103°57′	5,100	14.37	11.01	127
760	CO	40°12′	105°32′	8,400	16.07	11.20	98
761	CO	39°59′	105°25′	8,000	18.57	12.30	125
763	CO	39°06′	105°06′	7,800	18.32	14.13	119
Black Hills and high plains							
822 [c]	MT	46°15′	108°27′	3,800	10.93	8.22	141
824	MT	45°55′	106°36′	3,400	15.13	10.48	132
825	MT	45°41′	106°00′	3,600	15.13	10.48	132
827	MT	45°50′	104°28′	3,800	13.22	10.32	127
702	ND	46°56′	103°30′	2,500	15.42	12.11	111
701	ND	46°35′	103°27′	2,600	15.42	12.11	122
703	SD	45°51′	103°30′	3,200	13.52	11.11	135
704	SD	45°34′	103°11′	3,450	12.77	9.99	129
832 [c]	WY	44°53′	105°33′	3,900	17.61	11.92	128
833	WY	44°39′	104°16′	4,000	16.32	11.56	120
834	WY	44°27′	104°26′	5,500	16.32	11.56	120
835	WY	43°54′	104°11′	5,080	13.58	10.00	134
836	WY	43°40′	104°05′	4,080	13.67	10.23	134
837	SD	44°17′	103°50′	6,300	23.81	16.28	129
838	SD	43°55′	103°38′	5,680	17.07	13.56	117
839	SD	44°10′	103°35′	5,400	22.23	14.85	93
854	SD	43°13′	101°43′	3,300	16.11	12.66	128
853	NE	42°56′	102°30′	3,600	16.11	12.66	128
852	NE	42°31′	102°29′	3,800	19.31	13.95	132
722 [c]	NE	42°39′	103°05′	4,300	19.31	13.95	132
851	NE	42°42′	103°35′	4,200	17.49	13.47	128
723	NE	41°46′	103°50′	4,600	14.37	11.01	127
Low-elevation east plains							
757	SD	43°14′	100°58′	2,600	18.80	13.46	134
720 [c]	NE	42°41′	99°46′	2,300	20.31	15.72	149
856 [c]	NE	41°26′	100°01′	2,900	19.79	15.28	154
Colorado Plains and foothills							
759	NE	41°27′	103°05′	4,300	17.09	13.21	135
758	NE	41°13′	103°15′	4,500	17.35	13.33	137
858	CO	40°32′	105°08′	5,300	14.19	10.37	145
724	CO	39°06′	104°37′	7,400	19.41	14.27	119
860	CO	38°35′	104°56′	6,500	11.79	8.84	168
861	CO	37°55′	104°55′	6,600	14.93	9.73	131
Southern Rockies, NE. New Mexico							
765	CO	37°19′	104°43′	7,000	16.20	11.32	167
862	NM	36°57′	104°18′	7,350	17.43	13.99	147
863	NM	35°50′	104°58′	6,400	16.56	12.99	155

[a] Supplied by R. A. Read, Rocky Mtn. For. Range Exp. Stn., Lincoln, Nebr.
[b] April through September.
[c] Not included in the analysis.

Table 2.—Average survival [a] and total height after four and six growing seasons, by seed source

Ecotype and source	State	Survival	Height		6-year height as percentage of mean [b]
			4 years	6 years	
		Percent	*Centimeters*		*Pct.*
Transition zone					
754	MT	58	35	67	74
Central Montana					
815	MT	52	48	90	99
813	MT	79	45	77	85
812	MT	85	50	90	99
829	WY	50	45	79	87
Central Rockies					
830	WY	50	40	72	79
848	WY	68	48	85	93
845	NE	62	42	77	85
760	CO	70	46	79	87
761	CO	80	45	81	89
763	CO	87	45	78	86
Black Hills and high plains					
824	MT	58	63	107	118
825	MT	85	63	113	124
827	MT	68	53	94	103
702	ND	67	46	80	88
701	ND	35	52	96	105
703	SD	73	45	77	85
704	SD	90	64	113	124
833	WY	60	53	88	97
834	WY	77	55	97	107
835	WY	66	56	95	104
836	WY	47	55	93	102
837	SD	77	54	92	101
838	SD	73	43	73	80
839	SD	54	49	90	99
854	SD	43	52	92	101
853	NE	38	63	114	125
852	NE	58	51	89	98
851	NE	32	55	92	101
723	NE	57	46	84	92
Low-elevation east plains					
757	SD	78	73	140	153
Colorado Plains and foothills					
759	NE	63	44	79	87
758	NE	48	44	79	87
858	CO	48	52	89	98
724	CO	43	52	98	108
860	CO	23	47	89	98
861	CO	72	47	80	88
Southern Rockies, NE. New Mexico					
765	CO	43	63	114	125
862	NM	33	61	104	114
863	NM	60	67	122	134

[a] No mortality in fifth and sixth growing seasons.
[b] Average height at 6 years as percentage of mean for entire plantation.

RESULTS

By the end of the first growing season, the average survival for seedlings by seed source ranged from 30 to 93 percent. The average survival for all seedlings was 66 percent. After 1 full year, average survival by source ranged from 23 to 90 percent; overall, average survival dropped to 61 percent. Few seedlings died after that time, so the ranges were the same after six growing seasons (table 2).

There was some dieback during the first year; this made early height comparisons difficult. However, by the end of the second growing season, there were significant differences in the average height of seedlings from different sources. The shortest source averaged 19 cm; the tallest, 37 cm. The average height for all sources was 30 cm.

At the end of the fourth growing season, the average height for all sources was 51 cm. The shortest source, 754, averaged 35 cm; the tallest, 73 cm. Included in the tallest source, 757, was the tallest individual seedling at 108 cm. In the shortest source was the smallest seedling at 15 cm.

At the end of the sixth growing season, the average height for all sources was 91 cm. Source 757 averaged 140 cm; source 754 averaged 67 cm (table 2 and figs. 1 and 2).

With three exceptions, there were only minor changes in the rank of sources by height from the second to the sixth growing season. The height of seedlings from source 815 was below average after 2 years, but above average at 6 years. The height of seedlings from sources 833 and 852 was above average after 2 years and below average at 6 years.

Statistical analysis at the sixth year showed that there were highly significant differences in survival between sources, and significant differences in average height.

Seedlings from 8 sources were average or above in both height and survival; 10 sources produced seedlings that were above average in height but below average in survival; 12 sources produced seedlings that were above average in survival but that were below average in height; and seedlings from 10 sources were below average in both height and survival.

Figure 1.—A 170-cm tree from South Dakota (seed source 757).

Figure 2.—A 70-cm tree from Montana (seed source 754).

The eight sources that were above average in both height and survival offer the highest potential for reclaiming bituminous strip-mine spoils (table 3). The average height of seedlings from these sources was 108 cm compared to 91 cm for all sources; average survival was 75 percent, versus 60 percent for all seedlings planted.

There are no strong trends associated with the sources that produced the best seedlings. Six were in the Black Hills and high plains ecotype, but other sources in this ecotype produced seedlings that performed poorly. The fastest growing seedlings came from the easternmost extent of the range. This was the only source (757) in the low-elevation east plains ecotype that was compared in my study.

Three of the nine sources that were not compared because of limited data produced seedlings with superior characteristics (table 3). Two were from the central Montana ecotype. There were four other sources from this ecotype in my study; all performed fairly well and nearly met the requirements for inclusion with the superior sources. Superior seedlings from the third source for which data are limited came from the Black Hills and high plains ecotype.

Of the remaining six sources not compared, five produced seedlings that performed fairly well. Only source 856 in Nebraska produced poor seedlings. The 6-year average height of these seedlings was 85 cm, and only 25 percent survived.

The results indicate that ponderosa pine seedlings from some sources will perform satisfactorily on bituminous mine spoils. The growth rates and survival of these seedlings compare favorably with those of red pine (*Pinus resinosa,* Ait.), a favored species for reclamation in Pennsylvania. Davis *(1973)* reported that first-year survival was 80 percent for red pine planted in spring on an acid spoil (pH 3.6). Average height after five growing seasons was 64 cm. The fatest growing ponderosa pine seedlings (source 757) averaged 100 cm after 5 years. Seedlings from the eight superior sources averaged 80 cm.

Table 3.—Superior provenances [a] for plantings on bituminous strip-mine spoils

Ecotype and source	State	Average survival	Average height	Seedlings planted
		Percent	*Centimeters*	*No.*
Central Montana				
814 [b]	MT	84	95	50
823 [b]	MT	80	111	20
Black Hills and high plains				
825	MT	85	113	60
827	MT	68	94	60
704	SD	90	113	60
832 [b]	WY	76	105	20
834	WY	77	97	60
835	WY	66	95	60
837	SD	77	92	60
Low-elevation east plains				
757	SD	78	140	60
Southern Rockies, NE. New Mexico				
863	NM	60	122	60

[a] Both survival and height average or above for all origins tested.

[b] Not included in analysis but showed superior characteristics.

CONCLUSIONS

On the basis of data obtained from this study, seed from selected sources of ponderosa pine can be recommended for planting on bituminous strip-mine spoils in Pennsylvania (fig. 3). Additional testing of these

Figure 3.—Ponderosa pine test planting on Pennsylvania strip-mine spoil.

seedlings and those from other sources on a variety of spoils would be beneficial. The data also showed that there were only minor changes in relative performance after the second growing season. Therefore, it is possible to predict the performance of seedlings from each source with fairly good accuracy after only 2 years.

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