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# Ponderosa Pine Provenances for the Northern Great Plains

James L. Van Deusen



Research Paper RM-223  
Rocky Mountain Forest and  
Range Experiment Station  
Forest Service  
U.S. Department of Agriculture

# Ponderosa Pine Provenances for the Northern Great Plains

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## Abstract

Ponderosa pine trees representing 79 provenances were tested near Towner, N. Dak. Eight provenances can be recommended for planting in the northern Great Plains, based on 10 years in the plantation: 721 (Valentine, Nebr.); 720 (Ainsworth, Nebr.); 811 (Jordan, Mont.); (722 Chadron, Nebr.); 703 (Cave Hills, S. Dak.); 816 (York, Mont.); 704 (Slim Buttes, S. Dak.); and 757 (Rosebud, S. Dak.).

<sup>1</sup>Headquarters is at Fort Collins, in cooperation with Colorado State University. Research reported here was conducted at the Station's Research Work Unit at Bottineau, in cooperation with North Dakota State University, Bottineau Branch.



# Ponderosa Pine Provenances for the Northern Great Plains

James L. Van Deusen

## Management Implications

At least eight seed sources can be recommended for shelterbelt planting in the northern Great Plains. Nebraska sources 721, 720, and 722; South Dakota sources 703, 704, and 757; and Montana sources 811 and 816 have the combined height growth and survival capabilities needed for the northern Great Plains climate. They also were not damaged by source-specific attacks of insects, diseases, or animals. However, it is possible that, in the next 10 years, climatic extremes or other changes may cause slower

growing sources to increase and presently fast-growing sources to decrease; or, the relatively low levels of biotic stresses may increase so much that changes are necessary in the sources recommended.

Trees at the original collection sites are believed to be standing and producing satisfactory cone crops at the usual seed crop frequency for ponderosa pine of 2-to 3-year intervals. Specific directions to the recommended provenances are on file.<sup>2</sup>

<sup>2</sup>Rocky Mountain Forest and Range Experiment Station, Shelterbelt Laboratory, First and Brander, Bottineau, N. Dak.

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## Introduction

Ponderosa pine (*Pinus ponderosa* Laws.) is one of the few conifers known to be adapted to the northern Great Plains. It has the largest native geographic range of pines in North America and is a conifer widely used in shelterbelts throughout the Great Plains. However, even the widely distributed ponderosa is not native to large portions of the Great Plains, and must be tested to determine its suitability for a variety of sites.

Conifer windbreaks help lessen the drying, chilling, and aggravating effects of the persistent winds. In addition, erosive soils are less likely to be blown away, and snow is more uniformly distributed when prairie winds do not sweep, unmodified, across the fields.

Tree improvement research in the Great Plains is striving to identify species and seed sources of trees that will grow well under Plains conditions. Ponderosa pine can help satisfy that need, but best suited seed sources have not been identified for the variety of growing conditions encountered throughout the Plains.

A comprehensive study<sup>3</sup> was designed to 1964 to: (1) find ponderosa pine seed sources best adapted for shelterbelt use in different regions of the Great Plains; (2) determine the range and distribution of genetic variation in the eastern range of ponderosa pine; and (3) provide plant material and data for progeny tests, seed orchard establishment, and breeding programs.

<sup>3</sup>Nienstaedt, Hans, and David H. Dawson. *Study Work Plan: Ponderosa pine for the Great Plains Region. Document on file at Rocky Mountain Forest Range Experiment Station, Shelterbelt Laboratory, First and Brander, Bottineau, N. Dak.*

Bulked seed samples from 79 sources (fig. 1 and table 1) were assembled by the Rocky Mountain Forest and Range Experiment Station's Bottineau, N. Dak., and Lincoln, Nebr. field units. Seeds came from 10 to 20 randomly selected trees growing at each collection site.

Plantations were established in 1968 and 1969 at 24 locations from Alberta and Saskatchewan, Canada, southward through the Plains to Oklahoma, and as far east as Pennsylvania.

## Study Area

The North Dakota plantation was established in 1968, adjacent to the northern boundary of the State Forest Service Nursery at Towner, N. Dak., at an elevation of 1,480 feet (451 m). Average annual precipitation is 16.8 inches (427 mm), of which nearly 75% falls during the growing season. Average annual temperature is 39° F (4° C), but it can range from 100° F (38° C) to -40° F (-40° C). The soil at the planting site is a Sioux loamy sand on level to gently undulating land, covered by native grasses and weeds.

## Methods and Materials

Seedlings for this plantation were grown to 2 + 1 age in the Towner Nursery. The plantation was established with 79 provenances, randomly arranged in each of 15 replications. Each replication consisted of 2 rows of 40



Figure 1.—Collection locations of ponderosa pine for the North Dakota provenance test (distribution map from Critchfield and Little 1966).



Table 1.—Provenance location data for ponderosa pine provenance test at Towner, N. Dak.

Geographical clusters and provenance number	Source data			Geographical clusters and provenance number	Source data		
	Latitude	Longitude	Elevation		Latitude	Longitude	Elevation
	°N	°W	m		°N	°W	m
Oregon, Washington, Idaho, and Montana				Low Elevation Eastern Plains			
Bitterroots				855 NE	42.8	101.7	976
865 OR	44.0	121.3	1,311	757 SD	43.3	101.0	793
866 WA	48.3	111.9	488	721 NE	42.9	100.6	823
867 ID	44.0	116.0	1,037	720 NE	42.7	99.8	701
817 MT	47.0	113.8	1,037	856 NE	41.5	100.1	884
818 MT	46.7	114.2	1,433				
819 MT	45.9	114.2	1,250	Central High Plains			
820 MT	46.2	114.0	1,372	759 NE	41.5	103.1	1,310
				758 NE	41.3	103.3	1,372
Transition				858 CO	40.6	105.2	1,616
816 MT	46.7	111.8	1,372	859 CO	39.4	104.8	1,982
754 MT	47.1	110.9	1,387	762 CO	39.4	103.8	1,799
753 MT	47.0	110.3	1,220	724 CO	39.1	104.7	2,256
				860 CO	38.6	105.0	1,982
Central Montana				861 CO	38.0	105.0	2,012
815 MT	47.0	109.3	1,463				
814 MT	47.0	109.0	1,128	Black Hills and Northern Plains			
813 MT	47.9	108.6	1,433	811 MT	47.6	107.0	884
812 MT	47.5	109.5	1,037	822 MT	46.3	108.5	1,159
821 MT	45.8	109.0	1,159	727 MT	46.9	105.2	808
823 MT	46.1	107.4	884	826 MT	47.0	104.7	838
829 WY	44.8	107.4	1,555	702 ND	47.0	103.5	762
				701 ND	46.6	103.5	793
Central Rockies				824 MT	46.0	106.6	1,037
830 WY	44.7	107.1	2,134	825 MT	45.7	106.0	1,098
831 WY	44.2	106.9	1,768	827 MT	45.9	104.5	1,159
849 WY	42.8	105.1	1,585	828 MT	45.6	104.2	1,220
848 WY	42.6	105.7	2,104	703 SD	45.9	103.5	976
847 WY	42.3	105.3	1,677	704 SD	45.6	103.2	1,052
857 WY	41.2	105.3	2,348	832 WY	45.0	105.6	1,189
845 NE	41.5	104.0	1,555	833 WY	44.7	104.3	1,220
844 NE	41.2	104.1	1,585	834 WY	44.5	104.5	1,677
760 CO	40.2	105.6	2,561	835 WY	43.9	104.2	1,549
761 CO	40.0	105.5	2,439	836 WY	43.7	104.1	1,244
763 CO	39.1	105.1	2,378	837 SD	44.3	103.9	1,921
764 CO	38.0	105.3	2,683	838 SD	44.0	103.7	1,732
				839 SD	44.2	103.6	1,646
Southern Rockies and Plains				840 SD	43.8	103.4	1,280
765 CO	37.4	104.8	2,134	850 WY	42.9	104.5	1,524
862 NM	37.0	104.3	2,241	851 NE	42.7	103.6	1,280
863 NM	35.9	105.0	1,951	846 WY	42.2	104.5	1,280
864 NM	35.5	105.3	1,951	723 NE	41.8	103.9	1,402
766 NM	33.3	105.6	2,226	722 NE	42.7	103.1	1,311
767 NM	33.0	105.4	1,951	852 NE	42.6	102.5	1,159
768 NM	32.2	104.8	1,768	853 NE	43.0	102.5	1,098
869 AZ	35.2	111.8	2,134	854 SD	43.3	101.8	1,006

provenances each, or a total of 30 rows. Each plot had four trees from one provenance, planted in a line. Trees which died in the first year were replaced in spring 1969 from appropriate transplanted stock.

Rows 2 feet (61 cm) wide were tilled 12 feet (3.7 m) apart, and were oriented generally north-south. The 2-foot (61-cm) width adequately prepared the planting site, but native vegetation was not tilled between rows to retain control of the erosive soil. Trees were machine-planted in May, spaced 8 feet (2.5 m) apart within rows.

Because grass and weed competition is detrimental to tree survival and growth in the Great Plains, competing vegetation was annually cultivated or sprayed with herbicides in bands adjacent to tree rows during the 10-year period. Weeds between tree rows were mowed annually. Simazine at 2 pounds (907 g) a.i. per acre was applied, generally in mixture with dalapon at 10 pounds (4.53 kg) a.i. per acre. To add nutrients to the sandy soil, a granular 23-23-0 fertilizer was scattered in a 3-foot (1-m) circle around each live tree in three of the last four years.

## Results and Discussion

### Survival

After the first three field seasons, survival was good, except for the southernmost provenances. But among those, even the New Mexican provenances were surviving at a rate of one tree out of three. Southern Rockies and Plains trees were killed probably by low winter temperatures rather than competition for soil moisture.

Survival by age 10 reflected the combined effects of low temperatures and soil moisture stresses. Source 703 from northwestern South Dakota had 85% survival, which was twice the plantation average. Ten provenances, however, had less than 10% survival after 10 years. Tenth-year survival for all sources ranged from 0% to 85% (table 2).

Although low winter temperatures may have been responsible for early mortality, competition for soil moisture was probably the most critical factor in survival. Despite the tilling, spraying, and mowing, some portions of the rooting zone of plantation trees prob-

ably had strong competition from weeds and grasses for soil moisture at all times. Because the soil at the plantation site has a poor moisture-holding capacity, survival and growth heavily depend on current precipitation. Four of the last five years had below-normal precipitation during the growing season, April through August. In 1976, precipitation for that period was 3.91 inches (9.9 cm) below normal; in 1977, it was 1.3 inches (3.3 cm) below normal.

### Height

Tallest provenance was 721 NE (fig. 2a) which averaged 41 inches (104 cm), 50% taller than the plantation average (table 2). Height growth of all trees was not as good as expected; the plantation average of only 28 inches (70 cm) is equivalent to less than 3 inches (7 cm) per year (fig. 2b). Trees from the best provenance grew nearly 4 inches (10 cm) per year. Ponderosa pines at the nearby Denbigh Experimental Forest, on similar soils and from some of the same areas, have grown approximately 1 foot (30 cm) per year, for the past 40 years. Limited soil moisture, caused by grass and weed



Figure 2.—Two ponderosa pine trees after 10 growing seasons in the field. Tree in (a) is from the best provenance (721 NE), while the tree in (b) is from a North Dakota provenance (702), growing at approximately the average plantation rate.



Table 2.—North Dakota ponderosa pine provenance test; average survival and height growth for 79 provenances

Geographical clusters and provenance number	Survival 10-year	Tree height 10-year	Geographical clusters and provenance number	Survival 10-year	Tree height 10-year
	%	cm		%	cm
Oregon, Washington, Idaho, and Montana			Low Elevation		
Bitterroots			Eastern Plains		
865 OR	18	38	855 NE	53	74
866 WA	10	44	757 SD	62	98
867 ID	2	75	721 NE	82	104
817 MT	10	77	720 NE	72	98
818 MT	5	56	856 NE	58	75
819 MT	25	48			
820 MT	15	53	Central		
Transition			High Plains		
816 MT	72	86	760 NE	55	60
754 MT	77	81	758 NE	42	64
753 MT	75	66	858 CO	38	51
			859 CO	23	41
Central Montana			762 CO	63	58
815 MT	67	78	724 CO	38	55
814 MT	63	77	860 CO	18	34
813 MT	63	72	861 CO	8	45
812 MT	55	72			
821 MT	68	74	Black Hills and		
823 MT	58	80	Northern Plains		
829 WY	43	63	811 MT	82	90
			822 MT	70	74
Central Rockies			727 MT	70	86
830 WY	47	65	826 MT	70	68
831 WY	45	55	702 NE	57	68
849 WY	57	53	701 ND	50	63
848 WY	52	44	824 MT	60	80
847 WY	12	69	825 MT	58	87
857 WY	23	38	827 MT	57	72
845 NE	38	57	828 MT	52	73
844 NE	37	50	703 SD	85	79
760 CO	43	51	704 SD	73	72
761 CO	75	66	832 WY	43	58
763 CO	70	79	833 WY	42	68
764 CO	50	50	834 WY	45	74
			835 WY	52	61
Southern Rockies and Plains			836 WY	58	65
765 CO	15	35	837 SD	55	70
862 NM	2	15	838 SD	60	69
863 NM	2	8	839 SD	60	60
864 NM	0	0	840 SD	42	59
766 NM	0	0	850 WY	55	58
767 NM	0	0	851 NE	50	57
768 NM	0	0	846 WY	38	46
869 AZ	0	0	723 NE	68	75
			722 NE	73	82
			852 NE	45	65
			853 NE	52	72
			854 SD	43	59
			Means	<sup>1</sup> 42.4	<sup>2</sup> 69.5

<sup>1</sup>Survival percent transformed into arcsin  $\sqrt{\%}$  for each provenance, then averaged for the plantation and converted back to percent.

<sup>2</sup>Weighted by number of surviving trees in each provenance.

competition, probably reduced height growth for all provenances. Trees from the only two North Dakota provenances in the plantation (701, 702) grew at slightly less than the plantation average (table 2).

When height growth data at plantation ages 3, 5, and 10 were grouped into geographical clusters,<sup>4</sup> the clusters maintained their relative positions throughout the 10-year period (fig. 3). Height growth of provenances from the southern Rockies and Great Plains is distinctly inferior to other clusters.

Several of the tallest provenances at Towner also are among the tallest provenances at other planting sites (table 3). For example, provenances 721 NE, 720 NE, 757 SD, 811 MT, and 825 MT have been among the best growers in three to six other widely scattered plantations. It also offers encouragement that while trees at Towner generally are shorter than at other plantations, most of the best provenances at Towner have also been among the leaders elsewhere.

### Geographical Clusters

When the provenances were grouped into geographical clusters, there were statistically significant differ-

<sup>4</sup>Read, Ralph A. *Genetic variation in seedling progeny of ponderosa pine provenances*. Manuscript submitted to *Forest Science Monograph* in 1979.

ences in mean survival and height growth among clusters (table 4). No multiple range tests were made. Table 2 shows that most clusters have substantial performance variations among the included provenances.

### Early Performance Indicators

If trees that will continue to be outstanding growers can be recognized from juvenile growth, substantial time can be saved in tree improvement. There was an excellent correlation between average tree height at plantation ages 5 and 10 for the 10 tallest provenances.

Table 3.—Number of provenances, from lists of the 10 tallest provenances at comparison plantations,<sup>1</sup> which were also among the 10 tallest at Towner, N. Dak.

Plantation location	Number of sources	Years of record
Phillipsburg, Pa.	4	9
Watertown, S. Dak.	5	10
Alliance, Nebr.	4	10
Hastings, Nebr.	5	10
Junction City, Kans.	5	10
Norman, Okla.	5	10

<sup>1</sup>First decade data in process of analysis by Ralph A. Read.

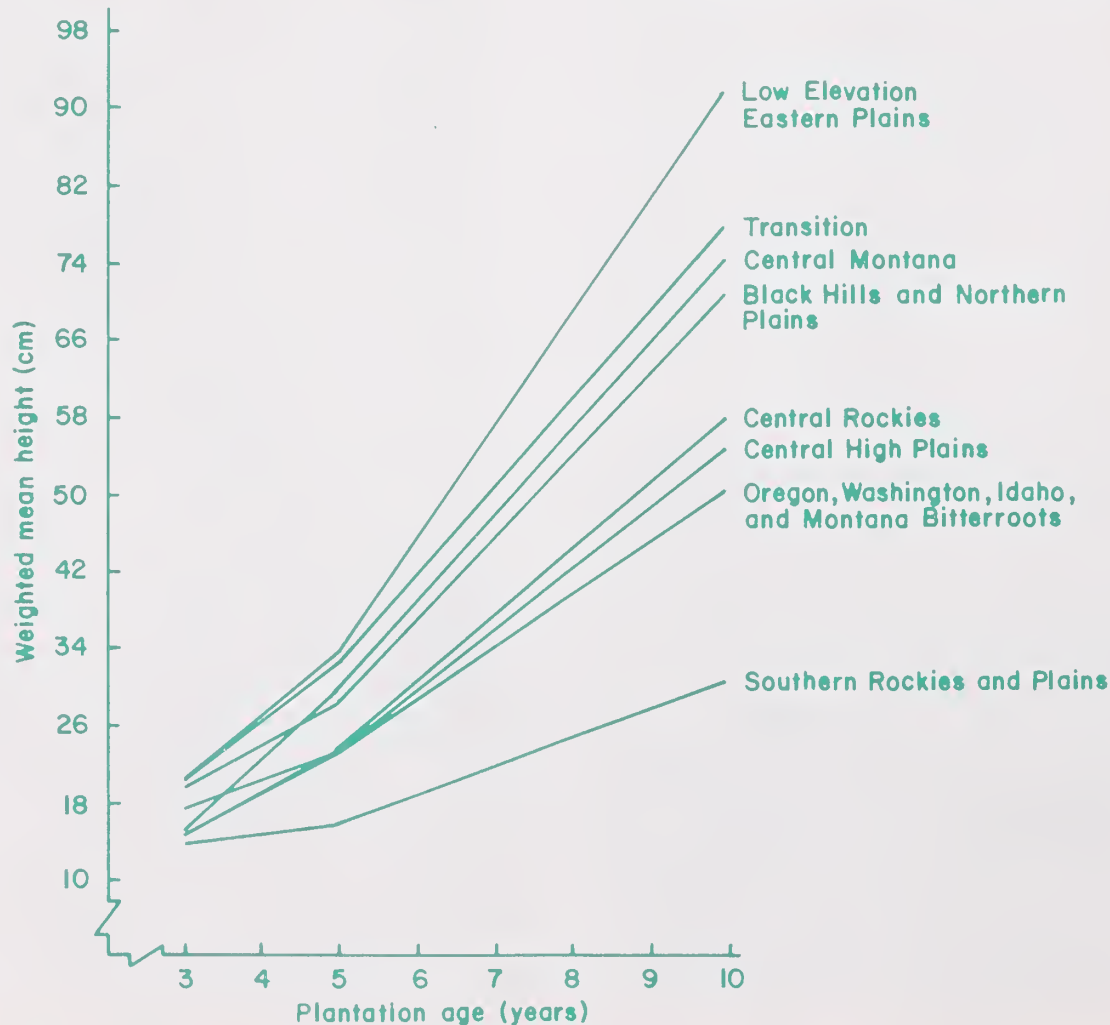


Figure 3.—Weighted mean height growth of eight geographical clusters of ponderosa pines at Towner, N. Dak.



Table 4.—Ten-year mean survival and height growth of eight cluster groups of ponderosa pine<sup>1</sup> provenances at Towner, N. Dak.

Geographical cluster	Means <sup>2</sup>	
	Survival <sup>3</sup>	Height <sup>4</sup>
	%	cm
Transition	74	78
Low Elevation Eastern Plains	66	91
Central Montana	60	74
Black Hills and Northern Plains	58	71
Central Rockies	45	58
Central High Plains	35	54
Oregon, Washington, Idaho, and Montana Bitterroots	11	51
Southern Rockies and Plains	5	30
Plantation total and averages	42	70

<sup>1</sup>The variety *scopulorum* is represented in all clusters except Oregon, Washington, Idaho, and Montana Bitterroots which is *var. ponderosa*, and Transition which is a transition between *var. scopulorum* and *var. ponderosa*.

<sup>2</sup>Analysis of variance indicated means differed significantly at the 1% level.

<sup>3</sup>Transformed into  $\arcsin \sqrt{\%}$  for provenances and converted back to percent for cluster averages.

<sup>4</sup>Weighted averages.

The 10 tallest provenances, listed in order of decreasing mean height, are:

Age 5	Age 10
721	721
811	757
757	720
720	811
825	825
722	816
816	727
727	722
824	754
754	824

None of the changes at age 10 involve a shift of more than two positions. Relative ranking of all 79 provenances could not be predicted so well between ages 5 and 10, but the leaders seemed to maintain their superiority. The list of 10 tallest provenances does not include all the recommended provenances for seed collections because recommendations for seed collections take survival into account as well as height growth. Some of the provenances with good survival grew almost as fast as the 10 tallest.

### Combining Traits

A single trait such as 10-year height growth or 10-year survival does not fully indicate performance. A very few tall trees, or survival of many short ones, is not enough to recommend those provenances as seed collection areas. Fortunately, the best growing sources

generally were also the ones with best survival and were not affected seriously by insects, diseases, or animals.

To decide which provenances to recommend for northern Great Plains plantings, a scheme suggested by Read<sup>5</sup> was used to combine the survival and height growth of provenances into a rank order. Four groups of six equal index classes (0-5) for survival and tree height were set up based on survival and height expressed as a percentage of the plantation mean. The average survival and height growth of each provenance, which had been calculated as a percentage of the plantation mean, was assigned to its appropriate index class. Then, the two indexes were summed for each provenance to make a total rating which combined relative survival and height growth.

For example, the range in percentages of the plantation mean for survival was 0% to 203%. Any provenance with a survival rate of 0% to 33% of the plantation mean was assigned an index of 0, while at the other extreme, those with a survival rate of 170% to 203% of the plantation mean, received an index rating of 5. Provenances 721 NE, 720 NE, and 811 MT rated 5 in each category, with a combined rating of 10 each.

To be recommended for northern Great Plains plantings, provenances must have a total rating of 9. Of all provenances rated, only eight were rated at 9 or 10: 721 (Valentine, Nebr.); 720 (Ainsworth, Nebr.); 811 (Jordan, Mont.); 722 (Chadron, Nebr.); 703 (Cave Hills, S. Dak.); 816 (York, Mont.); 704 (Slim Buttes, S. Dak.); and 757 (Rosebud, S. Dak.).

Mean survival and height growth of the eight leading sources was substantially better than plantation means. Mean survival for the leading sources was 73.9%, compared to the plantation mean of 42.4%. Mean height for the leading provenances was 90.1 cm; much higher than the plantation mean of 69.5 cm.

### Winter Injury

Native and planted pines throughout the northern Great Plains suffered varying amounts of winter injury during the winter of 1978-79. Ponderosa pines probably were damaged more than other species. At Towner, N. Dak., injury to plantation trees ranged from insignificant browning of some needle tips to tree mortality.

During spring 1979, before winter injury symptoms had been obliterated by new growth, all live trees in the plantation were surveyed for winter damage.<sup>6</sup> The leading survivors and best growers were from provenances whose trees were least affected by winter injury. Provenance 721 NE had 26 trees with few or no injury symptoms. The next four most resistant provenances had only 40% as many injury-free trees: 727 MT and 811 MT (11 trees); 753 MT and 829 WY (10 trees).

<sup>5</sup>Personal communication from Ralph A. Read. October 22, 1979.

<sup>6</sup>Personal communication from Richard Gilmore. North Dakota Forest Service.



## Biotic Stresses

No serious insect, disease, or animal damage has developed in the plantation. Damage from the western pine tip moth (*Rhyacionia bushnelli* Busck) has been of little consequence. The limited infestations that have been noted have been concentrated on the southern portions of the plantation, near existing rows of pole-size ponderosa pines that shelter the Towner Nursery. No provenance-related trends of infestation have appeared.

Common diseases such as the western gall rust (*Peridermium harknessii* J. P. Moore) are extremely rare in the plantation, even though gall rust is found in the vicinity.

Deer, porcupines, mice, or rabbits have made a minimum impact on plantation trees. Read (1971), however, reported preferences by jackrabbits for certain provenances in Nebraska.

## Literature Cited

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Van Deusen, James L. 1980. Ponderosa pine provenances for the northern Great Plains. USDA Forest Service Research Paper RM-223, 8 p. Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colo.

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**Keywords:** *Pinus ponderosa*, provenance test, shelterbelts

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Rocky  
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