Minnesota Forestry Research Notes

No. 277
April 1, 1981

PONDEROSA PINE PROVENANCE TESTS IN MINNESOTA

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ABSTRACT

Provenance tests established in Minnesota show that ponderosa pine (Pinus ponderosa, Laws.) from south of 40°N latitude and west of 112°W longitude should be avoided to ensure adequate survival and reduce climatic injury. Materials from southern and eastern Montana and the eastern high plains-low elevations grew tallest and had adequate survival and freedom from climatic injury.

Plantings of ponderosa pine in Minnesota have frequently been less than satisfactory because of poor early survival, excessive winter injury and slow juvenile growth. Given the geographically and climatically diverse natural range of this species, the use of seed from inappropriate origins may have contributed to these problems. Insight into this possibility is now being obtained from provenance tests established as a part of the North Central Regional Tree Improvement Project (NC-99) at University of Minnesota field stations. These tests were established in 1968 at the University's West Central Experiment Station at Morris (45.6°N, 95.9°W), Southwest Experiment Station at Lamberton (44.2°N, 95.3°W), and the Cloquet Forestry Center (46.8°N, 90.7°W), and in 1970 at the North Central Experiment Station at Grand Rapids (47.2°N. 93.5°W). Materials tested were grown from seed from 74 stand collections made by the Rocky Mountain Forest and Research Experiment Station USDA, from the high plains west to the foothills of the Rocky Mountains and in a few scattered locations in the western part of the species range (Table 1). With a few exceptions, the seedlings used to established all 4 tests represent the same stand collections and all tests are the same age from seed. Tests are randomized complete blocks with from 3 to 9 replications.

The materials, establishment procedures, test design and 5th year growth and survival were described previously (Tauer et al., 1974). Information regarding specific collections is on file with Carl A. Mohn at the College of Forestry, University of Minnesota. Height and survival data collected in the fall of 1977 and climatic injury observed during the 1977 growing season are reported below.

RESULTS

Survival - Survival percentages are based on the total number of trees planted, including replacements made between 1968 and 1971. Survival in the Cloquet and Grand Rapids plantings exceeded 90 percent in the first year following planting and was approximately 80 percent in 1973. Losses in these two plantings have been dramatic since 1973. The Cloquet plantation suffered almost complete mortality during the winter of 1975-76 and survival in the Grand Rapids planting fell to 60 percent by 1978. Because of excessive losses, the Cloquet planting was abandoned in 1977. The high losses probably reflect the effects of a drought in 1975-76 and increased exposure of trees as they outgrew the protection provided by snow cover. The two prairie region plantings (Lamberton and Morris) were characterized by low early survival (35-39%), in part due to a summer drought in 1968, but losses of only 2 to 5 percent between 1973 and 1978.

In Table 1, the 74 stand collections represented in the plantings have been combined into 10 regional groups suggested by R. A. Read[2] on the basis of a cluster analysis of three-year nursery data. A Chi-square test indicates a relationship between survival and these groups. There was a consistent trend in all plantations for higher

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Published by the College of Forestry, 1530 North Cleveland Avenue, St. Paul, Minnesota 55108. E. Sucoff, editor.

survival among northern origins. A significant deviation was the poor survival of the western materials from Washington and Idaho (region 5). These sources are from the western side of the continental divide and appear to have adapted to different environmental conditions. The data suggest that survival in Minnesota can be increased by avoiding materials from south of 40°N latitude and west of 112°W longitude.

Survival of individual stand collections varied greatly among test sites. For example, the average values for survival in the Lamberton, Morris, and Grand Rapids tests of stand collections from the Black Hills ranged from 24 to 67 percent.

Climatic injury - Extensive needle browning was observed in the three active tests during the 1977 growing season (Table 2). No fungi which could cause the injury were isolated in culture of the needles and the injury is assumed to have been caused by climatic factors.

For each tree in each plantation the percent of the previous year's needles showing browning was estimated to be the nearest quartile. The percent of trees with 75 percent or more of the previous years foliage free from browning is given by regional group and test site in Table 2.

Needle damage was most extensive in the Morris planting and occurred at a moderate level in the Grand Rapids test. The Lamberton test was almost free from such injury. Comparing regional groups, injury was greatest in southern and western origins. Avoidance of materials from south of 43°N latitude and west of 112°W longitude would effectively reduce this type of injury.

Variation among stand collections within regions was large (Table 2). Stand collections in which 80 percent or more of the trees had less than 25 percent of their foliage browned at Morris and Grand Rapids were found in all regions except the Central High Plains, the Southern Rockies and Far West (regions 5, 8, and 10).

A second type of injury was noted. Buds on terminals and lateral shoots either had not flushed or expanded abnormally. This injury was most common in the Morris test and its pattern paralleled that of needle browning.

Height Growth. Mean 1977 heights in the active test are given by regional group in Table 3. Data were evaluated using the means of four-tree field plots. Analyses of variance indicated that differences among regions were significant (.05 level) at each test location and for the combined analysis containing the 66 seedlots common to the three tests. At Morris there were significant differences among stand collections within regions and a significant interaction was found between test site and regional groups in the combined analysis.

The interaction between test site and regional groups is apparent when the rankings of regional means at test locations are compared. However, materials from Southern and Eastern Montana and the Eastern High Plains-low elevations (regions 3 and 7) performed best at all test sites and appear to be the most promising materials for planting throughout Minnesota. North central Montana and central Montana (regions 1 and 2), also performed well. At Lamberton, north central Montana was significantly shorter than regions 3 or 7. Therefore, materials from this region should be avoided in southern Minnesota. Central Montana contained only two sources which exhibited large height differences, 186 and 220 cm. This area shows potential but further screening is needed. Variation among stand collections within regions was large and the range of heights for stand collections given in Table 3 indicates that this level of variation should be considered.

Correlations. Average survival, freedom from winter needle injury, and height growth were found to be positively correlated when the combined data from the three active tests were examined. Statistically significant Spearman's Coefficients of Rank Correlation for combinations of these traits were: .79 for freedom from winter injury and survival, .72 for survival and height, and .63 for freedom from winter injury and height.

CONCLUSIONS

The differences with seed source for survival, freedom from winter injury, and height, and the favorable correlation among these traits, indicates that the use of appropriate seed could significantly increase the success of ponderosa pine planting in Minnesota. The pattern of variation observed, significant differences among geographic regions as well as among stands within regions, is consistent with results elsewhere (Wang and Patee, 1976; Barr and Collins, 1979).

We recommend that ponderosa pine planted in Minnesota originate from areas with the highest probability of yielding well-adapted materials (regions 3 and 7). This is a minimal step. In any substantial planting program, efforts should be made to obtain seed from specific stands identified as superior in these tests or to identify additional exceptional stands through screening. An indication of the potential for improvement using this approach is found in the average performance of the 5 tallest seed lots.

Stand Nr.	Region	Height[a] (cm)	Survival[a] (% trees)	75 percent plus freedom from needle browning[b] (% trees)
826	3	246	65	85
822	33	236	51	82
821	33	244	60	87
721	77	236	71	100
720	77	231	79	71
All Stands	--	188	40	62

[a]Lamberton, Morris, and Grand Rapids tests.

[b]Lamberton and Morris tests only.

LITERATURE CITED

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Table 1. Origin and survival of ponderosa pine in Minnesota provenance tests.

Regional Groups (Source Numbers)[a]	Origin: Latitude (°N)	Origin: Longitude (°W)	Origin: Elevation (Meters)	Number of Collections Represented	1977 Survival in Percent of Trees Planted by Test Location: Lamberton	Morris	Cloquet	Grand Rapids	Lamberton, Morris and Grand Rapids Combined: Group Means	Range of Stand Collections
1. No. Central Montana (812-815)	47.1-47.9	108.6-109.5	1036-1463	4	44	62	12	72	54	39-64
2. Central Montana (754, 816)	46.6-47.1	110.8-111.8	1372	2	55	68	12	68	61	58-64
3. S & E Montana (727, 811, 821-828)	45.6-47.6	104.1-109.0	808-1219	10	43	45	8	70	47	31-63
4. SW No. Dakota & NW So. Dakota (701-704)	45.6-46.9	103.2-103.5	762-1052	4	47	50	8	68	51	29-67
5. Far West (865,[c] 866, 867[b])	44.0-48.3	116.0-119.9	488-1036	3	16	24	0	33	22	17-46
6. Black Hills (832-840)	43.7-44.9	103.4-105.6	1189-1920	9	39	46	7	77	47	24-67
7. E. High Plains (low elev.) (720,721,757,855)	42.7-43.2	99.8-101.7	701-975	4	51	58	0	63	55	56-73
8. Central High Plains (722,723,758,759, 846,850-856)	41.2-43.2	100.0-104.5	884-1524	11	39	46	1	61	45	30-76
9. Central Rockies & Plains (high elev) (724,760-764,829, 830,831,844,845, 847,848[b],849,857-861)	37.9-44.8	103.8-107.3	1585-2682	19	30	38	5	60	37	21-55
10. So. Rockies (765,766,767,[c]768[c] 862,[d]863,864,869[c])	35.2-37.3	104.7-111.8	1951-2134	8	12	2	1	7	8	0-21
All Sources				74	35	39	4	60	40	0-76

[a] Location, latitude, longitude, and elevations for individual source numbers can be found in Rocky Mountain Forest & Range Experiment Station Research Note RM-297, Sept. 1975.

[b] Not in Cloquet test.

[c] Not in Grand Rapids test.

[d] Not in Lamberton or Morris test.

Table 2. Percent of surviving trees with 75 percent or more of the previous year's needles free from browning by plantation and regional group.

Regional Group	Nr. Stands	Test: Lamberton	Morris	Grand Rapids	Combined: Morris & Grand Rapids: Average	Range of Stands
1. No. Central Montana	4	100	70	86	75	69-84
2. Central Montana	2	100	71	88	76	66-87
3. South & East Montana	10	100	86	81	84	57-100
4. SW North Dakota; NW South Dakota	4	99	88	79	85	76-93
5. Far West	2-3	100	5	40	20	10-67
6. Black Hills	9	94	65	72	67	33-93
7. E. High Plains (low elev.)	4	99	72	88	76	55-100
8. Central High Plains	11	99	46	64	52	7-79
9. Central Rockies & Plains (high elev.)	19	97	29	66	42	0-95
10. Southern Rockies	4-7	53	0	20	7	0-12
All Groups		96	56	72	62	0-100

Table 3. Mean heights in centimeters by regional group and test planting of ponderosa pine in Minnesota.[a]

Regional Group	Stands	Test: Lamberton	Morris	Grand Rapids	Combined[c]: Average	Range of Stands
7. E. High Plains (low elev.)	4	239 a	232 a	195 a	221 a	185 - 236
3. S & E. Montana	10	229 a	218 ab	211 ab	219 a	198 - 245
2. Central Montana	2	214 ab	210 ab	187 abc	203 abc	186 - 220
1. N. Central Montana	4	196 bc	202 ab	212 ab	203 abc	191 - 213
10. S. Rockies	8[b]	167 c	197 ab	176 ab	192 abc	192
6. Black Hills	9	203 b	194 ab	189 abc	195 bc	180 - 225
4. SW North Dakota & NW South Dakota	4	188 c	217 ab	169 abc	190 c	173 - 209
8. Central High Plains	11	192 bc	201 ab	174 a c	188 c	166 - 218
9. Central Rockies & Plains (high elev.)	19	173 c	163 c	156 c	160 d	142 - 176
5. Far West	2	126	161 bc	164 abc	149 d	135 - 162
All Sources	73	191	192	180	188	135 - 245

[a] Mean heights in columns followed by the same letter do not differ from each other at the .05 level. Compared with Duncan's Multiple Range test.

[b] See Table 1 for number of stands at each test site.

[c] Contains only the 66 stands common to all tests.

Published as Misc. Jour. Series No. 1786 of the Univ. of Minn. Agr. Expt. Sta.