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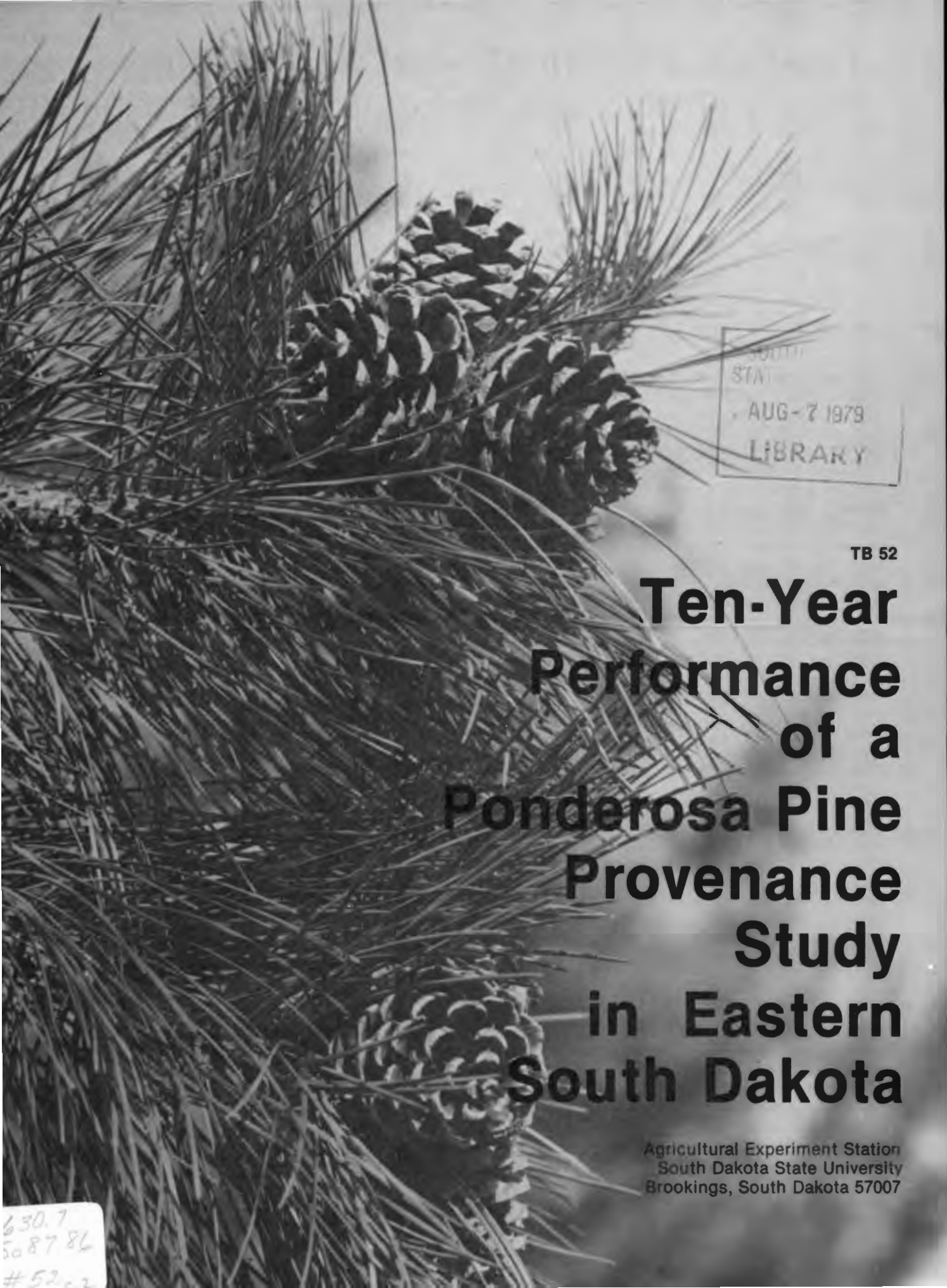

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Ponderosa pine (*Pinus ponderosa* Laws.) has for many years been one of the major conifer species planted in shelterbelts in South Dakota. However, initial survival of ponderosa pine has generally been poor, and early growth of surviving trees is relatively slow.

As a result, the conifer row is often ineffective in shelterbelts, decreasing the overall effectiveness of the entire shelterbelt.

Ponderosa pine has an extensive natural range and exhibits considerable genetic variability within that range (3, 4). Selection of proper seed sources might significantly improve initial survival and early growth of ponderosa pine planted in shelterbelts in South Dakota.

To identify sources of ponderosa pine which are best adapted to the climate of eastern South Dakota, a study having 73 seed sources or provenances was established in 1968. The study was set up as a part of a north-central regional project, and the trees were planted at the Big Sioux Conifer Nursery at Watertown, South Dakota (Fig 1).

Data on survival and height after the fifth and tenth growing seasons were collected. A severe storm in early November 1977 provided an excellent opportunity to evaluate the sources for susceptibility to winter injury. Information on an attack in 1975 by *Petrova metallica* (Busck), pitch twig moth, was also recorded.

Methods and Materials

Seedlings were derived from a seed source collection assembled by scientists from the Rocky Mountain Forest and Range Experiment Station. Bulked seed from 10 to 20 dominant or codominant trees at a specified location constituted a seed source.

The majority of the sources were from the eastern slopes of the Rocky Mountains and the adjacent Great Plains from Montana to New Mexico. This corresponds to the range of the interior variety of ponderosa pine (*P. ponderosa* var. *scopulorum* Engelm.). Three sources from the western range of ponderosa pine (var. *ponderosa*) were also included.

The collection of 80 seed sources was planted and grown at the U.S. Forest Service Bessey Nursery at Halsey, Nebraska, and at the Towner Nursery, Towner, North Dakota. In the spring of 1968, 2-1 seedlings of 73 sources were shipped form the nursery at Towner to Watertown. The plantation originally contained 14 replications in a randomized complete block design. Each replication contained a 4-tree square plot of each of the 73 seed sources. Trees were planted at an 8x8 foot spacing. First year mortality was replaced with excess 2-1-1 seedlings in early 1969.

The planting site, except for five replications, was plowed and disked the fall before planting. In five replications the plowing was not done until shortly before planting in 1968. Initial survival on these five areas was so poor that they were eventually abandoned. In addition, inconsistencies in the records of one other replication precluded using that data. Statistical analyses were based on 8 of the original 14 replications.

Winter injury data was collected after the winter of 1977-78; all trees were rated on a scale of from 1 to 5. A rating of 1 indicated no visible winter injury to needles or buds, and a rating of 5 indicated all needles and buds were dead. During the eighth growing season an intensive study of the occurrence of the pitch twig moth (*Petrova metallica*) was conducted in this plantation by entomologists from the U.S. Forest Service Shelterbelt Laboratory at Bottineau, North Dakota.

Results and Discussion

Table 1 summarizes data for each of the 73 sources after the fifth and tenth growing seasons and also groups the sources by geographic cline.*

Overall plantation survival after 5 growing seasons was 87%; after 10 growing seasons, it was 84%. Survival does not include any losses which occurred between 1968 and 1969. In some sources survival at 10 years was greater than survival at 5 years. The cause of this seeming inconsistency is that some seedlings which were judged dead at 5 years actually survived until the tenth year.

On the basis of the data presented in Table 1 and summarized by geographic cline in Table 2, seed sources from areas west of the Continental Divide and south of the 42nd parallel should be avoided in eastern South Dakota. Seed sources from the transition cline in Montana, the central Montana cline, the Black Hills and northern plains cline and low elevation eastern plains cline survived the best in eastern South Dakota. Especially well adapted to eastern South Dakota are seed sources from the low elevation eastern plains cline.

Surprisingly, seed sources from this same cline have consistently shown superior performance in other areas of the Great Plains such as Oklahoma (5), Kansas (1), Minnesota (6), the Black Hills (7), and North Dakota (Van Deusen, personal communications). Such apparent general adaptability in these sources suggests a genetic uniqueness which definitely deserves further study.

Analysis of variance (ANOVA) of the tenth year survival data indicated a significant difference ($p \leq .05$) among individual seed sources. Dunnett's multiple comparison test was used to test for differences in survival (Table 3). This test showed that 9 of

*Tentative grouping based on cluster analysis of 3-year data by R.A. Read (personal communication 1978).

3. Madsen, J.L., and G.M. Blake. 1977. Ecological genetics of ponderosa pine in the northern Rocky Mountains. Silvae Gen. 26 (1): 1-8.

4. Squillace, A.E., and R.R. Silen. 1962. Racial variation in ponderosa pine. For. Sci. Monogr. 2, 27 p.

5. Tauer, C.G., and R.L. Gardner. 1978. Nine-year performance of a central Oklahoma planting of ponderosa pine provenances. Okla. St. Univ. Agri. Exp. Stn. Bul. B-737, 8 pp. Stillwater, Okla.

6. Tauer, C.G., C.A. Mohn, and W.H. Cromwell. 1974. Early performance of ponderosa pine seed sources in Minnesota. Minn. For. Res. Notes No. 252, 4 pp. Univ. of Minn., St. Paul, Minn.

7. Van Deusen, J.L. 1974. Five year results of a ponderosa pine provenance study in the Black Hills. U.S. For. Serv. Res. Note RM-278, 4 pp. Rocky Mountain For. and Range Exp. Stn., Fort Collins, Colo.

8. Wang, C.W., and R.K. Patee. 1976. Regional variation of ponderosa pine, the five year results. Forest, Wildlife and Range Exp. Stn. Bul. No. 10, 8 pp. Univ. of Idaho, Moscow, Idaho.

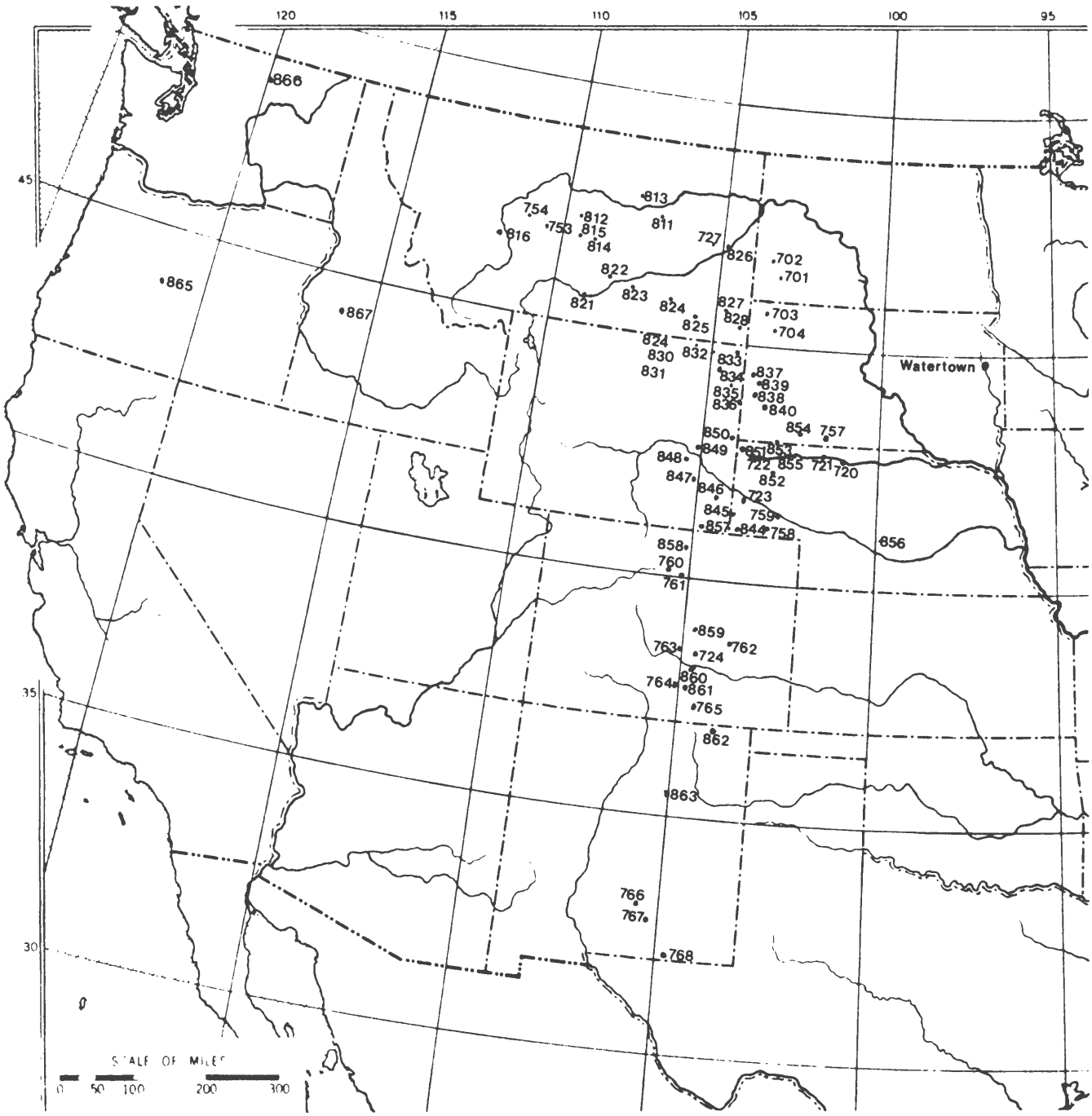

Figure 1. Collection locations of the 72 ponderosa pine seed sources tested at Watertown, South Dakota.

Cline & source number	Location Lat N°	Long W°	Elev m	Survival (%) 5 yr	10 yr	Height (cm & % of plantation mean) 5 yr		10 yr		Winter injury
720	42.7	99.8	702	97	97	114	133	266	135	1.7
856	41.4	100.0	884	84	84	95	111	249	118	1.9
Central High Plains										
759	41.4	103.1	1312	84	84	89	104	226	107	2.9
758	41.2	103.2	1372	88	88	94	109	228	108	2.8
858	40.5	105.1	1616	79	86	57	67	158	75	2.6
859	39.4	104.7	1982	86	75	66	78	178	84	4.3
762	39.4	103.8	1800	84	84	71	83	173	82	3.9
724	39.1	104.6	2257	88	88	78	91	206	97	4.0
860	38.6	104.9	1982	93	86	71	83	169	80	4.3
861	37.9	104.9	2013	71	61	60	70	141	66	3.8

Table 2. Survival, height, and winter injury in 1977 in eight ponderosa pine clines.

Cline	Survival (%)[1]	Height (cm)[1]	Height (% of Plantation Mean)	Winter injury (1-5)[1]
Far West	62 c	156 e	74	3.8 c
Transition	94 a	240 bc	113	1.9 a
Central Montana	91 a	231 c	109	2.1 b
Central Rockies	77 b	183 d	86	3.2 c
Southern Rockies	31 d	111 f	52	4.5 c
Black Hills & Northern Plains	92 a	245 b	116	2.2 b
Low Elevation Eastern Plains	93 a	281 a	133	1.8 a
Central High Plains	81 b	188 d	89	3.6 c
Plantation Mean	84	212		2.8

[1]Unlike subscripts denote a significant difference ($p \leq .05$) between mean values with Duncan's Multiple Range Test.

Table 3. Height, growth, survival and winter injury in 1977 of the 10 best ponderosa pine sources.

Source	Height at 10 years (cm)	Growth 1977 (cm)	Survival %	Winter injury (1-5)
721	292 *	33 *	97 *	1.8 *
757	291 *	32 *	94 *	1.8 *
720	286 *	31 *	97 *	1.7 *
855	279 *	33 *	91	1.9 *
822	270 *	28 *	97 *	1.9 *
701	266 *	29 *	100 *	1.7 *
853	265 *	31 *	97 *	2.3
836	265 *	29 *	94 *	2.4
816	263 *	26 *	100 *	2.1
854	263 *	32 *	100 *	2.3
Plantation Mean	212	23	84	2.8

*Denotes a significant difference ($p \leq .05$) between these values and the plantation mean.

Table 4. Relationship of cline to incident of attack by *P. metallica* in 1975 (Data after Dix and VanDeusen, 2).

Provenance cluster	Infestations per tree[1]
Black Hills & Northern Plains	5.5 a
Central Montana	5.4 a
Low Elevation Eastern Plains	5.0 a
Far West	4.6 a
Central High Plains	4.0 a
Transition	3.8 a
Central Rockies	3.5 b
Southern Rockies and Plains	2.4 b

[1]Unlike subscripts indicate a significant difference ($p = .05$) between mean values.

Table 5. Relationship of tree height to incident of attack by *P. metallica* in 1975 (Data after Dix and Van Deusen, 2).

Tree height (meters)	Number trees sampled	Infestations per tree[1]
0.0-0.6	13	0.4 a
0.6-1.2	126	1.0 a
1.2-3.0	196	4.3 b
1.8-2.4	119	9.0 c
2.4-3.0	21	11.2 d

[1]Unlike subscripts denote a significant difference ($p = .05$) between mean values.

in this plantation. First, none of the sources escaped infestation prior to 1975. Second, the incidence of attack by pitch twig moth was not significantly related to seed source (Table 4). Third, the height of the trees did significantly affect the incidence of attack by the pitch twig moth (Table 5). Since trees from the low elevation eastern plains were significantly taller than other clines, some correlation did exist between seed source cline and incidence of attack. However, the correlation is better related to tree height than source.

The overall effect of the pitch twig moth was to depress the growth of the faster growing trees in the plantation. Consequently, trees from those sources which showed the fastest growth rate in this study may actually give better results in a situation where they are not subject to attack by this or other twig moths.

Summary

Improvement in survival percentage and growth rates of ponderosa pine in shelterbelts in eastern South Dakota can be made if seed is collected from appropriate areas or stands.

In a regional study on ponderosa pine in Idaho, Wang and Patee (8) concluded that ". . . parent trees of desirable characteristics were concentrated in certain stands and possibly in general areas where the superior stands were located."

A similar conclusion can be drawn from this study. The low elevation eastern plains cline contained a majority of the superior performing seed sources. Within that area seed sources 720, 721, 757, and 855 appear particularly promising. In addition, seed sources 854 in South Dakota, 701 in North Dakota, and 816 in Montana all compare favorably with the low elevation eastern plains sources.

References

1. Deneke, F.J., and R.A. Read. 1975. Early survival and growth of ponderosa pine provenances in east-central Kansas. U.S. For. Serv. Res. Note RM-297, 4 pp. Rocky Mountain For. and Range Exp. Stn., Fort Collins, Colo.

2. Dix, M.E. and J.L. VanDeusen. 1978. "Major infestation of *Petrova metallica* (Busck) in a ponderosa pine provenance planting." *In* Proc of ND Acad of Sci 32, p.14. Uni. of ND, Grand Forks, ND.

the 10 best sources had survival rates better than the plantation average but that no significant difference existed among the 10 best sources.

An analysis of variance was also run on the height data after 10 years and the height growth data during the tenth year. These ANOVAs indicated significant differences among seed sources for each parameter. Dunnett's multiple comparison test showed that all of the 10 best sources grew significantly taller and faster than the plantation average (Table 3).

Similarly, an ANOVA on the winter injury data indicated a significant difference among individual seed sources. Dunnett's multiple comparison test indicated that 6 of the 10 best sources suffered significantly less winter injury than the plantation average (Table 3).

It was not possible to pick out one source which was obviously superior to all the rest in terms of adaptability to climatic conditions in eastern South Dakota. Rather, there were about six sources which seemed equally well adapted. Those sources were 720, 721, and 757 from the low elevation eastern plains cline; 854 which borders between the Black Hills and northern plains cline and the low elevation eastern plains cline; 701 from the Black Hills and northern plains cline; and 816 from the transition cline in Montana.

Three of these sources (701, 816, and 854) had survival rates of 100% after 10 years, which is exceptional for ponderosa pine in eastern South Dakota. However, average height for these three sources was from 20 to 30 cm less than the average heights of the other three sources (720, 721 and 757). This difference in height was not significant, because of the variability in tree heights within sources. Sources 720, 721, and 757 had survival rates of 97, 97, and 94% respectively after 10 years. These survival rates were not significantly different than the 100% of the other three sources.

Winter injury was negligible on all six sources although source 854, rated at 2.3, suffered more winter injury than the other five sources.

Incidence of attack by the pitch twig moth, by source, was not available. However, there are a number of interesting findings in the work done by Dix and Van Deusen (2)

Table 1. Origin, location, survival, height and winter injury of ponderosa pine in eastern South Dakota.

Cline & source number	Location Lat N°	Long W°	Elev m	Survival (%) 5 yr	10 yr	Height (cm and % of plantation mean) 5 yr		10 yr		Winter injury
Far West										
865	43.9	121.3	1312	59	59	69	80	158	75	3.8
866	48.3	119.9	488	65	69	83	96	213	100	3.0
867	44.0	116.0	1037	79	57	55	64	110	52	4.1
Transition										
816	46.6	111.8	1372	100	100	102	119	264	125	2.1
754	47.1	110.8	1388	88	88	93	108	230	109	2.0
753	47.0	110.3	1220	91	94	94	109	229	108	1.6
Central Montana										
815	47.1	109.2	1464	93	89	88	103	241	114	2.3
814	47.1	109.0	1128	81	84	78	91	212	100	2.3
813	47.9	108.6	1434	97	97	79	92	204	97	2.2
812	47.5	109.5	1037	97	97	115	134	254	120	2.0
821	45.8	109.0	1159	94	91	96	112	247	117	1.9
823	46.1	107.4	884	100	100	100	116	258	122	1.8
829	44.8	107.3	1556	81	81	70	82	188	89	2.3
Central Rockies										
830	44.6	107.1	4270	100	100	72	84	180	85	2.5
831	44.2	106.8	1769	64	64	62	72	183	87	2.7
849	42.8	105.0	1586	96	96	74	86	200	95	3.0
848	42.6	105.7	2104	84	84	68	79	193	91	2.5
847	42.2	105.2	1678	75	75	54	63	163	77	3.1
857	41.2	105.3	2348	93	72	72	84	174	82	3.5
845	41.5	104.0	1556	89	89	78	91	205	97	3.1
844	41.2	104.0	1586	71	79	69	81	178	84	3.4
760	40.2	105.5	2562	84	84	57	67	161	76	3.0
761	40.0	105.4	2440	78	78	63	74	171	81	3.8
763	39.1	105.1	2379	81	81	85	99	224	106	3.3
764	37.9	105.2	2684	78	72	67	78	160	76	3.9
Southern Rockies and Plains										
765	37.3	104.7	2135	88	66	64	75	67	32	4.6
862	36.9	104.3	2242	59	56	48	56	116	55	4.9
863	35.8	105.0	1952	69	22	47	55	57	26	4.4
766	33.3	105.6	2226	47	19	44	52	63	50	5.3
767	33.0	105.4	1952	19	9	53	61	28	13	5.2
768	32.2	104.8	2135	50	16	44	51	67	32	5.1
Black Hills and Northern Plains										
811	47.6	106.9	884	94	94	93	108	233	110	1.8
822	46.2	108.4	1159	97	97	107	125	270	127	1.9
727	46.9	105.2	808	91	91	100	117	252	119	1.8
826	47.0	104.7	839	81	81	102	119	258	122	2.0
702	46.9	103.5	762	97	97	101	117	239	112	2.2
701	46.6	103.4	793	100	100	113	132	266	126	1.7
824	45.9	106.6	1037	100	100	107	125	258	122	2.1
825	45.7	106.0	1098	81	81	108	126	265	125	1.9
827	45.8	104.5	1159	94	94	112	131	259	123	1.9
828	45.6	104.1	1220	88	88	100	117	252	119	1.8
703	45.8	103.5	976	100	100	105	123	239	113	1.9
704	45.6	103.2	1052	96	96	104	121	242	114	2.1
832	44.9	105.6	1190	100	100	88	103	225	106	2.2
833	44.6	104.3	1220	97	97	86	99	226	107	2.6
834	44.4	104.4	1678	97	97	106	124	254	120	2.3
835	43.9	104.2	1549	84	84	91	106	241	114	2.4
836	43.7	104.1	1244	94	94	110	129	265	125	2.4
837	44.3	103.8	1922	97	97	108	127	262	124	2.2
838	43.9	103.6	1932	97	97	98	115	245	116	2.3
839	44.2	103.6	1647	91	91	94	109	240	114	2.4
840	43.7	103.4	1281	88	88	104	121	260	123	2.6
850	42.9	104.4	1525	86	86	69	80	185	87	3.0
851	42.7	103.6	1281	78	78	86	100	216	102	2.5
846	42.2	104.5	1281	86	86	78	91	196	93	2.5
723	41.8	103.8	1403	69	69	83	97	215	101	3.0
722	42.7	103.1	1312	97	97	110	128	260	123	2.1
852	42.5	102.5	1159	93	93	95	111	229	108	2.8
853	42.9	102.5	1098	97	97	104	121	266	125	2.3
854	43.2	101.7	1006	100	100	105	123	263	124	2.3
Low Elevation East Plains										
855	42.8	101.7	976	91	91	116	135	280	132	1.9
757	43.2	101.0	793	94	94	122	142	291	138	1.8
721	42.9	100.6	824	97	97	113	132	292	138	1.9

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