Pacific Southwest Forest and Range
Experiment Station - Berkeley, California
Forest Service - U. S. Department of Agriculture

232.3/8

U. S. FOREST SERVICE RESEARCH NOTE PSW-9 1963

SEED ORIGIN AND SIZE OF PONDEROSA PINE PLANTING STOCK GROWN AT SEVERAL CALIFORNIA NURSERIES

By
Frank J. Baron and Gilbert H. Schubert[1/]

ABSTRACT: Ponderosa pine planting stock (1-0 and 2-0) grown from five different seed collection zones in the California pine region differed noticeably in size. On the west side of the Sierra Nevada, seeds from zones above 4,000 feet yielded smaller seedlings than those from lower zones, but larger seedlings than those from east-side sources. Average dimensions (seedling weight, stem diameter, top height) reflected these interzonal differences at each of five nurseries throughout the State.

The stepped-up seeding and planting program in California puts heavy demands on supplies of tree seed. In providing for increased quantity, we must not neglect seed quality. More and more evidence indicates that the geographic origin of tree seeds determines the growth patterns of planting stock. Within a species, the offspring from different seed sources have been recognized as geographic strains or "races." Among major species, the seedlings of different geographic strains or races appear to vary in performance. One such species is ponderosa pine (Pinus ponderosa Laws.).

Two major studies of ponderosa pine races have been published recently. In northern Idaho, Squillace and Silen (8) noted marked differences in growth and survival attributable to seed origin in a study of 50-year-old plantations. In California, multiple regression analyses

---

[1/] Frank J. Baron is research forester, Pacific Southwest Forest and Range Experiment Station, Berkeley, California. Gilbert H. Schubert is research forester, Rocky Mountain Forest and Range Experiment Station, Flagstaff, Arizona; he was formerly with the Pacific Southwest Forest and Range Experiment Station.

of much data showed strong effects of the elevation at which seeds were collected on nursery growth and field performance (1, 2). The results confirm earlier indications of "altitudinal races" along a narrow transect across the central Sierra Nevada (5). In general, the old maxim that "local seed is best" was upheld.

Unfortunately, the use of "local" seeds imposes heavy administrative burdens: large numbers of records must be maintained for collecting, processing, storing, and distributing many small lots of seed. Fowells (4) attempted to solve this dilemma by dividing the forested area into 13 zones, generalized from an existing vegetation-type map (11) of the State. For more than 16 years this "Seed Collection Zone Map" has been used by Federal, State, and private collectors to: (a) indicate the general origin of seeds; (b) permit combining seed lots when necessary, and (c) provide some assurance that seeds will be used in areas essentially similar to the collection area.

Recently Stone and Benseler (9) reported consistent differences in the general appearance of nursery stock grown from five of the seed zones. But we still lack numerical comparisons of the growth of planting stock from the various seed zones. This paper supplies preliminary quantitative comparisons of seedling size and weight for 1- and 2-year-old ponderosa pine planting stock involving five seed collection zones, five nurseries, and four different years.

Materials and Methods

The seeds used in these studies were collected by the U.S. Forest Service and stored under refrigeration for 2 or 3 years before use. Following standard procedure, the only information on origin was an identification by seed collection zone (fig. 1). Seed Zone I generally lies at elevations of 4,000 feet and higher east of the Sierra Nevada crest. Seed Zones II and IV generally lie between 2,000 and 4,000 feet elevation along the west slope and will be referred to collectively as "low" elevations. Seed Zones III and V for the most part lie between 4,000 and 6,000 feet elevation along the west slope, and will be referred to as "high" elevations. The east-side region has a distinctly different climate from the west side (8).

Three types of studies at the five nurseries (table 1) provided the data presented here. One was a study to determine the optimal lifting dates at various nurseries. A second was a study at the Placerville nursery to establish provisional grades for 1-0 planting stock. The third study, conducted at the Mt. Shasta nursery, compared the effect of seedbed density on the size of 2-0 planting stock.

In each study, seedbeds were drill sown with stratified seeds in April, and the seedlings were lifted either 1 or 2 years later. Tests were replicated in various degrees during the studies, which covered 4 years (1958 through 1961). Sample seedlings were collected at random from the various treatments. The top of each seedling was

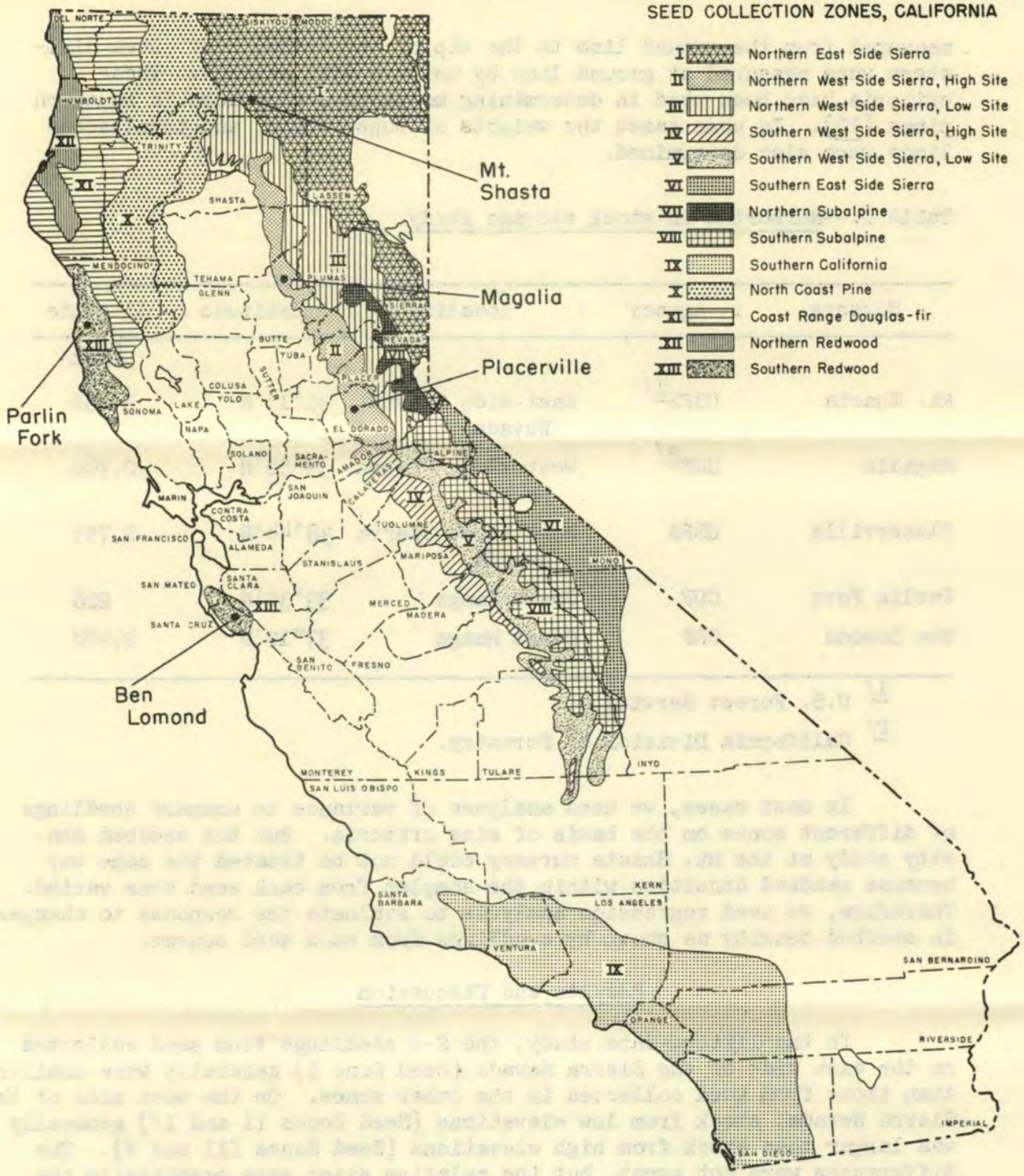

Figure 1.--Nursery locations and seed collection zones, California.

measured from the ground line to the tip of the apical bud. Stem diameters were measured at ground line by using a dial caliper. These criteria have been used in determining morphological grades in southern pines (10). In some cases the weights of tops, roots, and total seedlings were also determined.

Table 1.--Nurseries in stock storage study

Nursery	Agency	Locality	Latitude	Altitude
				Feet
Mt. Shasta	USFS[1]	East-side Sierra Nevada	41°15'N	3,252
Magalia	CDF[2]	West slope Sierra Nevada	39°52'N	2,760
Placerville	USFS	West slope Sierra Nevada	38°44'N	2,755
Parlin Fork	CDF	Coast Range	39°30'N	226
Ben Lomond	CDF	Coast Range	37°12'N	2,488

[1] U.S. Forest Service.

[2] California Division of Forestry.

In most cases, we used analyses of variance to compare seedlings of different zones on the basis of size criteria. But the seedbed density study at the Mt. Shasta nursery could not be treated the same way because seedbed densities within the samples from each seed zone varied. Therefore, we used regression analysis to evaluate the response to changes in seedbed density as shown by seedlings from each seed source.

Results and Discussion

In the lifting-date study, the 2-0 seedlings from seed collected on the east side of the Sierra Nevada (Seed Zone I) generally were smaller than those from seed collected in the other zones. On the west side of the Sierra Nevada, stock from low elevations (Seed Zones II and IV) generally was larger than stock from high elevations (Seed Zones III and V). The differences were not great, but the relative sizes were essentially the same at each nursery.

Nursery location had a pronounced effect on seedling size. Stem diameters and top heights of 2-0 trees from the Mt. Shasta nursery were the smallest, and those from the Ben Lomond nursery were the largest (tables 2 and 3). The 1-0 planting stock diameters re-emphasized the size superiority of lower elevation stock over that from higher elevations at nearly all nurseries (tables 4 and 5). In addition to diameters and

heights, the total fresh weight--termed by Show (6) "the best single expression of seedling development"--also was greater for stock from lower elevations (Zone IV) than from the higher elevations (Zone V).

In the subjective grading study at the Placerville nursery, the samples indicated that 1-0 stock from the lower elevations (Seed Zones II and IV) was larger than stock from a higher elevation source (Seed Zone III) (table 6). For some unexplained reason the Zone IV stock was shorter than Zone III stock. But the "large" and "medium" grades compared favorably with the average dimensions of similar stock shown in Table 5.

In the seedbed density study at the Mt. Shasta nursery, regression analysis of the stem diameter data indicated significantly different size responses among the three zones for stock grown at the various seedbed densities. The 2-0 stock from the east side (Zone I) again was smaller than that from the west side (Zones II or III) (table 7). Moreover, the stem diameter, total weight, and top height of the low elevation (Zone II) stock averaged greater than the corresponding dimensions of the higher elevation (Zone III) stock.

Some variation in ranking by size class of seedlings occurred in a few seed zones, but several recognized factors increased the variation among seedlings, including seed size, age of seed, mold development, seedbed density, soil moisture, and soil fertility (10). Moreover, considerable variations in microclimate probably existed within the seed zones (7).

Size differences between ponderosa pine seedlings from the various seed sources appeared to be reflected by stem diameters as well as by seedling weights. Since it is easier to measure stem diameter than seedling weight, we recommend the continued use of stem diameter measurements as a grading criterion, provided realistic limits are set. The actual values to be used as limits will depend upon the results of field outplanting tests. The nominal basis for culling pine seedlings or transplants in California nurseries has been to discard those below 0.11-inch stem diameter (3). Under this system--devised for the east-side nursery near Mt. Shasta--many trees from lower elevation nurseries would not qualify as plantable. New criteria should be devised for low elevation nursery stock.

If zonal differences persist, other grading limits may be justified. Fowells[2/] noted what appeared to be detectable size differences among the various seed zones. He suggested that it would be feasible to establish different grade categories for the different seed zones and for different species.

2/ Fowells, H. A. Diameter and count samples at Shasta nursery, Oct. 6, 1950. Memo on file Pacific Southwest Forest and Range Experiment Station, Berkeley, Calif.

Two important points arise from the current observations: First, segregation of seeds and planting stock, based upon the seed zones, yielded detectably different sizes of stock in the nursery; second, as reported previously (5), the fastest growing nursery seedlings came from seeds collected in the 2,000- to 4,000-foot range of elevation represented by Zones II and IV of the Seed Collection Zone Map (4).

In light of these findings, we appear justified in continuing to use the map, at least on an interim basis. We must recognize, however, that seed sources differ in a complex manner across an area as diverse as California. There are no clear-cut boundaries between altitudinal races.

Ultimately it may be necessary to record the precise location of each seed source. But for administrative purposes it is highly desirable to have as few zones as possible in a large-scale seed collection program. In any event, some amount of compromise will be needed to provide a feasible method of categorizing sources of tree seed in the light of current knowledge.

Literature Cited

1. Callaham, R. Z., and Hasel, A. A.
   1961. Pinus ponderosa - height growth of wind-pollinated progenies. Silvae Genetica 10:33-42.

2. _____, and Liddicoet, A. R.
   1961. Altitudinal variation at 20 years in ponderosa and Jeffrey pine. Jour. Forestry 59:814-820.

3. Corson, C. W., and Fowells, H. A.
   1952. Here's how--a guide to tree planting in the California pine region. U.S. Forest Serv. Calif. Forest and Range Expt. Sta. Misc. Paper 8, 26 pp.

4. Fowells, H. A.
   1946. Forest tree seed collection zones in California. U.S. Forest Serv. Calif. Forest and Range Expt. Sta. Res. Note 51, 5 pp.

5. Mirov, N. T., Duffield, J. W., and Liddicoet, A. R.
   1952. Altitudinal races of Pinus ponderosa, a 12-year progress report. Jour. Forestry 50:825-831.

6. Show, S. B.
   1930. Forest nursery and planting practice in the California pine region. U.S. Dept. Agr. Cir. 92, 74 pp., illus.

7. Squillace, A. E., and Bingham, R. T.
   1958. Localized ecotype variation in western white pine. Forest Sci. 4:20-34.

8. _____, and Silen, R. R.
   1962. Racial variation in ponderosa pine. Forest Sci. Monog. 2, 27 pp.

9. Stone, E. C., and Benseler, R. W.
   1962. Planting ponderosa pine in the California pine region. Jour. Forestry 60:462-466.

10. Wakeley, P. C.
    1954. Planting the southern pines. U.S. Dept. Agr., Agr. Monog. 18, 233 pp.

11. Wieslander, A. E.
    1935. A vegetation type map of California. Madroño 3:140-144.

Table 2.--Mean stem diameters of 2-0 ponderosa pine stock from 100 seedlings per seed zone

Nursery	West-side Sierra Nevada				East-side Sierra Nevada	Means[3]
	Zone II[1]	Zone IV[1]	Zone V[2]	Zone III[2]	Zone I[2]	
	Inches					
Mt. Shasta	.202	.228	.205	.174	.176	.197
Magalia	.264	.284	.250	.218	.213	.246
Parlin Fork	.337	.298	.283	.254	.239	.282
Ben Lomond	.364	.340	.319	.300	.281	.321
Means[4]	.292	.285	.264	.236	.227	

1/ "Low" elevation.
2/ "High" elevation.
3/ A difference between nursery means greater than 0.041 inch is significant at the 5 percent level.
4/ A difference between seed zone means greater than 0.012 inch is significant at the 5 percent level.

Table 3.--Mean top heights of 2-0 ponderosa pine stock from 100 seedlings per seed zone

Nursery	West-side Sierra Nevada				East-side Sierra Nevada	Means[3]
	Zone II[1]	Zone IV[1]	Zone III[2]	Zone V[2]	Zone I[2]	
	Inches					
Mt. Shasta	5.69	6.16	5.06	5.27	5.09	5.45
Magalia	7.55	8.13	7.28	7.32	6.38	7.33
Parlin Fork	9.13	9.61	8.87	8.25	8.45	8.86
Ben Lomond	10.31	10.63	9.55	9.40	9.46	9.87
Means[4]	8.17	8.63	7.69	7.56	7.34	

1/ "Low" elevation.
2/ "High" elevation.
3/ A difference between nursery means greater than 1.24 inches is significant at the 5 percent level.
4/ A difference between seed zone means greater than 0.26 inch is significant at the 5 percent level.

Table 4.--Mean stem diameters of 1-0 ponderosa pine stock from 50 seedlings per seed zone

Nursery	West-side Sierra Nevada				East-side Sierra Nevada	Means[3]
	Zone II[1]	Zone IV[1]	Zone V[2]	Zone III[2]	Zone I[2]	
	Inches					
Mt. Shasta	.090	.090	.060	.070	.060	.074
Magalia	.140	.120	.110	.100	.120	.118
Parlin Fork	.120	.130	[4] .150	.130	.110	.128
Ben Lomond	.140	.120	.120	.120	.120	.124
Means[5]	.122	.115	.110	.105	.102	

1/ "Low" elevation.
2/ "High" elevation.
3/ A difference between nursery means greater than 0.007 inch is significant at the 5 percent level.
4/ Unusually large plants.
5/ A difference between seed zone means greater than 0.004 inch is significant at the 5 percent level.

Table 5.--Mean dimensions of 1-0 ponderosa pine stock from 240 seedlings per seed zone

Nursery	Seed Zones[1]					
	IV	V	IV	V	IV	V
	Diameter		Weight		Height	
	Inches		Ounces		Inches	
Mt. Shasta	.082	.079	2.30	2.13	2.92	2.39
Magalia	.102	.083	2.67	1.74	2.84	2.41
Placerville	.113	.105	5.04	4.58	4.93	3.58
Ben Lomond	.133	.134	7.21	7.13	5.26	4.27
Means[2]	.107	.101	4.31	3.90	3.98	3.16

1/ Seed Zone IV is "low" elevation, and Seed Zone V "high" elevation.
2/ The following differences between zone means are significant at the 5 percent level: diameter = 0.004 inches; weight = 0.30 ounces; height = 0.60 inches.

Table 6.--Mean dimensions of 1-0 ponderosa pine stock, Placerville nursery, 1958, from three seed zones, 40 seedlings per zone

Subjective grades by size	Seed Zones[1]								
	II	IV	III	II	IV	III	II	IV	III
	Diameter			Weight			Height		
	Inches			Ounces			Inches		
Large	.124	.119	.118	6.2	8.7	6.0	4.9	5.2	5.3
Medium	.094	.085	.083	3.8	3.9	2.7	4.5	3.9	4.3
Small	.075	.068	.074	2.8	1.8	1.9	3.8	3.1	3.7
Cull	.071	.062	.055	1.3	1.6	1.1	2.9	1.8	2.4
Means[2]	.091	.090	.082	3.5	4.0	2.9	4.0	3.7	3.9

1/ Seed Zone III is "low" elevation and Seed Zones II and IV are "high" elevation.

2/ The following differences between zone means are significant at the 5 percent level: diameter = 0.008 inches; weight = 0.4 ounces; height = 0.2 inches.

Table 7.--Mean dimensions of 2-0 stock (Mt. Shasta, 1961) from 200 seedlings per seed zone

Seedbed densities (seedlings per sq. ft.)	Seed Zones[1]								
	I	III	II	I	III	II	I	III	II
	Diameter[2]			Weight			Height		
	Inches			Ounces			Inches		
20	.151	.143	.161	11.1	10.8	11.8	4.89	4.45	4.86
30	.126	.133	.141	7.6	8.7	9.0	4.35	4.26	4.38
40	.125	.126	.135	7.4	7.6	7.8	4.38	4.03	4.30
50	.096	.112	.121	3.9	5.9	6.8	3.49	4.01	3.92
60	.100	.101	.102	4.5	5.0	4.4	3.63	4.05	3.71
Weighted means	.121	.131	.138	7.07	8.53	10.68	4.18	4.22	4.35

1/ Seed Zone II is "low" elevation, Seed Zone III "high" elevation. Seed Zone I is east of the Sierra Nevada crest, of unknown elevation but probably higher than Seed Zone II.

2/ Regression of stem diameter on seedbed density: Zone I: $\hat{Y}_I = 0.121 - 0.0014(X - 42.5)$; Zone III: $\hat{Y}_{III} = 0.131 - 0.0014(X - 33.3)$; Zone II: $\hat{Y}_{II} = 0.138 - 0.0013(X - 34.9)$ ($\hat{Y}_I$, $\hat{Y}_{II}$, $\hat{Y}_{III}$, all differ significantly at the 5 percent level).

NOTICE: A uniform system of naming report series has been adopted for Forest Service Experiment Stations. Beginning January 1, 1963, research documents published by the Forest Service will be in one of these three series:

1. A numbered series, U.S. Forest Service Research Papers.
2. A numbered series, U.S. Forest Service Research Notes.
3. A numbered series, U.S. Forest Service Resource Bulletins.

The publishing unit will be identified by letters before the number, and the numbers will be consecutive in the order of publication dates. For example, this Station's first Note in 1963 is designated U.S. Forest Service Research Note PSW-1. Certain miscellaneous material, such as annual reports and experimental forest guides, will continue to be issued as unnumbered, nonserial publications.

The Research Note series formerly published by this Station closed with the release of Research Note No. 211, 1962.