Seed Source Variation in Lodgepole Pine and 1st-Year Root Development

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Seed sources of lodgepole pine show a tendency toward more shallow and less extensive 1st-year root growth with an increase in elevation of seed source location.

With few exceptions, lodgepole pine *(Pinus contorta* var. *latifolia* Engelm.) grows as a seral species immediately below and grading into the spruce-fir forest in the central Rocky Mountains (*2*). Although dense stands indicate abundant regeneration in some areas, seedling survival is critically dependent on the development of an adequate root system at the earliest stages of growth. Lodgepole pine may establish on a variety of sites, but it is not a particularly drought-resistant species (*1*). Shepperd and Noble (*4*) found that the first 3-weeks after germination were the most critical for a seedling's survival. Noble (3) found that the roots of lodgepole pine often reach a depth of less than 10 centimeters during the entire first season.

It seems that progeny capable of developing an adequate root system in the first season of growth would most successfully insure the regeneration of lodgepole pine at a particular site. This exploratory study was done to investigate 1st-year seedling root growth of several half-sib seedling families from different sources in the Front Range of Colorado. Great environmental extremes can be encountered over relatively short distances in this region, especially with respect to moisture along an elevational gradient. It was hypothesized that seed source adaptation to a particular site would be reflected in root development differences when seedlings from a number of different locations were grown together under common conditions. Root depth, number of lateral roots greater than 1.0 centimeter in length, and total length of lateral roots were evaluated for 13 half-sib families after one growing season.

Materials and Methods

Seed cones were collected in September 1978 from 13 individual parent trees representing a 1.55-degree range in latitude and a 432-meter range in elevation along the Front Range in Colorado (fig. 1, table 1). The cones were placed in screen mesh containers and hung in a warm room (25° C to 30° C) for cone opening and seed release.

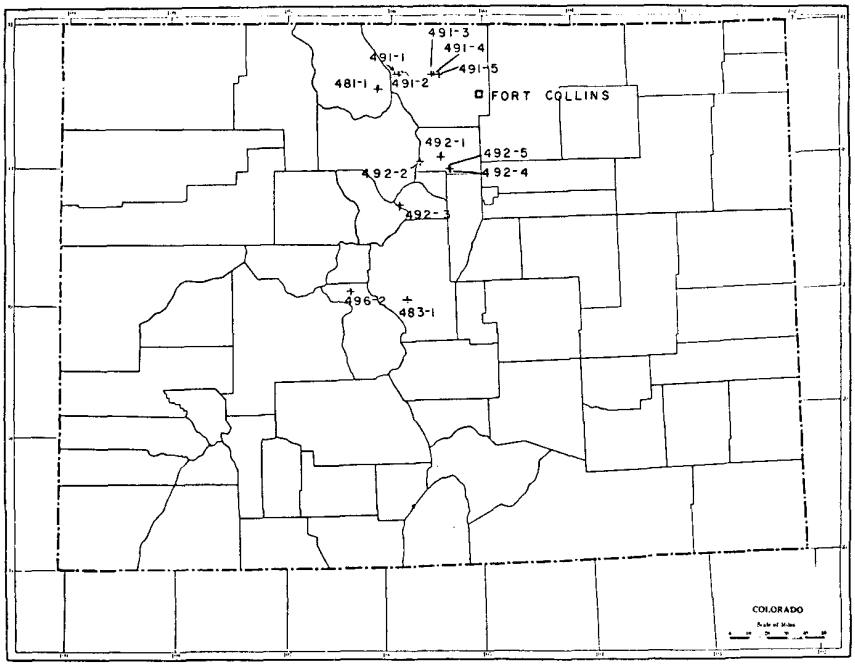

Table 1.—*Seed source location data*

Seed source	North latitude	West longitude	Elevation
	— — — *Degrees* — — —		*Meters*
492-4	39.97	105.38	2,481
492-5	39.98	105.39	2,499
492-3	39.67	105.96	2,621
491-4	40.57	105.55	2,682
491-3	40.57	105.56	2,700
492-1	40.03	105.51	2,740
481-1	40.40	106.13	2, 743
492-2	40.02	105.96	2,748
491-5	40.57	105.53	2,841
496-2	39.06	106.41	2,865
491-1	40.57	105.99	2,871
491-2	40.57	105.99	2,871
483-1	39.02	105.92	2,913
Range	1.55	1.03	432

Seeds from strongly serotinous cones were extracted by placing the cones in a drying oven set for 85° C for 24 hours. Following cleaning, the extracted seeds were stored in glass jars at O° C to 4° C until sown in the spring.

The seedbed was a 4.57- by 2.44- by 0.61-meter woodframed box filled with a commercial topsoil mix. In each of three replications of a completely randomized block planting design, seeds from a half-sib family were scattered over the surface of a randomly located plot and lightly raked into the soil. A 0.5-centimeter sawdust mulch was applied to the entire surface of the seedbed to conserve moisture.

Following germination, weekly watering and weed removal were the only plot maintenance activities for the duration of the growing season. At the end of the growing season, up to four seedlings from each plot were gently removed from the seedbed with a trowel for root development evaluation. Soil was carefully rinsed away by placing the seedling on a screen and gently immersing it in a bucket of water until all soil was removed. The cleaned seedlings were placed in labeled plastic envelopes and transferred immediately to the lab for measurement.

Laboratory measurements included unextended root depth, number of lateral roots greater than 1.0 centimeter, and total length of all lateral roots greater than 1.0 centimeter.

Seed source differences for the measured characteristics were analyzed by analysis of variance. Duncan's multiple range test was used to group source means for given characteristics. Simple correlation coefficients between either source latitude or source elevation and the measured characteristics were computed.

Results and Discussion

An analysis of variance was separately performed on source plot means for root depth, number of branch roots, and total branch-root length. With a null hypothesis of no difference between sources, F-test results were not significant at the 5-percent level of significance for root depth and number of branch roots, but were significant for total branch-root length. Duncan's multiple range test showed four groupings of source mean values for total branch-root length, whereas two large, homogeneous plot mean groupings developed from the root depth and number of branch root data (table 2).

An interpretation of these results in the context of elevational or latitudinal gradients was not apparent. Intensifying

Table 2.—*Means and standard deviations for root depth, lateral-root length, and number of branch roots by seed source.* [1]

Source	Root depth	Lateral root length	No. branch roots
	Centimeters	*Millimeters*	
492-4 $\bar{X}$ =	10.9[b]	18.0[ab]	6.7[abc]
sd =	1.9	4.2	1.8
492 -5	10.4[ab]	15.3[b]	9.8[d]
	0.7	6.6	5.9
492-3	9.2[ab]	7.4[a]	5.0[ab]
	1.5	1.8	1.7
491-4	10.2[ab]	8.4[ab]	5.6[ab]
	1.1	1.9	1.1
491-3	10.5[ab]	14.3[ab]	8.5[cd]
	1.7	4.7	2.1
492-1	9.6[ab]	9.9[ab]	6.4[abc]
	1.8	3.2	2.8
481-1	9.5[ab]	7.2[ab]	5.6[ab]
	1.1	2.5	2.5
492-2	9.4[ab]	6.3[a]	4.5[a]
	1.6	1.6	0.9
491-5	8.8[a]	11.5[b]	9.5[bcd]
	1.8	4.9	3.9
496-2	10.7[b]	8.4[ab]	6.6[ab]
	0.7	2.5	1.2
491-1	10.0[ab]	7.8[ab]	6.0[ab]
	0.9	2.8	2.5
491-2	9.8[ab]	8.4[ab]	5.8[ab]
	1.6	1.9	3.3
483-1	8.9[a]	11.5[a]	5.4[a]
	1.6	4.9	2.9

[1]Means for each variable followed by the same letters are statistically homogeneous by Duncan's multiple range test a = 0.05.

the sampling to include more source locations and to account for the effect of aspect of the seed source location may have given more definitive results. Nonetheless, simple correlation coefficients were calculated for each of the three root measures with both latitude and elevation of seed source (table 3). For all of the root-growth measures, an increase in elevation showed a decrease in growth. Correlations with source latitude were low in all cases. Figure 2 illustrates the source means and standard deviations for root depth plotted by elevation of source. The regression coefficient for the relationship was not significant, but the trend for shallower root depth for sources from higher elevations was evident.

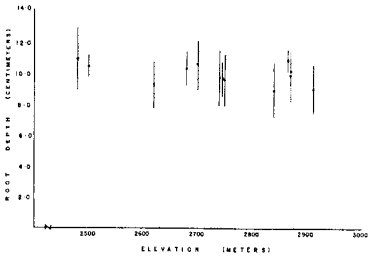

Figure 2.—*Means ± one standard deviation for root depth plotted by elevation of source.*

Figure 3 shows a similar relationship between lateral-root length and elevation of seed source. Where there were lateral-root length differences between the sampled sources,

Table 3.—*Simple correlation coefficients of latitude and elevation with measured characteristics*

	Root depth	Branch-root length	Number of branch roots
Latitude	.0417	.0005	- .2329
Elevation	- .4662	- .3423	- .2647

elevation or latitude apparently had little to do with explaining the variation.

It might be expected that in an area of such great environmental extremes as the Front Range of Colorado, selection pressures would cause dramatic differentiation of forest tree populations. With respect to lodgepole pine, adaptation to different locations was hypothesized in this study to be reflected in seed source differences in root development.

Although slight trends were apparent, the analysis did not strongly implicate elevational trends for the characteristics measured. Further studies that would account for a greater portion of the environmental variability at the source location (e.g., aspect, soil types) and that would use larger sample sizes should provide stronger evidence for or against the variation patterns noted here.

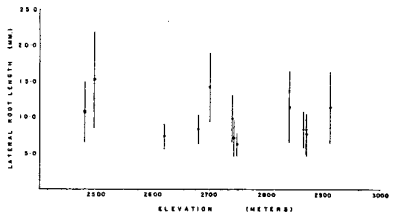

Figure 3.—*Means ± one standard deviation for lateral-root length plotted by elevation of source.*

Literature Cited

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