FOREST RESEARCH LAB
RESEARCH NOTE 64

genetic differences in red alder populations along an elevational transect

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introduction

Many Pacific Northwest conifers, especially Douglas-fir [*Pseudotsuga menziesii* (Mirb.) Franco], have been studied for years. Now the neglected hardwoods, broadleaved trees which comprise 5 percent of all western growing stock (Trappe et al. 1968), are receiving more attention.

Red alder (*Alnus rubra* Bong.) is the predominant hardwood in the Pacific Northwest and coastal Alaska. Oregon alone has 10 billion board feet of mature red-alder sawtimber (U.S. Forest Service 1958). Not only is it increasingly important economically, but red alder also is biologically valuable as a long-recognized nonleguminous fixer of nitrogen (Tarrant 1961). Researchers have accumulated substantial information about the biology of red alder, results suggesting that foresters may find alder management on selected sites or situations to be economically and biologically desirable (Trappe et al. 1968). In the last 3 years, the biological importance of red alder has been underscored by two international symposia in the Pacific Northwest: one to study the utilization and management of alder (Briggs et al. 1978), another to focus on symbiotic nitrogen fixation in the management of temperate forests (Gordon et al. 1979).

Because forest managers and geneticists need basic information about natural variations in populations of red alder, we studied conelet and seed characteristics, as well as early growth, of this species along an elevational transect in the Coast Range of Oregon.

methods and procedures

Beginning at sea level at Newport, Oregon, we marked a 43.56-km transect covering 152-m changes in elevation up to 915 m just below Marys Peak, the summit of the Coast Range in Oregon (Fig. 1). The influences of the maritime climate and day length are nearly the same along the transect, but temperature changes with elevation. At each of seven levels we randomly selected five trees within a 0.4-ha plot. Because red alder might not be found exactly on the transect at the particular elevation, we extended the transect width to 6.42 km (3.21 km on each side of the center line) for sampling.

From the five trees at each site, we collected 100 empty conelets (20 per tree). We weighed the conelets, noted coloration (based on Munsell Soil Color Charts), and measured half for size.

For each of the five trees from each elevation, we weighed three replications of 100 seeds, then combined all 1,500 seeds from each elevational source. Four replications of 100 seeds from each elevational source were germinated in growth rooms under 16-h photoperiods and three thermoperiods: 21°C/16°C (day/night), constant 10°C, and constant 21°C.

When their radicles protruded 0.5 cm or more, 10 germinated seedlings from each elevational source were planted in a row in one of four randomly assigned boxes (50

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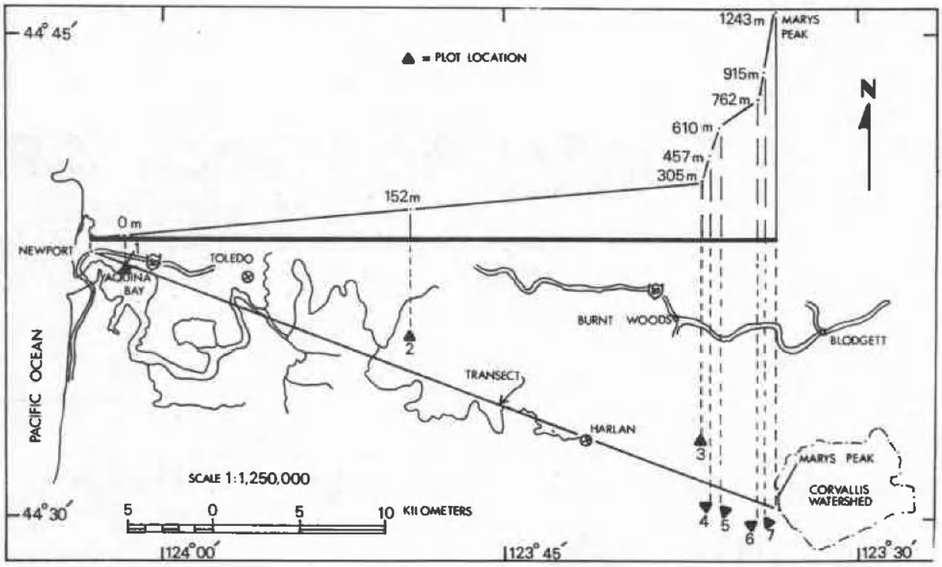

Figure 1.

Elevational levels for collection of red alder seed.

x 25 x 15 cm) containing forest soil collected from an alder site at 457 m (for lack of enough healthy seedlings, the 305-m and 915-m elevational sources were excluded from the transplanting). This was done for the seedlings in each growth room, and all transplanted seedlings were maintained in the same growth room and measured periodically for height. After 20 weeks, we measured the length and width of the leaves, as well as shapes, margins, color of upper and lower surfaces, and pubescence.

results

Conelet color changed from dark brown to yellowish brown as the elevation of the collection site increased (Fig. 2).

Conelet weight decreased 54 percent from lowest to highest elevation (Fig. 3). Weights leveled off at elevations between 457 m and 762 m, then dropped sharply at the highest site. An approximate volume figure calculated from conelet length and thickness also decreased as elevation increased (Table 1A). Analyses of variance show that elevation is a statistically significant ($P = 0.01$) source of variation in both conelet weight and seed weight (Table 1B).

Cleaned red-alder seed from the combined elevational sources (105 samples of 100 seeds each) averaged 0.409 g/1,000 seeds or approximately 2,439,800 seeds/kg.

Seed weight differed significantly between elevational sources (Table 1B). X-ray photographs showed that the low seed weights at elevations between 305 m and 915 m (Fig. 3) were associated with a high percentage of empty seeds.

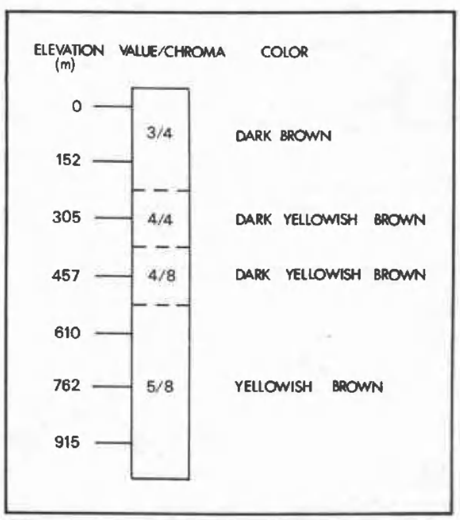

Figure 2.

Color of red alder conelets along an elevational transect between Newport and Marys Peak. Color names and values are based on the Munsell Soil Color Charts.

Germination was rapid, and by the fifth day, 77.3 percent and 78.8 percent of the seedlings had emerged in the 21°C/16°C and constant 21°C treatments. However, seed under the constant 10°C germinated more slowly—only 31.7 percent after 5 days—taking 10 days for 75 percent of the viable seeds to germinate.

Growth rates of the elevational sources did not differ until after 10 weeks (Fig. 4). After 20 weeks, the seedlings were tallest under the constant temperature regime of 21°C and shortest under the constant 10°C.

Length was the only leaf characteristic that varied with growth-room temperature, ranging from 4.5 cm in the 10°C room to 8.4 cm in the 21°C room.

discussion

Many traits differed with elevation along the Newport-Marys Peak transect, especially considering that (1) the transect was short (43.56 km); (2) five of seven elevational sources were within 6 km of the summit of Marys Peak, a rather short distance between collection points despite a rapid change in topography; and (3) the entire transect was located on the west side of the Coast Range.

Early growth differs for red alder grown naturally at various elevations and geographic locations, although we did not detect strong genotype x environment interaction (Table 2). Our results open up avenues for study of ecological preconditioning as suggested by Rowe (1964), who explained that phenotype expression can be frequently understood in the context of preconditioning.

For example, the immature seed is preconditioned not only by the milieu of the parent plant, but

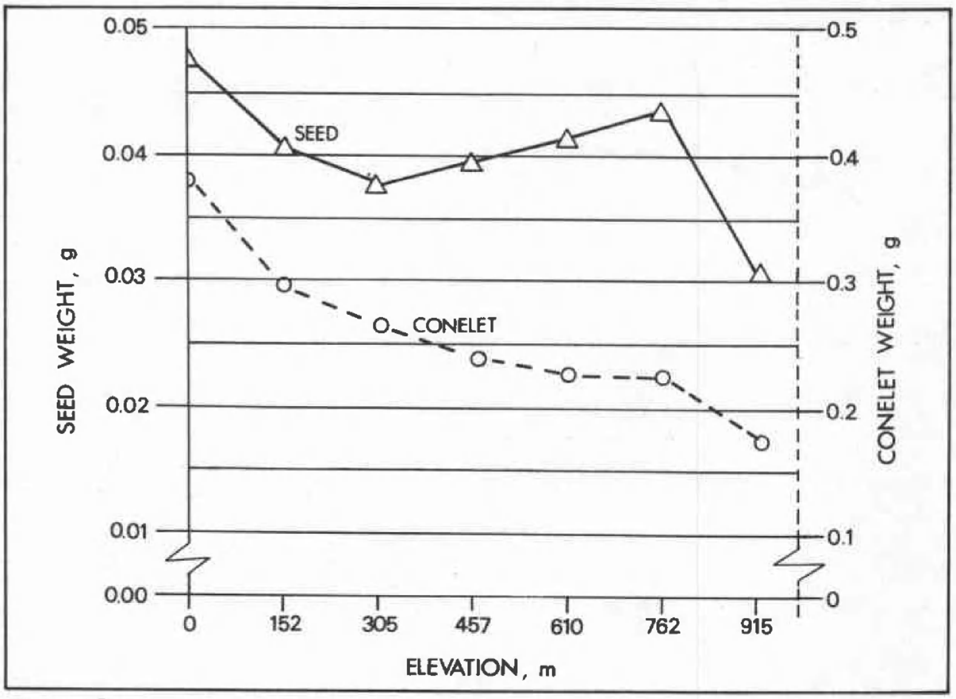

Figure 3.

Weight of conelets and seeds by elevation of collection site.

Table 1.

RESULTS OF ANALYSIS OF VARIANCE.

A. CONELET SIZE

Source of variation	d.f.	Length S.S.[a]	Length M.S.[a]	Thickness S.S.	Thickness M.S.	Length x thickness S.S.	Length x thickness M.S.
Elevations	6	0.75	0.125[b]	0.22	0.0366[b]	3.33	0.5550[b]
Replications	4	0.10	0.025	0.03	0.0075	0.28	0.0700
Error	24	0.25	0.010	0.13	0.0054	1.09	0.0454
Total	34	1.10		0.38		4.70	

B. WEIGHT OF CONELETS AND SEEDS

Source of variation	d.f.	Conelet weight S.S.	Conelet weight M.S.	Seed weight S.S.	Seed weight M.S.
Elevations	6	51.15	8.53[b]	0.0087	0.00145[b]
Replications	4	4.61	1.15	0.0000	0.00000
Error	24	18.32	0.76	0.0010	0.00004
Total	34	74.08		0.0097	

[a]S.S. = sum of squares; M.S. = mean of squares.

[b]Significant at $P < 0.01$.

also by past climatic conditions experienced by the plant itself. When seedlings of white spruce [*Picea glauca* (Moench) Voss] were brought to the same uniform environment, those grown under cool nights the previous season flushed later than those grown under warm nights (Waldron 1962). Flowering is frequently triggered by early acting environmental signals (Allen and Owens 1972). Therefore, the environmental history of a plant must be considered if the phenotypic variability of a population is to be understood.

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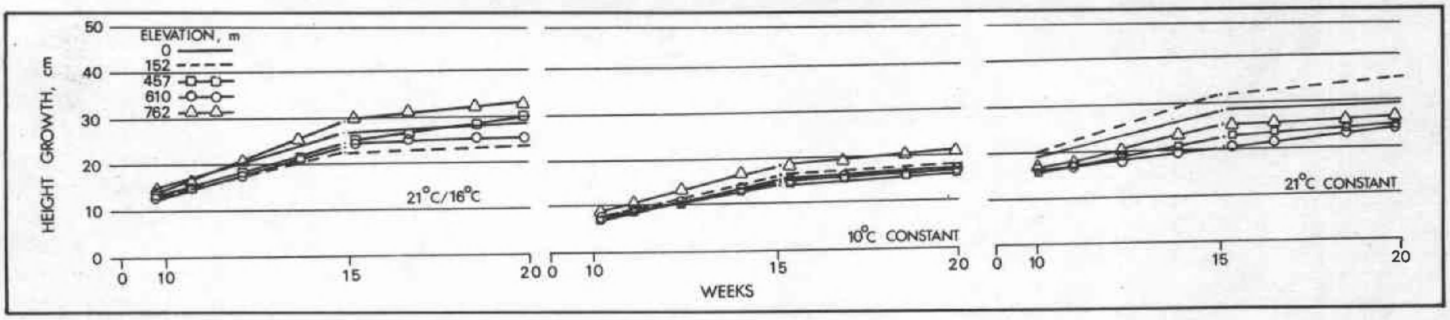

Figure 4.

Seedling growth by elevational source at different temperature regimes.

Table 2.

RESULTS OF ANALYSIS OF VARIANCE FOR SEEDLING HEIGHT.

Source of variation	d.f.	Height S.S.[a]	Height M.S.[a]
Main Plots			
Temperature treatment (T)	2	1,530.77	765.39[b]
Blocks	3	24.55	8.18
Error a	6	238.99	39.83
Subplots			
Elevations (E)	4	123.81	30.95
E x T	8	390.23	48.78
Error b	36	984.32	27.34
Total	59	3,292.67	

[a]S.S. = sum of squares; M.S. = mean of squares.

[b]Significant at $P < 0.01$.

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