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Early Wide Spacing in Red Alder (*Alnus rubra* Bong.): Effects on Stem Form and Stem Growth

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Abstract

A thinning trial was established in 1962 in a 7-year-old red alder stand in northwestern Washington. Spacings were 8 x 8 ft (dense), 12 x 12 ft (intermediate), and 16 x 16 ft (open). The effect of early thinning on growth and stem form was measured in 1982, 20 years after spacing treatment. There was negligible tree lean and sweep in open and intermediate stands except in areas affected by trees leaning into the plots from outside. Red alder trees generally appear to be displaced horizontally by competing trees toward nearby open areas. Production of straight, nonleaning trees can be achieved by wide and even spacing at an early age. Trees grown in this fashion will yield significantly more high-quality wood per unit volume than can be obtained from trees in unmanaged stands.

Keywords: Thinning effects, plantation spacing (-growth, stem form, precommercial thinning.

Introduction

Initial interest in managing red alder (*Alnus rubra* Bong) in the Pacific Northwest centered around the ability of red alder to fix large amounts of atmospheric nitrogen and improve other soil properties (Tarrant and Miller 1963). These effects have since been observed on a wide variety of sites (Bormann and DeBell 1981, Tarrant and others 1969). Alder-induced changes in soil properties can result in large increases in growth of associated species (DeBell and Radwan 1979, Miller and Murray 1978).

The rapid juvenile growth rate of red alder is well known to foresters who have spent considerable effort attempting to remove it from conifer plantations. Growth rate of red alder in unmanaged stands is high (Smith 1974, Smith 1978, Worthington and others 1960), but stem form is usually poor. Thinning increases growth of individual trees, especially in relatively young stands (Lloyd 1955, Olsen 1967, Smith 1978, Warrack 1964, Williamson 1968). Analysis of a young plantation spacing trial

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has shown that stand density is a key factor controlling the partitioning of photosynthate to stem growth (Bormann and Gordon 1984). Precommercial thinning in pure alder stands less than 17 years of age has not previously been evaluated.

The only available projections of growth in managed alder stands (DeBell and others 1978) are based largely on yield tables from unmanaged stands (Worthington and others 1960). Sensitivity analysis has indicated that small changes in projected alder yield will result in large change in profitability of alder grown alone or in crop rotation management systems (Tarrant and others 1983). There is, therefore, a need for better information on alder yield in managed stands.

Tree form must also be considered when evaluating the profitability of alder management. By rough estimate, approximately half of the wood volume in an alder stem is recoverable as lumber relative to wood volume recovery in a Douglas-fir (*Pseudotsuga menziesii* [Mirb.] Franco) stem of equal volume. Leaning trees contain more reaction wood resulting in lower wood quality. If lean and sweep of alder could be reduced through management, the amount of recoverable wood and wood quality would be increased. This would eventually create an increase in stumpage price.

Methods

The study area is in northwest Washington, near Arlington, in a natural stand of red alder that apparently developed in 1955 after a mature conifer stand was removed. An unreplicated thinning trial that consisted of three spacing levels (8 x 8, 12 x 12, and 16 x 16 feet [referred to as dense, intermediate, and open, respectively]) was established in 1962 (at age 7) by Pilchuck Tree Farm, Inc. One-tenth-acre, square quadrats were laid in a line with the dense spacing in the middle. A 16.5-foot strip, thinned to the dense spacing, was left between treatments. No buffer strips were established around the perimeter of these quadrats. The current spacing of the surrounding area appeared similar to the dense spacing treatment. Vegetation in the area consists of pure and mixed stands of Douglas-fir and red alder with occasional western hemlock (*Tsuga heterophylla* [Raf.] Sarg.) and western redcedar (*Thuja plicata* Donn ex D. Don). Common understory species include salmonberry (*Rubus spectabilis* Pursh) and elderberry (*Sambucus racemosa* L.). The soil is a gravelly silt loam developed on glacial till.

For the intermediate and open spacings, we measured diameter at breast height (d.b.h.), total height (linear distance from tree base to tree terminal), and degree and direction of lean on all trees in the quadrats. Lean is defined as the angle between two lines--one an imaginary vertical line originating at the tree base and the other a straight line from the tree base to the terminal bud. Tree volume was calculated using the equation by Curtis and others (1968). Twenty trees in the dense spacing were randomly selected in order to calculate an average height and degree of lean for that plot. A volume-d.b.h. equation was constructed from these trees to predict tree volume on a stand basis. Degree and direction of lean of all border trees adjacent to open and intermediate quadrats were also evaluated. Border trees were judged to be leaning into the plots if their horizontal direction of lean exceeded 10 degrees from the plot border line toward the plot.

Results

Many trees outside the open and intermediate stands leaned directly into the plots and greatly influenced the growth of trees in the plots near the perimeter (table 1). In the open and intermediate quadrats 86 percent and 56 percent of these trees, respectively, leaned into the plots. The ratio of these trees leaning in and out of the plots (12.5 and 5.0) was considerably higher than 1, the value expected if trees leaned in random directions. Thus, for both open and intermediate spacing, only the interior quarter of the 0.1-acre plots was considered to be representative.

Trees in the interior quarter of the open and intermediate quadrats had little or no lean, averaging only 1-2 degrees. Lean was much higher on the outer three-quarters of these plots. This is attributable to the effects of trees outside the plots leaning in. The highest average lean, nearly 4 degrees, was observed in the dense spacing. Examination of tree location and degree and direction of lean makes it clear that trees lean toward previously open areas if displaced by competing trees (fig. 1). This is further demonstrated by a row of alders planted in an open field (fig. 2). Here all adjacent trees lean in opposite directions. In general, curvature or sweep appears to be positively related to the degree of lean.

Wide spacing effectively redistributed growth to fewer trees. Cubic volume to a 4-inch top (CV4) per tree increased from 9.1 cubic feet in dense stands to 15.6 cubic feet and 25.4 cubic feet in intermediate and open quadrats, respectively. Site index (Worthington et al. 1960) based on the tallest 40 per acre (minimum of 4 trees) was 114 to 119.

Table 1--Effect of spacing on growth and tree lean

Variable	Dense spacing with side buffers only	Intermediate spacing		Open spacing	
		Entire plot no buffer	Interior quarter	Entire plot no buffer	Interior quarter
Average d.b.h.	7.0	9.1	8.9	9.9	11.2
Average height	76.7	81.5	83.2	82.3	84.5
Average height of four tallest trees 1/	84.0	87.8	85.8	87.4	84.5
Site index of four tallest trees 2/	114	119	117	119	115
Number of trees per acre	500	200	280	150	160
Percent mortality 3/	27	34	8	12	6
Average CV4 per tree 4/	9.07	16.53	15.55	19.44	25.38
CV4 per acre	5/ 4531	3306	4355	2916	4060
Percent leaning in 6/	-	58	-	86	-
Number leaning in per number leaning out 6/ 7/	-	5.0	-	12.5	-
Average lean	3.8°	3.4°	2.0°	2.9°	1.0°

- = no data

1/Equals tallest 40 trees per acre on 0.1-acre plots.
2/From Worthington and others (1960).
3/Current density relative to spacing density.
4/Using equations of Curtis and others (1968).
5/Volume in this plot based on d.b.h.-CV4 equations: CV4 = 3.06(d.b.h.) - 12.3; R^2 = 0.970.
6/Trees outside the plot that are leaning into the plot.
7/Disregards trees leaning nearly parallel (+/-10°) to plot line.

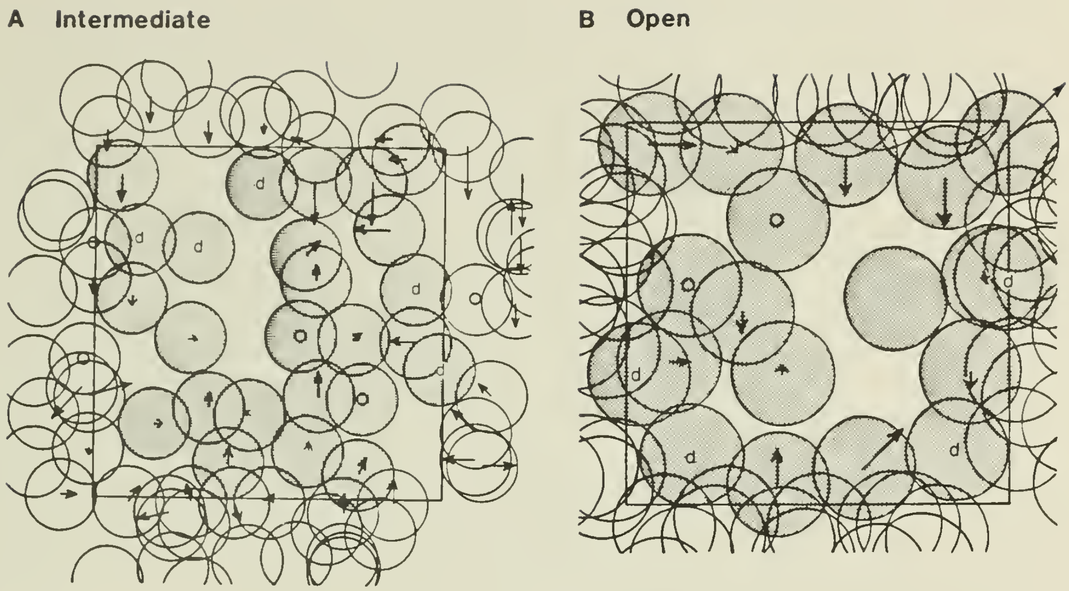

Figure 1.--Stem maps and degree and direction of lean for intermediate (A) and open (B) stands. The area of circles represents the area theoretically available for each tree based on treatment spacing (spacing distance squared). Arrows indicate direction of lean. The length of each arrow is proportional to the maximum degree of lean. A "d" next to trees within plot boundaries indicates a standing dead tree. An open circle at the tree center indicates there was no measurable lean.

Figure 2.--In a row of alder planted in an open field, adjacent trees tend to lean, in opposite directions, toward open areas.

Estimates of CV4 per acre at age 27 ranged from 2,916 to 4,531 cubic feet. A standing CV4 of 4,718 cubic feet per acre can be extrapolated from projections made by DeBell and others (1978) for a 28-year-old alder stand growing on site 115 with initial plantation spacing of 8 X 16 feet and thinned to 16 X 16 at age 9. This projected value is 16 percent higher than the volume observed in the open quadrat (4,060 cubic feet). This discrepancy may be explained in a number of ways. First, the projection includes an additional year's growth and assumes no mortality other than by harvest. If the CV4 of an average tree in the open quadrat is multiplied by the spacing density (170 tree per acre), the CV4 is calculated to be only 9 percent less than the projected value. Second, juvenile growth in a plantation might be expected to be higher than in a thinned natural stand because trees are planted and because they would probably experience less intraspecific competition before age 7. Thus, it appears these data are supportive of the projections by DeBell and others (1978).

Conclusions

This unreplicated case study offers evidence that thinning red alder at an early age is effective in reallocating stem growth to fewer stems. On this site it appears that after thinning to a 16 x 16 feet spacing at age 7, trees with an average d.b.h. of 12 inches can be produced in 28-29 years.

Trees in open stands did not lean and appeared to have little sweep. Lumber recovery from these trees should be much higher than that from trees in unthinned plots. Wood quality may also be improved because less reaction wood is formed. At least two-thirds of the length of stems in the open quadrat were free of branches. Branches in the live crown were not excessively large and a minimal amount of epicormic branching was noted. Measurements and observations suggest that stumpage price for trees in managed stands should be appreciably higher than that for unmanaged natural stands.

Lean in red alder is attributed largely to horizontal displacement of crowns toward openings. Trees with the least competition did not lean, even if openings were present nearby. Wide and even spacing should substantially reduce lean in red alder.

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Metric Equivalents

1 inch = 2.5 centimeters
1 foot = 30.5 centimeters
1 cubic foot = 0.0283 cubic meter
1 acre = 0.4047 hectare

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