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Pruning Density and Severity in Coastal Western Hemlock: 4-year Results

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Abstract

Pruning density is the relative number of trees pruned; *pruning severity* is the amount of live crown removed. Pruning density and severity experiments were installed in two coastal western hemlock (*Tsuga heterophylla* [Raf.] Sarg.) plantations, 12 and 13 years old, on Vancouver Island. The pruning density experiment indicated that a single 3-m pruning lift significantly reduced 4-year average diameter by 1.3 cm and height by 0.5 m, regardless of whether all or half the trees were pruned on a plot. Treatments in the pruning severity experiments reflected a range of residual crown lengths: 1.5, 2.5, 3.5, and 4.5 m, plus no pruning (control). After 4 years, there were obvious downward trends in both average diameter and height with increasing pruning severity. Significant growth reduction appeared below a threshold of about 50% retained crown ratio. The most severe pruning treatment (1.5 m) reduced 4-year average diameter by 4.3 cm and height by 1.5 m, compared with the control.

About Pruning

When applied properly, pruning can increase stand value by increasing the proportion of more valuable clear (knot free) wood. Historically, most pruning research on the Coast has focused on Douglas-fir, yet British Columbia's coastal western hemlock harvest was 1.8 times greater than Douglas-fir in 1995–96. The rise of western hemlock as a commercial species has also led to an interest in pruning, particularly given the suitability of western hemlock for millwork applications (mouldings and turnings), which favour clear wood.

Pruning severity refers to the amount of live crown removed. Growth reductions normally increase as pruning severity increases. The timing of pruning in young stands (less than 20 years old) must balance possible growth reductions with the need to produce clear logs in merchantable lengths (e.g., 3 m). Early pruning minimizes the diameter of the knotty core and dramatically increases clear lumber recovery, whereas delayed pruning lengthens the rotation required to achieve similar clearwood goals. For this reason, economics favours very early pruning, even at the expense of some growth.

Pruning density refers to the relative number of trees pruned within a stand. Simple economics favours pruning only the crop trees that will survive until final harvest. However, pruning only some of the trees in a stand may put pruned trees at a growth disadvantage compared with unpruned trees, possibly even threatening their status as future crop trees.

Few studies in North America have looked at the critical trade-offs between pruning density and/or severity and tree growth in young stands, especially for western hemlock.

Vancouver Island Studies

Pruning experiments were installed within two established orchard-progeny trials of open-pollinated coastal western hemlock (*Tsuga heterophylla* [Raf.] Sarg.) on Vancouver Island. The Jordan River site is located west of Victoria in the Very Dry Maritime Coastal Western Hemlock (CWHxm) biogeoclimatic subzone at an elevation of 20 m. The site was planted in 1981. At the time of pruning (age 13), stand height and diameter averaged 6.5 m and 8.6 cm, respectively.

The Naka Creek site is located north of Campbell River in the Submontane Very Wet Maritime Coastal Western Hemlock (CWHvm1) subzone at an elevation of 213 m. The Naka site was planted in 1982. At the time of pruning (age 12), stand height and diameter averaged 5.0 m and 6.4 cm, respectively.

Both sites were planted with 1-0 stock at 2-m spacing (2500 stems/ha) and were regularly brushed and weeded up to age 10. Trees on both sites averaged 5 years to breast height, with the 100 tallest trees per hectare averaging 2–3 years to breast height. Before pruning in 1993, both sites were alternate-row thinned to a 4-m spacing (625 stems/ha). Pre-pruning crown ratios (crown length / tree height × 100) averaged 86% at Jordan River and 93% at Naka Creek.

A pruning density study was installed only at Naka Creek. Four replications of three treatments were randomly assigned among twelve 0.0768-ha plots in an area adjacent to the severity experiment. The treatments represent three different pruning densities: all the trees pruned, half the trees pruned, and no trees pruned. Trees were pruned uniformly to 3 m above ground; trees less than 4.5 m tall were not pruned.

A pruning severity experiment was installed at both sites. Three replications of five pruning treatments were randomly assigned among fifteen 0.0576-ha plots at each site. The five pruning severity treatments (Table 1) targeted a range of pruning severity based on residual crown lengths of

TABLE 1 *Equivalent expressions of average live crown retention resulting from five pruning severity treatments at Jordan River and Naka Creek*

	Retained crown length		Retained crown as proportion of original		Retained crown
Site	Target[a] (m)	Actual[b] (m)	Length (%)	Volume (%)	ratio[c] (%)
Jordan River	1.5	1.5	31	11	26
	2.5	2.5	48	20	41
	3.5	3.4	56	28	49
	4.5	4.2	77	59	67
	Control[d]	5.5	100	100	86
Naka Creek	1.5	1.5	35	12	33
	2.5	2.5	56	31	51
	3.5	3.4	73	53	68
	4.5	4.0	89	82	83
	Control[d]	4.6	100	100	93

a Experimental treatment target.
b Actually achieved.
c Crown length / tree height × 100.
d No pruning.

1.5, 2.5, 3.5, and 4.5 m, plus no pruning (control); trees less than 4.5 m tall were not pruned.

Trees at both sites were measured immediately before and after pruning, and again after 4 years. In general, there were no significant diameter (breast-height) or height differences among the plots within each of the three experiments at the time of treatment. There was one exception: trees in the 3.5-m severity plots at Jordan River initially averaged 1.7 cm larger in diameter and 0.9 m taller than those in other treatments. This was most likely related to observed differences in soil drainage across the site.

Analyses of covariance in conjunction with orthogonal contrasts were used to test for statistically significant differences between treatments 4 years after pruning. For this report, statistically significant effects were determined at the $p < 0.05$ level.

Density: 4-year Results

For the Naka Creek density trial, pruning significantly reduced 4-year average diameters by 1.3 cm and heights by 0.5 m, regardless of whether all or just half the trees on each plot were pruned (Figure 1). Further analysis of the half-pruned plots also indicated that there was no difference in the growth of pruned trees that were surrounded by pruned trees compared with those surrounded by unpruned trees.

Severity: 4-year Results

The five pruning treatments were originally defined in terms of retained crown length; Table 1 and Figure 2 also show these same treatments expressed as retained crown length (as percentage of original), retained crown ratio, and retained crown volume. Crown volume was estimated from crown length and width measurements and adjusted for non-foliated interior crown volume.

Four years after treatment, at both sites there were obvious downward trends in both average diameter and height with increasing pruning severity. Two aspects must be considered when examining these trends. First, trees at Naka Creek were younger and shorter than trees at Jordan River. Consequently, the fixed crown-length retention treatments at NakaCreek had somewhat larger impacts on retained crown length, crown volume, and crown ratio than at Jordan River. Second, trees on the Jordan River 3.5-m treatment plots were initially taller, thereby skewing (decreasing) the impact of that particular treatment at Jordan River. Both of these effects are visible in Figure 2.

Compared with controls, pruning significantly reduced 4-year average diameters on all four pruning treat-

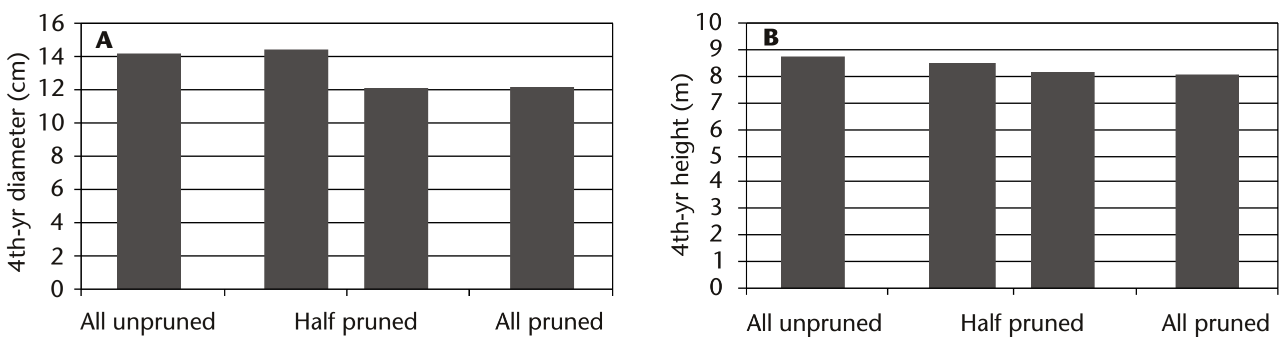

FIGURE 1 *Four-year average diameters (A) and heights (B) for the pruning density experiment at Naka Creek. Pruning density treatments were no trees pruned (left bar), all trees pruned (right bar), and half the trees pruned (centre bars: left, the unpruned trees; right, the pruned trees).*

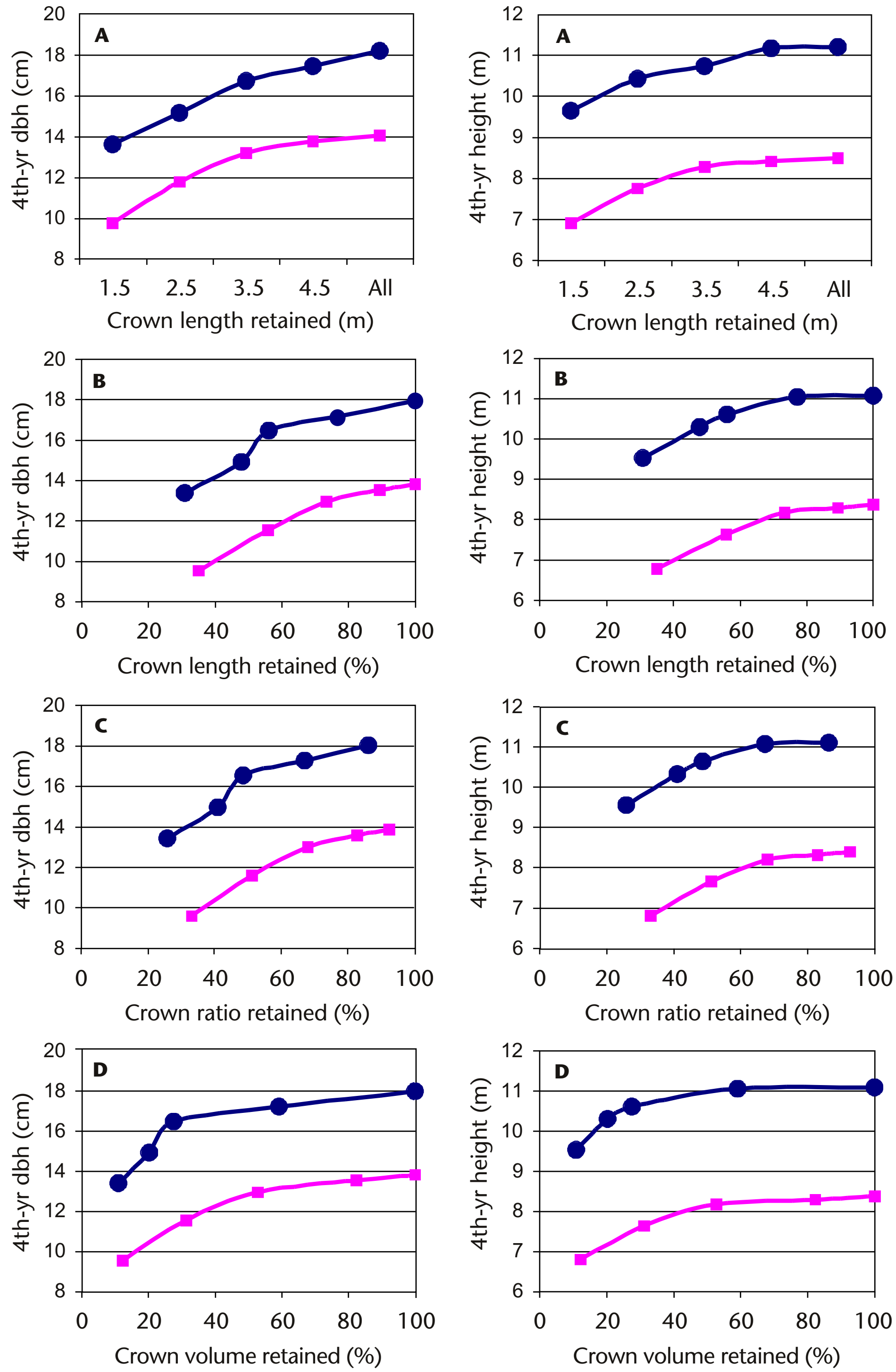

FIGURE 2 *Four-year average diameters (left) and heights (right) for the pruning severity experiments at Jordan River (upper lines) and Naka Creek (lower lines). Each pair of graphs expresses the same five pruning severity treatments in terms of retained crown length in metres (A), crown length as a percentage of original (B), ratio of crown length to tree height (C), and crown volume as a percentage of original (D).*

ments at Jordan River; this was the case at Naka Creek only on the three most severe treatments. Four-year average heights were significantly less than the unpruned controls on the three most severe treatments at Jordan River, but on only the two most severe treatments at Naka Creek.

At Jordan River and Naka Creek, the most severe pruning (1.5 m) reduced 4-year average diameter by 4.4 and 4.3 cm and heights by 1.5 and 1.6 m, respectively. Four-year mortality on the most severe pruning treatment averaged 9% at Jordan River and 15% at Naka Creek; mortality on all other treatments averaged 5% at both sites. After 4 years, the frequency of epicormic branching was quite low across all treatments, but was more frequent on the most severely pruned trees.

Operational Implications

Four years after pruning at the Naka Creek pruning density experiment, the height (crown position) of the pruned trees averaged 0.5 m shorter than that of unpruned trees overall. This height reduction was the same regardless of whether all or half the trees had been pruned on each plot (Figure 1). Continued monitoring of this experiment will be needed to determine whether this height reduction caused by pruning will have long-term effects on the crop tree status of pruned trees, especially on plots where half the trees were left unpruned.

With increasing pruning severity, the negative effects of crown loss appeared first in diameter and then in height at both sites. Four-year trends indicate that pruning severity began to have a significant impact on both height and diameter once pruning retained less than 3.5–4.5 m of crown. On both sites, this threshold is approximately equivalent to a retained crown ratio of 50%, which coincides with the current 50% crown retention guideline of the Forest Practices Code *Pruning Guidebook* (B.C. Ministry of Forests 1995). However, after 4 years, trees on both sites pruned to the Guidebook's retention minimum of 30% crown ratio (1.5-m treatment) were approximately 1 m shorter than trees pruned to the 50% guideline. Pruning to a 30% crown ratio appears to be too severe for trees this young. Continued monitoring of these experiments will provide data needed to better examine the trade-offs between economics (clear lumber recovery) and the potential for negative growth impacts.

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