Growth of Residual Branches on Pruned Coastal Douglas-Fir

Eric C. Turnblom, *and* **Randol L. Collier,** *Stand Management Cooperative, College of Forest Resources, University of Washington, Box 352100, Seattle, WA 98195-2100.*

ABSTRACT: *Anecdotal evidence gathered from pruning crew observations indicates that there may be enhanced branch growth at the new crown base in young pruned coastal Douglas-fir* (Pseudotsuga menziesii *var.* menziesii) *trees compared to unpruned trees. This has the potential to reduce the quality and value of the stem above the pruned portion of the bole. An analysis of the size of branches in the remaining crown on pruned trees and matched unpruned trees of the same size at the time of pruning indicates that residual branches do not increase in diameter or length in response to light and moderate pruning. However, with a severe pruning there was a modest increase in branch length. Residual branch size in response to pruning 4 yr after treatment appears to offer no real risk in degrading quality of the unpruned portion of the stem as a cost for increasing the quality of the pruned stem. West. J. Appl. For. 18(3):185–188.*

Key Words: Branch length and diameter growth, wood quality.

Pruning is one of the most labor intensive, thus most expensive silvicultural treatments that a forest manager can prescribe. The decision to prune or not depends upon whether the anticipated benefits, which may include such intangibles as aesthetics and greater growth of understory vegetation for habitat enrichment, justify the economic costs of the treatment. If done properly, pruning can increase the volume of the more valuable clear wood grown in a given rotation, thereby increasing the final value of the harvest. However, a mistiming or misapplication of the selected pruning regime can just as easily fail to improve the final yield of clear wood produced. For example, Collier and Turnblom (2001) found that epicormic branching in response to a severe pruning could threaten final clear wood yield in coastal Douglas-fir. Another potentially negative side effect of a pruning treatment might occur on the unpruned portion of the stem. Anecdotal evidence, from pruning crews making second lifts of pruning treatments in young coastal Douglas-fir stands, indicated that there may be enhanced branch growth at the new crown base of the pruned trees in contrast to unpruned companion trees. Should this be the case, then pruning Douglas-fir stands may potentially degrade the stem quality of the unpruned portion of the trees, and therefore reduce the total value of the final crop.

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In conifers, the crown is the sole source of photosynthate and the larger the crown is, the faster the tree can grow. Unfortunately, from a wood product perspective, the large crowns needed for fast tree growth will also lead to larger knots and hence lower grades of logs (NLRAG 1998), lumber and veneer (APA 1986, WWPA 1995) and lower quality of pulp (van Wedel et al. 1968). Studying the crowns of forest trees is difficult, awkward, and expensive and becomes increasingly so as the tree develops. The bulk of our knowledge of the dynamics of tree crowns has been deduced from analysis of knots by authors such as Fujimori (1993), Kershaw et al. (1990), and Maguire et al. (1994). It has been long known that crowns of trees grown in widely spaced stands tend to be longer and wider with larger diameter branches than those crowns of trees grown in denser stands. It has been established that branches in the lower portions of the crown in closed stands will cease to grow in diameter long before they die (Fujimori 1993, Kershaw et al. 1990, Maguire et al. 1994). Reukema (1959) termed these branches nonfunctional since it was hypothesized that branches putting on no growth would not export photosynthates to the main stem. Further, it has been hypothesized that the removal of these nonfunctional branches can actually improve the form, quality, and growth rate of the pruned tree (Fight et al. 1993). However, the response of these nonfunctional branches to silvicultural treatments is unknown. In general, it might be expected that the response of the individual branches of a tree to an increase in resources from thinning or fertilization would lead to increased branch growth, particularly if the branches are vigorously growing initially. In contrast, it may be that there would be no increase in the growth rate of the branches remaining after a pruning treatment, particularly if the branches were in a state of low vigor before pruning. However, if the least thrifty branches were removed by pruning, more resources might be available for those branches that remained above the pruning lift resulting in increased branch size. In this article we present the results of an analysis of the effects pruning has on branch size in length and diameter using data from pruned and unpruned trees (4 yr after the pruning treatment), which have been paired on the basis of prepruning dimensions.

Data and Methods

The Stand Management Cooperative started a crown reduction study in Douglas-fir stands in 1990 to examine stand conditions and pruning regimes and their positive and negative effects on tree, log, and lumber quality and yield. This study is part of a larger project designed to evaluate a wide array of treatment regimes on tree and stand growth and yield and wood quality (Maguire et al. 1991). The crown reduction study consists of fifty-six 0.08 ha plots in 18 installations located in Oregon, Washington, and British Columbia. Each of the 18 installations contains three 0.08 ha pruned plots. These plots were thinned to residual densities that would not exceed an operationally feasible number of trees/ha to prune by leaving one-half (ISPH/2), one-quarter (ISPH/4), or one-eighth (ISPH/8) of the initial stems/ha (ISPH). Each installation has this set of three pruned plots in one of two possible configurations. One configuration consists of two ISPH/2 plots and one ISPH/4 plot, the other consists of two ISPH/4 plots and one ISPH/8 plot. Also, each installation has either two or three control (unpruned) plots that have been similarly spaced. Actual stems/ha resulting from these spacings range from 210 to 670 SPH. The pruning treatments consisted of removing 20, 40, or 60% of the live crown present on every tree in the stand, when the dominant height reached approximately 9.1 m. A description of the stand data is found in Table 1.

To examine the effects of the crown reduction in detail, pruned trees were paired with unpruned trees in adjacent plots that were within 0.2 cm of dbh and 1 m of height at the time of pruning and growing under equivalent spacing regimes. Since prepruning branch dimensions are not available, we assume that because each pair of trees was chosen to be similar in dbh, total height, and crown length, it should follow that branches at corresponding heights on the bole also have similar dimensions. This assumption is supported by the form and function of branch diameter profile models for conifers found in the literature in that all predict similarly sized branches at a given height or relative height along the bole for trees of a given dbh, total height, and crown length or crown ratio (Maguire et al. 1999, Colin and Houllier 1991). Further, since the stands on which this study is based were selected for uniformity, which included the requirement that live crown ratios should be at least 80%, were planted at the same time with the same stock type, and received the same early vegetation control (if any), the assumption that similarly sized branches in both pruned and unpruned trees prior to pruning is tenable. This implies that any differences found between remaining branches on the pruned and unpruned trees some time after pruning can be attributed to the pruning treatment.

Pruned trees were chosen in a stratified random sample to ensure adequate representation across the diameter distribution found on the pruned plots, then trees from the corresponding unpruned plots were chosen purposively so that the initial dimensions of the unpruned trees matched the prepruning dimensions of the pruned trees as closely as possible. On these pairs of trees we collected the following data 4 yr after the initial pruning treatment: total height, dbh, stem diameter at one-third total height, at 5.3 m, and at the crown base, height of the crown base, and horizontal and vertical basal diameter and length of the largest branch at the base of the crown on the pruned tree. The relative height of the crown base was calculated for the pruned tree; then the whorl on the unpruned tree closest to that relative position was located and measured in the same manner. These measurements were difficult and time consuming to obtain in that they required climbing the unpruned tree and measuring the branches intact.

Due to the difficulty of getting the branch measurements, particularly those on the unpruned trees, only 285 pairs of trees from 18 installations could be included in this analysis. Using the assumption of equality in initial branch dimensions given a particular stand density, dbh, total height and crown ratio, we used simple differences in branch diameter and length between the pruned tree and its unpruned, paired tree as the response variable (observed difference). Therefore separate paired t-tests (Table 2) were run on the branch diameter and

Table 1. Description of sampled installations.

Installation ID	Elevation (m)	Aspect (deg)*	Slope (%)	King's SI_{50} (m)†	ISPH (no./ha)	Initial age (yr)
704	183	270	20	36	1,482	19
705	823	180	30	27	1,730	17
706	91	270	25	38	1,606	16
708	274	999	5	38	988	13
711	174	999	0	37	1,235	12
713	242	180	5	37	1,359	14
717	305	360	10	38	1,112	12
718	335	888	10	39	1,235	13
722	671	270	10	36	1,112	16
724	537	180	30	35	1,606	13
735	52	999	0	38	1,112	13
736	183	270	40	36	988	12

* 999 indicates that the installation is level with no aspect, while 888 indicates a variable aspect.

† Site index at breast height age 50 yr based on King (1966).

Table 2. Mean differences in largest branch diameter and largest branch length between pruned and unpruned young Coastal Douglas-fir trees for each pruning intensity treatment.

Live crown removal level (%)	Mean diameter difference (cm)	*t*	*Pr* > *t*	Mean length difference (m)	*t*	*Pr* > *t*	*N*
20	–0.0241	–0.842	0.4024	–0.3423	–1.315	0.1923	78
40	–0.0452	–1.691	0.0935	0.1786	0.910	0.3649	103
60	–0.0639	–1.847	0.0687	0.9692	3.948	0.0002	77

length differences for each group of plots receiving the 20, 40, or 60% live crown removal using SAS® software.

Results and Discussion

For the 20% of the live crown removal treatment, 78 pairs of trees were available for analysis. The mean difference in the largest branch diameter and largest branch length between pruned and unpruned trees on the unpruned portion of the bole was –0.0241 cm and –0.3423 m, respectively. These differences, when tested at a 5% level of significance, were not significantly different from zero (P = 0.4024 and P = 0.1923, respectively). This lack of difference might be explained by considering that all branches removed were from the lowest, perhaps least productive region of the live crown (Kershaw et al. 1990, Fujimori 1993, Maguire et al. 1994). Thus, the removal of these least vigorous, least productive branches induced no significant alteration in the carbon balance or other source-sink relationships in the trees (Sprugel et al. 1991). With such a small amount of crown removed it is likely that the new crown base is still within the portion of the crown that is least active photosynthetically. Therefore, the residual branches do not undergo any appreciable increase in either internal or external resources.

For the 40% pruning intensity treatment 103 paired trees were available for analysis. The mean difference in branch diameters was found to be –0.045 cm, which is not significantly different from zero when tested at the 5% significance level (P = 0.0935). Further, the mean difference in branch length was found to be 0.178 m and is also not significant at the 5% level tested (P < 0.3649). This indicates that branches in the unpruned stem segment are approximately the same diameter and length whether on trees having 40% of their live crown removed or on unpruned trees aside from random variation.

There were 77 paired trees available for analysis in the 60% pruning intensity treatment. While there was no difference in the largest branch diameters at the 5% level (P = 0.0687), the largest branch length between pruned and unpruned trees was different from zero (P = 0.0002). Branches on the pruned trees were longer than the branches on unpruned trees by an average of 0.969 m. Though it is recognized that branch diameters are highly correlated with branch lengths, a concomitant increase in pruned branch diameter was not observed, perhaps due to the response in diameter lagging temporally behind length response. For example, wood production leading to diameter growth of the stem and branches is almost last on the allocation priority list, trailing behind maintenance respiration, fine root production, seed and other reproductive tissue production, and vertical and lateral shoot elongation (Oliver and Larson 1996, p. 75, and references therein). Therefore the observed response is easily explained by considering the following. First, the remaining 40% of the crown is in a relatively high light environment to begin with so pruning does not increase the light available to these remaining branches; therefore the impetus to increase vertical elongation is lacking. Second, there are likely more internal resources (e.g., water and nutrients) available to the remaining branches, thus the remaining crown effectively utilizes these resources to increase lateral elongation of branches. This is presumably the most effective way for the tree to recover its lost crown because many points expanding laterally will increase crown volume quicker than the elongation of just the terminal leader. However, removal of 60% of the live crown does affect whole photosynthate production and stem growth (i.e., decreases both). Trees undergoing such severe pruning recover using two mechanisms—first, each year's height and branch growth re-establishes the crown, and second, epicormic shoot production occurs along the pruned portion of the stem (Collier and Turnblom 2001).

Conclusions

Branches at the pruned crown base were not affected by either light pruning (about 20% live crown removal) or moderate pruning (about 40% live crown removal) in terms of the diameter or length when compared to branches at the same height position on unpruned trees after 4 yr. However, severe pruning (about 60% live crown removal) produces statistically significant differences between pruned and unpruned trees in terms of branch length but not branch diameter. The observed reduction in branch length and the mild reduction in branch diameter in the pruned trees could be presumed to improve log quality in stands similar to those treated in this study. However, previous research demonstrated that with severe pruning there is a substantial risk of epicormic branching on the pruned portion of the bole that is likely to degrade the quality of the pruned log (Collier and Turnblom 2001).

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