Response of Young Red Alder to Pruning

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Abstract

Red alder (*Alnus rubra, Bong*.) is the most common hardwood in Washington, Oregon and British Columbia. It is used for a variety of products including firewood, pulp, and solid wood products such as furniture, cabinets and musical instruments. Pruning may be a viable management technique for increasing clear wood and, thus, value in managed stands but little information has been available. To determine the biological effects of pruning red alder, we selected 530 trees in 3-, 6- and 10-year-old plantations. Sample trees were from plots that had different previous silvicultural treatments, providing a range of growth rates. Pruning removed one third of the live crown, was performed on seven dates throughout the year, and included both live and dead branches as well as a sub-sample of intentionally damaged collars around dead branches. The rate of branch occlusion (healing) was well correlated with tree growth at breast height and with distance from the base of the live crown. Live branches occluded more rapidly than dead branches and dead branches occluded more rapidly if the branch collar was intentionally wounded during pruning. The number of epicormic branches induced by pruning was minimal, but increased with tree age and where trees were growing in an open condition. No stem breakage or sunscald was observed as a result of treatment. Six years following pruning, 91% of pruned branches less than 1 cm in diameter and 80% of branches 2–3 cm in diameter had completely occluded. Those that had not occluded by that time were on trees with low growth rates. Time of year of treatment had little effect on tree growth rates, occlusion rate, epicormic branch formation, and damage. Pruning young trees did not result in any damage or loss of growth. To maximize the amount of clear wood it would be best to prune as soon as logistically possible. Thus, if economic incentives are present for clear wood, landowners and managers may want to consider pruning young trees, taking into account the possible need for multiple lifts.

Keywords: red alder, *Alnus rubra*, pruning, branch occlusion, silviculture

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Introduction

It is well known that initial density affects diameter growth. We can produce larger diameter trees more quickly if they are grown at wider spacings than if they are grown at narrower spacings. Associated with wide spacings, however, is the production and retention of large diameter branches, especially on the lower bole of the tree. These branches reduce the log grade and consequently reduce the products (and values) for which the log can be used. Some foresters have speculated that the lowest-cost option to produce quality wood would be to grow the trees at spacings close enough to cause natural death and abscission of the lower branches. However, this strategy assumes that dead branches will be shed soon after the abscission process is complete and that stem breakage will occur at a point close to the tree bole. It will also either increase the time required to produce trees of a specified size or require thinning after branches have naturally abscised. An alternative strategy would be to plant at wide initial spacings and plan to artificially prune the trees. While pruning can be an expensive process, the costs may be justified if increases in log quality can be transformed into increases in log value.

Pruning red alder has not previously been examined in a comprehensive manner. The only published report is that of Berntsen (1961) where 21-year-old trees were pruned, then examined 22 years later to see what the effects were on wood quality. Bernsten concluded that pruning did increase the amount of clear wood produced, but warned that epicormic branches could result in defects such as knots or blemishes. No other information is available specific to alder, however, much information is available in the forestry or horticultural literature on the effects of pruning on plant growth and on methods for pruning (O'Hara 1989). In addition, there is substantial information in the botanical literature on the physiological responses of plants to wounding (i.e. the removal of live branches).

Studies on the time of year of pruning are generally limited to only a few dates and do not include information on the phenological status of the trees. In addition, the results differ by species and the response variable considered. For example, Krinard (1976) concluded that summer pruning of eastern cottonwood was better than spring pruning because it resulted in fewer and shorter epicormic branches. McQuikin (1950) recommended pruning eastern hardwoods (except red maple) in late winter or early spring to achieve fastest wood occlusion; he recommended pruning red maple in late spring or early summer to reduce excessive bleeding (sap exudation). Neely (1970) reported May-pruned eastern hardwoods healed more quickly than July- or March-pruned trees. October-pruned trees healed much more slowly than trees pruned at the other three dates. Childs and Wright (1956) reported higher incidence of infection in Douglas-fir spring-pruned wounds than fall-pruned wounds. Shigo (1976) reported different decay mechanisms invaded eastern hardwoods depended on the time of the wounding. Leben (1985) concluded that spring wounding of red maple resulted in less dieback around the wounds and less decay than fall wounding. Puritch and Mullick (1975) reported water stress substantially slowed formation of an impervious layer in grand fir seedlings. Biggs and Cline (1986) reported irrigation to speed up formation of the impervious layer at some sampling dates. Given the range of responses reported in the literature, we could not predict the time of year or growth conditions that would be optimum to prune red alder.

Most pruning studies have dealt with the removal of live branches, but a few have also examined dead branches. Shigo (1986) indicates that branch collars should not be damaged when live branches are pruned, but recommendations are contradictory on the treatment of dead branches. It appears that injuring the branch collar when removing the dead branches will greatly speed up filling in the cavity at the base of the branch, however, Shigo et al. (1979) suggests that this will increase the amount of decay associated with the dead branch. Casual observations have noted that occlusion rates over dead branches on red alder can be slow.

We designed a study to determine the biological effects of pruning young red alder. The study focused on four questions. Are there any negative effects, such as sunscald, sap exudation, or production of epicormic branches, associated with pruning young red alder? If there are negative effects, do they vary by time of year of pruning? What effects do factors such as tree age, growth rate or height on the bole have on the rate of occlusion? Are there positive or negative effects of wounding the collar area around dead branches? A second study (DeBell et al. 2006) quantified internal decay rates associated with a subset of treatments.

Materials and Methods

Alder plantations established at the Washington State Department of Natural Resources' Meridian Seed Orchard near Lacey, Washington and at the Centralia Mining Company—now owned by TransAlta Corporation—near Bucoda Washington, were selected to represent a variety of age groups and silvicultural regimes. The Meridian Seed Orchard included both thinned and non-thinned areas (at 1- and 2-m spacings respectively) from 3-year-old plantations established in 1989, and areas that had been previously irrigated and non-irrigated in 6-year-old plantations established in 1986. Trees selected at TransAlta were in 10-year-old plantations that had been established in 1982; these trees had been planted as part of a spacing trial and included a range of spacings from 2 to 4 m. Initial diameter at 1.3 m and total height are given in table 1. Mean annual precipitation at both locations is 1245 mm with 150 mm falling as rain from June 1 through September 30. Mean annual, mean January minimum, and mean

Table 1—Initial d.b.h. and height, and mean diameter growth from 1991 to 1997.

		Mean d.b.h.	Mean ht	D.b.h. growth 1991-1997 (cm)		
AGE	Treatment	1991 (cm)	1991 (m)	Min	Max	Mean
3	Thinned	4.8	4.7	2.1	12.5	7.5
	Not thinned	4.1	4.1	0.5	6.5	3.3
6	Irrigated	11.6	11.6	1.2	10.6	5.0
	Not irrigated	9.5	9.5	0.8	12.0	4.6
10	n/a	13.3	10.5	1.4	10.3	4.6

August maximum temperatures are 10.1, 0.1 and 25.1 °C, respectively, at the Lacey site and 10.6, 0.6, and 25.3 °C at the Bucoda site (Daly, 1994. http://www.ocs.orst.edu/prism).

The time-of-year portion of the study examined trees pruned on seven separate dates selected to cover the range in tree phenology. The dates (and general phenological condition) were: May 1 (budbreak and leaf expansion), June 15 (active height and diameter growth), August 1 (active diameter growth, height growth primarily over), September 15 (diameter growth continuing but some leaf abscission beginning), November 1 (leaf abscission almost complete), January 1 (deep dormancy, cold temperatures), and March 1 (trees still dormant but temperatures moderating). The first five dates were in 1992 and the last two were in 1993.

On each treatment date 20 trees from the 3-year-old plantation (10 thinned and 10 not thinned); 20, 6-year-old trees (10 irrigated and 10 not irrigated); and 20, 10-year-old trees were pruned to examine the effects of time of year, growth rate, and bole height on response. Pruning was done with a handsaw and the pruners were instructed to not wound the branch collars of either dead or live branches. Furthermore, at the May 1 pruning date, 40 additional 10-year-old trees and 60 additional 6-year-old trees were pruned at the same two sites. This second group of trees had the live branches pruned in the same manner as described above, however, half of all trees at each site had dead braches pruned by removing the entire branch collar (i.e., the swelling around the base of the branch, particularly on the lower side). Removing the entire branch collar (cutting the branch flush with the stem) considerably increased the size of the wound created for all but the smallest branches which had minimal branch collars.

Prior to pruning, all trees to be pruned were marked at 0.3 m on the bole and then every 1 m up the bole until pruning height was reached. Trees in the time-of-year portion of the study were pruned up to a point representing one-third of the existing live crown. For most trees this was approximately a height of 3.3–5.3 m, although 1 tree was pruned up to 7.3 m. All trees in the damaged-branch-collar portion of the study were pruned to 3.3 m. Each pruned branch was tallied by stem section from which it was removed (0–0.3 m, 0.3–1.3 m, 1.3–2.3 m, etc), whether it was alive or dead, and by 1-cm diameter class. Epicormic branches present before pruning were also tallied by stem section and then removed (usually with hand clippers).

After the 1992 growing season, all study trees were measured for stem diameter at 1.3 m, total height, and height to live crown. Diameter at 1.3 m, total height, and number and length of new epicormic branches was remeasured after each growing season from 1993 to 1997. Percent occlusion of all pruning wounds was also measured after each growing season from 1993 to 1997 by visually estimating the percent of the wound area that had been covered by callus (tissue formed over and around a wound). Each tree in the 10-year-old plantation was coded for proximity and direction of adjacent openings that might induce epicormic branching. These codes were not based strictly on spacing of adjacent trees, but also if the opening was sufficiently large to cause a discontinuity in crown closure and allow light to fall upon the bole of the edge tree. Form was assessed after the 1994–1997 growing seasons by measuring stem diameter at 0.3, 1.3, 2.3, and 3.3 m heights on the pruned study trees and on unpruned trees in the same plantations with 1992 diameters similar to those of the pruned trees.

Results and Discussion

Damage to pruned trees

Following pruning, no problems were encountered with sap exudation (bleeding), sunscald, stem lesions, top breakage, excessive production of epicormic branches, or damage by red-breasted sapsuckers on trees from any pruning date. Top breakage and sapsucker damage have been observed on red alder trees operationally pruned when 50% or more of the live crown was removed (C. Harrington, personal observation) but removal of 33% of the live crown in this study did not predispose the trees to damage.

The frequency of epicormic branches increased immediately after pruning (table 2). However, by 1997, the 3-year and 6-year old trees had less than 1 epicormic branch per tree and most of these branches were short and small in diameter. There was a reduction in the percent of trees with epicormic branches in all the plantations throughout the study period. The mean number of epicormic branches per tree remained relatively the same in the 6- and 10-year-old

Table 2—Frequency, mean number and size of epicormic branches at the time of pruning (1992 and 1993) and after the 1994 and the 1997 growing seasons.

Age	% Trees with epicormic branches			Mean number of epicormic branches per tree			% Epicormic branches with a length >=15 cm	
	1992-1993*	1994	1997	1992-1993*	1994	1997	1994	1997
3	41	69	29	1.2	1.9	0.7	0	36
6	5	27	19	0.1	0.8	0.5	3	27
10	33	91	89	0.8	7.4	7.3	65	80

*At time of pruning

plantations and decreased by 37% for trees from the 3-year-old plantation. No relationship was found between the time of year that pruning took place and the number of epicormic branches produced.

Epicormic branches were more likely to be present in a more open environment. At the time of pruning, 56% of the trees in the thinned portion of the 3-year-old plantation—the more open environment—had epicormic branches, compared to only 27% in the non-thinned portion (although both portions had a mean of less 2 small epicormics per tree). By the end of 1994, the crowns had closed in the thinned portion and the number of trees with epicormic branches and the mean number of epicormic branches per tree in the thinned and not thinned portions of the plantation were not significantly different. Although most areas in the 10-year-old plantation had a closed canopy, there were some openings sufficiently large enough to cause discontinuities in crown closure throughout the study period. Trees that had an opening directly adjacent to them (n=50) generally had more epicormic branches per tree than trees with no opening present within 2 rows (n=58), unless the opening was to the north side of the tree (fig. 1, a). If an opening was present 1 row away (n=41), it did not increase the number of epicormics formed unless the opening was in a southerly direction (fig. 1, b).

Berntsen (1961) suggested that production of epicormic branches could be a problem when pruning red alder; however, closer examination of the data from his study (Rapraeger 1949 report on Cascade Head pruning and thinning study, data on file, Olympia Forestry Sciences Laboratory) indicated that the stem sections he examined came from a 21-year-old red alder stand that was heavily thinned (two-thirds of the stems removed) and the large overstory conifers were girdled at the same time as pruning. Thus, the red alders were exposed to a major change in their light environment at the same time as pruning. Even so, the trees at Cascade Head had fairly low numbers of epicormic branches 10 years after these treatments were imposed (14 per tree on the 5-m section that had been pruned) and most (75%) were less than 0.1 cm in diameter. Thus, both the Cascade Head study and our observations confirm that although red alder does produce epicormic branches following pruning, it is not particularly prone to doing so. The results from the Cascade Head study are also consistent with our observation that epicormic branches are more likely to form and persist on older trees.

Growth Rate and Stem Form of Individual Trees

Stem form appeared to be very slightly altered by pruning in all the plantations; however, the differences were not significant ($p \leq 0.05$). The differences in form were most pronounced in the 10-year-olds and although differences between stem form in pruned trees in comparison to trees not pruned was greater in year 5 than in year 2 (fig. 2), it was still not statistically significant. From year 2 (1994) to year 5 (1997), the mean diameter of the bole at heights closer to the base of the live crown, once pruned, increased at a rate greater than the rates at sections lower down on the bole. If this trend continues, it appears the boles of pruned trees will become more cylindrical.

The rate of branch occlusion at various heights up the bole also indicates greater rates of diameter growth closer to the base of the live crown. For example, after 3 growing seasons (trees pruned in May, 1992), mean percent occlusion of live branches 2 to 3 cm in diameter pruned in sections at 1-m intervals (starting at 0.3) up the bole of the trees were 51%, 56%, 60%, 61%, 77%, and 95% (ending at 5.3 m height), respectively. Separated into tree age groups, all 3 ages showed the same trends, although it was more difficult to discern in the 3-year-olds due to smaller branch sizes, reduced number of sections, and more rapid percent diameter growth.

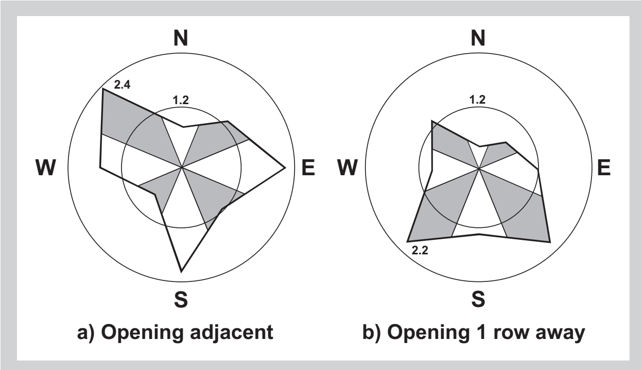

Figure 1—Mean number of epicormic branches in 1994 present on 10-year-old trees that a) had an adjacent opening and b) had an opening 1 row away. Trees with no opening within 2 rows had a mean of 1.2 epicormics per tree and are represented by the smaller inner circle.

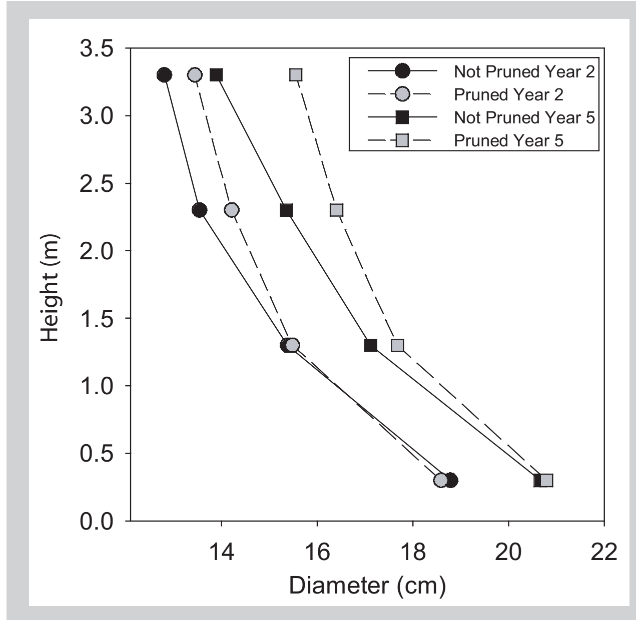

Figure 2—Stem diameter at 0.3, 1.3, 2.3 and 3.3 m height within the 10-year-old plantation on both pruned and non-pruned trees in years 2 and 5.

Factors affecting branch occlusion

There were substantial statistical differences in the degree of branch occlusion by initial branch size, tree size, tree age, and overall growth rate of the tree. For example, 2 years after pruning, mean percent occlusion of branch wounds in the 3-year-old and 6-year-old plantations ranged from only 67% (non-irrigated portion of the 6-year-old plantation) to 94% (thinned portion of the 3-year-old plantation) (fig. 3). Silvicultural factors that affected the rate of diameter growth, such as thinning or irrigation, also had an effect upon the rate of occlusion. Differences in rates of occlusion between the different tree ages can be attributed to both the initial differences in branch size by plantation and to tree growth rates. For example, branches 1 cm in diameter or smaller were 97%, 74%, and 45% of the branches pruned in the 3-, 6-, and 10-year-old plantations respectively.

Mean percent occlusion was also closely related to both branch size and basal area growth (fig. 4). Stem diameter growth varied significantly by age and treatment, as well as by initial tree size (table 1). Diameter growth as a percent of initial diameter prior to pruning (1991) to the end of the 1994 growing season was 49% for the 3-year-olds, 21% for the 6-year-olds, and 17% for the 10-year-olds. These age trends in growth rate as a percentage of initial diameters are also reflected in the mean percent occlusion by 2-cm diameter growth classes. For example, live branches 2 to 3 cm in diameter pruned in the 3-year-old plantation had a mean percent occlusion of 65%, 94%, and 100% for a d.b.h. (diameter at 1.3 m) growth of 0 to 2 cm, 2 to 4 cm, and 4 to 6 cm, respectively. For the same branch diameter and the same dbh growth classes, the mean percent occlusion was 59%, 70%, and 94% for the 6-year-old plantation and 31%, 46% and 51% for the 10-year-old plantation. So, for any given amount of d.b.h. growth, the younger trees grew more in respect to their initial diameter and occluded wounds at a faster rate.

As expected, at the time of the first occlusion assessment at the end of the 1994 growing season, the branches that had been pruned at the earlier pruning dates showed greater occlusion. For example, the percent of live 2 to 3 cm-branches that had reached 90% occlusion or greater was 16% for the May 1, 1992 pruning date, 14% for the June 15, 1992 pruning date, 2% for the August 1, 1992 pruning date, and 1% for the 4 subsequent pruning dates (September 15, 1992; November 1, 1992; January 1, 1993 and March 1, 1993). By the end of the 1995 growing season, the early spring treatments (May ‘92 and March ’93) exhibited slightly slower than expected occlusion rates, but branches of all size classes for all the pruning dates reached 90% or greater mean occlusion by the end of the 1997 growing season (fig. 5).

Occlusion of live vs. dead branches and effect of branch collar treatment

We compared the rates of occlusion for pruning live branches without wounding the branch collar, dead branches pruned without wounding the branch collar, and dead branches pruned by removing or damaging the branch collar. For each of the smallest branch size classes (the size classes where n>100), differences among the three categories were small at the time of the first assessment in 1994 and even smaller in 1995, but two consistent and statistically significant patterns were present. First, the mean rate of occlusion was greater for live branches than for dead branches that were pruned without wounding the branch collar (fig. 6). Second, even though damaging or removing the branch collar during pruning increased the

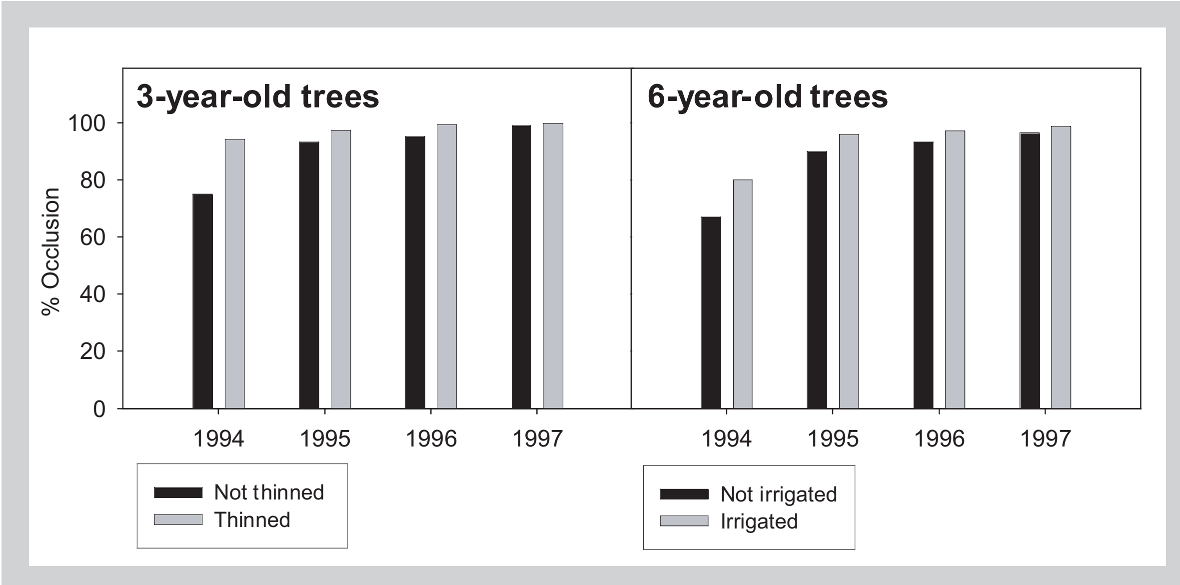

Figure 3—Mean percent occlusion of all pruned branches in the 3- and 6-year old plantations 1 to 5 years following pruning (dependant upon time of pruning).

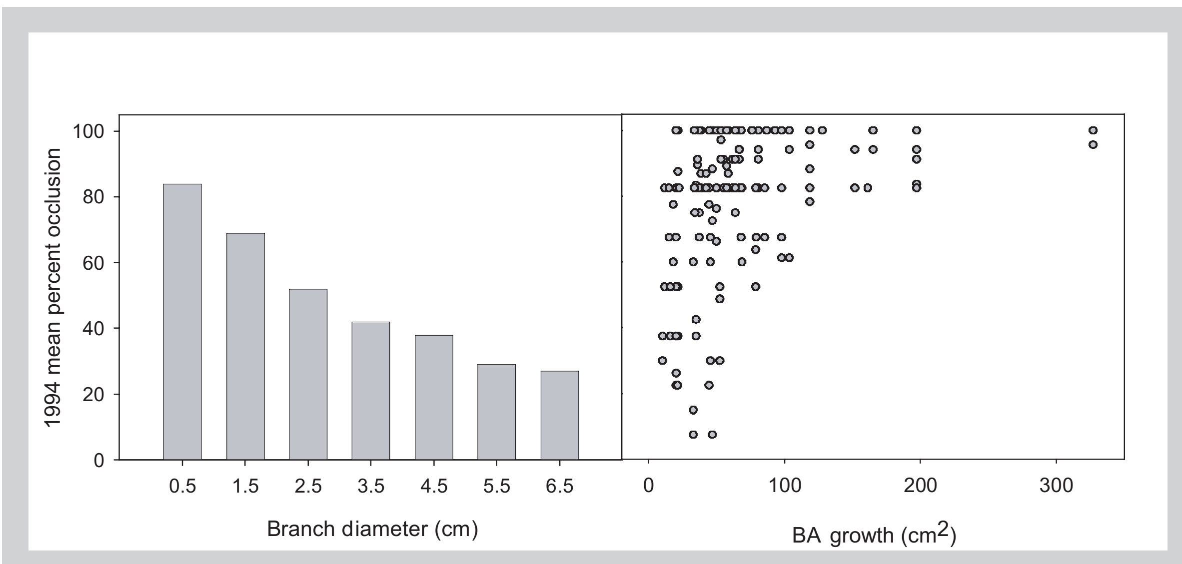

Figure 4—Relationship between percent occlusion of branches pruned in 3-, 6-, and 10-year-old red alder stands by diameter of pruned branch and basal area growth measured at 1.3 m.

size of the wound to be occluded, wounds associated with damaged branch collars occluded more quickly than those associated with undamaged branch collars. Although this difference in occlusion rates between injured and uninjured branch collars is unlikely to be of practical importance, it indicates that pruners do not need to be especially careful to avoid injuring branch collars. Additional examination of the wood around these wounds also indicated no difference in the amount of internal decay associated with damaged or undamaged branch collars or the time it took to form clear wood (DeBell et al. 2006).

Red alder wood decays rapidly after the death of the tree; thus, in past years some foresters have speculated that alder might not be a good candidate for thinning or pruning because of the potential damage associated with these activities. More recent evidence, however, has shown that living red alder trees are quite effective in compartmentalizing decay (Allan 1993). Allen's study on Vancouver Island showed decay volumes to be small and most decay associated with natural breakage did not spread outward beyond the location on the bole where damage was sustained. Additional assessments of decay

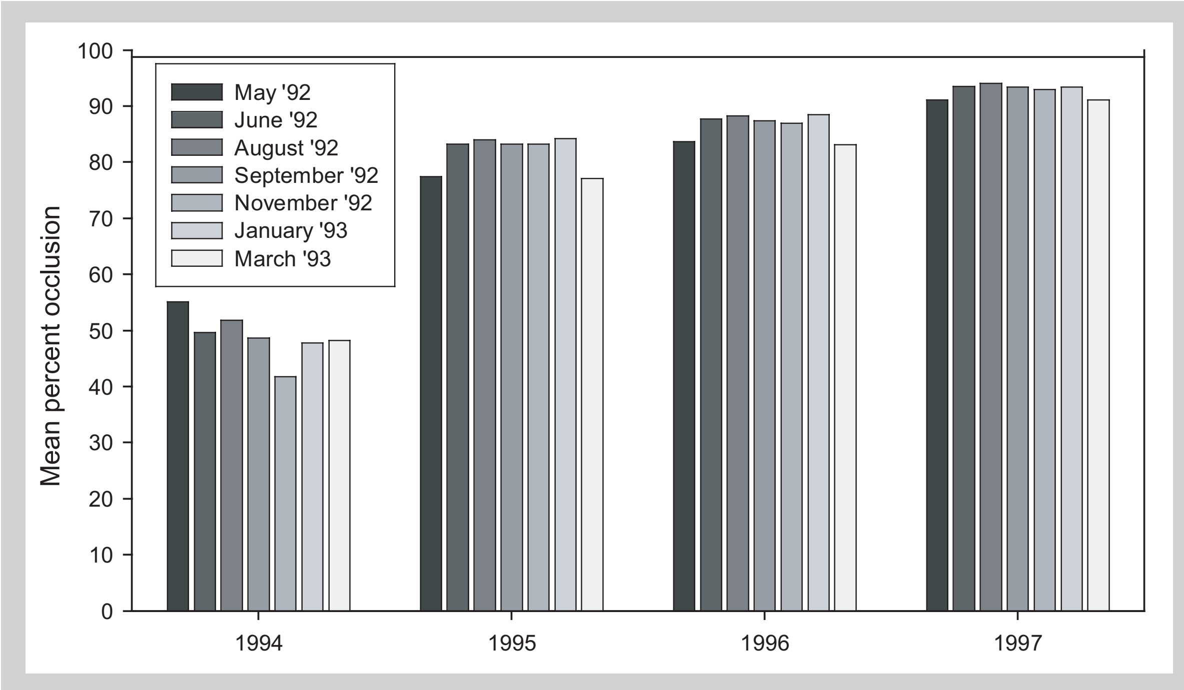

Figure 5—Mean percent occlusion for all branches sizes at all pruning dates at 4 successive assessment years.

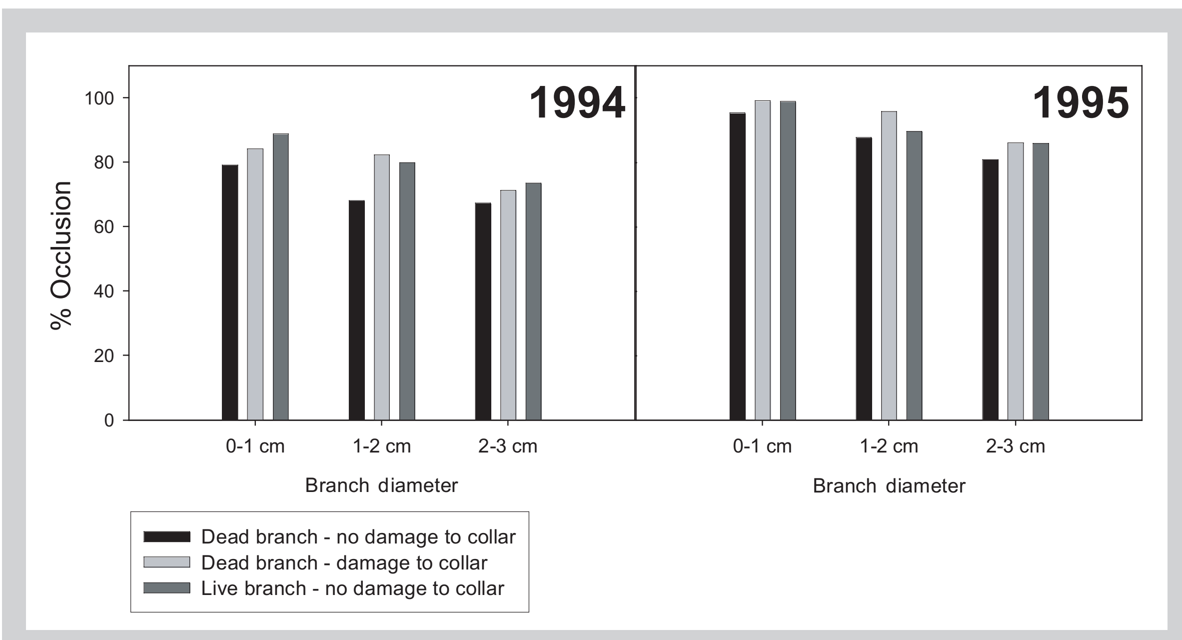

Figure 6—Comparison of occlusion rates by branch size classes and year for live branches pruned without damaging the branch collar and dead branches pruned with and without damaging the branch collar during pruning.

associated with pruning were made in the Cascade Head pruning study (C.W. Jacobs memo dated Feb 28, 1947 on rot found in alder stands, on file Olympia Forestry Sciences Laboratory). The wood in and near 25 knots on 6 pruned trees was assessed for signs of decay 10 years after pruning by sampling with an increment borer. On 24 of the 25 knots, the decay was found to be confined to the knot area; on the 25th knot, the rot extended to the pith and about 25 cm below the branch, but did not extend into the wood formed after pruning. The companion study to our young-stand pruning (DeBell et al. 2006) also found minimal amounts of rot associated with the branch scars. Thus, there is no evidence that decay will be a problem after pruning young red alder.

Conclusions

Pruning at plantation ages 3, 6, or 10, did not have negative effects on the incidence of decay or defects within the tree bole, production of significant numbers of epicormic branches, or growth of the tree. Contrary to reports for several other species, the results were consistent across all seven pruning dates; thus, time of year of pruning had little or no effect. Differences in rates of occlusion could largely be accounted for by the differences in growth rate due to tree age or other management activities (such as thinning or irrigation). Although our study examined the effects of wounding the branch collars only on dead branches, we suspect that incidental damage during the pruning operation to branch collars of live branches should not be a source of concern. However, because there was no practical benefit from removing the branch collar, and it would take more time and effort to do so, we would not recommend it as a standard practice.

Because both small and live branches occlude more quickly than large or dead branches, pruning at an earlier age would not only result in a smaller knotty core, but would produce straight-grained clear wood more quickly after pruning. In addition, if epicormic branches are a concern, pruning young stands appears to result in the lowest number of epicormic branches. Epicormic branch production was also most closely tied to the presence of openings on the south side of the tree, thus, trees north of stand boundaries or gaps are the poorest candidates for pruning. From a biological standpoint, there appear to be no obstacles and several benefits to pruning red alder at an early age; thus, the decision of timing of pruning should be based on economic factors.

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