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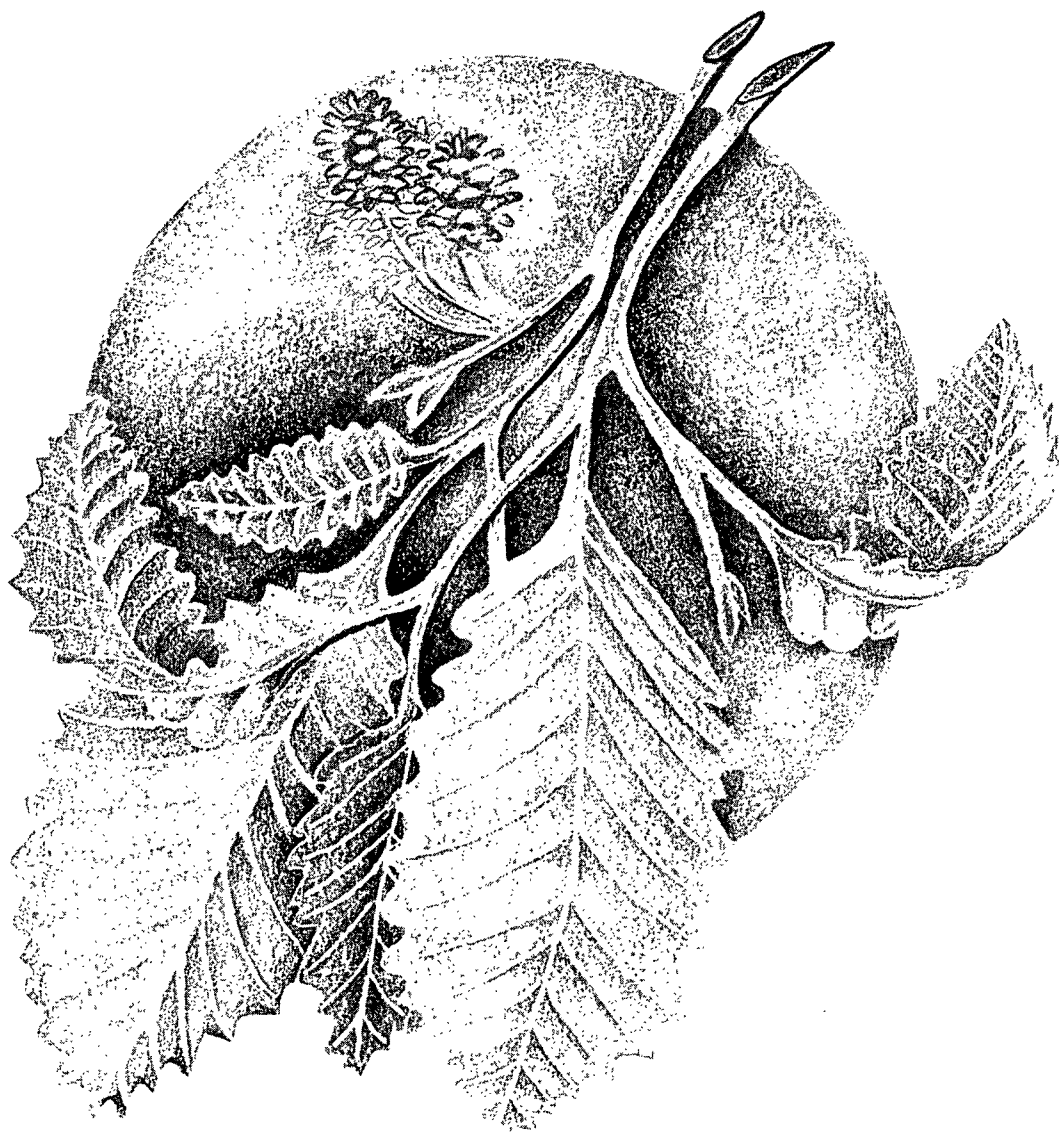


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Control of Red Alder by Cutting

Dean S. DeBell and Thomas C. Turpin

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Abstract

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Effects of tree age, month of cut, and height and angle of cut on sprouting of red alder stumps were evaluated in a study designed to develop an effective method for controlling red alder in Douglas-fir plantations. Ninety-five percent or more of alder stumps cut in June or July died by the end of the next growing season; mortality was 88, 70, and 22 percent for stumps cut in May, August, and September, respectively. Stumps of 4-year-old alder trees tended to have higher survival and taller sprouts than did stumps of 6- to 10-year-old trees. Height and angle of cutting had little influence on sprouting. Red alder can be controlled effectively by using cutting guidelines developed from these results.

Keywords: Red alder, *Alnus rubra*, control, plantations (Douglas-fir).

Summary

Red alder (*Alnus rubra* Bong.) competes with Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and other conifers in many young plantations and natural stands. Silvicultural options to reduce such competition are commonly exercised on public and private forest land. Until the mid-1980's, herbicide applications were the primary means of controlling red alder. Our study, designed to develop an effective alternative for control, evaluated effects of tree age, month of cut, and height and angle of cut on sprouting of red alder stumps. Ninety-five percent or more of alder stumps cut in June or July died by the end of the next growing season; mortality was 88, 70, and 22 percent for stumps cut in May, August, and September, respectively. Height growth and numbers of sprouts were also reduced by cuts in June and July as compared with cuts in May, August, or September. Stumps of 4-year-old alder trees tended to have higher survival and taller sprouts than did stumps of 6-to 10-year-old trees. Height and angle of cutting had little influence on sprouting. Red alder can be controlled effectively by using cutting guidelines developed from these results.

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Introduction

Red alder (*Alnus rubra* Bong.) is a rapid-growing, intolerant pioneer species favored by disturbance. A prolific and consistent seed producer, it often regenerates naturally in abundance after logging and burning. Alder competes with Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and other conifers for growth resources—light, moisture, nutrients, physical space—in many young plantations and natural stands. Competition with conifers can be particularly severe in the Coast Ranges of Oregon, and silvicultural operations to reduce such competition are commonly applied on public and privately owned forest land. The Siuslaw National Forest, for example, annually treats about 800 hectares of young Douglas-fir plantations to suppress red alder. Until the mid-1980's, herbicides—applied aerially or by tree injection—were the main way to control alder. A Federal Court ruling in March 1984 prohibited the use of herbicides on National Forest lands in the Pacific Northwest Region. This ruling stimulated a search for effective alternative methods to control red alder.

Cutting stems of red alder with chain saws, brush cutters, or hand tools seemed to offer a promising means of control. Although stumps of young red alder trees commonly sprout after they are cut, research on coppicing conducted at the USDA Forest Service, Pacific Northwest Research Station in Olympia, WA, indicated that sprouting is influenced significantly by several factors. A series of studies showed that sprouting of 4-year-old trees decreases with stump height and is much less when trees are cut in May, July, or September than in January; that sprouting vigor decreases with tree age; and that stump mortality may be greater if cuts are level rather than slanted (Harrington 1984). That last relation was not confirmed in two other tests, however.¹ Such results suggest that cutting prescriptions could be developed to minimize subsequent sprouting of red alder. To obtain the additional information needed to develop the prescriptions, the Siuslaw National Forest and the Pacific Northwest Research Station began a cooperative study in coastal Oregon in spring 1984. The objective was to define more precisely the relation of month of cut, tree age, stump height, and angle of cut to sprouting and to develop effective cutting prescriptions for controlling growth of alder in the Forest.

Description of Study Area

Study plots were in four Ranger Districts of the Siuslaw National Forest in the central portion of the Oregon Coast Range. The Siuslaw National Forest is in the Western Hemlock (*Tsuga heterophylla* (Raf.) Sarg.) Zone as described by Franklin and Dyrness (1973). The predominant tree species is Douglas-fir, but substantial amounts of Sitka spruce (*Picea sitchensis* (Bong.) Carr.) and western hemlock are also present. Red alder is the major hardwood species, and bigleaf maple (*Acer macrophyllum* Pursh) occurs as a minor species. Climate is maritime with an annual precipitation of 2000 to 3100 millimeters. Local soils are derived from sedimentary and volcanic parent materials and are very productive for conifers and hardwoods. Douglas-fir site index (50-year base) averages about 40 meters, and red alder site index (50-year base) averages 28 meters. The individual study plots were installed in areas that had regenerated naturally to red alder after the previous stand was clear-cut. The plots were in various topographic situations at elevations between 30 and 640 meters above sea level.

¹ Unpublished data on file: Forestry Sciences Laboratory, 3625 93d Ave., SW, Olympia, WA 98502.

Table 1—Age of red alder trees, month of cut, and Ranger District location of each study installation

Ranger District	Age of alder to be cut, by month				
	May	June	July	August	September
	<i>Years</i>				
Hebo	10	4	8	6	6
Alsea	6	8	10	4	4
Waldport	8	6	4	10	8
Mapleton	4	10	6	8	10

Experimental Design

The study consisted of 20 installations and was established as a split-plot design. The main plot treatments were month of cut and tree age; the subplot treatments were height and angle of cutting. One installation of each tree age (4, 6, 8, and 10 years) was established in the Forest each month from May through September 1984. The ages of trees to be cut in each installation were randomly assigned to each of the four Ranger Districts; resident silviculturists then located appropriate areas for plots (table 1). At each installation, 60 stumps were cut level, 20 each at heights of 10, 20, and 30 centimeters. Angled cuts were made on 20 stumps at each installation; the cut was an average of 20 centimeters in height and was slanted at 45° to either the northeast (10 stumps) or southwest (10 stumps). All cuts were made with chain saws. This design provided a statistical test of the main effects of month of cut, tree age, and cutting treatment on various sprouting characteristics. It also provided a test of the interactions between cutting treatments and age and between cutting treatments and month of cut (table 2). The tree age $\times$ month of cut interaction was assumed to be insignificant, and this interaction served as the error estimate to test main-plot effects (age and month of cut). This assumption was subsequently verified with Tukey's single degree of freedom test for nonadditivity (Steel and Torrie 1960). The second-order interaction among the three principal factors was not assessed because such a design would have expanded the study beyond available resources.

Each installation consisted of the measurement plot (80 alder trees, which were cut) and a surrounding buffer equal in width to average tree height. All trees in the buffer also were cut. Individual stumps were numbered and tagged, and diameters (15 centimeters above ground) were measured. In October 1984 and 1985, each stump was classified as living or dead based on the presence of living sprouts; number of sprouts per stump and height above ground of the dominant sprout were recorded. Mortality data were summarized as a percentage of total stumps per treatment subplot and transformed to arc-sine values; the number of sprouts was expressed both per subplot and per average living stump; sprout height was assessed both as the average height of sprouts measured and the tallest sprout measured on each subplot. The number of sprouts per subplot in the slanted treatments was doubled because these treatments were applied to only 10 rather than to 20 trees (stumps).

Table 2—Analysis of variance model for assessing effects of treatments on sprouting characteristics

Source of variation	Degrees of freedom
Month	4
Age	3
Error ₁	12
Cutting treatments (CT)	4
CT × month	16
CT × age	12
Error ₂	48
Total	99

Table 3—Analyses of variance results (F-test) for factors affecting sprouting characteristics of red alder stumps 2 growing seasons after cutting

Source of variation	Degree of freedom	Characteristic			
		Stump mortality	Number of sprouts per subplot	Dominant sprout height	
				Average	Tallest
----- Significance of F-test -----					
Month of cut	4	0.000	0.018	0.243	0.101
Age	3	.097	.262	.145	.081
Cutting Treatment (CT)	4	.201	.406	.009	.002
CT × month	16	.570	.326	.099	.148
CT × age	12	.242	.019	.010	.009

The October 1985 data on mortality, number of sprouts per subplot, and dominant sprout heights were tested for differences among treatments by analyses of variance according to the split-plot design (table 2). Means for treatments testing significantly different were separated at $p \leq 0.05$ by Tukey's procedure (Snedecor 1961). Data on number of sprouts per living stump were summarized but not analyzed statistically because many subplots had no living stumps. In addition, relations of tree age, stump diameter, and cutting height to various sprouting characteristics were examined by linear regression.

Results

The October 1984 data were collected too soon after some plots were cut (for example, August and September) to provide valid comparisons among all treatments. Thus, only results of the 1985 data are presented in this section.

Analyses of variance revealed that all treatment factors, via either main effect or interaction, had significant effects on at least one sprouting characteristic (table 3). Although some treatment factors did not test statistically significant ($p < 0.05$) for some sprouting characteristics, trends evident in the data have practical importance for cutting prescriptions.

Table 4—Effects of month of cut on sprouting characteristics of red alder cut at 5 different times (months)^a

Month of cut	Characteristic				
	Stump mortality	Number of sprouts		Dominant sprout height	
		Per subplot ^b	Per living stump	Average	Tallest
	Percent			---Centimeters---	
May	88a	21c	9	58a	72a
June	96a	7c	9	30a	42a
July	95a	9c	9	22a	27a
August	70b	58b	10	51a	77a
September	22c	198a	13	79a	130a

^a Means followed by the same letter were not significantly different at the $p < 0.05$ level.

^b Subplots consisted of 20 trees (stumps).

Effect of Month of Cut

Month of cut was by far the most influential factor affecting stump mortality and sprout development (table 4). Averaged over all ages and all cutting treatments, 95-96 percent of the stumps cut in June and July died by the end of the next growing season. Mortality of stumps cut in May was slightly but not significantly lower (88 percent). Mortality diminished to 70 percent for stumps cut in mid-August and dropped to only 22 percent for those cut in September.

The month of cut affected total sprouts per subplot in the same way it affected mortality; that is, sprout numbers per subplot were lowest for stumps cut in June and July (7 and 9 sprouts, respectively), slightly higher for May (21 sprouts); significantly higher in August (58 sprouts), and even higher for stumps cut in September (198 sprouts). These findings were influenced primarily by the number of stumps surviving and to a minor degree by number of sprouts produced per living stump.

Sprout growth as indicated by average height of dominant sprouts and the tallest sprout per subplot did not differ significantly with month of cut (tables 3 and 4). Trends were very similar, however, to those for stump mortality and number of sprouts. Growth was poorest for stumps cut in June and July, intermediate for May and August, and greatest for September.

Effects of Tree Age

Age did not have statistically significant effects on sprouting characteristics (table 3), but trends of practical importance were evident (table 5). Stumps of the youngest trees (4 years old) had the least mortality, the most sprouts per subplot, and the tallest sprouts. Mortality of stumps of trees 6 to 10 years old was 16 to 30 percent greater than that of 4-year-old trees, and dominant sprouts were much shorter. Number of sprouts per subplot and per living stump were much lower for 8- and 10-year-old trees than for 4- and 6-year-old trees. Best sprout growth occurred on stumps of 4-year-old trees.

Table 5—Sprouting characteristics of red alder cut at 4 ages^a

Age	Characteristic				
	Stump mortality	Number of sprouts		Dominant sprout height	
		Per subplot ^b	Per living stump	Average	Tallest
	<i>Percent</i>			<i>----- Centimeters -----</i>	
4	59	94	11	81	122
6	75	91	18	39	57
8	89	9	4	26	30
10	75	38	8	46	70

^a Differences among ages did not differ significantly at the $p < 0.05$ level.

^b Subplots consisted of 20 trees (stumps).

Table 6—Sprouting characteristics of red alder cut at various stump heights and angles^a

Stump height and cutting angle	Characteristic				
	Stump mortality	Number of sprouts		Dominant sprout height	
		Per subplot ^b	Per living stump	Average	Tallest
	<i>Percent</i>			<i>----- Centimeters -----</i>	
10 cm, level	80a	50a	12	41ab	63ab
20 cm, level	76a	60a	12	57a	85a
20 cm, northeast slant	71a	65a	11	47ab	62ab
20 cm, southwest slant	72a	61a	11	33b	48b
30 cm, level	74a	54a	10	62a	88a

^a Means followed by the same letter were not significantly different at the $p < 0.05$ level.

^b Subplots consisted of 20 trees (stumps) for all level cuts; means presented for slanted cuts were doubled because subplots consisted of only 10 trees (stumps).

Linear regressions for effects of age on numbers of sprouts per subplot or per stump and on sprout heights were significant ($p = 0.01$ to 0.03) and accounted for 8 to 11 percent of the variation in these sprouting variables. Linear regressions for effects of stump diameter (tested for use as a surrogate for age) on sprout heights were also significant ($p = 0.02$), and accounted for 9 percent of the variation in sprout heights.

Effects of Height and Angle of Cutting

Height and angle of cutting did not affect stump mortality or numbers of sprouts per stump or subplot (table 6). Heights of the dominant sprouts were significantly affected, however. Sprouts on stumps cut at 20 centimeters and slanted (45° angle) to the southwest were significantly shorter than those in stumps cut level at 20 or 30 centimeters above the groundline. None of the regressions relating sprouting variables to stump height were statistically significant.

Table 7—Height of tallest red alder sprout per subplot as related to tree age and cutting treatment^a

Stump height and cutting angle	Height of tallest stump sprout, by tree age			
	4 years	6 years	8 years	10 years
----- Centimeters -----				
10 cm, level	71c-e	62c-e	28de	93b-d
20 cm, level	160ab	70c-e	46c-e	67c-e
20 cm, NE slant	121a-c	58c-e	7e	63c-e
20 cm, SW slant	79b-e	25de	16de	72c-e
30 cm, level	176a	70c-e	54c-e	54c-e

^a Means followed by the same letter were not significantly different at the $p < 0.05$ level.

Interactions

The cutting treatment $\times$ month-of-cut interaction did not significantly affect any sprouting characteristic (table 3). The cutting treatment $\times$ age interaction was statistically significant for sprouts per subplot, average height of dominant sprouts, and height of tallest sprout per subplot (table 3). Data for this last variable illustrated the general nature of this interaction (table 7). Relative effects of cutting height on sprouting characteristics generally lessened with increased age; for example, greater differences in sprout heights among cutting heights were found for 4-year-old trees (105 centimeters) than for 10-year-old trees (39 centimeters). In addition, sprout growth tended to increase with increased stump height for trees cut at ages 4, 6, and 8 years, whereas it tended to decrease for trees cut at age 10 (compare sprout heights of stumps cut level at 10, 20, and 30 centimeters at various ages).

Discussion and Recommendations

The general influences of timing of cut (growing vs. dormant season months), tree age, cutting height, and angle of cut on sprouting of red alder stumps are reported by Harrington (1984). Our study confirmed the general influence of the first three factors for red alder trees distributed throughout the Siuslaw National Forest. We confined our examination of the factors to the range of months (growing season only), tree ages (4 to 10 years), and cutting heights (10 to 30 centimeters) of greatest importance in developing cutting prescriptions to control alder in Douglas-fir plantations. Our findings indicated the factors providing the greatest leverage for control, thereby enabling us to develop an effective cutting prescription.

Month of Cut

Several studies with other hardwood species indicate less vigorous sprouting after cuts are made during the growing season than when they are made during the dormant season (Belanger 1979, DeBell and Alford 1972, Strong and Zavitzkovski 1982, Wenger 1953). Such findings are generally attributed to lower food reserves in root and stump systems if cutting occurs after trees are fully leafed out but before the late part of the growing season when reserves again begin to accumulate (Hook and DeBell 1970, Wenger 1953).

In our study, month of cut affected stump mortality as much as or more than it affected number and growth of sprouts on surviving stumps. Because red alder wood is notably susceptible to decay, especially when logs are cut in the summer (Mackie and Williams 1984, Worthington and others 1962,) and fungal conks were observed on many stumps, pathogens also were probably important factors contributing to mortality of red alder stumps. Little work has been done, however, on identification or phenology of disease and decay organisms in red alder stumps. Such research might provide a biological method (for example, inoculation technique) to increase the effectiveness of cutting prescriptions or to extend the cutting period or age range for effective control.

Month of cut had a much greater effect on stump mortality and sprout production than any other factor—so much so that we believe it should take precedence over age in scheduling control operations. Cutting between June 15 and July 15 will provide the greatest control; with minimal risk, though, the cutting period can probably be extended to include the previous 3 weeks (that is, beginning around May 20) and a third week in July (that is, ending around July 20). Time of bud break for red alder in the Siuslaw National Forest ranges from the first to the third week of March, depending on elevation. The proposed cutting period begins 8 to 10 weeks after red alder breaks bud and continues for about 8 weeks. For locations farther north and at higher elevations, appropriate cutting periods might be somewhat later. Work in Washington shows, for example, that maximum mortality and poorest sprout growth occurs when trees are cut from early July through mid-August (Hoyer and Belz 1984). When these and other sprouting data were examined on a phenological scale, the 8 to 20 weeks after bud break were recommended as the most effective time for scheduling cutting operations.²

Tree Age

Stump sprouting decreases with age in several species, with the period of most satisfactory sprouting coincident with that of most rapid growth (Smith 1962). Sprouting of red alder stumps is most successful at 4 years (our study) and younger (Harrington 1984) and begins to decline while growth is still accelerating. The decline in sprouting success with age is associated with increased mortality and may involve pathogenic factors. At the end of the growing season in which the trees were cut, only 15 percent of the 8- and 10-year-old stumps had died, whereas 23 percent of the stumps of 4- and 6-year-old trees had died. By the end of the next growing season, mortality of stumps of all ages had increased substantially, but less so for 4-year-old trees (59 percent) than for 6- to 10-year-old trees (75-89 percent). Successful establishment of a developing sprout depends on a strong union forming between the sprout and some portion of the residual root system. Rapid decay of stump and root tissues probably would preclude successful establishment. Thus, the increased mortality in old, large red alder stumps may be partly related to a larger amount of exposed and injured tissue, enhanced conditions for decay, or more time being needed to form an effective union with the existing root system.

² Belz, D. 1986. Unpublished report, "Red alder severing window—400 series, second year report." 3 p. On file with: Washington State Department of Natural Resources, Forest Land Management Division, Olympia, WA 98504.

Although age differences were not statistically significant in our study, mortality of 4-year-old stumps averaged about 20 percent lower than that of 6- to 10-year-old stumps. Because of this general trend, results from other studies (including Harrington 1984), and experiences with unsuccessful control of alder when trees were cut at younger ages in the Siuslaw National Forest, we recommend that cutting operations to control alder begin when trees are at least 5 years old. At that age, red alder trees will be 3 to 8 meters tall, depending on site index (Harrington and Curtis 1986). Alder control operations done with precommercial thinning of conifer plantations would be efficient because only one cutting would achieve both release and proper stocking of conifer trees. This schedule may not be possible, however, where alder trees grow so rapidly that conifer crop trees would already be suppressed or likely to be damaged by falling alder trees. Inasmuch as stump diameter is strongly correlated with age in young alder and linear regressions of sprouting performance as related to diameter were similar to those for age, basal diameter might be used as a surrogate for age in developing prescriptions. We think that basal diameter should be at least 5 centimeters.

Height and Angle of Cutting

Although stump height affects sprouting success of other hardwood species (Belanger 1979, DeBell 1971) as well as red alder (Harrington 1984), we found no significant differences associated with cutting height per se in stump mortality, number of sprouts, or sprout heights. The range of stump heights in our study (10 to 30 centimeters) was narrower than that in Harrington's (1984) work (0 to 70 centimeters) and partially accounts for the difference in results. Perhaps even more important in the differing results was the young age (4 years, 2 + 0 seedlings in field for 2 years) and wide spacing (2.0 meters) of plantings used by Harrington (1984). Live lower branches remained on stumps of many of these trees and became dominant stems after cutting. No differences in mortality or number of sprouts were found between slanted and level cuts, but sprout heights were significantly shorter on 20-centimeter stumps slanted to the southwest than on 20-centimeter stumps cut level. This finding also is at variance with Harrington's (1984) findings but agrees with results from two other studies (see footnote 1).

Although sprouting was unaffected by height or angle of cutting, we do not believe that stumps should be cut any higher than the 30-centimeter maximum tested in our study. Because shorter stumps are likely to have fewer remaining live branches, we suggest that alder trees, particularly those in younger or less dense stands, be cut at 20 centimeters or shorter. We do not, however, see any reason to require level stumps and thus do not specify a cutting angle. Cutting stumps to be both low and level by chain saw would be difficult and probably would cause an increase in costs and accidents.

Neither of the interactions with cutting treatment ($\times$ age or $\times$ month of cut) affected stump mortality. The cutting treatment $\times$ age interaction did significantly affect sprout numbers and sprout height. The effects of this interaction—above and beyond those associated with main effects of cutting treatment and age—were of no importance in practical control programs.

Postscript

As soon as the results of our study were summarized, they were used by Siuslaw National Forest and other public land management agencies in Oregon to develop preliminary guidelines for contracts and in-house operations to control alder. The guidelines were as follows:

- Schedule cutting operations between late May and late July for the Siuslaw National Forest. (Note: Schedules for other locations should probably be modified because of differences in phenology of bud break; for example, begin cutting 8 to 10 weeks after bud break and cease cutting about 8 weeks thereafter.)
- Delay cutting operations until trees are at least 5 years old. In general, cut the oldest trees first to minimize damage to residual Douglas-fir.
- Cut trees to a stump height no greater than 20 centimeters.

Three growing seasons have passed since these preliminary guidelines were implemented on Forest Service, Bureau of Land Management (Eugene and Coos Bay Districts), and Oregon State Department of Forestry lands. Conversations with silviculturists of these agencies revealed that control operations were effective when the above guidelines were followed. A few attempts to cut alder trees younger than 5 years old (but within the recommended May-July period) resulted in resprouting and continued growth.

Acknowledgments

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English Equivalents

1 hectare = 2.47 acres
1 meter = 3.28 feet
1 centimeter = 0.39 inch
1 millimeter = 0.039 inch

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