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Sprouting of Old-Growth Redwood Stumps . . . first year after logging

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ABSTRACT: A survey of 104 old-growth stumps on the Redwood Experimental Forest, in northern California showed that (a) probability of a stump sprouting varied inversely with its diameter; (b) number of sprouts per sprouting stump and height of tallest sprout were not related to stump diameter; (c) lower portions of stumps sprouted more often and produced more sprouts than did higher parts; (d) height of tallest sprouts varied directly with number of sprouts; and (e) different kinds of damage produced different sprouting responses.

RETRIEVAL TERMS: Sequoia sempervirens; reproduction; sprouts; redwood management; tree damage.

Redwood (*Sequoia sempervirens* [D. Don] Endl.) has a characteristic unusual among conifers. It sprouts from dormant buds on the root collar and bole of the tree. Stump sprouts provide quick and cheap reproduction on cutover land. Some sprouts develop into merchantable trees. Beyond these few facts, little is known about redwood sprouting or sprout development.

Satisfactory restocking of old-growth cutover by sprouts alone is an open question,[1] yet some land managers depend entirely on sprouts to regenerate redwood. They may, however, seed or plant other species in redwood cutovers to assure satisfactory conifer restocking. Apparently many young-growth redwood stands are largly or entirely of sprout origin,[2] but greater knowledge of sprouting factors and relationships seems necessary for the most effective management of redwood.

We found several possible stump and sprout relationships in a survey of sprouting following regeneration cutting experiments[3] at the Redwood Experimental Forest, Del Norte County, California. Further study of these relationships could reveal the causative factors, which may be amenable to manipulation. Some of the information reported in this note may be directly applicable to current redwood management.

The Study

The 104 stumps examined in this survey are on plots, each 0.4 acre, in old-growth redwood cutover. They are in the first replication of a study of regeneration cutting methods. Ten plots are located in each of three different levels of stand removal: (a) Clearcutting, in which all merchantable trees were cut; (b) shelterwood, in which about three-fourths of the stand volume was harvested; and (c) selection, in which about half the stand volume was removed. Each level included trees of all sizes. Before logging, per-acre volumes averaged about 185 MBF gross (Scribner). About 84 percent of this volume was redwood.

Moderately steep north, west, and south slopes are represented in the logged areas, but only seven stumps

[1] Wiant, Harry V., Jr., and Powers, Robert F. *Sprouting of old-growth redwood.* Soc. Amer. Foresters Meeting Proc. 1966: 88-90. 1967.

[2] Lindquist, J.L., and Palley, M.N. *Empirical yield tables for young-growth redwood.* Calif. Agr. Exp. Sta. Bull. 790, 47 pp. 1963.

[3] This work was done in cooperation with the Simpson Timber Company and the Twin Parks Lumber Company, both at Arcata, Calif.

were tallied on south slopes. Elevations range from about 100 feet to about 900 feet. The area is about 2 miles from the ocean. The entire area was tractor-logged. Slash was disposed of by piling and burning, or by broadcast burning small patches.

About one-half of each unit was logged in 1959, and the other half in 1960. Stumps resulting from the 1959 logging were examined from September 1960 to March 1961; and those resulting from the 1960 logging were examined from August to October 1961. Each stump was examined once.

We defined individual first-year sprouts as single stems at least 1 inch tall when examined. Our definition was complicated by the fact that sprouting was a continuous process in the first year and a half after logging; that is, there was apparently no true dormant season for sprouting or sprout growth during this period.

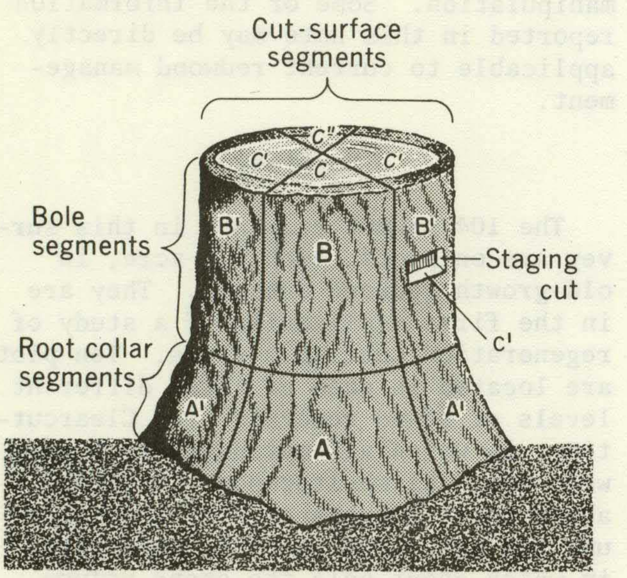

Figure 1.--*Diagram of stump segments. Unprimed letters are on downhill quarter, singly primed letters are on side quarter, and doubly primed letters are on uphill quarter.*

Each stump was visually divided into 12 segments for examination (fig.1). The "cut-surface" position included the surfaces of both felling cuts and staging cuts. It seemed worthwhile to make a distinction between top, side, and root collar areas of the stump because of possible differences in sprouting stimulus, growth habit, and firmness of attachment. On sloping ground, which was the universal case in this study, neither quarters nor positions occupy equal areas of stump surface.

Data collected for stumps and segments were:

Stumps	Segments
Cutting method	Damage
Aspect	Number of sprouts
Stump diameter	Height of tallest sprout
Tree age	

Ages of 24 stumps could not be determined, usually because of rotten centers. And the diameter of one stump could not be determined because it was almost entirely consumed by fire.

Damage on each segment was classified as follows:

Damage class	Criteria
None	Self-explanatory
Light burn	Burned, but cambium judged to be undamaged
Hard burn	Burned, and cambium judged to be damaged
Debarked	Bark removed or loosened
Buried	Covered with dirt

Segments with more than one kind of damage were assigned to the damage class associated with the sprouts; when no sprouts were present, segments were assigned to the damage class affecting the greatest amount of segment surface. No other forms of damage were found.

Table 1.--*Average tree age and stump sprouting characteristics, by diameter class*

Diameter class (inches)	All stumps		Sprouting stumps	
			Average per stump	
	Average[1] age	Sprouting frequency	Sprouts	Height of tallest
	Years	*Percent*	*Number*	*Inches*
< 36 (15)[2]	175	93	103	64
36-55 (14)	277	64	75	65
56-75 (21)	526	67	94	50
76-95 (22)	639	55	290	63
96-115 (13)	633	46	28	56
116 + (18)	743	44	123	78
Avg. 77 (103)	523	[3]61	126	62
Range 12-160	60-1,270	--	1-1,475	6-120

[1]Unknown ages were uniformly distributed throughout the range of diameters.

[2]Numbers in parentheses are numbers of stumps in each class.

[3]Sixty-two percent including stump with unknown diameter.

Results

In evaluating the data we recognized that sampling and biological conditions in the study imposed certain limitations. The results for whole stumps are a description of a population consisting of all stumps in our sample of randomly located but unreplicated plots. Results for segments are from a 100 percent subsample of all stump subdividions in the primary sample. Such data are not suitable for statistical analysis.

Stump segments rather than whole stumps are used to depict many of the relationships reported in this note because few stumps were entirely in a single damage category.

The sprouting relationships reported here are characteristic of the stumps examined, but other observations will be necessary to verify their applicability to other old-growth redwood cutovers.

Sprouting By Tree Diameter And Age

Small young stumps sprouted more often than large old stumps (table 1). Sprouting frequency ranged from 93 percent for the smallest diameter group to 44 percent for the largest, and averaged 61 percent.

The number of sprouts and the average height of the tallest sprout per sprouting stump were not related to diameter or age (table 1). This difference suggests that the ability to sprout, per se, may involve different factors than does the number and development of sprouts produced.

Distribution of damage did not appear to be related to diameter of the stump or age of the tree.

Sprouting And Location Of Segment

Generally, undamaged segments on the lower portions of stumps sprouted more often, and had more and taller sprouts when they did sprout than equivalent undamaged segments on higher portions (fig. 2). These relationships were essentially the same on both westerly and northerly aspects.

Increased sprouting and growth on the lower portions of stumps was generally true both between quarters (i.e., A>A'>A", and B>B'>B" in figures 1 and 2) and within quarters (i.e., A>B, A' >B', and A">B" in figures 1 and 2).

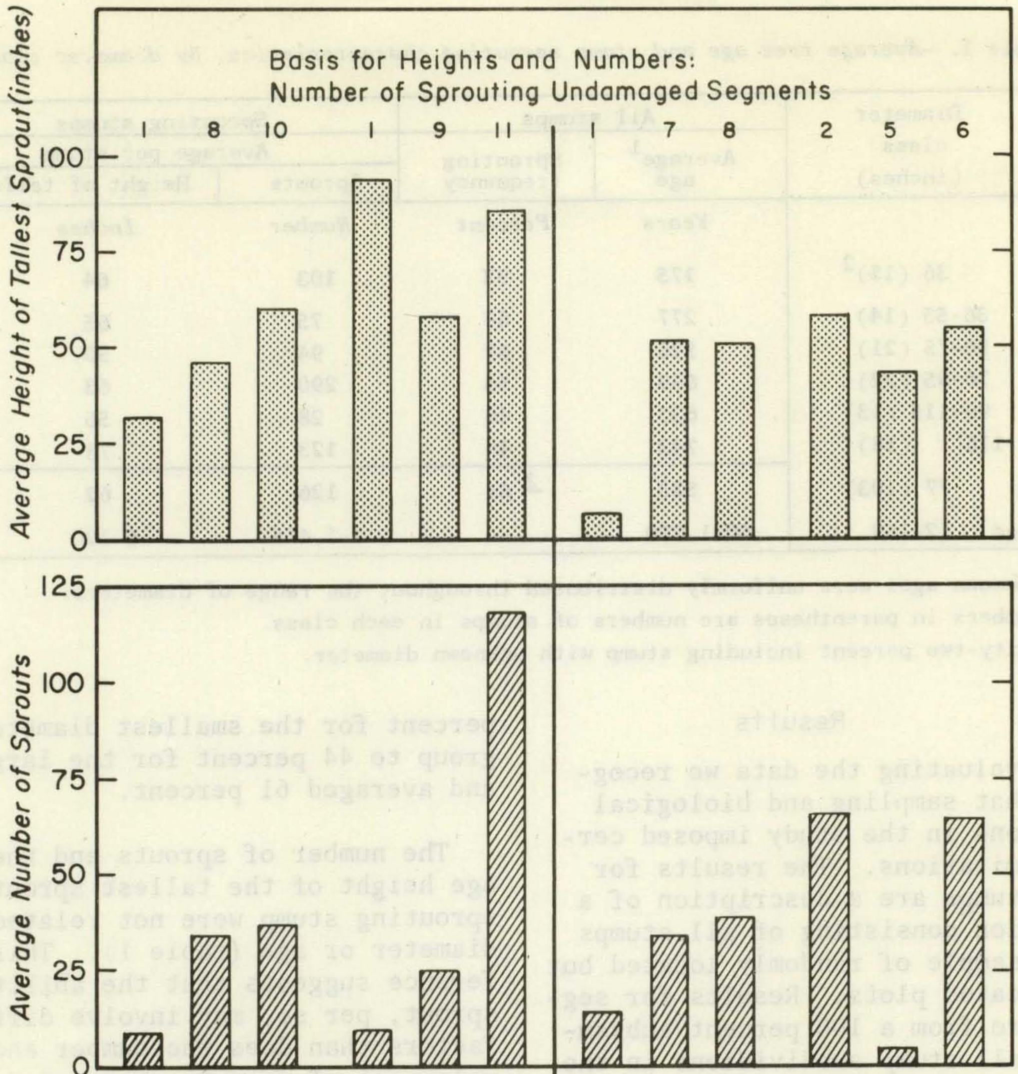

Figure 2.--*Sprouting frequency of undamaged stump segments, and average number of sprouts and average height of the tallest sprout per sprouting undamaged segment, by aspect group and segment location (see fig. 1).*

Table 2.--*Average sprouting frequency of undamaged root collar, bole, and cut-surface segments (all aspects and diameter classes combined)*

Segment position	Quarter			Combined average	Basis (total undamaged segments)
	Uphill	Side	Downhill		
	Percent			*Percent*	*Number*
Root collar	7	15	37	19	204
Bole	9	15	40	19	204
Cut-surface	2	2	13	5	207
Combined average	5	11	31	14	--
Basis (total undamaged segments)	140	321	154	--	615

Frequencies (fig. 2) were an exception to the within-quarter part of this general rule (e.g., A is not larger than B).

Since number-position and height-position distributions in figure 2 had essentially the same patterns, it follows that height of the tallest sprout varied directly as number of sprouts. There were not enough data to determine any relationship between height and position independent of numbers.

In all three parts of figure 2, data from westerly aspects more closely followed the general rule of "the-lower-the-better" than did data from northerly aspects. Also, the range of average values on northerly aspects was generally less than the range on westerly aspects, and distributional patterns for northerly data were rather faithfully repeated in the three parts of the figure. These relationships suggest the possibility of influences associated with the aspect of the site or the exposure of the stump part.

Because only 10 undamaged "cut-surface" segments sprouted on the 104 stumps in the study, we were unable to evaluate relationships of numbers and heights. But sprouting frequencies were compared with root collar and bole frequencies (table 2). The cut-surface position includes an indefinite portion of the bole position, as sprouts that originated below the cut-surface but grew upwards between bark and wood were recorded in this category. Considering the difference in cambial area of cut-surface segments relative to the cambial areas of the other segment positions, the cut-surface segments were good performers.

Possible relationships between sprouting and segment location, by cutting method, could not be studied because of differences in diameter distributions in the three cutting methods.

Sprouting And Damage

Frequency, numbers, and height all varied in different ways with different kinds of damage (fig. 3). On westerly aspects, light burning and burying appeared to be beneficial influences--both higher sprouting frequencies and more sprouts were associated with both kinds of damage. Hard burning and debarking appeared to have a detrimental total net effect. Effects of depth of burying were not evaluated.

Relationships of sprouting frequency and damage on northerly aspects were not the same as those on westerly aspects (table 3). Comparisons of numbers and heights on damaged segments on the two aspects were

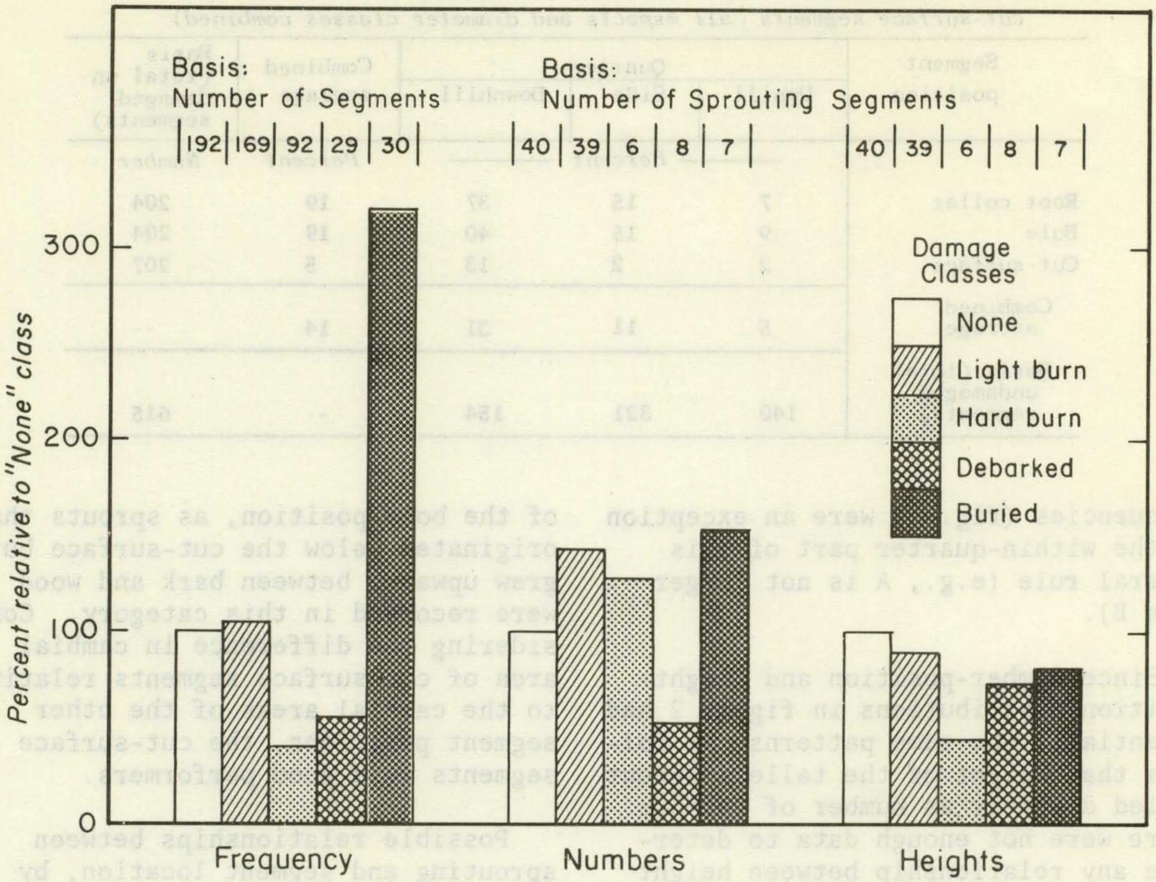

Figure 3.--*Sprouting on damaged root collar and bole segments on westerly aspects relative to values for undamaged segments, by damage class. (Averages of values for eight or fewer root collar and bole positions with segments having the specified damage.)*

not possible as there were no sprouting segments in the hard-burn class on northerly aspects, and only five sprouting segments in the three other damage classes combined.

Typical variations in damage appeared in the various cutting method-aspect combinations. Mechanical damage (debarking and burying) occurred more often in the clearcut units and on the steeper slopes, and fire damage occurred more often on southerly and westerly aspects.

Discussion

Two recently reported studies of redwood sprouting have relevance to this note. In a study in Mendocino County, Barrette[4] reported the absence of a relationship of sprouting to tree age or stump diameter. He did not comment on the possibility of a slight direct relationship suggested (to us) by his histograms. A direct relationship of sprouting to age or diameter is, of course, the opposite of the inverse relationship reported in this note. Barrette's published data indicate a considerable difference in the sample material of his and our study; for example, average stump diameter in Barrette's Mendocino County data was about 25 inches smaller than that in our data.

Wiant and Powers[5] conducted a study in two geographical areas: one in Del Norte County in a watershed adjacent to that of the Redwood Experimental Forest, and one in Humboldt County

[4] Barrette, Brian R. *Redwood sprouts on Jackson State Forest.* Calif. Div. Forestry State Forest Notes 29. 8 pp., illus. 1966.

[5] *Op. cit.*

Table 3.- *Average sprouting frequency of damaged root collar and side segments relative to frequencies on undamaged segments, by aspect group and damage class*

Aspect	Damage class				
	None	Light burn	Hard burn	Debarked	Buried
	Percent				
Westerly	100	103	40	55	321
Northerly	100	48	0	91	16
Combined	100	97	25	66	61
Total number of segments	361	179	101	55	80

about 50 miles south of the Experimental Forest. They reported statistically significant differences in each area in the relationships of sprouting frequency and height growth to diameter and age, but non-significant differences in numbers of sprouts. Their findings in regard to frequency and diameter were similar to ours (smaller stumps are more likely to sprout than larger). Their findings as to numbers are also similar to ours, but their height-diameter relationships are different. They also reported statistically significant differences between the two areas both in sample material and in height of the tallest sprout. Their sample material from both areas differed from ours, although not as strikingly as that from Mendocino County.

None of these studies sampled the same age of sprouts, which may account for some of the differences. No two agree very closely on sprouting frequency, which is probably the most important statistic. All studies sampled old-growth stumps, which may differ from young-growth stumps in sprouting relationships. And all studied relationships instead of factors.

The apparent differences in the three studies suggest a perhaps heretofore unsuspected complexity in redwood sprouting and point up the need for more intensive study. In any future studies, a shift in emphasis from relationships to factors would be appropriate.

Summary And Conclusions

Some relationships in redwood stump sprouting observed at the Redwood Experimental Forest are summarized below. Some of the factors that may be responsible for these relationships are suggested. The relationships are not inconsistent with the other reports of sprouting discussed earlier.

1. The potential "ability" of stumps to sprout is related to factors associated with tree size or age; stumps of small young trees sprout more often than those of large old trees.
2. The influence of these factors varies from one part of the stump to another so that different parts of the stump have different potential abilities to sprout; downhill parts sprout more often than uphill parts.
3. The potential abundance and potential growth of sprouts on a sprouting stump are related to different, or additional, factors not associated with size or age, but which also vary in influence from one part of a stump to another; lower parts of sprouting stumps have more and taller sprouts than higher parts, but smaller stumps--those that sprout most often--do not have more or taller sprouts than the larger.

4. Damage of different kinds modify the realization of the foregoing potentials in various ways.

5. Each of the above relationships may be modified by the aspect of the site or the exposure of the stump part.

6. Differences in stand characteristics and climate (and probably other stand and site factors) may modify the foregoing potentials or their realization or both.

The Author

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