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HARE CREEK SPROUT STOCKING STUDY ON JACKSON DEMONSTRATION STATE FOREST

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Redwood sprout regeneration on one of the 1985 Hare Creek Sprout Study area clearcut units.

Redwood sprout regeneration in the partial cut block of the 1985 Hare Creek Sprout Study.

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ABSTRACT

Redwood sprout regeneration after clear cutting and partial cutting of 85 year old young-growth stands in three cut blocks on the Jackson Demonstration State Forest is examined in this study. Slash was burned on one of the two clear cut blocks about six months after harvest, killing the initial crop of sprouts.

Six randomly located 0.4 acre study plots were installed in each block and all trees and stumps were mapped. Data included: diameter of all stumps and trees, number of clumps and sprouts per stump, and height of the tallest sprout on each stump.

Stocked milacre and 4-milacre quadrats averaged 10.9 +/- 5.0 and 30.8 +/- 13.2 percent respectively in the 18 plots. Redwood sprout regeneration averaged 390.7 +/- 63.9 clumps and 1739.7 +/- 706.9 sprouts per acre. Overall, 93.4 percent of the redwood stumps had sprouted at the end of the first growing season. There were no significant differences (.05 level) between the blocks in either number of clumps or sprouts per acre

KEYWORDS: redwood sprouting, coppice silviculture, clear cutting, partial cutting

INTRODUCTION

The importance of the redwood sprout population after logging to subsequent management of coastal redwood/fir stands needs to be determined. Future stocking potential of sprouts can affect planting levels and the species selected for planting. Regardless of the merits of redwood sprouts versus seedlings, the fact remains that managers often have to deal with a dense set of aggressive sprouts. How to take advantage of and deal with sprouting must be addressed.

Assessing the role of sprouts in restocking stands after logging has not received much attention. Some indecision about the value of sprouts comes from not being sure of the origin of older stems as most writers and researchers of redwood regeneration have always pointed out that redwood reproduces from both seed and sprouts. In current literature there is little detailed information about the amount of sprouting regeneration, or its eventual functional role in the management of this forest type.

Show (1932) reported that most second-growth stands were 25 to 35 percent stocked and were of sprout origin. Later, Person and Hallin (1942) noted that in Humboldt and Mendocino Counties, an average of 7.8 percent of the stocking originated from sprouts. Yield tables of Lindquist and Palley (1963) reported that 65 percent of the second-growth redwood stems sampled in their study were of sprout origin. Reasons for the difference between stocking values of the 1942 and 1963 studies are related to the sampling systems used by the studies and the age of the sprouts considered.

Person and Hallin used a random milacre sampling system on small regeneration and their stocking estimate is expressed as quadrats with sprouts as a percent of number of quadrats examined. Old-growth stands, on the other-hand, seldom had more than 30-40 redwood trees per acre. Consequently, the probability of sampling a stump was low, and only a few areas had redwood tissue that could sustain sprouting. However, because of its tenacity and ability to grow well in clusters, redwood can develop several stems in a small area. As a result, a low percentage of stocked quadrats can mean a much greater number of established trees per acre. Point samples used by Lindquist and Palley select sample trees by size; larger trees have a greater probability of being selected. The yield table values show that redwood sprouts represent the most important part of the crop trees in the stands sampled.

Analysis of the regeneration 20 years after logging a clearcut second-growth stand on Jackson Demonstration State Forest showed that most redwood stumps sprouted (Henry, 1985). The degree of sprout stocking is affected by the number and distribution of redwood stumps in the cut stand. Planting costs can be reduced significantly when an adequate number of well distributed sprouts are established. The choice of species to plant may also be influenced by the density of the fast growing sprout clumps which may retard planted Douglas-fir seedlings. Finally, where redwood sprouting is successful the species composition of future harvests could be quite different from the current second-growth stands. Repeated cropping may create nearly pure redwood sprout

stands unless major efforts are made to maintain other species.

OBJECTIVES

The main emphasis of this study is to develop a long range analysis of the role of sprouts in future management of commercial redwood stands. Sampling the initial sprout population provides a baseline for determining how they develop over time. It is anticipated that many of the original sprouts in the initial survey will die.

Establishment of the plots in three managerial treatments permits a long range examination of sprout development following: clearcut without burning, clearcut with burning and selection cut with no slash treatment. Specific objectives of the study include:

1. Determine if silvicultural treatment affects the initial number and distribution of sprouts, and how these change over time.

2. Determine if there are correlations between sprouting and the number and size of redwood stumps.

3. Develop a method of predicting sprout stocking prior to harvest which can be used for planning planting operations.

4. Establish a set of permanent plots with map documentation of the sprout portion of the stand regeneration. These plots can be used later for studies of precommercial thinning.

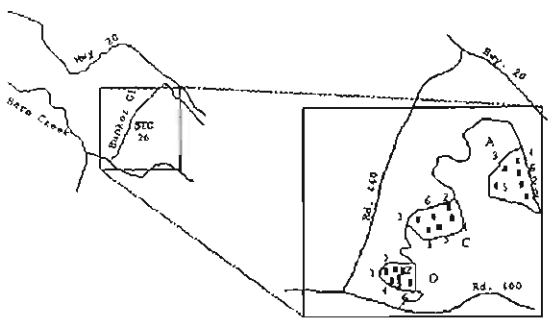


Figure 1. Location of 1985 Hare Creek sprout study and layout of the sample plots.

FIELD METHODS

Three blocks of the Hare Creek 1983 timber sale were selected for sampling (Figure 1). The blocks were all in section 26, T18N, R17W about 5 miles from the coast and southeast of Fort Bragg. Descriptive values from the sample data show an age of 80-85 years and a redwood site index of 155-160. The species distribution, based on the stumps, was 59 percent redwood and 41 percent whitewood.

Two blocks were clear cut; block C, a 20-acre parcel, was unburned and block D, a 10-acre parcel, was burned six months after logging. The third area, block A, was selectively logged and not burned. All logging was finished by the spring of 1984. All sprouts were approximately the same age when sampled. Burning slash in block D, autumn of 1984, destroyed the original crop of sprouts; the sprouts measured were those which grew back in 1985. Before the start of field work a layout of the plot distribution within each block was made. All field work in the unburned blocks was completed by May of 1985. Sampling the burned block was delayed until the fall to give new sprouts an opportuni-

ty to have a complete growth season.

Six random 0.4 acre plots were located in each block. Plots are 132 feet square with posts set at each exterior corner. An interior plot of 0.2 acre (93.3 feet square) was established within the 0.4 acre plot thus creating a buffer area approximately 38 feet wide around the interior plot. All plot boundaries are oriented to cardinal directions.

A transit was used to prepare stem maps of the trees and stumps inside each plot. The X and Y coordinates of each tree or stump are referenced from the northwest corner of the plot where X and Y are equal to zero. The coordinates of each stand element are computed from their angles and distances from the transit. All trees and stumps in the plots were located and put on the maps.

Variables recorded were species, diameter (at breast height or stump top), stump height, number of crown and/or root clumps, estimated total number of crown and/or root sprouts, and height of the tallest sprout. A clump was defined as a distinct group of sprouts on the stump which are separated from other sprouts. Simply being near a stump is not sufficient proof of sprouting. Conversely a single stem without a visible stump does not mean that the tree is of seedling origin. Many clumps reported in this study occur in locations where no stump was visible or were on small stumps that will be grown over in 20 years. Sprout clumps found but not associated with a stump were also mapped. These locations were assumed to have a stump of zero diameter and height.

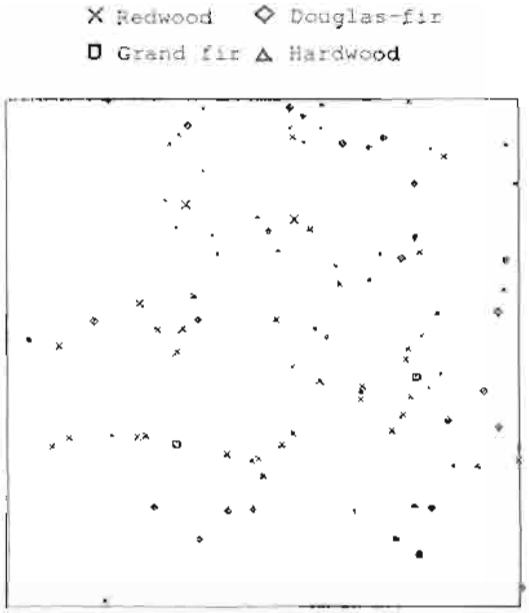


Figure 2. Distribution of stumps in a 0.4 acre plot showing the species, location and relative size.

RESULTS

Maps showing the distribution of stumps and associated sprouts represent a major aspect of this study (figure 2). The maps and data will be used later to determine how the initial sprouts developed into stems. The maps will allow future workers to know where all stumps with sprouts occurred in the initial inventory. Correlation of established stems to the initial sprout population will be useful in discussing the value of sprouts in restocking logged land.

Quadrat stocking

In addition to the plot stem maps showing the location of stems and stumps, quadrat grid maps that show the number of clumps in each of 400 milacre quadrats in each of the 18 plots were also created (Figure 3).

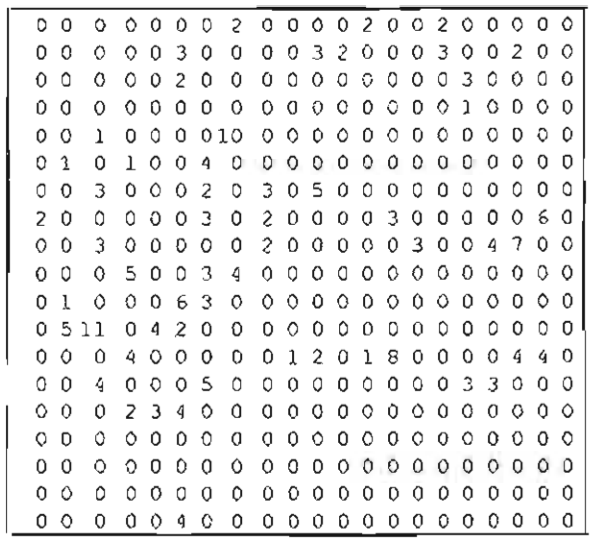


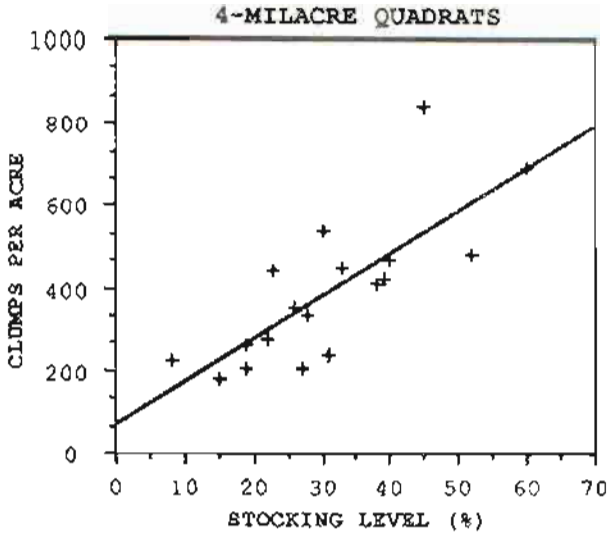
Figure 3. Distribution of stocked milacre quadrats. Numbers show the clumps in each of 400 quadrats of each mapped plot.

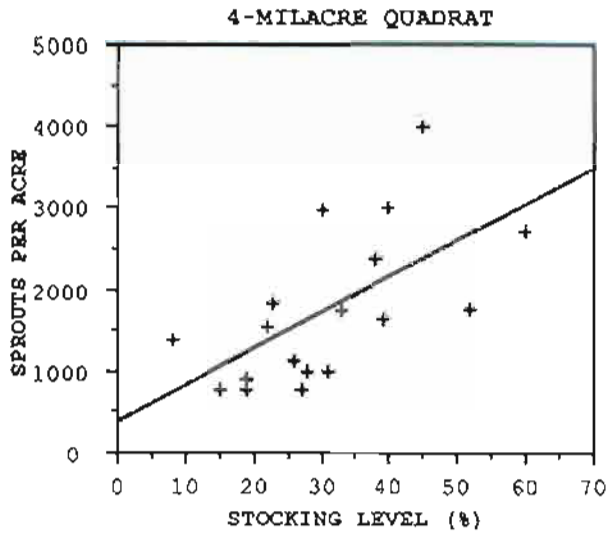
These maps show the spatial arrangement of stocked and non-stocked quadrats for each plot. A summary of the stocked quadrats (Table 1) reveals that quadrat size effects the percent of stocking. Average stocking of the 4-milacre quadrats is 30.8 percent, three times that of the 1 milacre quadrats which were 10.9 percent stocked. In the three blocks, the percent of stocked milacre quadrats is 3 percent more than that reported by Person and Hallin's 1942 study of cut-over old-growth. The 11 percent of the milacre stocked quadrats represent 110 stocked quadrats per acre with an average of 390.2 clumps per acre. Recent results from the Whiskey Springs studies on Jackson Demonstration State Forest indicate that it is reasonable to expect at least one established tree per clump in 15 years. This projects to a minimum of 390 redwood sprout stems per acre from the initial sprouting now in place.

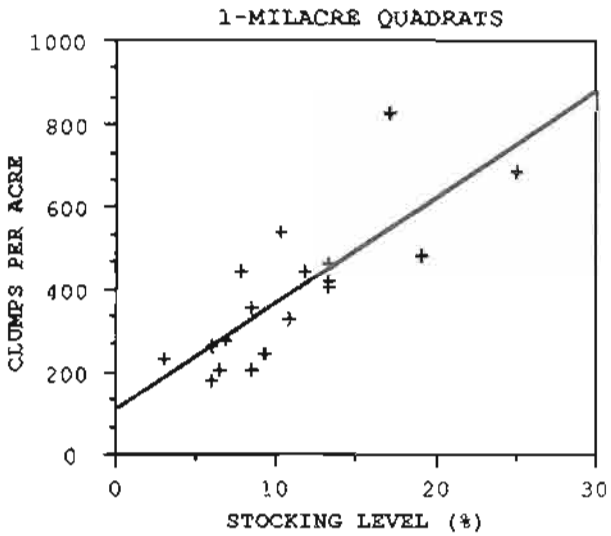
Analysis of variance (ANOVA) of the percent of stocked quadrats, Table 1. of both sizes reveals no significant differences among the three treatments. There were also no significant differences among the average number of locations with sprouts. Since the three blocks have no differences in the initial sprout stocking, homogeneous initial stand stocking can be assumed. Differences in sprout development, which may later arise, may be more closely related to treatment by cutting or burning.

Table 1. Summary of the stocked quadrats of the 18 mapped 0.4 acre plots. Number of sites with sprouts from the map data expressed in per acre terms.

Plot	Sprouted Sites No. per acre	1-Milacre percent	4-Milacre percent
Block C, Clearcut, unburned			
1	165.0	13.2	39.0
2	87.5	6.0	19.0
3	145.0	10.7	28.0
4	105.0	8.5	26.0
5	117.5	7.8	23.0
6	157.5	11.8	33.0
Ave.	129.6	9.7	28.0
S.D.	31.0	2.7	7.2
Block A, Partial cut, unburned			
7	90.0	6.0	15.0
8	100.0	8.5	27.0
9	110.0	9.2	31.0
10	327.5	25.0	60.0
11	225.0	19.0	52.0
12	90.0	6.5	19.0
Ave.	157.1	12.4	34.0
S.D.	98.1	7.8	18.1
Block D Clearcut, burned			
13	160.0	13.2	40.0
14	80.0	6.8	22.0
15	157.5	10.2	30.0
16	152.5	13.2	38.0
17	235.0	17.0	45.0
18	57.5	3.0	8.0
Ave.	140.4	10.6	30.5
S.D.	63.7	5.0	13.7
All Blocks			
Ave.	142.4	10.9	30.8
S.D.	66.6	5.4	13.2







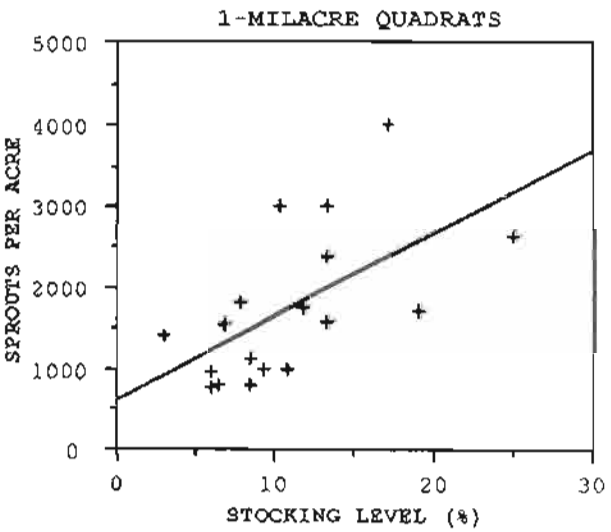


Figure 4. Clumps per acre over quadrat stocking levels for the 18 plots.

Figure 5. Sprouts per acre over quadrat stocking levels for the 18 plots.

Linear regressions that express the relationship of clumps and sprouts to the quadrat stocking level are detailed in Table 5. The correlation coefficient (R), shows the degree of correlation between two variables. Clumps per acre have the strongest relationship to quadrat stocking, whereas sprouts per acre are less well correlated. All values of R, as tested by the critical values of R (Table 21, Zar, 1974), are shown to have a significant positive linear relationship of sprouting to quadrat stocking. Graphically these relationships are shown in Figures 4 and 5. Stocking of either size quadrat has a linear equation that is useful to estimate sprouting activity (Table 6).

Levels of sprouting

Descriptions of the sprout pop-

Table 2. Summary of the per acre values of sprouting on three sets of six (18) 0.4 acre plots.

Plot	Sprout Sites	Stumps	Clumps	Sprouts	Sprouted	Average height
No.	number per acre				(%)	(inch)
Block C, Clearcut, unburned						
1	165.0	170.0	420.0	1627.5	97.1	29.9
2	87.5	87.5	265.0	885.0	100.0	42.9
3	145.0	145.0	332.5	990.0	100.0	34.2
4	105.0	107.5	352.5	1130.0	97.7	39.1
5	117.5	120.0	440.0	1825.0	97.9	42.3
6	157.5	162.5	447.5	1722.5	96.9	44.0
Ave.	129.6	132.1	376.2	1363.3	98.3	38.7
S.D.	31.0	32.5	72.0	408.5	1.4	5.6
Block A, Partial cut, unburned						
7	90.0	90.0	180.0	770.0	80.5	22.7
8	100.0	150.0	207.5	780.0	63.3	19.0
9	110.0	147.5	240.0	985.0	85.1	24.2
10	327.5	292.0	695.0	2727.5	97.4	27.3
11	225.0	227.5	482.5	1770.0	92.3	20.5
12	90.0	92.5	202.5	772.5	89.2	21.9
Ave	157.2	166.7	334.5	1300.8	84.6	22.6
S.D.	98.1	79.4	208.8	798.4	11.9	2.9
Block D Clearcut, burned						
13	160.0	165.0	467.5	3015.0	96.9	32.0
14	80.0	87.5	277.5	1547.5	91.4	33.5
15	157.5	160.0	540.0	2987.5	98.4	44.5
16	152.5	155.0	410.0	2385.0	98.3	34.6
17	235.0	237.5	837.5	4002.5	98.9	42.9
18	57.5	57.5	227.5	1392.5	100.0	46.8
Ave.	140.4	143.7	460.0	2555.0	97.3	39.0
S.D.	63.7	63.6	218.6	988.9	3.1	6.4
All Blocks						
Ave.	142.4	147.5	390.2	1739.7	93.4	33.5
S.D.	13.9	17.6	63.9	706.8	7.6	9.3

ulations for each sample plot are given in Table 2. There was considerable variability in the number of sprouts and clumps found in blocks A and D as compared to block C. Because of this variability there are no significant differences among the number of sprouts or clumps in the three blocks. The overall view is that regardless of the silvicultural system or slash treatment, redwood stumps can produce a large number of clumps and sprouts. Normally there is a large number of well established vigorous sprouts within a year of logging. Note in Table 2 that in the partially cut blocks some plots have more sites with sprouts than stumps; some uncut trees have sprouts near the base of the stem.

Table 3. Average number of crown clumps and sprouts per acre for the three logged blocks.

Block	Clumps per Acre			Sprouts per Acre		
	Ave.	S.D.	Percent of Total	Ave.	S.D.	Percent of Total
C	78.3	19.6	20.8	218.8	67.4	16.0
A	41.2	28.7	12.3	117.9	101.6	9.1
D	30.4	29.3	6.6	121.7	101.5	4.8
Total	50.0	25.1	12.8	152.8	57.2	8.8

Average sprout height of the tallest sprout at each site is also shown in Table 2. The average heights and standard deviations of the sprouts in blocks C and D are nearly equal although the average height of sprouts in block A is about 16 inches less. Analysis of variance reveals a significant height difference among the blocks. The Neuman and Kuels multiple range test (MRT) (Zar, 1974) indicates that the partial cut block (A) is significantly different from the clearcut blocks (C and D). There is, however, no difference between the clearcut blocks.

The percentage of redwood stumps with established sprouts is also reported in Table 2. Analysis of variance of this data reveals a highly significant difference among the three blocks. The MRT test reveals that the difference is between the partial cut block (A) and the two clearcut blocks (C and D). There is no difference between the sprouting percentage of the two clearcuts. Clearcut block sprouting exceeded 95 percent, and the partial cut sprouting exceeds 80 percent. Ages of the stands are generally 80-85 years at stump height.

Table 4. Cumulative percent of redwood stumps and sprout clumps by stump diameter class. Averages for the three blocks are based on six plots per block.

Diameter Class	Redwood Clumps Block			Redwood Stumps Block		
	C	D	A	C	D	A
inches	Percent			Percent		
1	11.9	9.8	25.3	24.1	21.1	36.7
5	20.3	22.7	33.4	33.1	40.0	43.1
10	28.0	37.6	44.1	41.2	54.0	55.2
15	49.7	60.9	62.6	59.7	72.4	71.0
20	69.5	82.4	76.7	75.2	88.1	82.3
25	83.6	88.6	87.7	86.1	92.9	91.7
30	92.3	95.9	97.9	93.6	97.3	97.2
35	98.6	98.3	99.2	98.5	98.8	98.9
# per acre	376.2	460.0	334.5	129.6	140.4	161.7

Information from a nearby commercially thinned 40-year stand showed 95 percent of the redwood stumps had sprouted. There is no evidence that the older stumps have lost any capacity to sprout heavily. Excluding plot 8, block A has a sprouting rate of 89 percent, much like that of the clearcut blocks although the variability is greater.

Crown sprouting rate

Sprouting was recorded as being at the root collar or higher on the stump. Clumps not directly in contact with the ground were considered as crown clumps. Overall 12.8 percent of the clumps and 9.6 percent of the sprouts were classed as crown origin (Table 3). Analysis of variance of the clump data shows a highly significant difference among treatment blocks. The heaviest crown sprouting is in block C, the unburned clearcut, with 21 percent of the clumps and 16 percent of the sprouts classed as crown. The lowest incidence of crown sprouting is in the clearcut and burned block (D) with clumps of 6.6 percent and sprouts 4.8 percent. Differences between the two blocks may be attributed to slash treatment. Crown sprouts have a higher risk of loss when the underlying stump tissue fails. Block D was burned six months after logging destroying the initial crop of sprouts. Sampling was delayed until new sprouts had grown, but many burned crown clumps had not resprouted by the fall of 1984. The total number of clumps in the burned block, including root collar and crown clumps, is 122 percent of the clumps in the unburned block but crown clumps in the burned block are 39 percent of crown clumps in the unburned. Since there is no difference in the number of stumps per acre there is a strong suggestion that burning has reduced the amount of high risk crown sprouts.

Small stump sprouting

Small diameter stumps are important to the total sprout restocking. The cumulative percent of sprouts and stumps by diameter class are shown in Table 4. About 25 percent of the clumps occur on the stumps which are 5 inches or less (38 percent of the stumps). This portion of the stand contributes to sprout regeneration capacity far beyond its volume. Stumps larger than 25 inches (10 percent) have only 13.4 percent of the clumps. The 14 stumps with a diameter greater than 25 inches (10% of all stumps) have only 13.4 percent of the sprout clumps (52). Whether sprouts growing on the small stumps develop in value as do those on larger stumps can only be evaluated after a period of time. Small stumps, 1-2 inches, are not likely to be visible after a period of 10-15 years; this makes it difficult to identify tree origin. Tracking sprout locations with maps allows correct attribution of the origin of each stem.

Table 5. Regression summary for number of clumps and sprouts as a function of stump diameter. Values are: a=intercept; b=slope coefficient; R=correlation coefficient

	Clumps per Stump			Sprouts per Stump			Height per Stump			No. of
Plot	a	b	R	a	b	R	a	b	R	Obs.
1	1.94	0.042	0.37	7.18	0.190	0.32	27.9	0.141	0.10	66
2	1.97	0.073	0.43	6.83	0.228	0.32	35.2	0.539	0.22	35
3	1.66	0.083	0.57	4.22	0.341	0.65	24.8	1.281	0.68	58
4	1.60	0.097	0.59	3.55	0.397	0.51	31.3	0.429	0.25	42
5	2.09	0.109	0.50	10.55	0.320	0.34	31.8	0.670	0.27	47
6	2.43	0.037	0.23	5.98	0.445	0.55	36.3	0.693	0.31	63
7	1.45	0.044	0.45	3.50	0.402	0.64	23.7	-0.078	0.08	36
8	1.47	0.060	0.46	4.58	0.322	0.39	17.6	0.145	0.14	40
9	1.85	0.026	0.19	6.65	0.187	0.25	26.8	-0.208	0.17	44
10	1.43	0.091	0.51	5.52	0.398	0.41	23.2	0.525	0.27	131
11	1.60	0.060	0.41	4.45	0.379	0.47	18.6	0.212	0.19	90
12	1.51	0.047	0.37	5.36	0.207	0.37	19.7	0.135	0.10	36
13	1.98	0.112	0.55	9.69	1.090	0.59	27.0	0.603	0.11	64
14	2.50	0.062	0.31	10.65	0.551	0.33	32.7	0.094	0.05	32
15	1.86	0.132	0.74	4.44	1.230	0.63	29.9	1.240	0.53	63
16	2.02	0.079	0.43	8.47	0.855	0.65	26.8	0.934	0.44	61
17	1.57	0.212	0.85	4.92	1.290	0.83	29.1	1.470	0.66	94
18	2.24	0.116	0.71	6.60	1.190	0.82	34.1	0.862	0.46	23

Regressions and correlations

The second study objective was to determine whether useful relationships exist between sprouting levels and stump diameter. These relationships were examined using linear regression analysis and by plotting the data. Regression summaries for each of the 18 plots are shown in Table 5. Visual examination of the plotted data and the equation statistics show little correlation in most of the plots; seldom do the R values exceed 0.60. The equations estimate number of clumps or sprouts per stump based on stump diameter. The range of clump and sprout numbers for a stump of a given diameter is wide, and it is not possible to make reliable estimates of a stump's sprouting capacity based on stump diameter. The average standard error of estimate (SEy) is 1.32 clumps; this is 48.5 percent of the average of 2.81 clumps per stump. For sprouts the SEy averages 64.2 percent of the average of sprouts per stump.

There is also little correlation between sprout height and stump diameter. Results of linear regression analysis (Table 5) show that R seldom is greater than 0.50, and most values range from 0.10 to 0.30. This level of correlation is low and does not give confidence in estimates of height from stump diameter. Plotting the data shows that heights associated with a specific stump diameter are too variable.

Numbers of sprouts

The plot data has also been analyzed to quantify relationships that describe stand sprout response, specifically the number of redwood stumps per acre and the number of sites per acre with sprouting. Most redwood stumps in the clearcut blocks have sprouted, but sprouting response in the partial cut block appears to be different. Regression equation summaries showing the relationship are given in Table 6.

Table 6. Summary of linear regressions and correlation of sprouting and stand values per acre. Computed from data from 18 plots shown in Tables 1 and 2. (a = regression line intercept, b = regression line slope, R = correlation coefficient, N = number of observations).

Dependent Variable	Independent Variable	Regression Summary a	b	R	N
# of Clumps	% stkd. 1mil.	104.58	26.288	0.798	18
# of Sprouts	% stkd. 1mil.	565.05	108.099	0.619	18
# of Clumps	% stkd. 4mil.	69.45	10.404	0.774	18
# of Sprouts	% stkd. 4mil.	375.03	44.260	0.622	18
# of Clumps	# RW Stumps	31.34	2.434	0.823	18
# of Sprouts	# RW Stumps	250.01	10.100	0.645	18
# of Clumps	# Sprtd Sites	65.99	2.278	0.858	18
# of Sprouts	# Sprtd Sites	394.41	9.450	0.673	18
# of Crown	# RW Stumps	35.04	0.086	0.286	18
# of Clumps	# RW Stumps	5.22	2.994	0.901	12
# of Clumps	# Sprtd Sites	9.48	3.027	0.903	12

Graphic displays of the data are shown in Figures 6 and 7. The number of clumps per acre is better correlated than number of sprouts per acre with the variables tested. The number of sprouted sites per acre is better correlated to the number of clumps per acre than to the number of redwood stumps per acre. Most of the difference results from conditions in the partial cut block (A). The partial cut block has one plot with less stump sprouting and all of the plots within the partial cut blocks have some leave trees that have sprouted. The number of redwood stumps and sprout sites in the clearcut blocks are essentially the same as there are no trees left to influence the sprouting patterns. Because of this difference between the clearcut blocks and the partial cut blocks a separate regression analysis was performed using only those plots in the two clearcut blocks; the results are included in Table 6.

Variability is much less in these

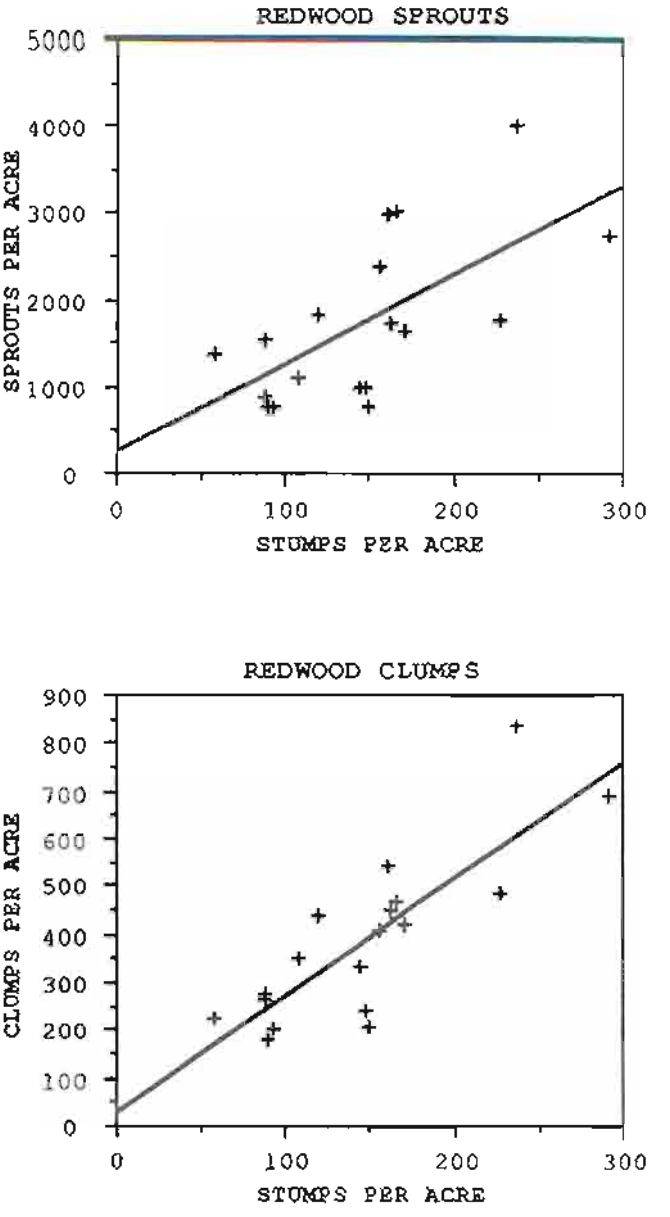


Figure 6. Sprouts and clumps per acre over number of redwood stumps for the 18 plots.

12 plots and the correlation value is higher. Estimates of sprouting potential in stands to be clearcut might be improved by using these equations.

Estimates of sprouting potential are more reliable when based on the number of sites with sprouts. However, while the number of redwood stumps can be directly

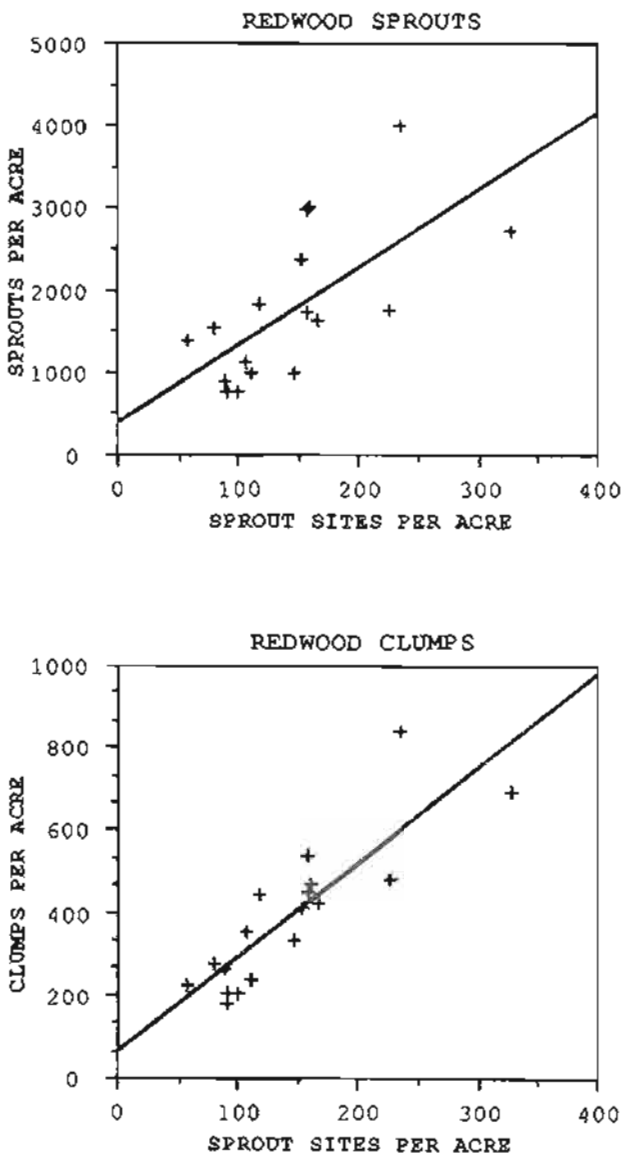


Figure 7. Sprouts and clumps per acre over number of sprouted sites for the 18 plots.

determined by sampling, estimates of the number of sprouted sites can be calculated by multiplying the number of redwood stumps by the 96 percent rate of sprouting. Slash burning did not reduce the total amount of sprouting in any way that seriously affects stocking. Some initial crown clumps did not resprout after the burn, but this reduction of high risk crown clumps is beneficial. However, an important difference between blocks C and D may be the heavy thicket of Ceanothus and Arctostaphylos seedlings in the burned block. How this brush competition develops should be monitored to determine its effect on natural sprouting and planted seedlings.

SUMMARY AND CONCLUSIONS

Stocking by sprouts in milacre quadrats in these second-growth stands is not much different than reported by Person and Hallin (1942). However, the number of clumps and sprouts suggests a robust fast growing sprout population that could be a stand of 400 established trees per acre in a few years. This sprout population may not have the best spatial distribution that management would like. Some additional interplanting of redwood or Douglas-fir may be required to stock obvious openings. This study showed that one should not depend on 1 milacre sampling to assess sprout stocking. If one assumes an established stem per clump in 20 years the stocking of the 4-milacre quadrat is a more useful measure of site occupancy. The average of 31 percent stocking means 77 4-milacre quadrats per acre with an average of 5.1 established stems per quadrat. Redwood averaged 60 percent of the total number of stumps in the blocks, and sprout regeneration averages 390 clumps with 1,739 sprouts per acre. The average height of the tallest sprout at each sprout site is nearly 3 feet, and about 90 percent of the sprouts are of root collar origin.

Prior studies (Linquist, 1979) have shown that it can be reasonably assumed that at least one well established sprout stem per clump site will be forthcoming

and it will be a part of an aggressive well established sprout component that is vital to the final crop. Estimates of future sprout regeneration in harvest units can be computed using one of the equations given in Table 6.

The number of redwood stumps is the most useful measure for making predictions of sprout regeneration; these estimates are most useful in planting to meet desired stocking levels. Planting has to be controlled so that it improves distribution of the new stand at the least cost.

Small suppressed redwoods are often overlooked, but they appear to have a vital role in the sprout restocking of logged sites. Nearly 25 percent of the clumps were on stumps 5 inches or less in diameter. There appears to be no difference in the vigor of sprouts between small stumps and large stumps. It is important that small suppressed stumps be recognized and included when sampling the redwood stump component.

There is little to be gained by using the prediction equations of clumps or sprouts per stump from stump diameter (Table 5). Most of the stumps will sprout, but the relationship of sprouting to stump diameter is poor and of limited utility. Sprout height was also found to be poorly related to stump diameter. It is sufficient to know that in the first growth season many of these vigorous sprouts will reach 4.5 feet.

RECOMMENDATIONS

Specific facts about the sprout population revealed in this study lead to some specific operational suggestions. The main idea of these recommendations is that the sprout population will develop into a vigorous component of the next stand. It is expensive and unwise to ignore the impact of the native sprout population on management activity. Costs of planting are high, and unnecessary trees should not be part of restocking activity.

1. Sample the cut blocks to determine the number of redwood stems; and include the small stems down to the 1 inch class.

2. Estimate the number of clumps per acre to expect on the existing redwood. These estimates will help the ordering of seedlings from the nursery.

3. Work closely with planting operators to develop an understanding of how to adjust planting patterns to existing sprout populations.

4. When planting seedlings they should not be planted close to the heavy clumps of sprouts.

5. Evaluate effects of burning in relation to brush competetion on planted seedlings. There may be heavy brush growth following the burn.

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