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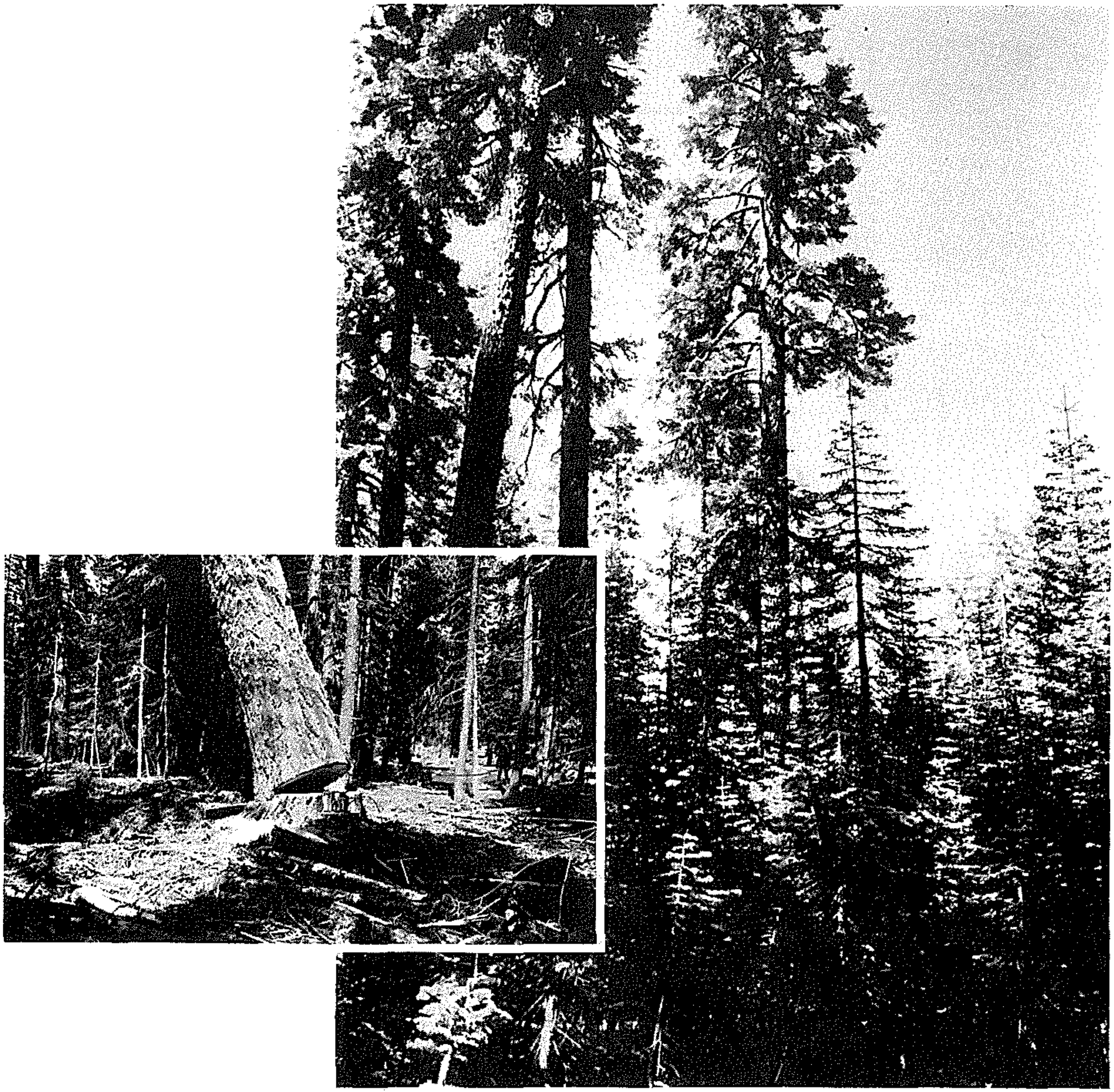
Overstory Removal: stand factors related to success and failure

Robert J. Laacke **Gary O. Fiddler**



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Cover: A suitable stand for overstory removal must have at least two size classes. Inset—Large merchantable trees are removed leaving advance regeneration for the future crop.

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IN BRIEF . . .

Laacke, Robert J.; Fiddler, Gary O. **Overstory removal: stand factors related to success and failure.** Res. Paper PSW-183. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1986. 6 p.

Retrieval Terms: crop tree selection, mixed conifers, overstory removal

A variety of factors, including public concern over practices that dramatically change forest appearance, make overstory removal an attractive harvest alternative to clearcutting and regeneration. To be successful, an overstory removal must leave a stand adequately stocked with well-distributed crop trees. Crop trees must have the capacity to reach final harvest with a combination of time, volume, and value considerations that equal or exceed those attainable by a newly regenerated stand.

Twenty-nine areas on nine Forest Service overstory removal sales in northern California were sampled before and after harvest. Preharvest and postharvest condition and size of the advance regeneration (understory) were recorded. Understory trees were classified as acceptable or unacceptable using standards for dominance, height growth, appearance and crown that indicated ability to quickly respond to release.

Postharvest stands were classified as satisfactory or unsatisfactory according to the number and size of the crop trees in the residual stand. Discriminant analysis was used to identify preharvest variables related to the success of the overstory removal. Only two variables were strongly enough related to the postharvest condition to be included in the discriminant function and both were related to the overstory removed. The two variables were arithmetic mean diameter at breast height and the total longitudinal (cross-sectional) area of the overstory trees.

A discriminant function was used to classify the stands studied as "good or bad risks" for overstory removal, based on preharvest data. The equation is presented.

The conclusion was that overstory removal can be accomplished, although it is risky. Large numbers of advanced regeneration before harvest do not ensure that the postharvest stand will be adequately stocked with acceptable quality crop trees. No evidence was found in this study of operational overstory removal sales that condition of the preharvest understory can be used to predict or estimate the postharvest condition in terms of acceptable crop trees remaining. Instituting extraordinary control measures to protect the understory may be necessary.

INTRODUCTION

Managers of public and private forest land are increasingly compelled by economic considerations, legislative requirements (especially in California), and company or agency policy to produce the maximum return and regenerate harvested forest land as quickly and economically as possible. At the same time, public concerns about visual impacts of management produce pressure to avoid management practices, such as clearcutting, that dramatically change forest appearance. As a result, any approach that eliminates the need for a heavy regeneration cut with attendant visual impact tends to be extremely attractive. Overstory removal offers such opportunities.

An overstory removal cut is applied to a stand with at least two age or size classes, the older (or larger) of which is merchantable and is removed. The removal should leave an adequately stocked stand with well-distributed crop trees that have the capacity to yield a product with a combination of time, volume, and value considerations equal to or exceeding those attainable by a newly regenerated stand. If the residual stand cannot meet this criterion, overstory removal should not be attempted and the stand should be regenerated.

Protection of future crop trees in the understory is paramount in an overstory removal and is possible, although relatively expensive (Barrett and others 1976). Therefore, to avoid the extra costs of having to remove and regenerate an unacceptable and perhaps unmerchantable residual stand, overstory removal should be prescribed only when the probability of success is high. To estimate likelihood of success, two questions must be answered: (1) What set of characteristics identifies understory trees as acceptable crop trees? (2) What stand factors unacceptably reduce the probability of successful overstory removal? Helms and Standiford have provided a reasonable approach to answering the first question (Helms and Standiford 1985, Standiford 1978). The study reported here was designed to address the second.

This paper reports a study of operational overstory removal cuts in northern California to determine which stand factors are related to stocking with acceptable crop trees after harvest.

METHODS

Nine timber sales on the Plumas, Modoc, Klamath, Lassen, and Shasta-Trinity National Forests in northern California were chosen for study. All were operational sales designed and implemented as overstory removals and were cut over a period of 3 years. All were in the true fir, "east-side pine," or Sierra Nevada mixed-conifer timber type. Overstory volumes removed ranged from 72 to 707 m^3/ha (753-7432 ft^3/acre) with a mean of 282 m^3/ha (std. dev. 153). Overstory data are presented in *table 1*.

Depending on stand size and condition, up to 5 homogeneous units were delineated in each sale for a total of 29 units. Individual units ranged from 0.73 to 3.0 ha with a mean of 1.7 and standard deviation of 0.5 ha (1.8 to 7.4 acres, mean 4.1, std. dev. 1.2). Understory plots were circular and systematically located on a randomly oriented grid. Each plot was divided into quarters, and data was recorded by quadrant. Initially, 30 percent of the unit was sampled using 1/40th-acre (0.01 ha) plots. Based on estimates of within- and between-plot variation from 189 preharvest and postharvest plots, plot size was reduced to 1/80th acre (0.005 ha). Data were collected on all the overstory trees to be removed within the unit. To avoid possible operator bias, sampling was done without the operator's knowledge and sample plots were not marked. Sampling resulted in two independent sets of data for each area, one preharvest and one postharvest.

The following preharvest data were collected for all understory trees in each quadrant:

Species
Diameter at breast height (d.b.h.) by 5.08-cm (2 in) classes
Trees less than 1.37 m (4.5 ft) tall were recorded as "less than d.b.h."

Each understory tree in each plot was judged acceptable or unacceptable as a crop tree on its ability to respond quickly to release. This ability was estimated in the field using criteria patterned after Helms and Standiford (1985) and Standiford (1978). The criteria used to identify acceptable trees for all species in this study were these:

Dominant or codominant crown class
Constant or increasing yearly height growth
Vigorous appearance
No crown damage
30 percent or greater live crown.

The following were measured for all overstory trees in each unit:

Species
D.b.h. (outside bark)
Height to base of live crown
Total tree height
Radius of base of crown (width of base divided by 2)
Radius of top of crown (width of crown top divided by 2).

These measurements were used to calculate basal area and the longitudinal area of the tree (cross-sectional area of bole plus crown) and, therefore, the area potentially impacted when the tree fell.

Postharvest measurements were the same as preharvest with the addition that all unacceptable trees were classified as either damaged or undamaged. After harvest, no overstory trees remained.

Table 1—*Overstory characteristics of timber stands on five National Forests in northern California, by timber sale and forest type*

Sale and unit		Mean d.b.h.		Stems /ha	Stems /acre	Volume removed			Forest type[1]
		cm	*in*			*m³/ha*	*ft³/acre*	*fbm/acre*	
A	1	86.4	34	24.7	10	265	2,782	18,920	MC
	2	104.1	41	34.6	14	478	5,021	34,145	MC
	3	86.4	34	42.0	17	512	5,387	36,630	MC
	4	91.4	36	34.6	14	528	5,553	37,758	MC
	5	134.6	53	22.2	9	707	7,432	50,539	MC
B	1	73.7	29	24.7	10	97	1,019	6,926	EP
	2	76.2	30	19.8	8	152	1,598	10,867	EP
	3	76.2	30	19.8	8	159	1,670	11,358	EP
	4	83.8	33	22.2	9	233	2,450	16,658	EP
C	1	71.1	28	12.4	5	72	753	5,117	EP
	2	66.0	26	46.9	19	225	2,369	16,110	EP
	3	66.0	26	49.4	20	217	2,276	15,479	EP
D	1	73.7	29	29.7	12	240	2,524	17,164	EP
	2	61.0	24	54.4	22	260	2,733	18,586	EP
	3	71.1	28	24.7	10	171	1,800	12,237	EP
E	1	83.4	34	44.5	18	490	5,146	34,992	MC
F	1	81.3	32	37.1	15	152	1,599	10,876	EP
	3	83.2	33	29.7	12	245	2,570	17,479	EP
	4	99.1	39	34.6	14	213	2,243	15,251	EP
	5	86.4	34	22.2	9	205	2,154	14,645	EP
G	3	81.3	32	37.1	15	332	3,495	23,765	TF
	4	96.5	38	29.7	12	413	4,339	29,506	TF
H	1	132.1	52	17.3	7	474	4,978	33,853	MC
	2	94.0	37	19.8	8	240	2,525	17,170	MC
	3	91.5	36	19.8	8	245	2,578	17,530	MC
	4	124.5	49	7.4	3	159	1,672	11,369	MC
	5	132.1	52	14.8	6	348	3,660	24,890	MC
I	2	81.3	32	17.3	7	155	1,626	11,054	TF
	3	68.6	27	27.2	11	137	1,438	9,779	TF

[1] MC = mixed conifer; EP = east-side pine; TF = true fir.

ANALYSIS

To be acceptable, a residual stand had to fit one of these two classes: (1) have a minimum of 247 acceptable trees per hectare (100/acre) taller than 1.37 m (4.5 ft); or (2) have a minimum of 198 acceptable trees per hectare (80/acre) if the average d.b.h. of the acceptable trees was equal to or greater than 16.5 cm (6.5 in). Of the 29 units, 13 were classified as satisfactory following harvest, and the rest unsatisfactory. Stepwise discriminant analysis was used to identify the variables associated with the two classes. Preharvest independent variables chosen for the analysis were these:

Arithmetic average overstory d.b.h.
Number of overstory trees per acre
Longitudinal (cross-sectional) area of overstory trees per acre
Sum of d.b.h.'s of acceptable understory trees per acre
Sum of d.b.h.'s of all understory trees per acre
Total basal area per acre of acceptable understory trees
Total basal area per acre of all understory trees
Number of acceptable understory trees per acre
Number of all understory trees per acre
Arithmetic average d.b.h. of all understory trees per acre
Arithmetic average d.b.h. of all trees per acre.

RESULTS

The preharvest characteristics most closely associated with postharvest stand classification were these four:

Arithmetic average d.b.h. of the overstory
Total longitudinal (cross-sectional) area per acre of overstory trees
Total number of all understory trees per acre preharvest
Sum of d.b.h.'s of all understory trees per acre preharvest.

Of these characteristics, only the first two had an F value large enough to be included in the discriminant function (approximate F statistic = 7.140 with 2 and 26 degrees of freedom). The discriminant function correctly classified stands that ended up with acceptable postharvest stocking 83.3 percent of the time and those with unacceptable postharvest stocking 82.4 percent of the time. One way to test a discriminant function without new data is the "jackknife approach," in which individual stands are removed from the data set, and the discriminant function is recalculated and then used to classify the removed stand. With this approach, acceptable stands were correctly classified 83.3 percent of the time and unacceptable stands 76.5 percent of the time.

The value of the function illustrated below is calculated using values of X (average d.b.h. of overstory) and Y (longitudinal cross-sectional area of overstory trees expressed in hundreds of square feet), determined from stand measurements. (Note that metric units cannot be used in the function as presented.)

$$F(X,Y) = -0.20244X + 0.01520Y$$

The result is compared with the discriminant constant, in this case −4.22332, and—if the value of the function exceeds the constant—the stand is classified as acceptable (a "good risk"). If the calculated function is equal to or less than the constant, the stand is classified as unacceptable (a "poor risk") for overstory removal by the criteria of this study. For example, for a stand with an average overstory d.b.h. of 28 inches and a total longitudinal cross-sectional area of 13,000 ft^2 (using 130 because calculations are in hundreds of square feet), the function yields a value of −3.69232, which is greater than −4.22332. This hypothetical stand would, therefore, be acceptable for overstory removal by the standards of this study.

Although the discriminant function was developed using data from sites on nine National Forests in northern California encompassing a wide range of stand conditions, its applicability to other stands has not been tested.

DISCUSSION

All of the stands tested were more than adequately stocked, by total tree count alone, after harvest (*table 2*). The minimum numbers of acceptable crop trees used as classification criteria (i.e., 247/ha or 198/ha >16.5 cm) are arbitrary and do not represent a suggested minimum standard. These relatively low numbers might be practical, however, when one considers the plentiful "unacceptable" trees on these units. Their growth could compensate for having so few trees capable of quickly responding to release.

Of the eight preharvest understory variables tested, none was sufficiently related to postharvest stand condition to be included in the discriminant function, including the number of preharvest crop trees. Both the number and proportion were highly variable between plots (*table 3*). The same was true of the postharvest stand (*table 2*). Starting out with many understory trees and a high proportion of acceptable crop trees did not ensure an acceptable postharvest condition.

Six units (generally those with few crop trees before harvest) showed an actual increase in acceptable trees after harvest (compare *tables 2 and 3*). Acceptable trees on three of the six units increased sufficiently for them to be classified as satisfactorily stocked. Field data were collected by the same crews and classification of trees constantly checked. Therefore, this anomaly was assumed to be the result of the anticipated sample error arising because separate and independent samples were used to estimate preharvest and postharvest stand conditions.

Table 2—*Postharvest characteristics of understory trees in stands on five National Forests in northern California, by timber sale*

Sale and unit		Metric units						English units					
		All trees		Crop trees				All trees		Crop trees			
		No./ha	*D.b.h.(cm)*[1]	*Total/ha*	*Pct*[2]	*No./ha*	*D.b.h.(cm)*[1]	*No./acre*	*D.b.h.(in)*[3]	*Total/acre*	*Pct*[4]	*No./acre*	*D.b.h.(in)*[3]
A	1	1,727	14.5	381	22	255	20.1	699	5.7	154	22.0	103	7.9
	2	2,604	10.9	618	24	378	11.7	1,054	4.3	250	23.7	153	4.6
	3	1,596	11.9	304	19	264	19.3	646	4.7	123	19.0	107	7.6
	4	2,402	11.2	106	4	89	20.1	972	4.4	43	4.4	36	7.9
	5	2,459	18.3	86	4	62	30.5	995	7.2	35	3.5	25	12.0
B	1	5,362	8.1	67	1	67	27.9	2,170	3.2	27	1.2	27	11.0
	2	3,492	8.6	25	1	25	29.0	1,413	3.4	10	0.7	10	11.4
	3	2,763	9.4	22	1	22	40.6	1,118	3.7	9	0.8	9	16.0
	4	645	16.8	99	15	99	26.7	261	6.6	40	15.3	40	10.5
C	1	657	20.8	205	31	205	25.7	266	8.2	83	31.2	83	10.1
	2	1,977	10.2	316	16	311	17.5	800	4.0	128	16.0	126	6.9
	3	4,334	9.1	289	7	289	17.0	1,754	3.6	117	6.7	117	6.7
D	1	2,674	9.9	272	10	272	18.5	1,082	3.9	110	10.2	110	7.3
	2	2,254	10.4	363	16	363	18.5	912	4.1	147	16.1	147	7.3
	3	3,417	10.7	482	14	482	16.8	1,383	4.2	195	14.1	195	6.6
E	1	2,011	10.9	306	15	306	19.8	814	4.3	124	15.2	124	7.8
F	1	2,120	9.9	47	2	47	38.6	858	3.9	19	2.2	19	15.2
	3	1,989	9.1	32	2	32	39.6	805	3.6	13	1.6	13	15.6
	4	2,118	9.9	64	3	47	26.9	857	3.9	26	3.0	19	10.6
	5	1,868	10.4	116	6	116	31.2	756	4.1	47	6.2	47	12.3
G	3	1,023	14.5	104	10	104	26.7	414	5.7	42	10.1	42	10.5
	4	2,224	13.0	109	5	109	31.8	900	5.1	44	4.9	44	12.5
H	1	1,344	15.5	133	10	126	29.5	544	6.1	54	9.9	51	11.6
	2	1,937	14.0	203	10	198	28.2	784	5.5	82	10.5	80	11.1
	3	1,443	14.0	217	15	170	25.7	584	5.5	88	15.1	69	10.1
	4	1,816	15.0	72	4	64	14.2	735	5.9	29	3.9	26	5.6
	5	2,933	16.8	141	5	44	6.6	1,187	6.6	57	4.8	18	2.6
I	2	1,572	18.3	170	11	170	39.9	636	7.2	69	10.8	69	15.7
	3	3,267	14.2	277	8	277	32.8	1,322	5.6	112	8.5	112	12.9

[1]Average diameter at breast height of trees taller than 1.37 m.
[2]Percentage of all trees represented by potential crop trees (including those shorter than 1.37 m).
[3]Average diameter at breast height of trees taller than 4.5 ft.
[4]Percentage of all trees represented by potential crop trees (including those shorter than 4.5 ft).

Table 3—*Preharvest characteristics of understory trees in stands on five National Forests in northern California, by timber sale*

Sale and unit		Metric units						English units					
		All trees		Crop trees				All trees		Crop trees			
		No./ha	*D.b.h.(cm)*[1]	*Total/ha*	*Pct*[2]	*No./ha*	*D.b.h.(cm)*[1]	*No./acre*	*D.b.h.(in)*[3]	*Total/acre*	*Pct*[4]	*No./acre*	*D.b.h.(in)*[3]
A	1	1,594	14.2	430	27	368	19.1	645	5.6	174	27	149	7.5
	2	2,256	11.4	914	41	739	13.7	913	4.5	370	41	299	5.4
	3	2,713	10.7	1,077	40	731	14.5	1,098	4.2	436	40	296	5.7
	4	2,439	12.7	875	36	726	15.7	987	5.0	354	36	294	6.2
	5	1,362	17.0	385	28	343	29.7	551	6.7	156	28	139	11.7
B	1	5,347	8.4	1,275	24	937	10.9	2,164	3.3	516	24	379	4.3
	2	5,686	8.9	1,964	35	1,663	10.9	2,301	3.5	795	35	673	4.3
	3	3,588	9.9	1,166	33	1,156	14.5	1,452	3.9	472	33	468	5.7
	4	1,282	12.2	588	46	568	14.7	519	4.8	238	46	230	5.8
C	1	855	15.2	610	71	608	16.3	346	6.0	247	71	246	6.4
	2	3,791	10.2	1,737	46	1,334	11.9	1,534	4.0	703	46	540	4.7
	3	4,067	9.1	1,255	31	865	12.4	1,646	3.6	508	31	350	4.9
D	1	3,212	8.6	635	20	630	12.4	1,300	3.4	257	20	255	4.9
	2	3,667	8.6	825	23	791	12.7	1,484	3.4	334	23	320	5.0
	3	3,445	8.9	749	22	749	15.0	1,394	3.5	303	22	303	5.9
E	1	4,292	10.9	1,013	24	803	16.8	1,737	4.3	410	24	325	6.6
F	1	2,874	10.4	215	7	215	20.8	1,163	4.1	87	8	87	8.2
	3	3,879	8.9	35	1	35	14.2	1 570	3.5	14	1	14	5.6
	4	2,669	8.4	104	4	104	20.8	1,080	3.3	42	4	42	8.2
	5	2,842	8.1	89	3	89	17.0	1,150	3.2	36	3	36	6.7
G	3	1,987	13.5	346	17	346	22.6	804	5.3	140	17	140	8.9
	4	3,919	14.5	158	4	158	33.8	1,586	5.7	64	4	64	13.3
H	1	3,249	14.0	121	4	121	28.2	1,315	5.5	49	4	49	11.1
	2	2,992	13.2	156	5	156	35.8	1,211	5.2	63	5	63	14.1
	3	1,925	16.5	116	6	116	46.0	779	6.5	47	6	47	18.1
	4	2,688	15.0	205	8	198	34.5	1,088	5.9	83	8	80	13.6
	5	4,922	14.0	210	4	190	24.9	1,992	5.5	85	4	77	9.8
I	2	2,953	15.5	106	4	106	44.5	1,195	6.1	43	4	43	17.5
	3	2,506	16.5	183	7	183	35.6	1,014	6.5	74	7	74	14.0

[1]Average diameter at breast height of trees taller than 1.37 m.
[2]Percentage of all trees represented by potential crop trees (including those shorter than 1.37 m).
[3]Average diameter at breast height of trees taller than 4.5 ft.
[4]Percentage of all trees represented by potential crop trees (including those shorter than 4.5 ft).

CONCLUSIONS

Overstory removal can be accomplished, although it is risky. Large numbers of advanced regeneration before harvest do not ensure that the postharvest stand will be adequately stocked with acceptable quality crop trees. We found no evidence that condition of the preharvest understory can be used to predict or estimate the postharvest condition in terms of acceptable crop trees remaining.

The quality of the residual stand should be the criterion for determination of success or failure of overstory removal. And, unless economically releasable trees are present before harvest, none will be present after harvest. These data indicate that the factors most closely associated with acceptable and unacceptable conditions after harvest are physical characteristics of the overstory that is removed. Practical experience and published research suggest that operator care and skill can also be significant in protecting advanced regeneration.

For these reasons, overstory removal should be approached with caution and receive the attention needed to ensure its success.

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Laacke, Robert J.; Fiddler, Gary O. **Overstory removal: stand factors related to success and failure.** Res. Paper PSW-183. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1986. 6 p.

Overstory removal can offer economic and esthetic advantages over clearcutting and regeneration, but projecting success is difficult. Twenty-nine units on nine operational overstory removal cuts in northern California were studied to determine what factors are related to satisfactory or unsatisfactory stocking after harvest. Stocking determinations were based on number of trees meeting minimum crop tree standards. Although all of the postharvest stands contained adequate numbers of trees, only about half passed minimal stocking standards based on number of trees meeting crop tree criteria. Only 2 of 11 preharvest stand characteristics tested were sufficiently associated with postharvest condition to be identified in discriminant analysis. The two characteristics were arithmetical average diameter at breast height of the overstory and total longitudinal cross-sectional area of the overstory trees. These two variables correctly identified postharvest stands as stocked 83 percent of the time and as unstocked 77 percent of the time, based on preharvest conditions.

Retrieval Terms: crop tree selection, mixed conifers, overstory removal