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A Broadcast Burn in Second-Growth Clearcuttings in the North Central Sierra Nevada

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ABSTRACT: At the Challenge Experimental Forest, 29 acres of slash were broadcast burned on five small clearcut plots (2 to 10 acres) at a cost of $57.00 per acre. Fuel-weight measurements showed reductions of 68 to 84 percent after the burn. Modifications to plot size, shape, and orientation could reduce this cost.

Vast amounts of highly flammable slash, ranging from 88 to 110 tons per acre, remain after logging in mixed conifer and hardwood stands. Broadcast burning is one way to reduce the high fire hazard and enhance coniferous regeneration. But how well would this work and what would it cost? Answering these questions was the objective of a study conducted on the Challenge Experimental Forest, Yuba County, California.

During the winter of 1962-63, 68 acres were clearcut in 12 circular plots of 2, 5, and 10 acres, with four replications of each plot size. The plots were circular so that natural seed fall and regeneration could be studied. Slopes ranged from 11 to 36 percent, with an east and southwest aspect. All merchantable stems (to a 10-inch top d.i.b.) were removed, and the remaining conifers and hardwoods were pushed over by a heavy dozer tractor (fig. 1). The slash was allowed to dry during the summer for broadcast burning in the fall. How it would burn, the firing technique, and the manning plan to be used all depended on the amount of fuels, their size, and approximate species composition.

Detailed fuel weight sampling seemed best to give us the necessary answers. Coniferous slash data were obtained from Chandler's slash weight tables[1] and applied to a 100-percent cruise on each clearcut plot. Cull logs which remained after logging were measured and their volumes calculated. Submerchantable coniferous stems were sampled from randomly located 0.01- and 0.05-acre subplots. Trees greater than 6.0 inches d.b.h. were sampled on the larger subplots, stems less than 6.0 inches on the smaller ones. Tables on crown weights, tree heights, and hardwood total tree weights, applicable to

[1] Chandler, Craig C. Slash weight tables for west-side mixed conifers. U. S. Forest Serv. Pacific SW. Forest & Range Exp. Sta. Tech. Paper 48, 21 pp. 1960.

Figure 1.--A typical clearcut plot after logging and pushing. The continuity of the heavy slash made broadcast burning easier.

Challenge data, were developed and applied to determine the hardwood fuel weights.[2] All results were then converted to a dry-weight basis.

Burning Prescription

Preplanning is the key to a safe, successful burn. During the preceding winter, a burning prescription was prepared which set forth necessary conditions of fuel moisture, relative humidity, temperature, and synoptic weather (table 1). Within this prescription, a safe, satisfactory burn can be achieved under prevailing Challenge conditions. Though the lower limits are "wet," a satisfactory burn can be obtained by using concentrated ignition techniques. The upper limits of the prescription, although quite dry, are still low enough to prevent serious spotting should it occur. Under no circumstances was burning to start until the prescribed conditions were present.

The prescription became part of the burning plan, which included details of manning, equipment, and safety. Firelines, 16 feet wide, were bulldozed around the plot perimeters and widened to 30 feet in potentially dangerous areas. All snags were felled for a distance of 200 feet in the surrounding timber.

[2]Sundahl, William E. Slash and litter weights after clearcut logging in two young-growth timber stands. (In preparation for publication, Pacific SW. Forest & Range Exp. Sta., U.S. Forest Serv., Challenge, Calif.)

Table 1.--*Challenge prescribed burn index element tables*

FINE FUEL MOISTURE

1

Fuel stick moisture content	Relative humidity																				
	00 06	07 09	10 12	13 15	16 20	21 27	28 34	35 41	42 48	49 53	54 58	59 63	64 68	69 72	73 76	77 82	83 87	88 92	93 99
01.0-04.5	1.5	1.5	2	2.5	3	4	5	5	6	7	8	8	9	10	11	12	15	16	18+
05.0-10.0	2	2.5	3	4	4	5	6	6	7		9	10	10	11	12	14	16	18	18+
11.0-15.0	3	4	4	5	5	6	7	7	8	9	10	11	11	12	13	15	17	18+	18+
16.0-20.0	4	5	5	6	6	7	8	8	9	10	11	12	12	13	14	16	18	18+	18+
21.0-25.0	5	6	6	7	7	8	9	9	10	11	12	13	13	14	15	17	18+	18+	18+
26.0-30.0	6	7	7	8	8	9	10	10	11	12	13	14	14	15	16	18	18+	18+	18+
31.0-35.0	7	8	8	9	9	10	11	11	12	13	14	15	15	16	17	18+	18+	18+	18+
36.0-40.0	8	9	9	10	10	11	12	12	13	14	15	16	16	17	18	18+	18+	18+	18+
41.0-45.0	9	10	10	11	11	12	13	13	14	15	16	17	18	18	18+	18+	18+	18+	18+
46.0-50.0	10	11	11	12	12	13	13	14	15	16	17	17	18	18+	18+	18+	18+	18+	18+

SPREAD INDEX

2

Fine fuel moisture	Wind speed (m. p. h.)																		
	00 02	03 05	06 07	08 09	10	11	12	13	14	15	16	17	18	19	20	21	22 23	24+	
1.5	14	19	23	28	33	37	40	43	47	51	55	61	66	70	74	83	89	100	
2	13	17	21	25	30	34	37	40	43	47	51	56	61	65	70	77	82	92	
2.5	12	15	20	24	28	32	35	38	41	44	47	52	56	61	67	72	77	86	
3	11	14	18	22	26	29	32	34	38	41	44	48	52	57	62	67	73	81	
4	10	13	16	20	23	26	29	31	34	37	39	43	47	51	55	60	64	72	
5	8	11	14	17	20	22	25	28	30	33	35	38	41	45	49	53	57	62	
6	7	9	12	14	17	19	21	24	26	28	30	33	35	39	44	47	49	54	
7	6	8	10	12	15	17	19	21	22	24	26	29	31	33	39	42	44	46	
8	5	7	9	11	13	14	16	17	19	20	22	25	26	29	33	36	38	41	
9	5	6	7	8	10	11	13	14	16	17	18	21	22	25	28	30	32	36	
10	4	5	6	7	8	9	10	12	13	15	16	17	18	20	24	25	27	29	
11	3	4	5	6	7	8	9	9	11	12	12	13	15	16	19	20	22	24	
12	2	3	3	4	5	6	6	7	8	9	9	10	11	13	14	15	16	18	
13	1	2	2	3	3	4	4	4	5	6	6	7	8	9	10	11	12	13	
14	0	0	0	0	0	1	1	2	3	3	4	4	5	6	7	7	8	8	
15	0	0	0	0	0	0	0	0	0	0	1	1	1	2	3	4	4	5	
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	2	2	
17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	
18+	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
II 41-60%	00 01	02 04	05 06	07	08	09	10	11	12	13	14	15	16	--	17	18	19	20+	
III 61%+	00	01 02	03 04	05 06	07	08	--	09	10	11	12	--	13	14	15	16	--	17+	
Slope class	Wind speed (m. p. h.)																		

INTENSITY INDEX - TIMBER FUELS

3-T

Fuel stick moisture content	Buildup										Fuel stick moisture content
	000.0 001.9	002.0 003.9	004.0 006.9	007.0 010.9	011.0 016.9	017.0 025.9	026.0 039.9	040.0 061.9	062.0 099.9	100.0 200.0	
	Code										
	1	2	3	4	5	6	7	8	9	0	
01.0	57	62	67	71	76	81	86	90	95	100	01.0
01.5	54	60	64	68	73	78	83	87	92	97	01.5
02.0	51	56	61	65	70	75	80	86	89	94	02.0
02.5	49	53	58	63	67	72	77	82	87	91	02.5
03.0	46	51	56	60	65	70	75	79	84	89	03.0
03.5-04.0	44	49	53	58	62	67	72	77	82	86	03.5-04.0
04.5-05.0	40	44	49	54	58	63	68	73	78	82	04.5-05.0
05.5-06.0	36	40	45	50	54	59	64	69	74	78	05.5-06.0
06.5-07.0	3	37	42	46	51	56	61	65	70	75	06.5-07.0
07.5-08.0	30	34	39	44	48	53	58	63	68	72	07.5-08.0
08.5-09.5	26	31	35	40	45	49	54	59	64	69	08.5-09.5
10.0-12.0	23	27	32	37	41	46	51	56	61	65	10.0-12.0
13.0-16.0	19	24	28	33	38	42	47	52	57	62	13.0-16.0
17.0-20.0	16	20	25	30	34	39	44	49	54	58	17.0-20.0
21.0+	13	17	22	27	31	36	41	46	51	55	21.0+

TIMBER BURNING INDEX

4

Intensity index	Spread index																				
	0 2	3 4	5 6	7 8	9 10	11 12	13 14	15 16	17 19	20 22	23 25	26 28	29 31	32 34	35 39	40 44	45 49	50 54	55 60	61 67	68 74	75 81	82 90	91 100
0-12	0	0	1	1	1	1	2	2	2	2	3	3	4	4	5	5	6	6	7	8	9	9	10	11
13-19	0	1	1	2	2	2	3	3	4	4	5	5	6	7	7	8	9	10	12	13	14	15	17	19
20-26	0	1	1	2	3	3	4	4	5	6	6	7	8	9	10	11	13	14	16	17	18	21	23	26
27-32	1	1	2	3	3	4	5	5	6	7	8	9	10	12	13	14	16	18	20	22	24	27	30	33
33-36	1	1	2	3	4	5	6	6	7	8	10	11	12	14	15	17	19	21	24	26	29	32	35	39
37-39	1	2	2	3	4	5	6	7	8	9	11	12	14	15	17	19	21	23	26	29	32	35	39	43
40-42	1	2	3	4	5	6	7	8	9	10	12	13	15	16	18	21	23	25	28	31	35	38	42	47
43-46	1	2	3	4	5	6	7	8	10	11	13	14	16	18	20	22	25	28	31	34	37	41	45	50
47-49	1	2	3	4	5	6	8	9	10	12	14	15	17	19	21	24	27	30	33	36	40	44	49	54
50-52	1	2	3	5	6	7	8	9	11	13	15	16	18	20	23	26	29	32	35	39	43	48	52	58
53-56	1	2	4	5	6	7	9	10	12	14	16	18	20	22	24	27	31	34	38	42	46	51	56	62
57-59	1	2	4	5	7	8	9	11	12	14	17	19	21	23	26	29	32	36	40	44	49	54	59	66
60-62	1	3	4	5	7	8	10	11	13	15	18	20	22	24	27	31	34	38	42	47	52	57	63	69
63-66	1	3	4	6	7	9	10	12	14	16	18	21	23	25	28	32	36	40	44	49	55	60	66	73
67-69	1	3	4	6	8	9	11	13	15	17	19	22	24	27	30	34	38	42	47	52	58	63	70	77
70-72	1	3	5	6	8	10	11	13	15	18	20	23	26	28	32	36	40	44	49	54	60	66	73	81
73-76	1	3	5	7	8	10	12	14	16	18	21	24	27	29	33	37	41	46	51	56	62	69	76	84
77-79	1	3	5	7	9	11	12	14	17	19	22	25	28	31	34	38	43	48	53	59	65	72	79	87
80-82	1	3	5	7	9	11	13	15	17	20	23	26	29	32	36	40	45	50	55	61	68	75	83	91
83-86	2	3	5	7	9	11	13	15	18	21	24	27	30	33	37	42	47	52	58	64	71	78	86	95
87-89	2	4	6	8	10	12	14	16	19	22	25	28	31	34	38	43	49	54	60	67	74	81	89	99
90-92	2	4	6	8	10	12	15	17	20	23	26	29	32	36	40	45	51	56	62	69	76	84	93	100
93-96	2	4	6	8	11	13	15	17	20	24	27	30	33	37	42	47	53	58	64	72	79	87	96	100
97-100	2	4	6	9	11	13	16	18	21	24	28	31	35	38	43	49	55	60	67	74	82	90	100	100

Enter index on Fire Weather and Danger Index Record.

A storm on October 11 set the stage for burning. By October 22 fuel moisture sticks located both in the surrounding timber and in the clearcuts indicated a "go." Fuels in the clearcuts were relatively dry, while the duff and litter under the timber was substantially wetter. Other portable instruments indicated the following range in conditions on the day of the burn:

	percent
Fine fuel moisture	7-8
Spread index	5-6
Intensity index	41-51
Timber burning index	3

Fire Organization

Five men using drip torches ignited specific areas within each plot as designated by the burning boss. During ignition, a six-man "hotshot" crew was standing by, moving to each plot as it was ignited. A four- to six-man crew was assigned to each 10-acre plot (or to two smaller plots) for holding and possible suppression. Tankers and dozer tractors were strategically placed near the plot being ignited and at points where potential spot fires could occur. As soon as a plot had been burned, two men from the holding crew remained on patrol, with the remainder moving to the next plot.

Ignition Pattern and Burning

The ignition pattern was designed to locate the major convection column at the center of each plot. Plots on steeper ground required preliminary burning-out of critical "escape" areas along the top boundaries. Successive strips of fuel were then ignited until the upper one-third of the plot had burned. The remainder of the plot was then burned by using center, strip and perimeter firing techniques. By the time the lower plot perimeter was ignited, the fire was burning hottest near the plot center. Hence, the fire "drafted" towards the center, relieving the pressure on the plot edges.

Five plots were burned, with the fire behaving as desired. But then an unexpected storm halted all burning on the remaining seven. Thus only 29 out of 68 acres were burned.

Fuel Weights

Post-burning fuel weights were sampled by means of a random start-systematic design originating from the clearcut plot center. Each clearcut was stratified into four fuel weight classes which reflected different burning intensities. The number of milacre subplots was proportionate to the fuel class: the poorer the burn, the greater the number of subplots. Although 130 subplots were sampled, no statistical evaluation was possible because of a surprisingly high variation in the fuel moisture content.

Figure 2.--After broadcast burning. Nearly all fine fuels are gone and only large ones remain. The mineral soil seedbed should then be receptive to seed from the bordering trees.

A comparison of the before-and-after fuel weight measurements showed a large reduction in slash (table 2). And 354 of 400 quarter-milacre regeneration plots now have a mineral soil seedbed (fig. 2).

Cost

Disposing of large amounts of slash is usually costly regardless of the method used. Burning bunched or piled slash costs from $5 to as much as $75 per acre. The costs of broadcast burning clearcut blocks on comparable areas generally range from $5 to $25 per acre. The costs of slash disposal by broadcast burning in this study were as follows:

Item	Cost (dollars)
Manpower (includes 9 overhead, 34 crewmen, and 2 support personnel)	1,216.58
Equipment (includes use-rate of two bulldozers, one 4,000-gallon water wagon, four Class II tankers, and eight radio-equipped pickup trucks)	353.50
Other expenses (includes gasoline and diesel fuel for drip torches, fusees, ignition aids, etc.)	97.10
	$1,667.18

Table 2.--*Fuel weights before and after broadcast burning on five clearcut plots, Challenge Experimental Forest, 1964*

Plot (acres)	Fuel size				Total fuels		Fuel reduction
	Less than 4 inches[1]		Greater than 4 inches[2]				
	Before	After	Before	After	Before	After	
	Tons per acre (dry weight)						*Percent*
2	59.0	7.5	34.0	19.7	93.0	30.3	67.8
2	66.6	6.5	40.5	11.8	107.1	27.2	74.6
5	59.4	8.8	50.5	15.4	109.9	17.7	83.9
10	60.0	7.6	28.1	22.7	88.1	24.2	72.5
10	67.4	4.3	33.3	13.4	100.7	18.3	81.8

[1]Includes humus, needles and litter.
[2]Includes cull logs.

For 29 acres, this amounts to a cost of $57 per acre. But had the entire 68 acres been burned as planned, the costs would have been reduced to $24.50 per acre.

Conclusions

Weather remains the critical factor. Only a few days are usually available each year when burning can be achieved. When fall burning is planned, the entire burning organization must be geared to burn the blocks or plots as rapidly as possible. From experience gained in this study, we recommend the following when planning a broadcast burn as a slash disposal technique:

1. Have the cutting areas large enough to allow proper firing techniques and to generate enough heat for proper burning.
2. Locate the clearcut blocks with an eye to easy burning. Run them to the ridge-top wherever possible, avoid sharp ravines in flank lines, and have them at right angles to the hill contour.
3. Shape the blocks to be somewhat rectangular and thus avoid bends and the headaches of an undercut line.
4. For tanker access, "blade" the firelines near those trouble spots which are to be initially burned out.
5. Keep the size of the burning crew flexible. Tailor it to the number of blocks to be burned in a given day, the terrain, type of slash, and the weather.

If the prescription is correct, few control problems should be encountered. Likewise, if the blocks are properly located, flank and bottom lines are easily held with only a small holding crew. By having both the ignition and holding crews present at ignition, the fire is heavily manned when it is most dangerous.

The Authors

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