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An Experimental Prescribed Burn to REDUCE FUEL HAZARD IN CHAPARRAL

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ABSTRACT: The feasibility of reducing fuel hazard in chaparral during safe weather conditions was studied in an experimental prescribed burn in southern California. Burning was done under fuel and weather conditions when untreated brush would not burn readily. Preparatory treatment included smashing of brush on strips with a bulldozer, and reduction of moisture content of leaves and fine twigs with a desiccant. Seventy percent of green fuels were consumed by the fire. Costs per acre for the treatments were about $13.50.

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RETRIEVAL TERMS: chaparral; fuel hazard reduction; prescribed burning; southern California.

Prescribed burning has long been suggested as a means of reducing the amounts of chaparral fuels and of preventing large fires. But some forest officers remain skeptical about the value of this method in reducing fuel hazards. One problem, they point out, is that differences in fuel and weather conditions between those of a prescribed burn and a wildfire are often small, and too often shift rapidly from prescribed to wildfire conditions. Some of California's worst fires have started from escaped prescribed burns. California Division of Forestry records show 8 percent as much area burned in escapes as burned under permit from 1945 to 1968;[1] and that 1 out of 8 prescribed fires burned outside the prescribed boundaries.[2]

A series of light-burn test fires were conducted at Camp Pendleton, San Diego County, California, in 1954, under "safe" burning conditions, with humidities of 30 percent, or higher, and winds of less than 10 miles per hour. Fuels "before and after" were studied. Chandler[3] reported that only sage, the lightest fuel type, burned completely, that burns in chamise were spotty, that scrub oak, the heaviest brush type, did not burn at all, and that little hazard reduction was accomplished in heavy chaparral fuel. Chandler suggested that prescribed fire in southern California could be used for special purposes, but that fuel preparation would be required. More recent studies of burning under prescription conditions were conducted in northern California, and prescribed burning guidelines issued.[4]

To gain more experience in use of fire to reduce hazard on selected southern California brushy areas, we outlined a plan for several small burns, with the first to come in spring 1969. Specific objectives of these experimental burns were:

- To study the feasibility of using prescribed fire to reduce and maintain hazard at a low level in southern California chaparral.

• To gain experience in using prescribed fire and fuel treatment for "safe" effective burning in chaparral.

• To conduct a burn for the benefit of forest fire researchers and others who wanted to test instruments and fire retardants, and to study effects of fire on soil, vegetation, and air quality.

TEST SITE

Four acres of chaparral 5½ airline miles south of Banning, California, in the North Mountain Experimental Area were selected. A 1967 wildfire burn and a fuel-break separated the test plot from a large mature brush stand. Elevation was 3,800 feet, mean annual precipitation about 23 inches, and soil a sandy loam from quartz diorite. Exposure was predominantly east and northeast. Slope varied between 30 and 70 percent.

The brush cover was moderately dense mixed chaparral, without herbaceous understory, and with little ground fuel. The dominant species was chamise *(Adenostoma fasciculatum* H.& A.*)* 5 to 6 feet tall. Bigberry and Eastwood manzanita *(Arctostaphylos glauca* Lindl. and *A. glandulosa* Eastw.*)* 6 to 7 feet tall were scattered throughout the stand, as were patches, 8 to 12 feet tall, of mountain mahogany *(Cercocarpus betuloides* Nutt.*)* and scrub oak *(Quercus dumosa* Nutt.*)*. There was occasional desert ceanothus *(Ceanothus greggii* Gray*)*, and still less chaparral honeysuckle *(Lonicera interrupta* Benth.*)*, sugarbush *(Rhus ovata* Wats.*)*, and squaw bush *(Rhus trilobata* Nutt.*)*.

PREPARATION FOR BURNING

The test plot was to be burned in spring while moisture content of surrounding brush was still too high for the brush to burn readily. Fuel treatment would be needed to reduce moisture content of the brush. Two suggestions from local fire experts were followed. After a fireline was constructed on April 25, bulldozer-width strips were crushed each chain or chain-and-a-half across the plot and also one strip around the perimeter, wherever the bulldozer could travel *(fig. 1)*. A desiccant—cacodylic acid—at 12½ pounds per acre in enough water to total 10 gallons per acre, was sprayed by helicopter on May 8 to dry the fine fuels.

Weather and Fuel Conditions

To insure, insofar as possible, that the fire was kept under control within established firelines, limits on weather and fuel conditions were prescribed by an experienced fire control specialist.[5] His "prescription" required that no fire be set unless burning be accomplished within these in-plot limits:

Plot conditions:	Maximum	Minimum
Air temperature. . . . . . .F.°	84	40
Fuel stick moisture. . . . pct.	15	5
Relative humidity. . . . . . . .pct.	58	28
Surface wind speed. . . . . . .m.p.h.	10	none
Fine fuel moisture[6].	10	6
Intensity index[6]	54	32
Spread index[6]	16	4
Brush burning index[6]	9	3
Ignition index[6]	52	5

Weather data were taken on-site by continuous recording for 10 days before the burn. During the days just before and the day of the fire, minimum humidities averaged around 30, and maximum temperatures 77 to 80. Winds were variable, from the northwest, west, southwest, or south, up to 10 miles per hour, with gusts of 12 to 15 miles per hour. Forecasts of weather conditions were obtained from the Fire Weather Unit, Los Angeles office, U.S. Weather Bureau.

Enough data were collected for us to estimate fuel moisture and brush volume before and after the burn.

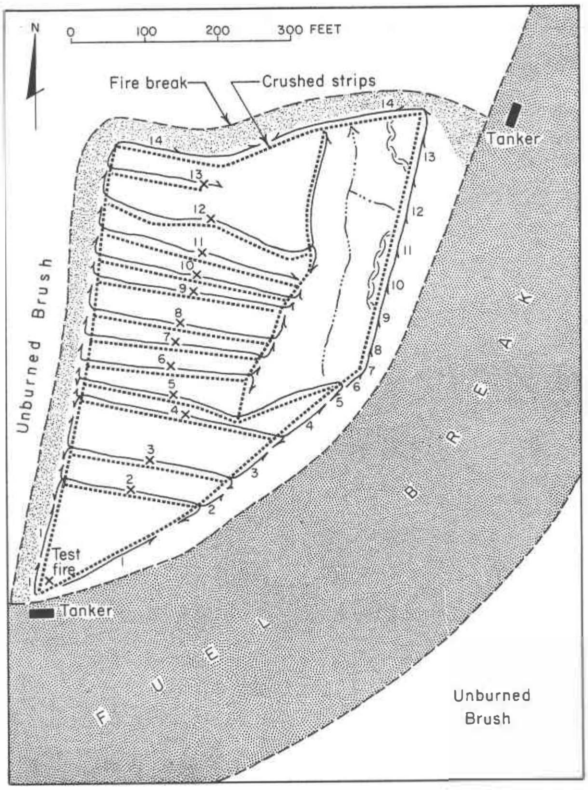


Figure 1—*Firing sequence for prescribed burn on a 4-acre plot on the North Mountain Experimental Area.*

Fuel samples for moisture determination of dominant species were collected on three transect lines across the plot, and the moisture contents averaged for each species and size class. "Dead fuel" was assumed to hold 10 percent moisture, about what was indicated by fuel moisture sticks.

Estimating Volume of Fuel

Three milacre subplots were sampled in what was judged to be representative chamise, manzanita, mountain mahogany, and scrub oak. Brush rooting within the subplots was cut at ground level, weighed, and samples of several size classes collected for moisture determination. Subplots paired with these were established so that unburned fuel could be sampled after the burn.

Data on the proportion of chamise plants in each size class were available. Using this as a guide, we estimated weight distributions of the other important brush species *(table 1)*.

An estimate of space on the burn plot occupied by the principal species was: chamise, 60 percent; manzanita, 15 percent; mountain mahogany, 12 percent; scrub oak, 10 percent; and others, chiefly desert ceanothus, 3 percent.

THE BURN

Manpower and Equipment

A fire truck-tanker[7] was stationed at the head of the fire near the southwest corner *(fig. 1)*, and another near the northeast corner on the windward side. A 15-man conservation crew was used for last-minute work and spot lookout and suppression during the burn. Four men did the firing as directed by the fire boss. An automatic weather station recorded wind speed and direction, temperature, and humidity. Pibal observations and a portable rawinsonde unit supplied data on the air above ground level.

Burning the Plot

To help protect against spotting, the fuel-break was burned, south and east of the plot, starting at 11 a.m. Current grass growth was still too green to burn readily, but accumulated herbaceous growth from past years carried the fire.

The test plot was ignited at 2 p.m. The temperature was 80° F. and the humidity 28 percent. Wind was 10 to 12 miles per hour from the west-northwest. Upper winds to 10,000 feet were from the west at 15 to 20 miles per hour, above 10,000 feet from the south to southwest. All weather and fuel conditions were within the prescription except wind, which was borderline.

Table 1—*Fuel weight distribution of brush plants, by size class, in subplots, North Mountain Experimental Area, California*

Diameter size class (inch)	Chamise[1]	Manzanita	Mountain mahogany	Scrub oak
	Percent			
0 - 1/8	13.2	10	12	10
1/8 - 1/4	26.0	25	22	18
1/4 - 1/2	21.6	25	23	20
1/2 - 1	29.5	27	30	30
>1	9.7	13	14	22

[1]Source: Clive M. Countryman. (Unpublished rep. on file at Forest Fire Laboratory, Pacific SW. Forest & Range Exp. Sta., Riverside, Calif.)

A test fire was ignited at the southwest corner of the burn, which was also the point of greatest elevation, then the plot was ignited from the same point a few feet along the sides *(fig. 1)*. Ignition next was in the center of the first smashed strip, and each way to the east and west edges and along the sides. Each of the 13 strips was ignited in turn in the same manner. Each between-strip area was allowed to reach peak intensity before the next strip was fired. Thus, burning could have been reduced at any time. The firing took 22 minutes.

RESULTS

Fuel Moisture

Moisture content of chamise leaves and twigs to 1/8-inch diameter averaged about 130 percent when the desiccant was applied on May 8. In manzanita leaves and fine twigs it was 152 percent; in mountain mahogany, 121 percent; and in desert ceanothus, 117 percent.

On May 15, moisture content of leaves and fine twigs in chamise and manzanita was 81 to 83 percent; in scrub oak (not sampled earlier), 95 percent; and in mountain mahogany, 104 percent. A week later, moisture content of manzanita, mountain mahogany, and scrub oak fine fuel had not dropped by more than 1-2 percent. About a week before the May 26 burn date, all plants began to turn brown—particularly the leaves and fine twigs of chamise. This fuel component averaged 52 percent when the plot was burned.

Moisture content of twigs larger than 1/8-inch diameter was not affected by the desiccant. Chamise and scrub oak twigs 1/8- to 1/2-inch diameter had 65 to 70 percent moisture throughout the study period; manzanita 85 to 95 percent; and mountain mahogany 80 to 85 percent. Moisture content averaged slightly

Table 2–*Moisture of brush plants in test plots, by diameter size class in mid-May*

Diameter size class (inch)[1]	Chamise	Manzanita	Mountain mahogany	Scrub oak
	Percent			
1/8 - 1/4	69	99	82	69
1/4 - 1/2	69	85	80	68
1/2 - 1	60	71	68	60
1-1/2 - 2	40	--	--	--
2-1/2 - 3	--	48	47	57

[1]Only one moisture sample was analyzed for the two largest size classes; duplicate or triplicate samples obtained for others.

higher in 1/8- to 1/4-inch-diameter stems than in stems of 1/4- to 1/2-inch diameter.

In mid-May the moisture content of brush cut from milacre subplots for fuel volume determination was recorded *(table 2).*

Pre-Burn Fuels

Fuel volume of dominant shrubs growing in nearly pure patches within the burn plot were:

	Live brush	*Dead brush*	*Total*
	(tons per acre)		
Species:			
Chamise	23.5	6	29.5
Manzanita	27.5	5	32.5
Mountain mahogany	29.0	19	48.0
Scrub oak	48.0	5	53.0

The data were combined with estimates of species distribution over the 4-acre plot, and with post-fire data to produce a summary of pre- and post-burn vegetation *(table 3).*

The average fuel volume of the 4-acre plot was determined to be 35 tons per acre. Just over half of this volume was chamise which had the lowest fuel volume of the major species, but occupied three-fifths of the area. Scrub oak grew in patches, or thickets. And height of oak and fuel volume, in these patches, was double that of chamise. Mountain mahogany was nearly as tall as scrub oak, but stems were slender, and fine fuel volume was only slightly more than that of manzanita. Manzanita was about the height of chamise, but had larger stems.

About 20 percent of the fuels were dead. More mountain mahogany–35 percent–was dead than any other species studied. Only 10 percent of fuel in scrub oak was dead, but 20 percent of the manzanita and chamise.

Fuel Consumption

Brush on the smashed strips ignited readily from the drip torches, blazed up within a few seconds, and was almost completely consumed *(fig. 2).* Flames swept from the strips into the standing brush where the burning was often intense.

Nearly all dead fuel of all species was consumed *(table 3),* as were most of the desiccated fine fuels. Some unburned scrub oak fine fuel was left, and considerable mountain mahogany in the 1/8- to 1/4-inch size class remained after the fire.

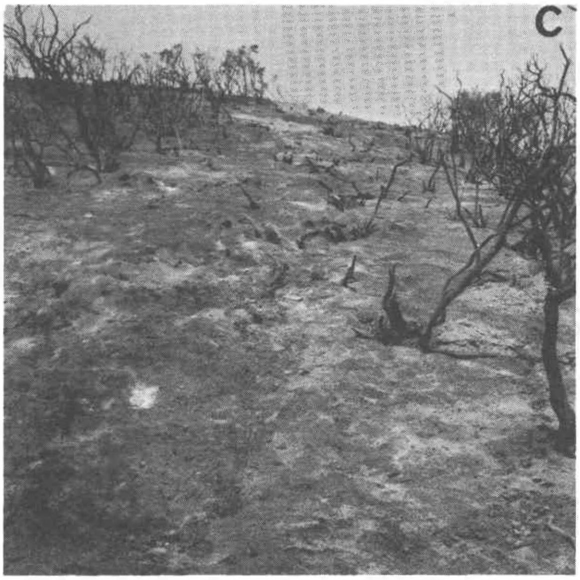
About 70 percent of all green fuels in the test plots were consumed. More live chamise–85 percent–burned than any other species. Nearly all of the smaller chamise stems were consumed. About 75 percent of the live manzanita fuels burned, but only 40 to 45 percent of mountain mahogany and scrub oak.

Temperatures of 1,250°F. were recorded 31 inches above the soil surface.[8] Recording instruments placed at 74 inches went off the chart at about this same temperature, and were back to this level before the recording scale could be adjusted. Thus, this peak was missed. Countryman[9] recorded temperatures

Table 3 – *Average fuel volumes of principal brush species before and after prescribed burning, North Mountain Experimental Area, California*

Species	Standing live brush				Dead brush		Total fuel		Fuel consumed	
	Pre-burn	Post-burn	Pre-burn	Post-burn	Pre-burn	Post-burn	Pre-burn	Post-burn	Live brush	Dead brush
	Av. ht. in ft.		*Tons/acre*		*Tons/acre*		*Tons/acre*		*Percent*	
Chamise[1]	6.0	2.0	15.0	2.0	4.0	0.2	19.0	2.2	85	95
Manzanita	6.5	3.5	4.0	1.0	1.0	0	5.0	1.0	75	100
Mountain mahogany	11.0	9.0	3.5	2.0	2.0	.1	5.5	2.1	45	95
Scrub oak	12.0	11.0	5.0	3.0	.5	0	5.5	3.0	40	100
Total	--	--	27.5	8.0	7.5	0.3	35.0	8.3	70	95

[1]Includes desert ceanothus and traces of other species estimated to occupy about 3 percent of the area.



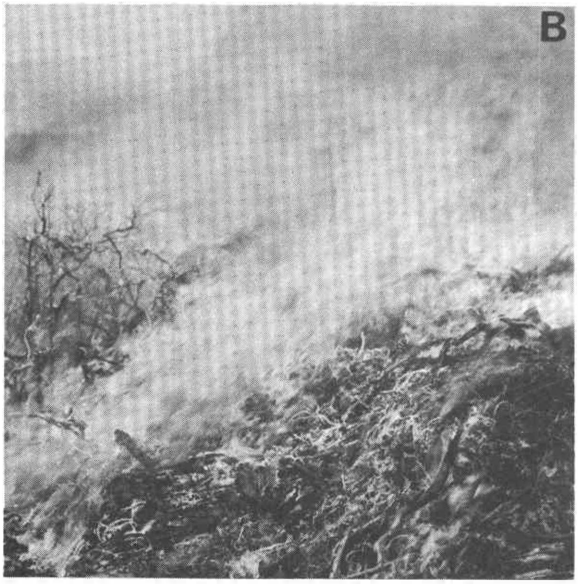


Figure 2—A, *Dozer-blade wide strips were smashed across and around the burn plot;* B, *smashed brush ignited readily and carried fire into the standing brush;* C, *the dry compacted brush burned completely.*

above 2,000°F. 15 feet above burning piled brush and trees, and temperatures approached 2,000°F. near the top and in the fuelbed. These measurements suggest that the missing temperature peak may have been considerably hotter than 1,250°F. in this fire.

Spotting

Four spot fires in mature brush were caused by burning material carried across the 300-foot-wide fuel-break, and burned-out material traveled at least 200 feet beyond this point. One observer stationed southeast of the plot reported measuring a 20-mile-per-hour gust during the burning operation, and shortly after three of the "smokes" appeared. The fourth was not visible until about 5 p.m. when smoke appeared from a wood rat nest. All fires were quickly extinguished by the tanker and conservation camp crews. This condition points up the importance of doing prescribed burns when surrounding brush is not readily flammable, of having fire suppression force on hand, and of burning within a carefully prescribed prescription.

Burning Costs

Costs are difficult to determine for a small burn, and they are disproportionately higher than costs for larger areas. In 1954, Sampson and Burcham[10] analyzed 190 controlled burns in northern California ranches. They found that costs decreased as burn size increased to about 440 acres, then increased slightly through 640 acres. Obviously costs from 4 acres cannot be applied directly to larger areas.

Desiccant cost is the one most easily identified in our study. Cacodylic acid as the commercial Phytar 560[11] cost $4.50 per gallon for a product containing 2½ pounds, acid equivalent, per gallon. Our 12½ pounds, a.e., per acre cost $22.50. A lesser amount might desiccate leaves and woody twigs, but take longer.

If immediate drying is not required, 4 pounds, a.e., of 2,4-D or a mix of 2,4-D and 2,4,5-T at 4 to 6 pounds per acre will desiccate small twigs and leaves, and over a period of weeks or months many larger stems. Varying proportions of the stand will be killed. Herbicide costs per acre will vary from about $3.50 to $9.00 depending on the proportions and rates used.

Green *et al.*[12] estimated helicopter and allied costs of broadcast spraying at about $4.00 per acre when 100 acres were being sprayed. Assuming that costs now are one-fourth higher, application cost could be estimated to be $5.00 per acre for similar sized spray jobs today.

Using 1947-48 data, Sampson and Burcham[10] determined that rancher costs were near $3.00 per acre for 40-acre burns, and around $2.50 for 100-acre burns. Assuming cost increases of 3 percent annually, current prescribed burning costs would be $4.00 to $5.00 per acre for 40- to 100-acre burns. Bentley[4] estimated about $5.00 per acre, not including crushing or spraying, but including fireline preparation.

For desiccating brush with 2,4-D, the cost will be at least $8.50 per acre. And it will be considerably more if the acreage is small and the brush is dominated by species resistant to 2,4-D or if quick desiccation is demanded. If other burning costs are estimated to be $5.00, then $13.50 per acre is suggested as a minimum cost for preparing brush for safe burning under conditions of rough terrain. If several hundred or more acres are to be treated, costs may be less, but could be several times this for 5 to 10 acres.

Notes

[1] California Division of Forestry. *Brushland range improvement–annual report.* Sacramento, Calif. 22 p., illus. 1968.

[2] Raymond, F. H. *Controlled burning on California wildlands.* Proc. Calif. Tall Timbers Fire Ecology Conf. 1967: 151-152. 1967.

[3] Chandler, Craig C. *"Light burning" in southern California fuels.* U.S. Forest Serv. Calif. Forest & Range Exp. Sta. Res. Note 119. 2 p. 1957.

[4] Bentley, Jay R. *Conversion of chaparral areas to grassland–techniques used in California.* U.S. Dep. Agr. Agr. Handb. 328. 35 p., illus. 1967.

[5] Harry E. Schimke, who also served as fire boss during the burn.

[6] From the Wildland Fire Danger Rating System used by California fire agencies.

[7] The tankers were supplied by the U.S. Forest Service and California Division of Forestry, which also supplied the conservation crew.

[8] Palmer, Thomas Y. *Comparison of aspirated and radiation compensating thermocouples.* (Manuscript in preparation.)

[9] Countryman, Clive M. *Mass fires and fire behavior.* U.S. Forest Serv. Pacific SW. Forest & Range Exp. Sta. Res. Paper PSW-19. 53 p., illus. 1964.

[10] Sampson, Arthur W., and Burcham, L. T. *Costs and returns of controlled brush burning for range improvement in northern California.* Calif. Div. Forestry Range Improv. Studies l, 41 p., illus. 1954.

[11] Trade names and commercial enterprises or products are mentioned solely for information. No endorsement by the U.S. Department of Agriculture is implied.

[12] Green, L. R.; White, V. E.; and Plumb, T. R. *Some brush conversion costs on southern California fuel-breaks.* U.S. Forest Serv. Pacific SW. Forest & Range Exp. Sta. Fuel-Break Rep. 12, 18 p. 1963.

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