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FUEL-BREAK REPORT NO. 9

Guidelines for Fuel-Breaks in Southern California

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FOREWORD

These guidelines were initially prepared as part of the FUEL-BREAK Program[1] by Jay R. Bentley, Craig C. Chandler, and Verdie E. White, of the Pacific Southwest Forest and Range Experiment Station, from suggestions by field personnel. The guidelines were reviewed and revised by a committee as follows: Robert H. Blanford, Elmer Chambers, and Len Chatten of the California Division of Forestry; Harvey T. Anderson and R. M. Van Wagner of the Los Angeles County Fire Department; and Lynn R. Biddison and Lloyd R. Britton of the U. S. Forest Service. They were reviewed again in February, 1963 by J. R. Bentley, Robert H. Blanford, Lynn R. Biddison, Lloyd R. Britton, Elmer Chambers, Chief Victor Petroff, Ralph M. Van Wagner, and Verdie E. White. Lisle R. Green acted as chairman. Tentative photo and illustration selections were made at this time.

1/ The Fuel-Break Program is conducted cooperatively by the California Division of Forestry, the Los Angeles County Fire Department, and the U. S. Forest Service.

This report was published for the Fuel-Break Executive Committee by the Pacific Southwest Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture, Berkeley, California.

Cover Picture: A section of the North Mountain fuel-break constructed by the California Division of Forestry in Riverside County.

THE NEED FOR FUEL MODIFICATION

Large fires still occur regardless of intensive fire control planning and action. Three of the factors which contribute to this problem are:

UNFAVORABLE WEATHER CONDITIONS--a factor over which we have little control. But we can learn to use our knowledge of weather more effectively in controlling fires.

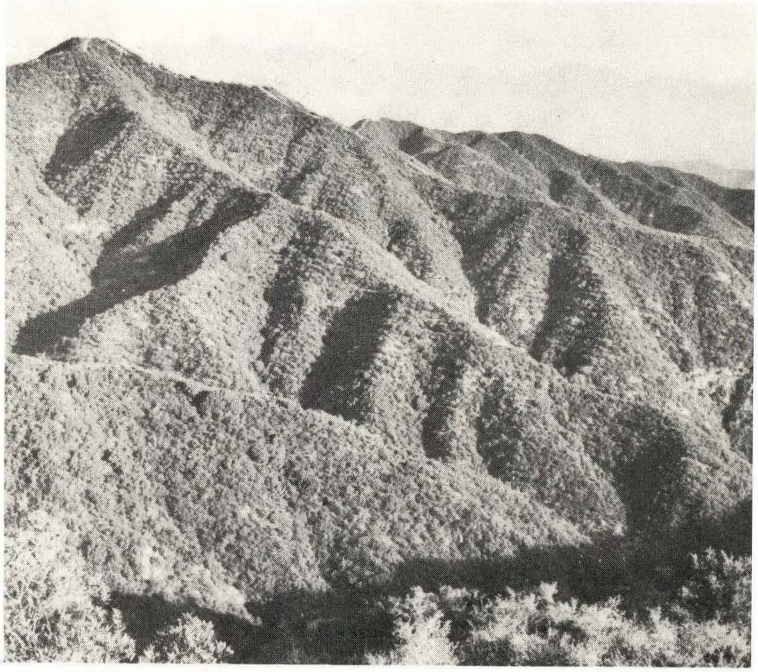
STEEP, ROUGH TERRAIN--a factor we can't change even though continuous progress has been made in providing better access by roads and air.

UNBROKEN EXPANSES OF WOODY FUELS--a factor that is subject to improvement. A good start has been made, within the limits of available funds, but the next logical step is to put more emphasis on modifying fuels.

Modification of all the natural fuels is a tremendous job. If we look at all of the millions of acres that are involved, the task appears impossible. It's not just a big physical job; it also involves economic, social, and legal problems that are overwhelming.

A simpler approach is possible, and it is feasible. This approach is to modify the fuel on selected areas at strategic locations which will break up the expanses of natural fuel. On these selected areas the fuel will be permanently changed to one of light volume. These areas are called "fuel-breaks."

Figure 1.--Steep, rough terrain plus an expanse of almost unbroken woody fuel and unfavorable weather conditions create an awesome fire problem in southern California.



OBJECTIVES OF THE FUEL-BREAK APPROACH

The main purpose of fuel-breaks is to divide continuous natural fuels into smaller units as an aid in confining fires and in protecting communities, recreation areas, or other areas of high value. The approach is to set up a system of strategically located control lines that are ready to be safely manned and effectively held under a wide range of burning conditions.

> These potential control lines are located within a wide strip (a fuel-break) on which a permanent, stable cover of low fuel hazard has been established.

Thus, building of fuel-breaks is merely a phase of standard pre-attack or pre-suppression work which includes location of tractor ways, fire-breaks, and other fire control facilities.

However, fuel-breaks aim at correcting two conditions that have limited the effectiveness of present day firefighting techniques. These present conditions are:

> The difficulty of quick, safe manning of critical line locations when needed.
>
> The need for widening many firebreaks before they can be used effectively.

Once fuel-breaks have been established, fire control plans can provide for manning of the fuel-breaks during or soon after initial attack on a fire.

Fuel-breaks are intended to aid control of fires under burning conditions that now hinder control in unbroken fuels on steep terrain. The wide breaks will not necessarily stop a rapidly moving fire when spot fires are starting well ahead of the main fire. The prepared breaks, however, can help stop the lateral spread and make possible confining of such fires, and thus reduce the burned acreage, suppression costs, and resource damages.

FEATURES OF A FUEL-BREAK

A FUEL-BREAK is a wide strip or block of land on which the native vegetation has been permanently modified so that fires burning into it can be more readily controlled. In firefighting terms, one fuel type has been changed to another which offers lower resistance to fire control effort.

A fuel-break has a low-growing ground cover.

- This cover should protect the soil against erosion.
- It should have light fuel volume so that if it burns, heat output will be low.
- It should produce fewer flying sparks or embers which may start spot fires across the break.

If trees and shrubs are present within a fuel-break, the woody fuel is not continuous.

- Trees and shrubs should be pruned sufficiently high to prevent their ignition by burning ground fuels.
- Individual trees and shrubs, or clumps of trees and shrubs, should be spaced to prevent running crown fires within the break.

Fuel-breaks, with safety zones as needed, provide safety for fire-fighting personnel under hazardous conditions.

- Safety zones must be built according to standards established by the firefighting agency.
- The fuel type in the breaks and safety zones must be of a kind which can be safely burned out for protection of personnel and equipment.

Potential control lines are located within fuel-breaks and maintained so that they can be fired and held at the proper time.

- Interior strips and roadbeds, kept clean to mineral soil during the fire season, are called "firebreaks," in contrast to the wide fuel-breaks which have a permanent cover of vegetation.

Fuel-breaks are made accessible to motorized equipment whenever possible.

A FUEL-BREAK SYSTEM is a series of breaks tied together to form continuous, strategically located control lines around land units.

Figure 2.--A fuel-break has low growing ground cover to protect the soil.

Figure 3.--Fuel-breaks contain well pruned, natural cover which is not continuous.

Figure 4.--A narrow strip or roadbed firebreak kept clean to mineral soil during the fire season provides a potential control line within the fuel-break.

FUEL-BREAKS AND FIRE CONTROL PLANNING

Fuel-break systems are an integral part of the pre-attack and pre-suppression inventory and fire control planning. The fuel-breaks and other planned improvements are well meshed to provide the best possible fire control plan.

The intensities of fuel-break systems, the numbers and locations of fuel-breaks and the sizes of the intervening units of natural fuels, are determined by the fire control objectives. But the intervening units must be kept as small as can be justified if the fuel-break systems are to aid greatly in reducing the size of future fires.

Entire fuel-break systems are planned at one time, rather than piecemeal as funds for the work become available. The planned systems should include all of the breaks considered necessary in the long-range program, when the need for intensive fire control may be greater than at present.

A complete fuel-break plan is needed for several reasons:

> Complete fuel-break plans show the size of the over-all job and the amount of funds needed to accomplish it.
>
> The plan will be a sound guide for quick action on land treatment after a wildfire occurs. The fuel-break areas for which sowing and spraying treatments have been planned are pre-selected.
>
> The plan will assure that funds are best used as they become available, for both initial and follow-up work on the high priority breaks.

The fuel-break plan should be developed and coordinated with other resource improvement plans.

Areas on which improvement of the resource value will also reduce fuel hazard should be integrated as part of the fuel-break system where possible. Examples of such areas are:

> Land of suitable site on which brush is converted to grass for range forage.
>
> Areas from which brush is cleared to promote better use of recreational values and to protect the values from loss by fire.

Any such areas that have high strategic value for fire control should be of high work priority under the resource development plan.

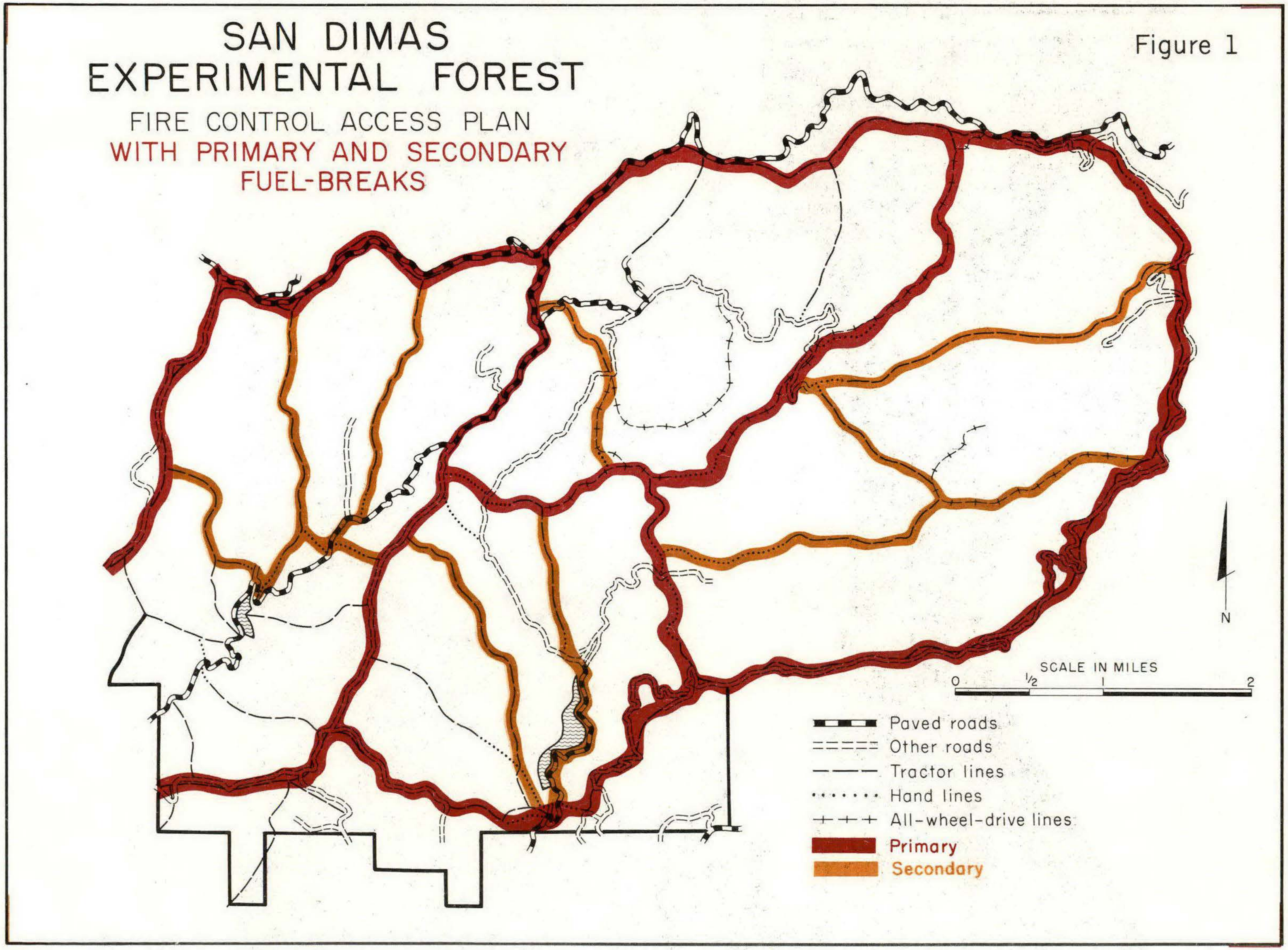


Figure 5.--The complete fuel-break system, planned in advance and coordinated with other resource objectives, is an integral part of effective fire control planning.

Figure 6.--Hazard reduction work along roads and motorways can be tied in with fuel-break development.

PRIORITY FUEL-BREAK LOCATIONS

The first fuel-breaks to be built ordinarily will be those of primary importance in helping prevent fires from sweeping for miles across country. These primary breaks commonly will be on prominent ridges that separate major drainages or sub-drainages, but they are not restricted to any specific topographic feature. They may be at the base of mountains, in bottoms of wide river drainages, or at other locations. They may be located to separate populated areas from unbroken fuel masses.

Wide breaks along all fire control roads often will be next in priority. Roadside fuel-breaks will make for safer access, and they will make these accessible areas more usable as fire control lines.

Fuel hazard reduction work, which can be tied into the fuel-break system, is essential. Priority locations are:

Around organizational camps and similar areas where human safety, as well as investments, must be protected.

Behind residential areas, mountain communities, and other concentrations of homes.

Around groves of trees, either natural or planted, that have high scenic or historical value and cannot be replaced.

Around all new plantations or recreational areas where planted trees or other vegetation must be protected from fire.

Around other areas with high investment in buildings and facilities.

After all of the high priority fuel-breaks and the potential resource development areas have been located on a map, possibilities for intensifying the fuel-break system should be thoroughly explored. Often, some short connecting breaks will greatly reduce the average size of the natural fuel units enclosed by fuel-breaks.

Figure 7.--The best fuel-break location is on a ridge to which motorized equipment has access.

Figure 8.--Fuel-breaks may be located at the base of mountains where they can prevent fire from burning into rough terrain.

Figure 9.--Canyon bottoms frequently provide good fuel-break locations.

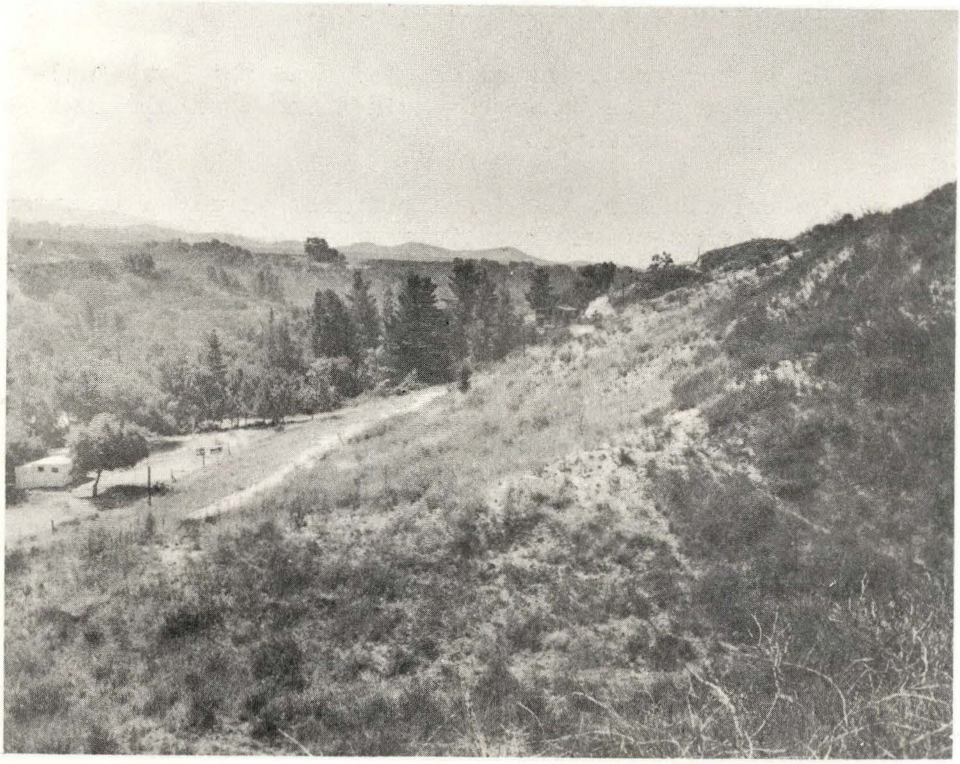


Figure 10.--Fuel-breaks may be located to separate populated areas from unbroken fuel masses.

SOME FACTORS AFFECTING FUEL-BREAK WIDTHS

In general, the wider the break the easier and safer the job of holding a fire on it. However, practical considerations will limit the width of most fuel-breaks to that considered necessary to accomplish the fire control objectives.

> A minimum width (see page 11) will usually suffice if the objective is to provide safe firing and holding of a line without slop-over fires under most burning conditions.
>
> An extremely wide break will be necessary if the objective is to prevent all slop-over fires and greatly reduce the probability of spot fires, under extreme weather and fuel conditions.

Several factors will tend to keep fuel-break width at or near the minimum.

> On valuable steep watersheds the area of poor sites on which native brush is replaced with a new cover will be limited until research shows that the new cover is equally as effective as the native cover in preventing floods and erosion.
>
> On timber-producing sites, the area put into fuel-breaks must be balanced against the possible loss of timber production.
>
> On private land the legal problems involved in obtaining rights-of-way may limit the widths, except where the fuel reduction is shown to be to the land owner's advantage.
>
> On all lands the fiscal limitations, of course, can limit fuel-break widths. However, rather wide breaks may be built on some areas which have been recently burned over because the breaks can be built with less expense at that time.

THEORETICAL SURVIVAL AND IGNITION DISTANCES

Predicted peak radiation intensities can be useful in estimating the minimum distances from which hazardous fuel should be removed to provide safety for personnel or to prevent direct ignition from radiation. However, in using these predictions of radiated heat, it is necessary to consider that the flame front may extend well past the fuels which are burning.

Radiation calculations for given conditions of fuel, topography, and weather have agreed closely with the few measured radiation values which have been made under wildland fire conditions.

Tests have shown that skin burns which require medical treatment can be expected whenever radiation exceeds 0.3 calorie per square centimeter per second. The distances to which this amount of radiation would extend from the flame front have been approximated for different burning conditions and different fuels (table 1). For each condition, the distance is the theoretical maximum that could be expected at one point for either of two situations: (1) all of a line fired at one time, or (2) a fire hitting the line before it is fired.

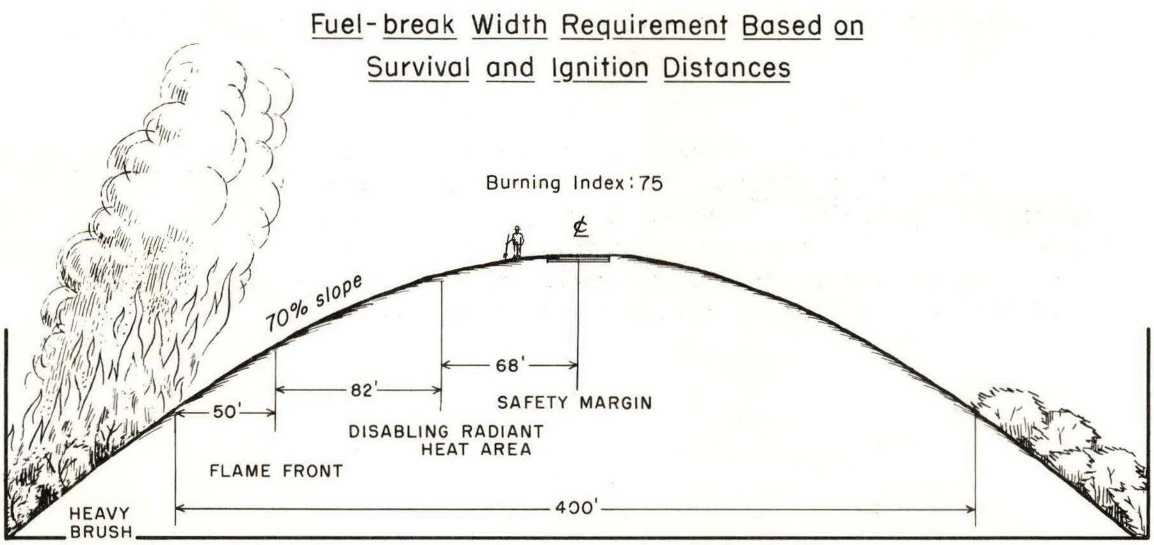


Figure 11.--This diagramatic sketch shows the recommended distance for personnel safety for the given terrain, fuel type, and burning conditions (table 1).

Table 1.--Distance from the flame front calculated as necessary to prevent disabling burns from radiated heat

Burning conditions			Distances needed in--		
Terrain	Burning index[1]	Occurrence[2]	Light brush	Medium brush	Heavy brush
		Percent	Feet	Feet	Feet
Flat	12	50	12	16	21
"	27	10	21	32	38
"	75	1	32	45	56
"	100	--	39	57	81
70% slope	12	50	20	25	35
"	27	10	31	46	57
"	75	1	47	63	82
"	100	--	73	88	112

1/ The Burning Index of the Wildland Fire Danger Rating System measures the effect of weather on the difficulty of fire control. The index is a relative measure of how fast a fire will spread and how intensely it will burn. An index of 0-5 is considered low fire danger, 6-11 is considered moderate, 12-18 is high, 19-26 is very high and 27 or over is extreme.

2/ Percent of days during fire season with given burning index or higher.

The calculated distances from the flame front necessary to prevent ignition from radiation are half of the above distances. Hence, ignition from radiation across a wide fuel-break should not be a problem. Pre-heating of the fuel by radiation, which tends to increase the potential for ignition by sparks or small embers, will be greatly reduced below that on the narrow breaks used in the past.

SUGGESTED MINIMUM WIDTH OF FUEL-BREAKS

Each fuel-break must be tailored to fit the terrain, fuel, and expected weather conditions. The width will not be uniform; it will be wider at critical points and narrower at other points. These widths must be based on the judgment of experienced men.

The theoretical distances shown in table 1 can be used to check this judgment as follows: On steep terrain, with a burning index of 75 and with heavy brush fuel, the control line must be more than 82 feet from the edge of the fuel-break to protect men on the line from disabling burns--if the flames are vertical. But if the flame front extends 50 feet inside the break, the distance of the control line from the edge of the break must be 82 plus 50 feet, or 132 feet. If some safety margin is allowed, the control line must be at least 200 feet from the edge of the break. Assuming that the control line is in the center of the break, the total width of the fuel-break must be about 400 feet for this hypothetical situation.

Men experienced in fighting fires in southern California brushfields have suggested an arbitrary minimum width of 200 feet for fuel-breaks. The break would be wider at critical points such as saddles and flat ridges.

On a ridgetop fuel-break, the crest of the ridge will prevent direct radiation of heat from one side of the break to the other. Even so, fuel-breaks of near minimum width must be manned with caution. On flat land, with no ridge-crest barrier for protection, the fuel-breaks must be wider.

Safety zones must be built on all fuel-breaks, according to standards set by the fire control agency, to protect personnel under the most hazardous fire weather and fuel conditions.

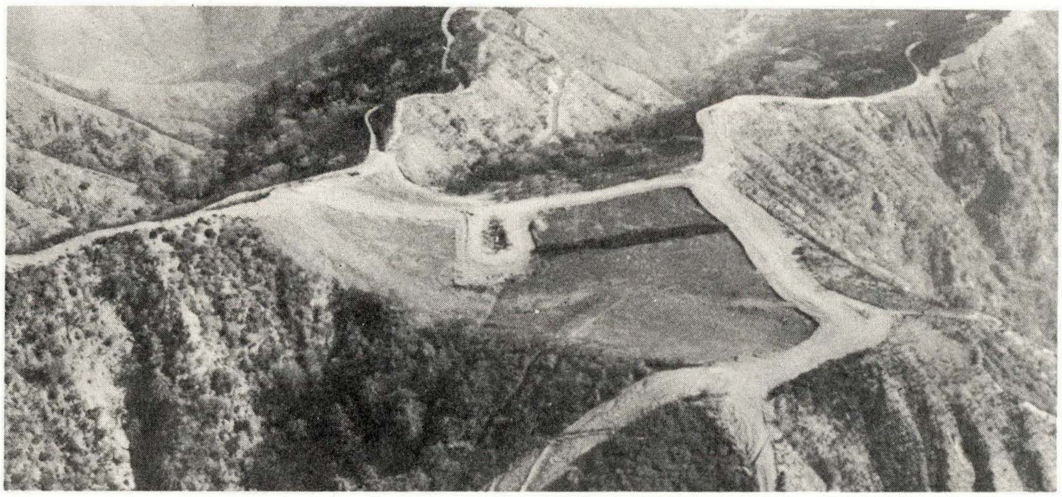


Figure 12.--Safety zones are included in the fuel-break system where needed. They provide safety for firefighting personnel under extreme conditions.

LANDSCAPING FUEL-BREAKS

The effects of any fuel-break on the appearance of the countryside should always be considered. In many situations, the fuel-break can enhance the natural scenery. In all cases, it need not impair the landscape.

In most situations, the landscaping of fuel-breaks must be accomplished by artful manipulation of the naturally occurring vegetation. This can be done by making pleasing overall patterns of vegetation and by leaving selected trees or shrubs to break the monotony of a low-growing ground cover.

In special situations, an attempt to improve the landscape may require planting of trees or shrubs. All such planting should take into account the fuel hazards which may be developed, and the need for protecting the new planting from destruction by fire.

Following are a few guides--some do's and don'ts--to keep in mind while planning and laying out fuel-breaks:

> Fuel-breaks do not need to have "straight sides" that give an unnatural appearance.
>
> Fitting fuel-breaks to the natural land forms--broad ridges, benchlands, or valley bottoms--will make them more attractive.
>
> A pleasing savannah appearance can be developed on many areas by leaving well spaced trees or large shrubs that are well pruned.
>
> Timber types and some woodland types on fuel-breaks should be thinned enough to keep crown fires from running across the break.
>
> If chemical spraying is to be used for control of brush, trees and shrubs should not be planted until the chemical work has been completed, usually a period of 2 to 4 years. Species which are especially susceptible to 2,4-D and 2,4,5-T should not be planted.
>
> The ground cover should be kept away from planted trees to conserve moisture and to protect the trees from possible fire.

Figure 13.--Fuel-breaks can be landscaped with selected native cover to give a pleasing vegetative pattern at no expense to the break's effectiveness.
(Photo courtesy California Division of Forestry.)

Figure 14.--Cleanup work after a fire has left enough of the live trees to create a pleasing savannah landscape.

REMOVING EXCESS WOODY FUEL

All excess woody fuel which could burn must be removed as the first step in building a fuel-break. The objective is to leave a low volume of fuel with a low total heat output near the control line.

The problem is to determine how much cleanup of woody fuel is needed.

> Hand cutting or bulldozing, with burning or chipping, gives adequate cleanup.
>
> Disking of light brush will adequately reduce the woody fuel by chopping it into the soil. But if heavier brush is disked or is mashed down with a dozer blade or a roller, it will be necessary to dispose of the excess woody material.

As a minimum cleanup effort on burns, remove all unburned stems near the control line and near shrub or tree crowns left within the fuel-break. The other unburned stems should be knocked down so that they present less of a fire control hazard and will not interfere with sowing and spraying operations.

If the woody material on a burn consists mainly of scattered stubs from which the branches have been burned, it may not add seriously to the potential heat near the control line. But, a thick stand of shrub carcasses will add 5 to 15 tons, or more, of fuel per acre. This excess heavy fuel should be removed.

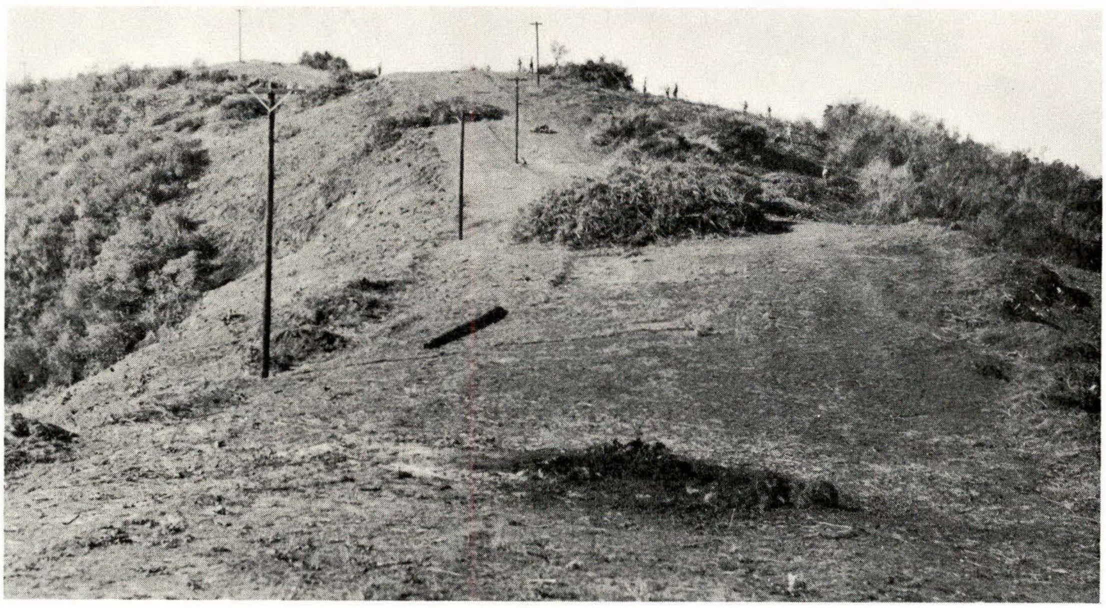


Figure 15.--Hand cutting is one way of removing excess woody fuel. The cut material is stacked in tight piles and burned during "safe" conditions.

Figure 16.--Mechanical clearing with a bulldozer is an effective way to remove excess fuel on accessible areas.

Figure 17.--A heavy roller will thoroughly crush some species such as chamise. The smashed material may be disposed of by burning as is or after it is piled.

Figure 18.--A thick stand of shrub carcasses will add 5 to 15 tons of fuel per acre. This heavy fuel should be removed.

MAINTAINING A LOW-VOLUME GROUND COVER

The objective at present is to maintain a ground cover that if ignited will burn with a low total heat output near the control line within a fuel-break.

This objective assumes that the cover on a fuel-break will be flammable and that it will burn readily during critical fire periods--a condition which will exist until practical methods are developed for widescale establishment and maintenance of a "fireproof" cover.

A dry weight of 2 tons per acre has been arbitrarily set as the maximum volume of ground cover desired on a fuel-break. A cover of grass and its litter will be less than this volume on most sites in most years.

Even though all grass covers are somewhat flashy fuels during dry weather, fire behavior in grass is predictable and firefighters can more readily fire out control lines in this kind of fuel. The rapid burning of grass covers in many cases may be an advantage rather than a disadvantage. Fire control in the grass cover can be aided by establishing perennial grasses because they are less flammable than annuals during part of the year.

A major problem on fuel-breaks is to keep down the brush regrowth. If sprouting brush is allowed to grow a few years before it is killed, it will add several tons of combustible fuel per acre. Dry brush and grass will produce a fuel mixture in which fire can spread rapidly with high heat output.

Plan the following operations for brush control on fuel-breaks:

Start chemical spraying of sprouts and seedlings the first spring after removal of the brush topgrowth.

Continue follow-up spraying each year until the sprouts are killed.

If the initial spraying is necessarily delayed until the sprouts have produced an excessive amount of fuel, this woody material should be removed from the fuel-break before chemical spraying is started.

Figure 19.--If allowed to grow, sprouting brush may add several tons of fuel per acre in a few years. It will soon reduce the effectiveness of the break.

Figure 20.--Broadcast spraying of herbicides is an effective way to control sprouts and seedlings. This D-7 tractor is at work on first year sprouts.

Figure 21.--Sprouts that are more than 2-2½ feet tall should be removed. Herbicides can then be used to control any regrowth that develops while it is still small.

ESTABLISHING A PROTECTIVE SOIL COVER

The new ground cover on a fuel-break must have sufficient volume to stabilize the soil--the main reason for establishing the cover.

A ground cover will develop from natural revegetation of herbaceous plants, dominantly annual grasses, if the fuel-break areas are not sown. Once established this natural cover probably will be adequate for soil protection on most sites. However, sowing of grass seed in many cases will be advisable in an attempt to speed establishment of a full cover and to improve it.

An attempt should be made to establish the best possible permanent cover on all fuel-break areas which are to be sown. Perennial grasses, on sites where they are adapted, are considered better than annuals because of deeper permanent root systems, more stable production, and more green leafage during part of the fire season.

Sowing commonly will be needed on areas where dense brush has been removed by wildfire, bulldozing, or disking. Some guides for sowing are:

> Sow before the fall rains.
>
> Cover the seed on all areas where a tractor can be used, either by drilling or by pulling a roller over areas where seed has been broadcast sown.
>
> Do not sow ryegrass or mustard on areas where perennial grasses are to be sown, because these two species compete excessively.

Here are a few simple guidelines for judging adequacy of new fuel-break covers:

> The new stand during the first two years should be fairly continuous, with only a few spots devoid of vegetation.
>
> The fully developed cover of green vegetation and litter should obscure most of the mineral soil from view during the winter, except on the poorest sites.
>
> Soil washing should not be apparent.

Intensive hand work, such as contour sowing or planting, may be necessary to establish a satisfactory cover on critical areas within important watersheds.

Drainage ditches and mechanical structures must be built on fuel-breaks wherever concentrated runoff presents serious erosion problems.

Figure 22.--Sowing grass is often necessary on areas burned by fire. This rangeland drill provides a positive method of plant establishment.

Figure 23.--Contour sowing or planting may be necessary on critical areas where cover is absolutely essential for soil protection.

PREPARING BARE FIRE-CONTROL LINES WITHIN FUEL-BREAKS

The strips to serve as fire control lines within fuel-breaks must be kept bare to mineral soil during the fire season. Because removing all of the vegetation, or preventing its growth, is an expensive operation and presents a continuing erosion hazard, the bare strips should be made as narrow as is compatible with fire control needs.

If wide bare strips are to be used, the possible effects of soil erosion must be carefully weighed against the possible value of the additional width for control of fires.

The bare strips may be roadbeds, bulldozed lines, disked lines, handscraped lines, or lines kept bare by use of soil sterilants. All of these methods of removing vegetation may develop some erosion hazard.

Water turnouts must be maintained, as needed, on all bare strips. All tractor work should be aimed at preventing development of continuous berms which channel water within the bare strips.

Guides to locations of the bare strips are:

A continuous bare line should be located near the center of each fuel-break. Where building of additional bare strips is feasible, they should be put near each edge of the break.

Bare strips across the fuel-breaks at intervals of a few hundred feet are recommended to reduce the possibility of fire spreading rapidly in dry grass along the length of a fuel-break.

Bare strips are particularly recommended at the edges of a fuel-break in locations where they will be needed to control not only fires outside the break, but also those that start within the break. Examples of such locations are: fuel-breaks around campgrounds, organizational camps or homesites, and fuel-breaks along certain roads.

Figure 24.--Drainage ditches are a "must" on fuel-breaks where concentrated runoff presents a serious erosion problem.