A Homeowner's Guide to Fire and Watershed Management at the Chaparral/Urban Interface

Klaus W. H. Radtke

COVER PHOTO: Living in chaparral areas understandably appeals to many people. However, living safely in these areas requires an awareness of fire and erosion problems. In dealing with these problems, wildfire safety must be balanced with watershed safety.

Acknowledgments

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Introduction

Several guides and booklets have been written to help the homeowner deal with particular aspects of living in the fire-prone wildlands of the Pacific Southwest. Until now, however, none has given the homeowner comprehensive advice on managing his property effectively so as to reduce the chance of wildfire and mudflow disasters and the hardships, both personal and financial, they bring. This booklet attempts to provide such advice in a practical, non-scientific, yet professional manner, through basic principles and guidelines.

This booklet is based on and contains excerpts from the PSW General Technical Report *Living More Safely at the Chaparral-Urban Interface,* a guide to hillside property management for fire and watershed protection. Both publications were written by the same author under cooperative contracts between the Pacific Southwest Forest and Range Experiment Station (Forest Service, U. S. Department of Agriculture) and the County of Los Angeles. They are based on research by the Forestry Bureau of the Los Angeles County Fire Department and the Forest Fire Laboratory of the Pacific Southwest Station in Riverside, California. They also incorporate state-of-the-art knowledge in various wildland disciplines, and the experience gained by the author in dealing with fire and floods in his work and as a homeowner at the chaparral boundary.

The booklet first provides a brief description of the chaparral plant community, followed by sections describing some basic considerations of watershed and fire management. Later sections deal with improving safety around the home through home design, landscaping, and maintenance; protecting oneself and one's property during a wildfire; and, finally, providing emergency treatment of hillsides after a fire.

After fire, chaparral recovers by means of seeds, sprouts, and bulbs.

The Chaparral Plant Community

California's chaparral plant communities consist of many different woody shrubs and herbaceous species that have adapted over millions of years to frequent fires and extended periods of drought. The mixture of plant species in the chaparral communities varies with such factors as aspect and steepness of slope, soils, elevation, fire frequency, and local climate. Although California's climate causes chaparral vegetation to be especially subject to large devastating wildfires, similar plant communities and associated fire and watershed problems occur in other western states and other countries.

Chaparral communities are characterized by a rich diversity of plant species. Although no single characteristic is present in all chaparral species, several adaptations to the hot, dry climate commonly occur. For example, some species have thick leathery leaves that are small or even needle-like. This design helps the plants to tolerate severe summer drought. Other drought tolerance characteristics include waxy and hairy leaf surfaces and leaves that have a high aromatic oil content. Some plants become dormant and shed some or all of their leaves during prolonged drought. A deep, extensive root system which increases drought tolerance and plant survival on steep slopes is another characteristic common to many chaparral species.

Chaparral plants survive periodic fire by sprouting and by germination of seeds stimulated by the fire. Soon after burning, new sprouts grow from the roots and root crowns of many plants. Then, fall and winter rains trigger prolific germination of herbaceous species, often resulting in a colorful array of wildflowers in spring. Seeds of woody plants also germinate prolifically.

Plant species differ in their susceptibility to fire. Their age and physiological state (whether flowering or dormant, for example) also influence how well they burn. For chaparral-type vegetation in general, the most important factors influencing flammability and fire behavior are fuel moisture (the moisture content of living and dead plant material), fuel loading (the amount of plant material per unit area), and the ratio of fine dead fuel to living fuel.

Herbaceous native plants and aerially seeded ryegrass cover the mountains again at the end of the rainy season after a fall fire.

Fuel moisture is high in winter and spring, but gradually decreases during the hot, dry summer months. The dead-to-live ratio, as well as the fuel loading, increase, causing increased fire danger as plants mature and become old.

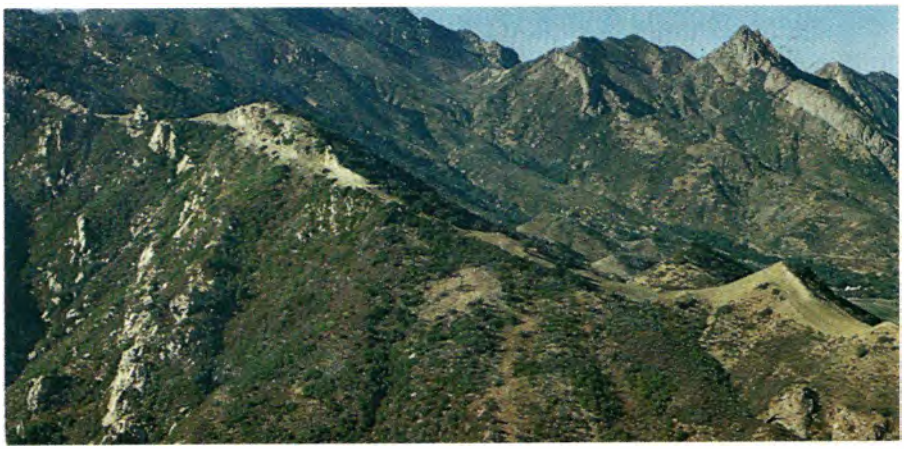
Fire history records indicate that plant succession patterns influence fire frequency in chaparral communities. Chances of having a second fire within the first few years after an area burns are high because of the large amount of herbaceous fuels such as grasses and flowering annual plants that follow the first burn. These plants readily become dry and carry a low-intensity fire. As the woody plants begin to dominate an area again, germination of the shorter-lived herbaceous species is inhibited. This greatly reduces fire danger for about the next 10 years because of the high proportion of live, succulent plant parts and the low proportion of fine dead plant material on the shrubs.

Fire frequency tends to be greatest in a subunit of chaparral called coastal sage vegetation. This specialized chaparral type is dominated by plants that tend to grow more herbaceous material each year than do woody chaparral shrubs.

Plants and soil on south-facing slopes are drier than on north-facing slopes because they are exposed to more direct heat from the sun. Species on these sites burn more readily than vegetation on cooler, wetter sites.

Summary

- Chaparral communities have adapted to summer drought, frequent fires, and steep unstable slopes.
- Chaparral plants are able to recover after fire by sprouting and by fire-stimulated germination of seeds.
- The flammability of chaparral vegetation depends on its moisture content, the ratio of dead-to-living fuel, and the amount of vegetation per unit area.
- The stage of plant succession and the severity of a site affect the likelihood and intensity of a fire.



Five years later young woody plants have replaced the herbaceous species; at this stage they do not carry fire readily.

Watershed Management Considerations

A watershed can be defined as all the land and water within the confines of a drainage area. Its depth extends from the top of the vegetation through the soil to the underlying geologic strata that restrict water movement. Chaparral soils and their underlying soil mantle can store great quantities of water. Rainfall intensities rarely exceed the soil infiltration rate of well-vegetated chaparral watersheds. Watershed problems occur when protective vegetation is removed as by wildfire or land development.

The main objective in watershed management of chaparral lands is to maintain vigorous, multi-aged stands of vegetation which can respond favorably to periodic disturbance (by fire). The main objective in home-owner watershed management is to maintain a dense cover of deep-rooted, healthy vegetation that will stabilize the watershed and control the flow of water from it. Soils engineering techniques, which are discussed in detail in *Living More Safely at the Chaparral-Urban Interface,* may also be necessary to control runoff and drainage.

In order to meet the various objectives, a watershed has to be managed as a unit and the erosional processes must be well understood. The first requirement means cooperation among property owners, the second is outlined below.

Erosional Processes

Chaparral vegetation is commonly found on steep hillsides, even on slopes that exceed the angle of maximum slope. This angle, often called the angle of repose, is the steepest angle that bare soil will maintain. For most natural slopes and most soils, the angle of repose is about 34° (67%). Beyond this angle, soil and rocks are totally under the influence of gravity and may slide downhill unless anchored by plants. Vegetative cover, root depth, and root strength affect the extent to which landslides occur. Slope failures are much less common with deep-rooted vegetation than with grasses, and with dry soils than with soils that have been saturated by winter storms or overwatering.

Slopes of varying steepness are illustrated in *Figure 1.* The relationship between slope ratio, degree of slope, and percent slope is also presented.

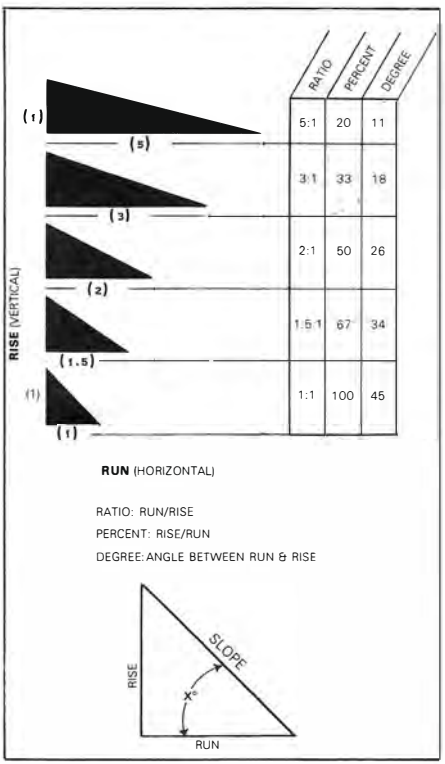


Figure 1. Slope ratio, percent slope, and degree of slope are shown for some hillsides of varying steepness.

Landslides often result when the toe (base) of a slope is undercut so that hillside stability is weakened.

A large landslide on slopes covered with chaparral.

A large landslide on slopes covered with coastal sage.

A landslide in a residential area.

Slope failures after annual grasses have replaced the deep-rooted native vegetation.

Soil failures are most common on slopes ranging from 25° to 45° (49% to 100%) making proper management of such steep hillsides extremely critical. Beyond 45°, rock slides are the most common erosional process.

Dry creep, the downhill movement of dry soil and debris, is common on steep slopes with little vegetative cover. It often exceeds wet erosion during low rainfall years and is especially important after fire. The dry creep settles at the base of slopes where it waits to be flushed downstream and perhaps into homes by occasional storms of high intensity.

Soil slips and landslides account for almost 50% of the total erosion on a watershed. Unlike dry creep, these soil movements normally occur when the soil is saturated. They are readily visible and directly translate into financial losses to downstream as well as upstream homeowners. When heavy rains fall on hillsides left bare by fire or improper brush clearance, the water cannot infiltrate rapidly enough into the soil, running instead over the soil surface and causing excessive erosion and swollen streams. The soil from the bare hillsides and the dry creep that has collected in the canyons then combine to create mudflow disasters.

Water-repellent Soil

Damaging fires not only burn the vegetative cover, but can also cause the soil to become hydrophobic (water repellent). Normally, slight water repellency of soils is caused by the breakdown of organic material and certain chemicals in plant litter. Hot fires accentuate this by concentrating these water-repellent chemicals. Some of the chemicals are volatilized by heat from the fire, resulting in gases that penetrate deeper into the soil. There the gases cool and condense, coating the soil particles with the water-repellent substances. Since rains cannot readily penetrate this layer of coated soil particles, water quickly saturates the shallow wettable surface layer. Sheet or rill erosion occurs after the surface layer is saturated. More information on hydrophobic soils is presented in the watershed management chapter of *Living More Safely at the Chaparral-Urban Interface.*

Summary

- Watershed management aims at maintaining a deep-rooted, dense cover of healthy plants.
- Such a plant cover controls surface erosion and reduces slippage by anchoring the soil.
- Deep-rooted plants pump water out of the soil, leaving it free to absorb winter rains.
- Most postfire mudflow originates from debris accumulated in canyons by previous surface erosion, soil slips, and landslides.
- Fire can accentuate the water repellency of soil.

Fire Management Considerations

Wildland fire management attempts to predict and control fire behavior by managing vegetative fuels to control flame length, rate of spread, and heat intensity.

Fire Factors

Wind is an important element affecting fire behavior. Wind not only controls the direction and spread of fire, but also greatly affects the flammability of plants by reducing fuel moisture, preheating the plants, and bending the flames ahead of the fire.

Most major wildfires occur during extreme fire weather brought on by the warm Santa Ana or foehn winds. With the onset of these winds, which blow from the north or east, temperatures increase rapidly, even into the night, and relative humidity declines drastically. Under such conditions, fires in mature chaparral cannot be controlled unless the fuels are exhausted.

Topography is also a critical factor in fire safety. It affects windspeed and direction, and is responsible for differences in heat radiation and fire spread. The most important topographic effect to remember is that fire spreads much faster uphill than downhill.

Ignition

A fire is the flame, heat, and light caused by burning (oxidation) after an object has reached ignition temperatures and has been ignited. Ignition temperatures are influenced by the rate of airflow (supply of oxygen), rate of heating, and size and shape of the object. Once ignition has occurred, sustained combustion requires a continuous supply of oxygen and fuel.

Wildland fuels, such as grasses, coastal sage scrub, chaparral, and trees, have various ignition requirements which depend largely on their moisture content and size. For example, dry grass has the lowest heat requirement for ignition, and grassy areas therefore have the highest fire frequency. Woody chaparral shrubs in coastal areas normally do not become dangerously dry until late summer or fall.

Heat Sources

Heat transfer is by conduction, convection, and radiation. The flame is the visible burning gas and vapor produced by the fire and provides (along with airborne sparks) a direct ignition source for fuels that have reached ignition temperatures.

Convection heat is the transfer of heat by atmospheric currents and is most critical under windy conditions and in steep terrain. With light wind and on level terrain, the convection heat column is almost vertical. Radiation heat is transfer of heat by electromagnetic waves and can, therefore, travel against the wind. For example, it can preheat the opposite side of a burning slope in a steep canyon or a neighboring home to the ignition point. Conduction is the direct transfer of heat by objects touching each other. An example would be

the transfer of heat from a stack of burning firewood to the side of the garage against which it is stacked.

The interaction of the three types of heat transfer with topography can be illustrated by visualizing a burning match as shown in *Figure 2*. When the match is held head up, heat transfer is by conduction only, and the match burns slowly. The situation is comparable to a wildfire burning downhill. If the match is held horizontally, heat transfer is by conduction and radiation, and the match burns a little faster. When the match is held head down, it is consumed rapidly because conduction, convection, and radiation heating are occurring together. The situation is comparable to a wildfire burning uphill.

Reducing the duration of heat and length of flames produced by nearby vegetation can be critical to protecting your home from fire. Flame length in chaparral fuels can be reduced by maintaining low-growing, widely-spaced plants. For example, on steep slopes, 30-foot flames occur in 6-foot-tall mature chaparral at winds of less than 10 miles per hour. Reducing the vegetation to 2 feet in height would reduce the flames to 10 feet. When wind-speed increases to 50 mph, as it often does during extreme Santa Ana weather conditions, the flame length for 2-foot-tall continuous fuels increases to 35 feet and for 6-foot-tall fuels to more than 100 feet.

The duration of heat can also be a critical factor. For example, the time period for heavy chaparral fuels to be consumed may be more than 10 minutes, but if the continuity and height of such fuels can be reduced, the duration of the flame and its associated heat can often be shortened to seconds. Thus, a yard tree which may take several minutes to burn may represent a greater hazard to a home than nearby discontinuous chaparral.

Summary

- Wildland fire management includes modification of the size, arrangement, and kind of vegetative fuels.
- Vegetation modifications reduce the ignition potential, flame length, and heat output of a fire.
- Heat transfer methods (conduction, convection, and radiation) vary in their contributions to a fire depending on wind and topography.

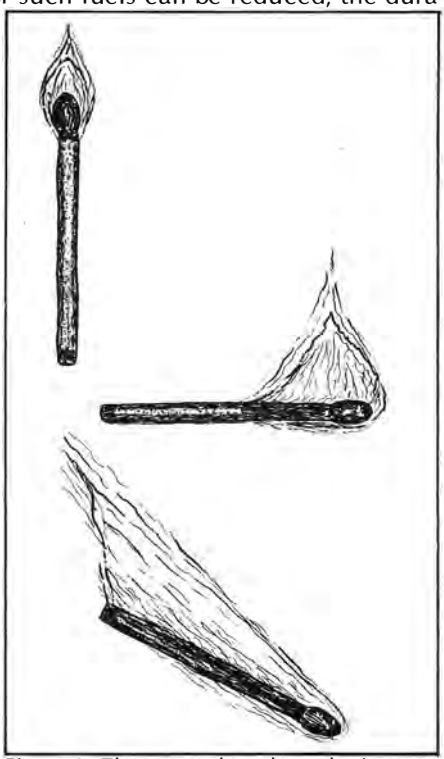


Figure 2. These matches show the interaction of the three types of heat transfer.

Even in light fuels, convection currents in steep terrain can create long flames that can ignite a house.

This burning mountain shows that houses situated on ridges and sideslope are extremely vulnerable to fire.

Fine dead fuels in the interior crown make many broad-leaved trees flammable.

Conifers generally are also highly flammable and produce long flames.

Owning a Fire-safe Home

The fire safety of a home depends on the continuity and loading of the fuels around it, the location of the home with respect to topography, and the design of the structure itself.

Legal Brush Clearance Requirements

California Resource Code 4219 requires clearance of flammable vegetation for a minimum distance of 30 to 100 feet around any structure located in a fire hazardous area. The clearance distance is subject to local enforcement, and in extremely hazardous areas, local fire authorities may require clearance beyond 100 feet. However, the intent of the code is readily defeated if basic fire safety principles are not carried into home design and homesite selection.

Information adapted from a brush clearance leaflet which has been handed out for many years by fire agencies in Los Angeles County is given on the inside back cover.

Fire Topography

The relationship between topography and fire behavior is a factor over which the homeowner has little control. He should, however, be aware of the relationship as it relates specifically to his property. *Figure 3* points out that homes located in natural chimneys, such as narrow canyons and saddles, are especially fire-prone because winds are funneled into these canyons and eddies are created. Studies on homes burned along ridges have shown that homes located where a canyon meets a ridge are more likely to burn than

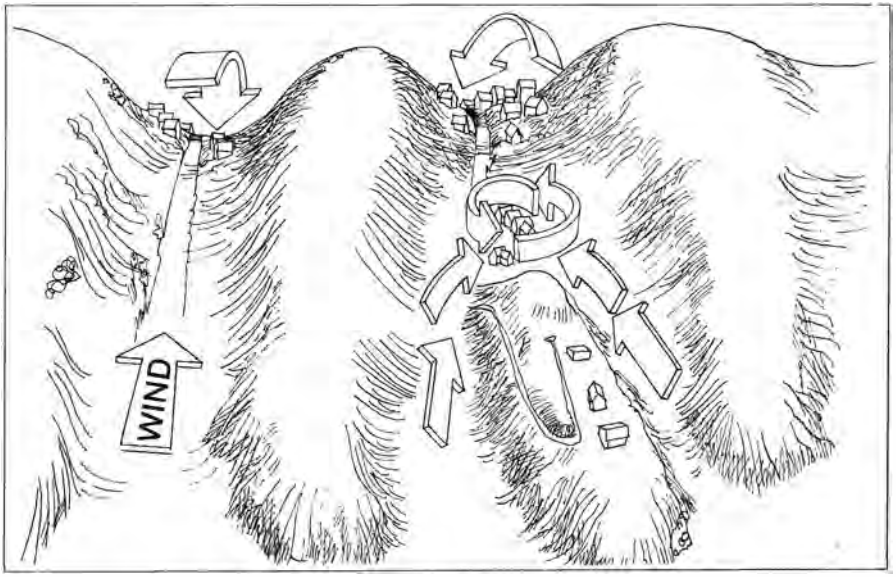


Figure 3. Winds tend to channel through natural chimneys, making narrow canyons and saddles particularly fire-prone.

other ridge-top homes. In very steep and narrow canyons, radiating heat may also be a major factor in fire spread and home losses.

Figure 4 illustrates how homes without adequate setbacks on narrow ridges are often lost because flames and convection heat hit the home directly. Homes located on the slope, especially stilt and cantilevered homes, are particularly vulnerable in this respect.

Building Design

Building density and design are important safety considerations because a burning home can ignite adjacent homes.

The roof is the most vulnerable part of a home because it is exposed to airborne sparks. The wood shingle roof has been the single most important element in home losses during wildland fires. It is also a major source of airborne firebrands capable of igniting nearby structures. Studies of structural losses during wildfire in southern California have shown that with 100 feet of brush clearance, a home with a wooden roof has a 21 times greater chance of burning than a home with a nonwood roof. Although most fire insurance rates are approximately 25% higher for wood roofs than for nonwood roofs, this rate does not compensate for the true difference in risk.

Exterior materials used on wildland homes should have a fire-resistance rating of 1 to 2 hours, meaning that they should consist of materials such as stucco, metal siding, brick, concrete block, and rock. This is especially critical for parts of a home exposed to winds from the north or east, or that are positioned at the top of a slope. *Figures 5* and *6* graphically summarize the principles of topography, vegetation, and architectural design that can improve

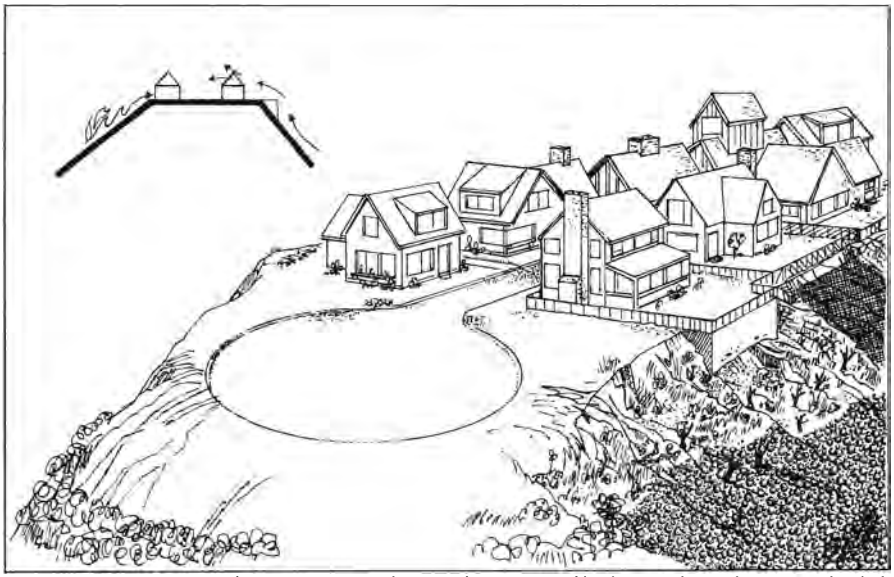


Figure 4. On narrow ridges, homes without adequate setbacks, such as those on the left, are particularly vulnerable to fire.

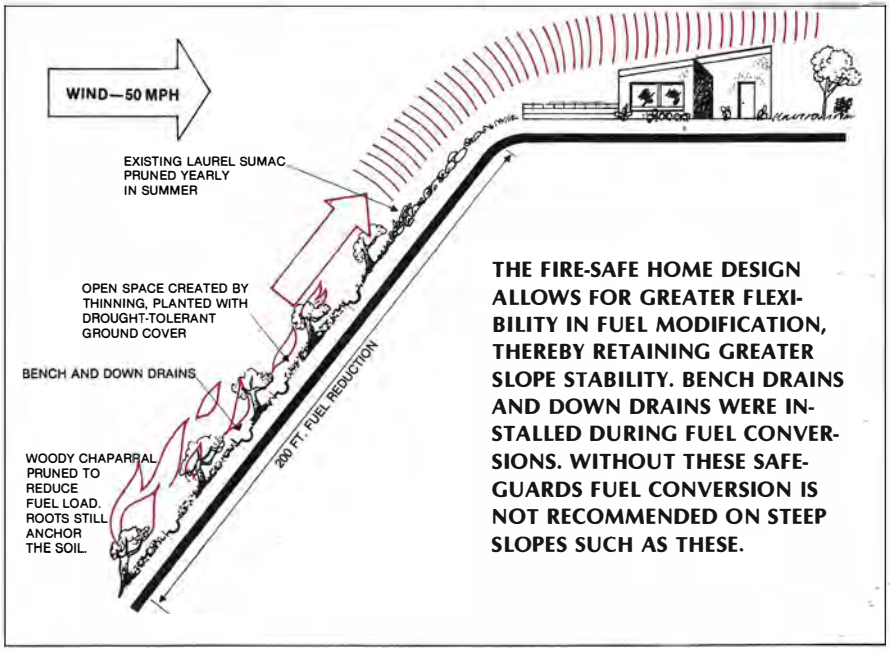


Figure 5. Here are some ways to reduce fire risk by preplanning:

1. *Fire-resistant roof; preferably Class A, such as tile*
2. *Stucco or other nonflammable siding of at least 1 hour fire-resistant rating*
3. *Reduced overhang (preferably closed eaves)*
4. *Roof slanted to accommodate convection heat*
5. *Safety zone (slope setback) of at least 30 feet for single story home*
6. *Pool used to create safety zone*
7. *Shrubs and trees not directly adjacent to home nor overhanging the roof*
8. *A deck with exterior materials of at least 1 hour fire-resistant rating.*

Fire safety is further increased by fuel reduction to twice (200 ft.) the legal minimum (100 ft.). Slope stability is maintained by retaining native plant specimen within the 18-foot legal distance for fuel separation. The flame length is still continuous but the amount and duration of the heat output is greatly reduced compared to a 100-foot or less clearance.

the fire safety of a planned or an existing home. Many positive features of home design are shown in Figure 5. Note that reduced overhangs or boxed eaves protect the house from ignition and heat or flame entrapment. Undereave vents should be located near the roofline rather than near the wall. Exterior attic and underfloor vents should not face possible fire corridors and should be covered with wire screen (not to exceed 1/4 inch mesh). Picture windows and sliding glass doors should be made only of thick, tempered safety glass and protected with nonflammable shutters. Stone walls can act as heat shields and deflect the flames. Swimming pools, decks, and patios can be used to create a setback safety zone as well as to provide safety accessories.

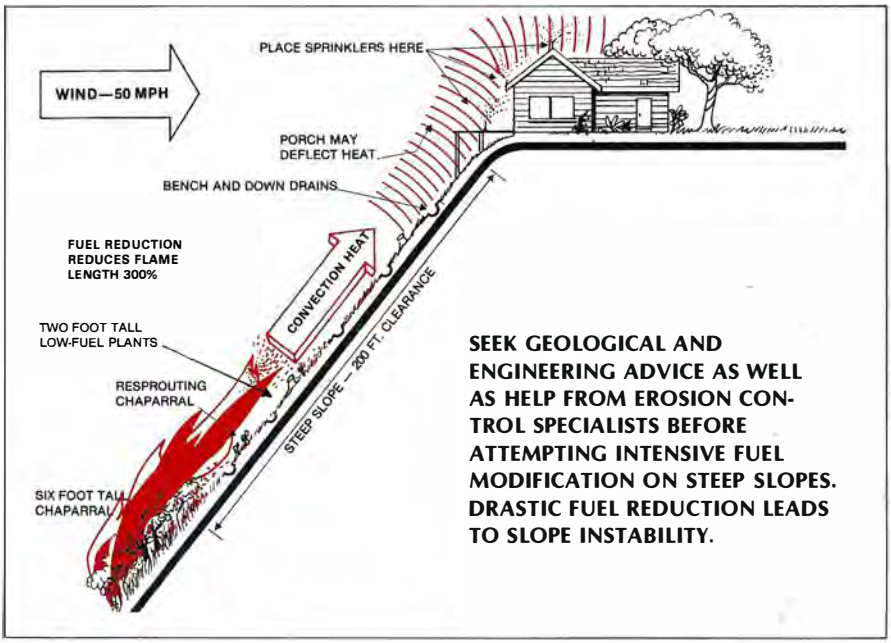


Figure 6. Here are some ways to modify an existing property to reduce fire risks:

Negative Features	Modifications
1. Wood shingle roof	*Fire-resistant roof*
2. Wood siding	*Nonflammable siding*
3. Large overhang (open eaves)	*Reduced overhang (closed eaves)*
	Vent covers for fire emergency
4. High gable roof	*Redesigning is too expensive*
5. No safety zone (no slope setback)	*Create setback with a deck where exterior material has a fire-resistant rating of 1 hour or more*
6. Large picture windows	*Install nonflammable shutters*
7. Tree crown overhanging the roof	*Prune tree*

Sprinklers placed on a wooden roof provide added safety, but don't depend on them.

Your Pool as a Water Source

Pools can provide a convenient water source for use before or during a fire. Fire engines should be able to get within 10 feet horizontally of the pool. If this is not possible, the pool should be equipped with a bottom drain and pipe system that terminates horizontally or below pool level in a 2½-inch valved standpipe equipped with a fire hydrant with national standard thread. A floating pool pump or portable gasoline pump with a suction hose that can reach the bottom of the pool can assure a usable water source even when water pressure and electricity fail. You will also need a fire hose and nozzle.

Fabric fire hoses are fine for use with pool pumps that are designed for firefighting, but should not be used on home faucets because they readily kink as water pressure drops. All outdoor faucets should be equipped with strong 5/8-inch rubber hoses that will not burst when the nozzle is turned off. A ladder should be available to reach the roof.

For more information on how to enhance the fire safety of a home, see *Living More Safely at the Chaparral-Urban Interface.*

Summary

- California Resource Code 4219 requires clearance of flammable vegetation for a minimum distance of 30 to 100 feet from any structure in a fire hazardous area. Local ordinances determine the clearance distance and may be more restrictive.
- Location of a home with respect to topography affects its likelihood of burning.
- The design of a home should reflect fire safety considerations. The wood shingle roof is the largest single cause of structural fire losses.
- With some planning, the water in your pool can be an important water source for fighting a fire.

Wood shingle roofs require an inappropriate amount of manpower and water during a wildfire because they are easily ignited by flying sparks.

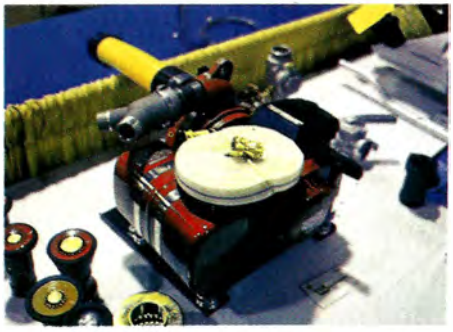
Wood sidings are almost as fire-prone as wood roofs.

The following safety features may save your home during a wildfire:

Boxed eaves that prevent heat entrapment even if the wood siding catches on fire.

Vents located near the roofline rather than the wall.

Shutters, even emergency plywood shutters, that protect windows.



Gasoline pool pumps and accessories.

Landscaping for Fire and Watershed Safety

The key to landscaping in fire-prone watershed areas is to selectively replace highly flammable native plants with lower-growing, less flammable plants of equal root depth and root strength.

In reality, optimum rooting depth and fuel volume generally work at odds with one another. That is, low-growing plants usually have relatively shallow root systems and tall plants have relatively deep and broad lateral root systems. Landscaping requires a compromise between minimizing fuel volume and maximizing root depth.

Rooting Depth and Fuel Volume

As a rule, nonwoody ground covers have an effective root depth of less than 3 feet and can be labeled "shallow rooted" for use in steep terrain. Grasses also belong in this category. Shallow-rooted plants should not be used as permanent cover on steep slopes unless they are interplanted at 10-foot centers with taller shrubs and 20-foot centers with trees. Interplanting is also required in stabilization of fill slopes.

Woody ground cover shrubs generally are moderately deep rooted, with roots ranging from 3 to 6 feet in depth, and can be effectively used on slopes in conjunction with taller shrubs and trees. Most plant species found in the coastal sage community fall into this root depth category.

Plants with roots ranging from 6 to 15 feet or more in depth include most woody shrubs in the chaparral community as well as small, drought-tolerant landscape trees. Very few commercially available woody ground covers, with the exception perhaps of prostrate (twin peak) coyote brush and prostrate acacia, have an effective root depth greater than 6 feet. Plants with roots much in excess of 15 feet include some native shrubs such as scrub oak and laurel sumac, and trees of larger stature.

Deep-rooted coyote brush is a good drought-tolerant ground cover for moderately steep slopes.

Drought Tolerance and Sprouting Ability

Drought tolerance and sprouting ability are also important considerations when selecting plants. Water will be an increasingly sparse and expensive resource in the future. The plant's ability to survive on little

water as well as to resprout after a fire or when neglected (neglect could be a result of water shortage) can mean savings over the years on water bills, maintenance costs, replanting costs, and hillside repairs.

Herbaceous or semiwoody ground covers like vinca or ivy, woody ground covers like coyote brush, hedges such as oleander and myoporum, and even some coniferous trees like Canary Island pine and Chir pine do not need to be replanted because they resprout readily.

Most native plants also resprout, and some native shrubs such as sugarbush, scrub oak, ceanothus species, and chokecherries can be nurtured into short-stemmed trees. At spacings of about 25 feet, these plants can be kept relatively fire retardant through occasional pruning. Resprouting broadleaved trees, such as oaks, California pepper, Brazilian pepper, sycamore, black locust, and California laurel, to name just a few, can be effectively blended into the landscape setting. For fire safety, trees must be pruned and should be limited to the number necessary to provide shade and slope stability.

The use of herbicides and pre-emergent chemicals must be closely monitored in hillside landscaping. Overuse can kill landscape plants and sterilize soils. Fortunately, the deepest rooted chaparral shrubs are also the hardest to kill with herbicides. Since these shrubs serve the dual function of anchoring the soil to the bedrock and pumping water out of the ground, soil slippage is almost never observed where they are present. Mortality of such plants often results in slippage 5 to 10 years later after the roots have rotted away. The original cause of such delayed slippage is seldom recognized.

Hillside Landscaping

Some ground covers and low-fuel shrubs commonly used for hillside landscaping in southern California are listed in *Table 1* along with their characteristics and some suggestions about where they should be used. The plant species listed, except where indicated, are able to form a solid ground cover for the

Test plantings such as these indicate that Acacia ongerup *(arrow) is a highly drought-tolerant and fast growing woody ground cover.*

slopes recommended. However, there is no guarantee that the species prevent slippage when the soil becomes saturated. Interplanting ground covers with shrubs and trees, as discussed earlier, will maximize slope stability. Plants that require high maintenance or that are readily browsed, such as most ceanothus species, are not included in *Table 1*.

The columns in *Table 1* headed "aspect," "soil depth," and "irrigation" must be read as a unit. Soil depth figures apply to medium-textured, loamy soils. The irrigation figures apply to coastal regions of southern California and attempt to show relative watering needs of the plants listed. The figures assume that soil moisture is recharged to 12-inch depth during watering. In reality, this goal is rarely achieved through overhead watering because of sprinkler design and time period necessary for irrigation. The effective rooting depths indicated in *Table 1* are based on moisture withdrawal by roots after soil moisture has been depleted in the upper soil layers.

Erosion netting reduces soil erosion on steep slopes.

The term "fire retardance" as used in *Table 1* reflects differences in fuel volume, inherent flammability characteristics of the plant, and ease of fire spread. For example, under extreme autumn fire conditions, on steep slopes with nongusting winds of 30 mph, a 2-foot-tall solid ground cover with "high" fire retardance is expected to produce a flame less than 10 feet long and to reduce the rate of fire spread. Under similar conditions, a plant with "low" fire retardance may ignite readily, will carry the fire, and can produce flames approaching 25 feet in length. For comparison, mature chaparral under these conditions can produce flames exceeding 80 feet in length.

The following example will illustrate the use of *Table 1*. Capeweed is listed in row 1 of the table. Column 1 shows that the species is most effective for planting on slopes not exceeding 25°, but may be used on a limited scale on slightly steeper slopes. The shallow root system of capeweed may trigger soil slippage. The next three columns are to be read as a unit and show the relationship between aspect, soil depth, and irrigation requirements. For example, the first line shows that on a north-to-east aspect with less than 1 foot of soil depth, established plants require summer irrigation once to twice a month. The remaining columns are self-explanatory.

Ice plants have a shallow root system that was not able to prevent this slippage.

This sloping lawn sheds water onto the adjoining bank, causing slippage.

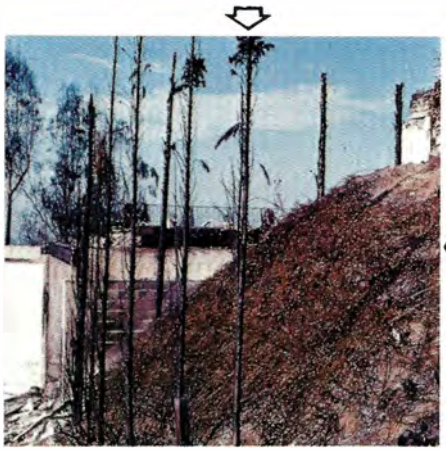
Capeweed on the bank is excellent to prevent surface erosion but its shallow root system is unable to prevent soil slippage.

Ice plants, listed in row 5, have been used extensively for hillside planting because they are low growing, drought tolerant, fire retardant, and aesthetically pleasing; they are easily established on harsh sites, and require minimal maintenance and watering. However, during high intensity storms, by far the greatest slope failures are found on hillsides planted with ice plants. A wise homeowner will acquire the written opinion of a geologist regarding slope stability before planting ice plants extensively on slopes in excess of 15°. Most species of ice plants are best suited for rock garden situations or for harsher sites with relatively stable geology and thin soils.

Slope Engineering

Slope engineering techniques such as concrete bench and down drains, designed to slow and direct excess water flow, are necessary on most steep slopes around homes. Their use becomes critical when modification of native vegetation is attempted in geologically unstable areas or areas with past soil-slip problems. The homeowner is responsible for the maintenance of any drainage devices on his land and the devices should be listed in the deed for the property. Any modification of vegetation on the hillside where the layering (dip) of the bedrock parallels the slope, as shown in *Figure 7*, should be undertaken with extreme caution because of the natural instability of the slope. Increasing the infiltration rate of water into the soil and reducing the root strength and root depth per unit area can result in almost immediate soil failures during winter rains.

More information on various aspects of hillside landscaping including slope engineering techniques, proper watering methods, plant selection, and selective brush conversion is available in *Living More Safely at the Chaparral-Urban Interface*. No book, however, should be a substitute for onsite expert advice from specialists familiar with hillside landscaping and hillside problems.



Landscape plants such as Italian cypress (arrow), junipers, and most pines are highly flammable. Even mature ivy will burn (arrow).

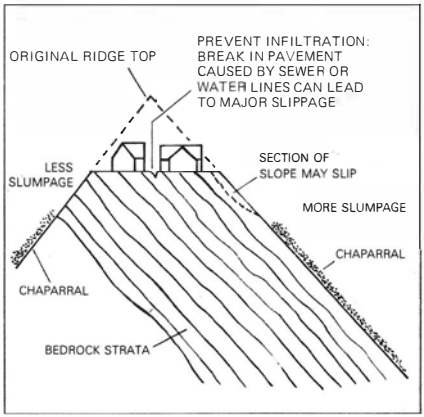


Figure 7. Rock strata may determine hillside problems.

Summary

- Slope stabilization may be achieved by the use of deep-rooted plants in conjunction with slope engineering.
- Fire management requires low-fuel or low-growing plants to reduce flame length and heat output.
- As a compromise between watershed and fire safety, a combination of taller, deeper rooted plants should be interplanted with ground covers.

Citrus orchards make good greenbelts and reduce firespread.

Bench drains (arrow) enhance slope stability; they break up the length of the slope and allow a greater choice of species for landscaping.

Table 1. Evaluation of some popular low-growing plants used in wildland-urban landscaping.

SPECIES	EFFECTIVE... On slopes (degrees) to 25	25 to 35	35+	On aspects N to E	S to W	At soil depths (feet) to 1'	1'-3'	3'+	If irrigated summer to fall	At elevations (feet)
1. *Arctotheca calendula* (Capeweed)	X	'X'		X		X			1-2M	Up to 2,000
				X			X		1M	
				X				X	2S	
					X	X			2M	
					X		X		1M	
					X			X	<1M	
2. *Acacia ongerup*	X	X	'X'	X		X			<1M	Up to 2,000
				X			X			
				X				X	None	
					X	X			>1M	
					X		X			
					X			X	1S	
3. *Baccharis pilularis* cultivar "twin peak" coyote bush (brush)	X	X	'X'	X		X			<1M	Up to 4,000
				X			X			
				X				X	'None'	
					'X'	'X'			>1M	
					X		X			
					X			X	1S	
4. *Cistus crispus* Descanso rockrose	X	X		X		X			1M	Up to 4,000
				X			X			
				X				X	'None'	
					X	X			<2M	
					X		X			
					X			X	1-2S	
5. *Carpobrotus, Delosperma,* etc. Iceplants	X	See text		X		X			<1M	Up to 2,000
				X			'X'			
				X				X	'None'	
					X	X			1M	
					X		'X'			
					X			'X'	'1-2S'	
6. *Hedera canariensis* Algerian ivy (Freeway ivy)	X	X	'X'	X		X			1W	Up to 2,000
				X			X		1M	
				X				'X'	2S	
					'X'	'X'				
					X		X		2M	
					X			X	1M	
7. *Osteospermum fruticosum* African daisy	X	'X'		X		X			2M	Up to 2,000
				X			X			
				X				'X'	<1M	
					'X'	X			1W	
					X		X			
					X			X	1-2M	
8. *Vinca major* Periwinkle	X	X		X		X			>2M	Up to 4,000
				X			X			
				X				X	<1M	
					'X'		X			
					X			X	1-2M	

Abbreviations:
X = Suitable for this category
'X' = Plant not totally suitable for this category
– = Not recommended for this category
W = Week
M = Month
S = Summer

> = greater than
< = less than
A blank under 'Irrigation' denotes an intermediate watering schedule.

CHARACTERIZED BY . . .				
Growth habit	Fire retardance	Resprouting ability	Rooting depth (effective)	COMMENTS
Spreading ground cover 6 to 8 inches tall	High	If watered	1 to 3 feet	Very low maintenance. Takes occasional foot traffic. Showy yellow flowers. Weedy in manicured setting. Frost sensitive. Draws bees. Spreads by runners. Full sun to partial shade.
Spreading shrub 12 to 30 inches tall	Low; decreases with increase in fuel	Poor	Greater than 6 feet	Low maintenance. No foot traffic. Showy yellow flowers. Draws bees. Most drought-tolerant and quickest-spreading woody plant tested. Full sun.
Spreading shrub 12 to 24 inches tall	Low	Vigorous	Approximately 6 feet	Prune back every 5 years or less often. No foot traffic. Inconspicuous flowers. Hard to establish from flats in midsummer. Healthy green color. Full sun.
Semi-upright shrub 12 to 24 inches tall	Low to medium	Poor	3 to 4 feet	Medium to low maintenance. No foot traffic. Showy pink flowers; draws bees. Ground cover for easily accessible drysite areas. Attractive if watered; unattractive if not maintained. Full sun.
Trailing ground cover 4 to 18 inches tall	Generally high	Depends on severity of fire	Mostly 1 to 2 feet	Low maintenance. No foot traffic. Showy multicolored flowers. High foliage moisture and weak root system causes slippage on steeper slopes, especially fills. Full sun to partial shade.
Trailing ground cover 8 to 12 inches tall	Medium	If watered	3 to 4 feet	Low maintenance. Tolerates foot traffic. Excellent for minimizing erosion on long, steep cuts. Leaves will burn if watering is neglected. Excellent understory to a variety of trees. No flowers. Full sun to shade.
Trailing ground-cover less than 12 ins. tall	Medium to high	If watered	3 feet +	Moderate to high maintenance. Tolerates some foot traffic. Showy white flowers and other hybrid colors. Freezes at 25° F. Fertilize and water regularly. Full sun to partial shade.
Trailing ground-cover less than 18 inches tall	Medium	If watered	3 feet	Low maintenance. Occasional foot traffic. Showy blue flowers. Does well under partial overstory where somewhat neglected. Sun to shade.

For further plant recommendations, see

Living More Safely at the Chaparral-Urban Interface.

Maintenance for Fire and Watershed Safety

Landscape maintenance is necessary to keep man-made structures separated from surrounding vegetative fuels; to keep the amount of vegetative fuels at a safe level; to create a safety zone for residents, firefighters, and fire equipment; and to assure that water flow from the property is channeled properly. Giving correct priorities to maintenance needs and carrying out maintenance and safety inspections on a regular basis is the key to minimizing the effects of natural disasters.

For fire and watershed maintenance, the area around the home should be divided into three perimeters of defense:

1. 0 to 30 feet: year-round maintenance
2. 30 to 100 feet: seasonal maintenance
3. 100 feet or more: yearly inspections, periodic maintenance

Maintenance Adjacent to the Home

The area within 30 feet of the home is most critical for fire and watershed safety. Maintenance of nonflammable landscaping such as lawns, border plantings, flower gardens and vegetable beds, and structures such as pools, concrete decks, and recreation areas helps to reduce fire hazard close to the home. This area, for the most part, is level and all water from it should drain toward the street. Rain gutters, pipes, and drainage devices should be cleaned out on a regular basis. Additionally, all leaves should be removed from the roof before the fire season begins.

Foundation shrubs and trees are a necessary part of the landscaping. However, these plants often grow into an "urban forest" fuel problem, so that landscape plants rather than surrounding native plants become the primary cause of fire loss. Year-round maintenance should consist of pruning and regular watering of individual plants. Together, these measures decrease plant volume, increase plant moisture content, and reduce or eliminate dead fuels. (Caution: Unnecessary watering of drought-tolerant landscape plants may cause root rot of a native plant nearby.)

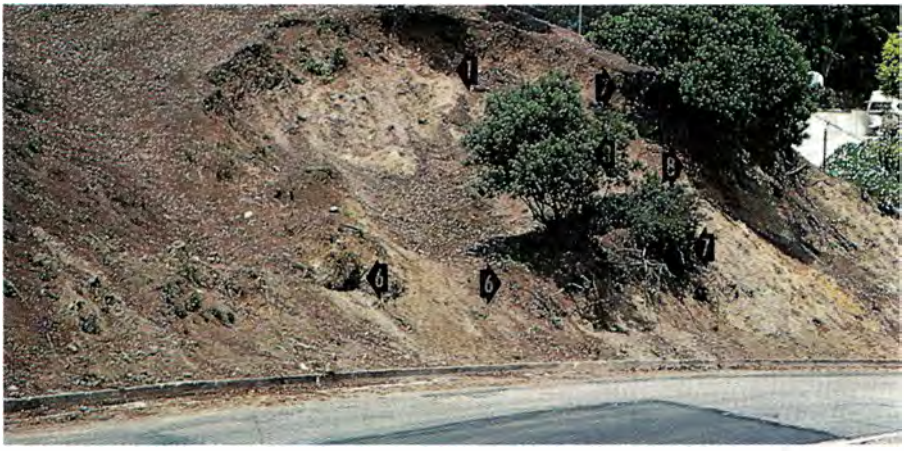
This home, designed to be fire-safe, also has a 30-foot safety zone.

Native plants can be thinned out to form an effective greenbelt zone that is easily maintained. Concrete bench drains should be cleaned as required.

Trees must receive the same regular maintenance as foundation shrubs. Oak trees, such as coast live oak, usually contain a high amount of dead twigs and branchlets. The crowns of such oaks are exposed to higher windspeeds than exist at ground level. These conditions can produce large flames that are readily bent onto the roofs of nearby structures. Eucalyptus trees are also notorious for their tendency to spread fire.

30- to 100-foot Greenbelt Area

Seasonal fire maintenance in the 30- to 100-foot greenbelt zone around the home should consist of removing dead woody plants, occasional pruning of trees and shrubs, and eradication of weedy species. To maintain healthy plants and strong root systems, pruning of most native plants should be done



Ground squirrels contributed to this landslide. Numbers of entrances to their burrows are shown beside the arrows.

during the summer. Ground cover shrubs may also need to be thinned periodically. In thinning and pruning, care must be taken not to expose the soil surface to a greater degree than can be safely covered by surrounding plants before the rainy season. Well-pruned, healthy shrubs require several years to build up an excess of flammable live and dead fuel. Therefore, a complete maintenance job can last a long time.

This native plant (center) is dying because of root rot caused by over-watering of the young coyote brush around it.

Watershed problems in this greenbelt zone are often critical. Yearly, before the winter rainy season, all drainage devices must be inspected to assure that they are functional and not clogged with debris. After major storms, all rain gutters, pipes, concrete bench and down drains, and other such devices, must be reinspected. Bench drains are easily blocked by minor soil slips. This forces uncontrolled water flow over the slope and results in supersaturated soils and mud flow.

Greenbelt Extension Past 100 Feet

The intensity of fire maintenance beyond 100 feet from the home is dictated by topography and design of the structure. Minimum maintenance for a home designed with fire safety in mind should consist of reducing the amount and continuity of the vegetation as well as thinning out the most flammable species. Selective maintenance can be done in areas where topography is favorable and geology stable (gentle slopes, rock outcroppings, etc.) every 10 years or less without causing any accelerated soil erosion. Such "feathering out" of older vegetation on portions of a watershed while favoring younger plants reduces the possibility and effect of major wildfires.

Rodents such as gophers and ground squirrels can be a major cause for soil slips because they weaken root systems and build underground tunnels where water can concentrate. For further discussion of animals detrimental to hillside stability, see the Watershed Management chapter in *Living More Safely at the Chaparral-Urban Interface.*

Summary

- Maintenance of landscaping and structural additions around the home is essential to fire safety and watershed protection.
- Maintenance needs are most critical within 30 feet of the home, but periodic fuel reduction and maintenance of drainage devices are required at greater distances from the home.

What To Do When Caught in a Wildfire

If your home is threatened by wildfire, you may be contacted by a fire or law enforcement official and advised to evacuate. If you are not contacted in time to evacuate, or if you decide to stay with your home, the following suggestions will increase your chances of safely and successfully defending your property.

Before the fire approaches your house:

1. If you plan to stay, evacuate your pets and all family members who are not essential to protecting the home.
2. Be properly dressed to survive the fire. Cotton fabrics are preferable to synthetics. Wear long pants and boots and carry with you for protection a long-sleeved shirt or jacket, gloves, a handkerchief to shield the face, water to wet it, and goggles.
3. Remove combustible items from around the house. This includes lawn and poolside furniture, umbrellas, and tarp coverings. If they catch fire, the added heat could ignite your house.
4. Close outside attic, eave, and basement vents. This will eliminate the possibility of sparks blowing into hidden areas within the house. Close window shutters.
5. Place large plastic trash cans or buckets around the outside of the house and fill them with water. Soak burlap sacks, small rugs, large rags. They can be helpful in beating out burning embers or small fires. Inside the house, fill bathtubs, sinks and other containers with water. Toilet tanks and water heaters are an important water reservoir.
6. Locate garden hoses so they will reach any place on the house. Use the spray-gun type nozzle, adjusted to a spray.
7. If you have portable gasoline-powered pumps to take water from a swimming pool or tank, make sure they are operating and in place.
8. Place a ladder against the roof of the house opposite the side of the approaching fire. If you have a combustible roof, wet it down or turn on any roof sprinklers. Turn on any special fire sprinklers installed to add protection. Do not waste water. Waste can drain the entire water system quickly.
9. Back your car in the garage and roll up the car windows. Disconnect the automatic garage door opener (in case of power failure you could not remove the car). Close all garage doors.
10. Place valuable papers and mementos inside the car in the garage for quick departure, if necessary. Any pets still with you should also be put in the car.
11. Close windows and doors to the house to prevent sparks from blowing inside. Close all doors inside the house to prevent draft. Open the damper on your fireplace to help stabilize outside-inside pressure, but close the fireplace screen so sparks will not ignite the room. Turn on a light in each room to make the house more visible in heavy smoke.
12. Turn off pilot lights.

13. If you have time, take down your drapes and curtains. Close all venetian blinds or noncombustible window coverings to reduce the amount of heat radiating into your home. This gives added safety in case the windows give way because of heat or wind.

When the fire approaches:

As the firefront approaches, go inside the house. Stay calm, you are in control of the situation.

After the fire passes:

After the fire passes, check the roof immediately. Extinguish any sparks or embers. Then, check inside the attic for hidden burning sparks. If you have a fire, get your neighbors to help fight it. The water in your pool and the water in your garbage cans, sinks, toilet tanks, etc., will come in handy now. For several hours after the fire, recheck for smoke and sparks throughout the house.

Remember:

In a major conflagration, fire protection agencies will probably not have enough equipment and manpower to be at every home. You cannot depend totally on their help. One of the firefighters' principal responsibilities is to stop the spread of fire from house to house. Therefore, if one home is on fire, firefighters might have to pass it by to save another in the path of the fire.

Your careful planning and action during a fire can save your home. Be prepared. Talk with your neighbors to see what resources you have. Ask your fire or forestry personnel for professional advice and assistance.

When caught in the open:

When you are caught in the open, the best temporary shelter will be found where fuel is sparse. These places could include road cuts and banks, large boulders, rock outcroppings, large logs, and depressions in the ground. Here are comments on some good and bad places to go:

Automobile

Move the car to bare ground or sparse fuel areas, close all windows and doors, lie on the floor and cover yourself with a jacket or blanket. The fuel tank of the car will normally not explode until the car is well on fire or may not explode at all. So, keep calm and let the fire pass.

Road Cut

If caught without shelter along a road, lie face down along the road cut or the ditch on the uphill side (less fuel and less convection heat). Cover yourself with anything that will shield you from the heat of the fire.

Chimneys

Never be caught by fire in natural chimneys. These are narrow, steep canyons that concentrate heat and updraft. Temperatures may exceed several thousand degrees Fahrenheit during a fire.

Saddles

While hiking out of an area where fire is in progress, avoid topographic saddles if possible. Saddles are wide natural paths for fire winds, and vegetation here will normally ignite first.

In the Open

Look for areas with sparse fuel (for example, soft chaparral such as black sage or grassland rather than chamise chaparral), if possible, within a depression. Clear as much fuel as you can while the fire is approaching and then lie face down in the depression and cover yourself with anything that will shield you from the heat. Smoke may create as great a survival problem as the flames do. If you are caught on a steep mountaintop or sharp ridge, the backside (or fire leeward side) will provide more safety. Be aware, however, that fire eddies often curl over ridges.

Before hiking in fire-prone areas, seek additional advice from wildland firefighting agencies. They may supply pamphlets and can give you specific tips for wildland fire survival.

Summary

- Stay calm—you are in control of the situation.
- If you decide to stay with your home during a wildfire, evacuate all family members who are not essential to protecting the home.
- Dress properly to shield yourself from the heat and flames.
- Take steps to prepare your home for the approaching fire.
- As the fire approaches, move inside and stay until it has passed.
- Move outside, survey the situation, take action, and help neighbors.
- If caught in the open, seek shelter where fuel is sparse

Postfire Emergency Measures

The steps to take in emergency rehabilitation of an area after a fire depends on the location, the time of year, the intensity of the fire, the erosion potential, and the kinds of plants present. *Figure 8* illustrates some postfire emergency rehabilitation measures.

If the fire occurs in midsummer and the burned watershed cover consists primarily of landscape plants with a large proportion of resprouting ground covers and shrubs, all that may be necessary for rehabilitation is to periodically irrigate and fertilize. Adequate moisture, heat, and nutrients will encourage rapid resprouting so that a good foundation plant cover can be established before the heavy winter rains return.

Postfire management of native plants is similar to the procedure outlined above. Plants should be allowed to resprout and establish themselves from seed. Thinning of seedlings, as well as removal of dead stems and branches, can begin the following spring after the rainy season is over. The first year's thinning of native plants should be very light, followed by heavier thinnings the second and third year after clear species patterns and densities have emerged.

Timing becomes critical when a hot fire occurs in late fall. In neighborhoods where steep, long slopes overlook canyons and endanger the lives and property of canyon residents, neighbors should work together to quickly establish an emergency vegetation cover before heavy winter rains begin.

Vegetative Measures

Aerial emergency seeding efforts by public agencies primarily employ ryegrass and are a "band-aid" measure meant to duplicate or complement nature's

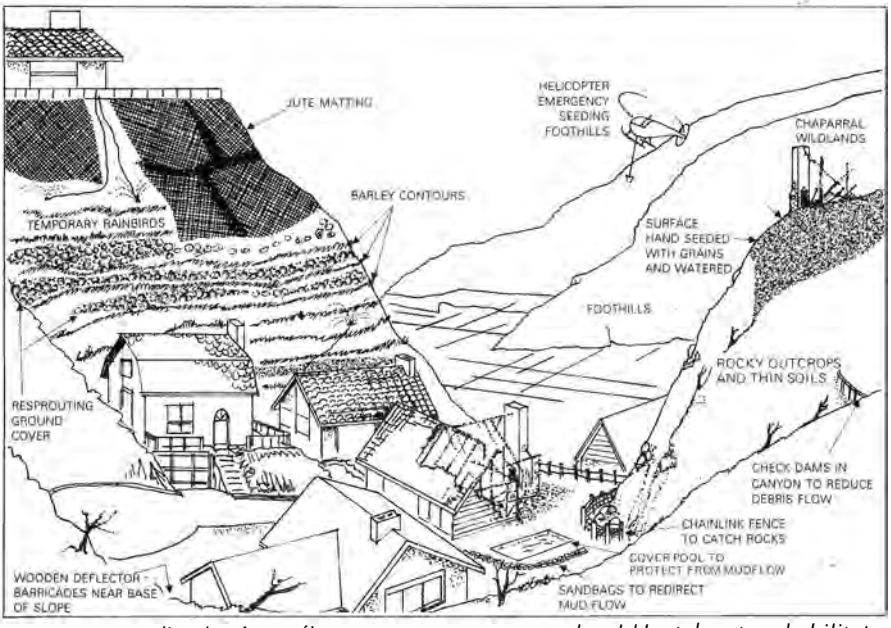


Figure 8. Immediately after a fire, emergency measures should be taken to rehabilitate the watershed.

own "band-aid" of postfire herbaceous plants. However, ryegrass seeds exposed at the soil surface will not germinate and root unless encouraged by 4 to 5 days of moist, overcast weather. Seeds of annual grasses present before the fire will germinate quickly with any moisture because most seeds are incorporated into the soil layer.

The least time- and labor-consuming emergency measure for homeowners is to broadcast annual ryegrass or other quickly germinating species at the rate of 15 to 30 lb./acre, rake the seeds about 1/2 inch deep into the soil where feasible and then water lightly and regularly. Watering may be necessary two or more times a day during hot weather.

Grasses have fibrous root systems that are very effective in competing for soil moisture. When replanting of shrubs or ground covers is planned for the spring or begins immediately after the fire, annual grasses must be separated from such plants and should be seeded in contour rows. Such rows should parallel the slope and are easily established with a hoe. They should be spaced about 3 feet apart but could be closer in steeper terrain and on fine textured soils with low infiltration rates. The ground covers are planted between the contour rows.

Contours are very effective in reducing erosion because the ridges and trenches form a series of miniterraces allowing water to infiltrate into the soil. This increases plant growth, reduces runoff, conserves soil moisture, and prevents soil losses. Do not use contour rows in active landslide areas. Cover these with plastic using the guidelines discussed in the next section.

Barley is an effective species for contour row planting. Seeds should be soaked overnight in gunny sacks (cloth bags) in leaky trash cans. Excess water, which may contain germination-inhibiting substances leached from the seed coat, should be channeled into the street. The recommended seeding rate is 150 lb./acre with about an equal amount of ammonium phosphate fertilizer. Seeds should be buried about 1/2- to 1-inch deep and the soil tamped. Barley is readily available from feed stores, but buy only recleaned barley; rolled barley (used for feed) will not germinate. Annual grasses, such as ryegrass and barley, die with the return of hot weather and then present a fire hazard.

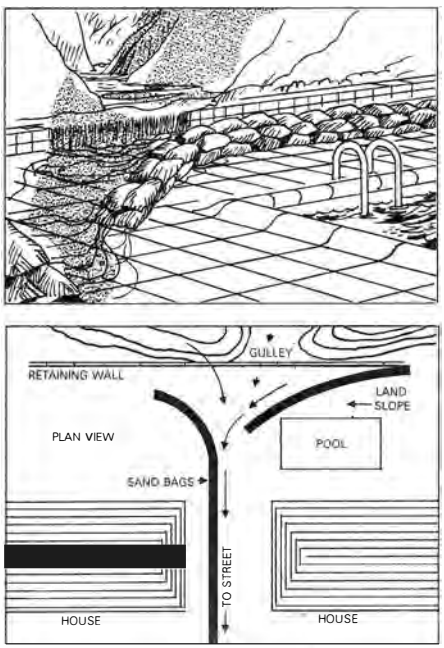


Figure 9. Sandbags divert flowing mud.

Mechanical Measures

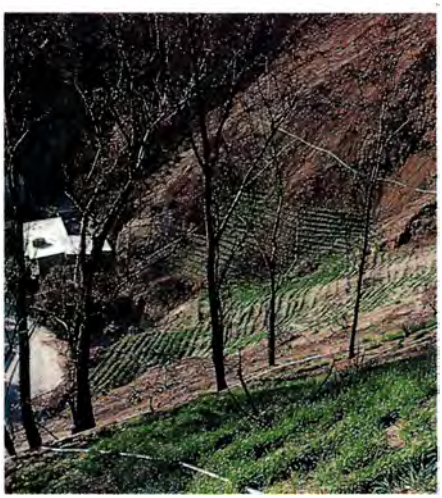
Flood control offices in most major cities provide excellent advice and pamphlets on mechanical measures

for use in emergency situations. The most effective methods for homeowner use are wooden deflector barriers (usually plywood) and sandbags that rechannel mudflow safely around structures. *Figure 9* shows that the placement of such structures is critical in achieving the desired results. Sandbags should be filled half-full with sand or soil and the flaps tied under and pointed in the direction of the water source. Bags should be tamped and tightly fitted and each layer staggered, as when building a brick wall. Rows should not be more than three layers high unless they are pyramidal or supported by a building.

Some other effective measures are check dams to reduce gully erosion, chain link fences to control rock fall, and guniting of steep slopes and spreading of plastic to eliminate water infiltration. Plastic sheets should be 6 mil (0.006-inch-thick) because they are sturdier than 4 mil. The slope should be covered completely and the plastic should be anchored by partially filled sandbags. On steep slopes, the sandbags should be connected using ropes. Plastic sheets that cover only a small section of a slope (as when some sheets have blown away) concentrate the rainwater and are responsible for localized saturated soils and slippage.

Summary

- Survey fire damage in relation to topography (the whole watershed) and structures.
- Obtain expert advice immediately and coordinate quick action with other residents.
- Use vegetative as well as mechanical emergency measures effectively, taking care to avoid possible damage to other properties.



Barley contours reduce soil erosion on highly erosive granitic soils.

The plastic is well anchored and covers the whole slope.

Brush Clearance Information

You are only required to clear your own property. Clearance on other property is the responsibility of the owner. Contact your local forestry or fire personnel if such clearance is needed.

Brush Clearance Law*

- A fire fighter who must protect your home from a brush fire would like every advantage he can get. He would like to see every bit of hazardous vegetation cleared away, right down to mineral soil.
- The homeowner, on the other hand, appreciates the beauty of the brush and the seclusion it offers. He also realizes that during a major fire conflagration, fire fighting personnel are 'spread thin' and the homeowner may become the key to saving his own home. Can you save your home or can it save itself?
- Both foresters and homeowners realize the danger from soil erosion that will result from a barren hillside; nevertheless, the native brush must be cleared by law to a point where a home will stand a good chance of being saved in the event of a fire.

In the Native Brush Around Your Home

- Remove native brush and other hazardous vegetation for a distance of 100 feet around all structures and 10 feet from the sides of roads and driveways that are used by more than one residence.
- Within 30 feet of the structure, relandscape with low-growing plants, such as lawns, ivy, succulents, etc. that do not transmit fire readily.

  Exception: You may retain "specimen native shrubs" if they are trimmed 2 feet above the ground, do not exceed approximately 7 feet in diameter, are maintained free of all dead wood, duff, dry leaves, etc., and are not closer together than 18 feet air space. Notice that landscape trees are not involved in this regulation unless they present an unusual fire hazard (which they normally do) or are within 10 feet of the outlet of a chimney.

In and Around Your Home and Garage

- Allow no trees, shrubs or other vegetation to grow within 10 feet of the outlet of any chimney. Screen the chimney to prevent sparks from igniting the roof or brush. Use half-inch wire mesh.
- Keep all trees, shrubs, or other vegetation adjacent to or overhanging any structure free of dead limbs, branches, and other combustible matter.
- Keep the roof and rain gutters free of dead leaves, twigs and other combustible matter.
- Keep all combustible rubbish in non-combustible rubbish containers with tight-fitting lids.
- Stack woodpiles neatly and compactly in a location remote from the house and garage.

**Adapted with changes from homeowner guidelines by the Los Angeles (City) Fire Department.*