# OAKLAND/BERKELEY HILLS FIRE

Oakland/Berkeley, CA

October 20, 1991

NFPA INTERNATIONAL

# FIRE INVESTIGATIONS

NATIONAL FIRE PROTECTION ASSOCIATION

1 Batterymarch Park, PO Box 9101, Quincy, MA 02269-9101 USA
Telephone: 1-617-984-7263 E-mail: investigations@nfpa.org

All non-NFPA photographs have been removed from this document.

## TABLE OF CONTENTS


**Abstract** ..... 3

**Background** ..... 5

**Factors Affecting the Wildland Fire** ..... 7
- Vegetation ..... 7
- Residential construction ..... 8
- The Weather ..... 9

**The Fire** ..... 11
- Intensity ..... 12
- Response ..... 13
- Communications ..... 14
- Water ..... 14
- Narrow roads ..... 15
- Mutual aid ..... 15
- Utilities ..... 16
- Evacuation ..... 16

**Discussion** ..... 17

**Recommendations** ..... 19
- The fire service ..... 19
- Legislators ..... 22
- Planners ..... 22
- General public ..... 22

**Today** ..... 23

**Source List of Organizations** ..... 24


## ACKNOWLEDGMENTS


This report has been prepared by the National Fire Protection Association (NFPA) in cooperation with the Oakland and Berkeley, California Fire Departments and the California State Fire Marshal's Office. The project was sponsored by the National Wildland/Urban Interface Fire Protection Initiative to further the goals of the Initiative, established in 1986. Those goals are to create general public awareness of the wildland interface problem, to encourage formation of partnerships among problem-solvers and interest groups, and to focus on the development of local solutions to wildland/urban interface fire problems. The report is the fourth in a series of reports prepared and approved by the Initiative sponsors. It is not the intention of NFPA nor of the Initiative to have the report pass judgment on, or fix liability for, the loss of life and property resulting from the Oakland/Berkeley fire. The Initiative is sponsored by the U.S. Department of Agriculture Forest Service; U.S. Department of Interior, including the Bureau of Land Management, Fish and Wildlife Service, National Park Service, and the Bureau of Indian Affairs; U.S. Fire Administration; the National Association of State Foresters, and the National Fire Protection Association. Contact information for each of these organizations is provided in this report.

This analysis was undertaken as part of efforts to achieve the goals of the Initiative. The purpose was to document the fire, determine to the extent possible the variables causing destruction, and make recommendations on how to prevent similar occurrences. Thomas Klem, director of NFPA's Fire Investigations Department, was report manager and technical editor and advisor. William Baden, senior fire service specialist at NFPA, is the NFPA Initiative project manager and was the technical advisor for this report.

The information in this report is provided to assist planners, local officials, fire service personnel, and homeowners in developing firesafe homes and communities in the wildland/urban interface. That interface is where wildland and residential systems join and affect each other.

This wildland fire is only one of many that occur throughout the world each year. It is the fourth such fire the Initiative has reported on. Under the Initiative's sponsorship, the NFPA will review, analyze, and document additional wildland/urban interface fires that cause destruction to homes and other structures.

The preparation of this report would not have been possible without the assistance and cooperation of the Oakland and Berkeley, California fire departments, and the California State Fire Marshal's Office. Particularly, we want to thank Fire Chief Lamont Ewell of the Oakland Fire Department, Fire Chief Gary Cates of the Berkeley Fire Department, State Fire Marshal Ron Coleman, and former State Fire Marshal James McMullen.

In addition, on-site assistance and technical guidance and insight was provided to NFPA by Division Chief Joe Garcia and Art Cota, California State Fire Marshal's Office, Jack Snell and Ken Steckler, National Institute of Standards and Technology, and various representatives of the California Department of Forestry, California Office of Emergency Services, cities of Oakland and Berkeley, and the Department of Forestry, University of California Berkeley.

Each of these organizations has made significant contributions to the technical accuracy of the report. Further, the extraordinary work of Maureen Tobin in the preparation of the document, and Chris McCusker for design, layout, and graphics, are acknowledged.

Finally, Paul E. Teague, associate editor of Design News and former editor of Fire Journal, was principal writer.

COVER PHOTOS: NASA, KTVU-TV/OAKLAND

# Abstract

LYSAGHT, GAMMA-LIAISON

**A devastating conflagration occurred in the scenic hills above the cities of Oakland and Berkeley, California, on October 20, 1991. Burning embers carried by high winds from the perimeter of a small but growing duff fire ignited overgrown vegetation and led to the further ignition of tree crowns and combustible construction materials of adjacent homes, including many with wood-shingle roofs.**

The result was a major wildland/urban interface fire that killed 25 people including a police officer and a fire fighter, injured 150 others, destroyed nearly 2,449 single-family dwellings and 437 apartment and condominium units, burned over 1,600 acres, and did an estimated $1.5 billion in damage. Furthermore, not only did the city of Oakland suddenly lose a substantial tax base in these poor economic times, but they have since discovered that 30 percent of the homeowners have decided not to rebuild in the Hills.

The conflagration that day was so intense that fire fighters were helpless in their attempts to suppress it, and the affected residents suddenly found themselves encircled in flames, blinded by smoke, and helplessly looking for escape routes. One crew of fire fighters felt they would be overrun by the firestorm, but made a defensive stand when they realized they could not escape. They manned their hose lines and gathered a cluster of trapped civilians into a home that soon became threatened, and fought for their lives. Using large caliber hose lines to protect themselves and to prevent ignition of the home, they successfully survived the fire.

While fire officials labeled the cause of the original fire "suspicious," the reasons for the fire's rapid spread were neither suspicious nor surprising. A five-year drought had dried out overgrown grass, bushes, trees, and shrubs, making them easily ignitable. The parched leaves of closely spaced eucalyptus and Monterey pine trees touched in certain areas and overhung homes in others. Untreated wood shingles were the predominant roof covering for homes in the area. Unprotected wood decks extended out from many of the homes and over sloping terrain that was covered with easily ignitable combustible vegetation. That day, unseasonably high temperatures, low relative humidity, and strong winds pervaded the area, further setting the stage for potential disaster. The only atypical factors not found in other major wildland fires studied over the years were the prolonged drought and a December freeze the year before that killed much of the native and ornamental vegetation, making them even more susceptible to fire and adding to the total fuel load in the area.

With these factors at hand, once open flaming occurred, the fire was pushed beyond its original boundaries by fierce

S. RINGMAN, SIPA PRESS

winds that averaged 20 miles per hour and gusted up to 35-50 miles per hour. The flames then fed on the unbroken chain of dry vegetation and the combustible construction materials of the homes. The fire was virtually out of control within only a few minutes of its start. On-scene fire fighters tried to retreat to the border of the fire but found that it was moving faster than they could reposition their apparatus. Then with the additional affects of the topography of the land, the fire began to move in several directions involving more homes and vegetation and soon building into a massive firestorm. When this critical level of a wildland fire is reached, not only is its intensity difficult to suppress, but also its potential for spreading far beyond its current boundaries is inevitable. A firestorm involves massive burning and needs an abundant amount of air in order to sustain itself, and since the fire had no natural bounds, there is plenty of air and fuel for its continued rapid, uncontrolled growth. Then, this phenomenon creates its own "wind" to supply air to the fire, and when these winds combine with the strong prevailing winds, a turbulence results that causes the fire to be unmanageable. As the combustibles burn, buoyant forces carry burning embers upward where they eventually cool and deposit the still flaming materials on unaffected areas creating numerous additional fires. This was the chaos that fire fighters first confronted and which they would face for over 6 hours. Indicative of this described rapid growth development and spread of the Oakland Hills fire is the fact that 790 homes were consumed in the first hour of the fire!

It is not surprising that the fire quickly overwhelmed the initial fire fighters, who fought valiantly. No fire department, however, could have effectively intervened at this point in such an intense fire. Further complicating its control were the narrow winding roads and the fire's turbulent fury and blinding smoke conditions that restricted and even halted the fire fighters' access to the fire area. Furthermore, the steep slopes within the hills, some at a 30-degree pitch, also facilitated fire spread and further hampered fire fighting. Congestion on those roads, downed power lines, and flying embers swirling along exit paths from several directions at once caused near-panic conditions among residents trying to flee the fire. Faced with this, some residents abandoned their cars and started running, worsening the congestion. Unfortunately, 25 people, mostly those with little warning, were overrun by the rapid spread of the fire.

Where defensive stands were made by the fire fighters, high winds overpowered fire streams, gas lines ruptured, electrical power failed, and water reservoirs dried up. In addition, the sudden and massive buildup of fire fighters, summoned to the fire from neighboring departments, soon overwhelmed radio and telephone traffic making it nearly impossible for the incident commanders to coordinate fire fighting activities.

These were the conditions confronting fire fighters on the scene. The massive firestorm conditions kept fire fighters on the defensive throughout the conflagration, giving them no chance to mount a sustained and effective attack until weather conditions improved. Their only hope until then was to slow the fire spread where and when they could.

The weather, which greatly affected the growth and helped sustain the fire, eventually changed and ultimately helped the fire fighters bring the fire under control. By early the first evening, the winds died down to a five-mile-per-hour breeze, nudging the flames back over areas already burned and giving fire fighters the time they needed to begin to bring the fire under control. Fire fighters drew a perimeter around the fire early the next morning, declared it contained by the third day, and had it under control by the fourth day.

The wildfire in the Oakland and Berkeley Hills was the worst in California's history. It, like all fires, holds many lessons. While the 1990 Stephan Bridge Road fire in Michigan showed that wildland/urban interface fires can spread rapidly over flat terrain, the Oakland Hills fire reminds us that similar spread phenomenon can occur even in urban areas not typically thought of as being included in the wildland/urban interface. Oakland is a large city, and while there are wooded areas within its boundaries, residents may have thought they were immune to wildfires. Unfortunately, wildland/urban interface fires can affect city residents too, so they, like the population in rural America, have to be aware of the dangers and be prepared.

In its aftermath, many have questioned whether this fire typifies the fire of the future. The answer is that it might.

# Background

**The general area in which the fire occurred is near the cities of Oakland and Berkeley, California. The area includes the major commuting routes, Highways 24 and 13, to these cities and to San Francisco, less than 20 miles from the site. The highways also connect to the Caldecott Tunnel that provides commuters access to the bedroom communities further north.**

J. SMALLEY/PICTURE CUBE

J. SMALLEY/PICTURE CUBE

NIST

The various residences within the Oakland and Berkeley Hills are located among the mountain-like terrain that rise from the base of their cities. To the casual observer, the homes are camouflaged by vegetation and perhaps only narrow windy roads are detectable. The homesites provide a panoramic view of San Francisco, Oakland, the Golden Gate Bridge, and the San Francisco Bay, thus providing an ideal setting for a home. Because of its setting, the Oakland and Berkeley Hills have been a magnet for people seeking to "get away from it all" while still having access to it all. Many people worked a lifetime to afford houses in the area, most of which cost more than a million dollars each. The homes varied in design and construction, but, in general, most were wood frame construction and most were single-family detached dwellings. There was, however, a 400-unit apartment complex near the entrance to the Caldecott Tunnel and a cluster of hundreds of townhomes in the Hiller Highland area.

Perhaps not known to those moving into or already living in the Hills was that they were living in an area having the characteristics of a wildland/urban interface. The "interface" is where man-made developments and wildland fuels meet at a well-defined boundary. It is also an area where, because of its dense fuels, wildland fires can and do occur. The impact of wildfires in the wildland/urban interface has increased proportionately with the dramatic surge of people moving to these areas. The number of people moving to and building in wildland areas has grown dramatically over the last 25 years increasing the risk of a devastating fire. Our population has glorified the tranquility of life in the woods. Nowhere is that more evident than in California. But this tranquility is not without associated risks.

Before such wildlands were settled, wildfires would commonly occur but the fires would have a cleansing effect on the forests, clearing out thick stands of trees and consuming weakened or dead vegetation. They would spawn new life into the forest. As man began to move closer to the forests, many of the fires also began to consume homes and sometimes lives along with vegetation. With man's entrance, the cleansing benefit of the fires and other natural effects were changed. We began to suppress the fires, as we well should, but in a sense this can have the effect of increasing the severity of wildfires if other measures are not imposed.

Even in colonial times, when virtually every settlement formed its own mini wildland/urban interface, wildfire must have terrified the settlers. As towns and villages grew, the danger to people and their homes from wildfires worsened. On the same day as the famous Great Chicago Fire, October 8, 1871, a lesser known but equally intense wildfire destroyed the community of Peshtigo, Wisconsin. An isolated lumber town surrounded by woods, Peshtigo had wooden sidewalks as well as combustible roofs. A dry summer and fall made vegetation more susceptible to fire, and high winds spread it rapidly. When the fire was over, the community had been leveled, and 800 people in and around Peshtigo had died. That day approximately 300 people perished in the Great Chicago fire. This combination of dry vegetation, combustible construction, and high winds has been a factor in virtually every wildland/urban interface fire.

One wildland fire of more recent times was the Santa Barbara "Paint" Fire in June 1990, which had many similarities to the fire in the Oakland Hills. Preceded by a four-year drought, the arson-caused fire was ignited during a time of record heat and was spread by fierce winds, some as high as 60 miles per hour. Flammable wood shingle roofs were a major factor in the fire that killed one person and destroyed $250 million of public and private buildings, including 438 family dwellings, a 28-unit apartment complex, and 15 businesses.

Closer to Oakland and also similar to the 1991 fire was the wildfire northeast of Berkeley, which began in September 1923. It spread quickly, moving from the fields to structures in the city within two hours of ignition. The fire burned 130

acres, 584 buildings, and caused $10 million in damages.

Furthermore, in September 1970, a fire in the East Bay Hills southeast of the University of California Berkeley campus destroyed 38 homes, damaged 7 others, and caused $3.5 million in damages. Ironically, some of the homes destroyed in that fire were rebuilt, then destroyed again in the 1991 blaze.

December 1980 saw yet another fire, this one emerging from Wildcat Canyon located just north of the 1991 fire in Berkeley to destroy 6 homes and injure 3 people within 20 minutes.

After the 1923 wildfire in Berkeley, the City Council passed legislation requiring fire-resistive wood coverings for roofs, then rescinded the legislation before it could take effect. The Oakland area destroyed in the 1991 fire had no local fire protection regulations on fire-resistive roofs. Ironically, this issue still has not been fully resolved in this country.

In 1982, Berkeley designated a section of the city as the Hazardous Hill Fire Area. This designation included a rigorous inspection program. In June 1991, four months before the fire, Berkeley passed an ordinance requiring Class A roofs in a specific area. However, the area of the city consumed by the fire was not part of that designated area.

Aside from their susceptibility to dry, hot air, abundant parched vegetation, high winds, and combustible construction, all these wildland/urban interface areas shared one other risk factor: a different level of fire protection. One of the ironies of the migration out of cities and into rural areas is that among the things people "get away from" are city services like fire protection. People take it for granted in the city, tend to balk at its extra cost in rural areas, and don't even miss it until they need it, when suddenly they realize it may not be as quickly available as they had assumed it to be.

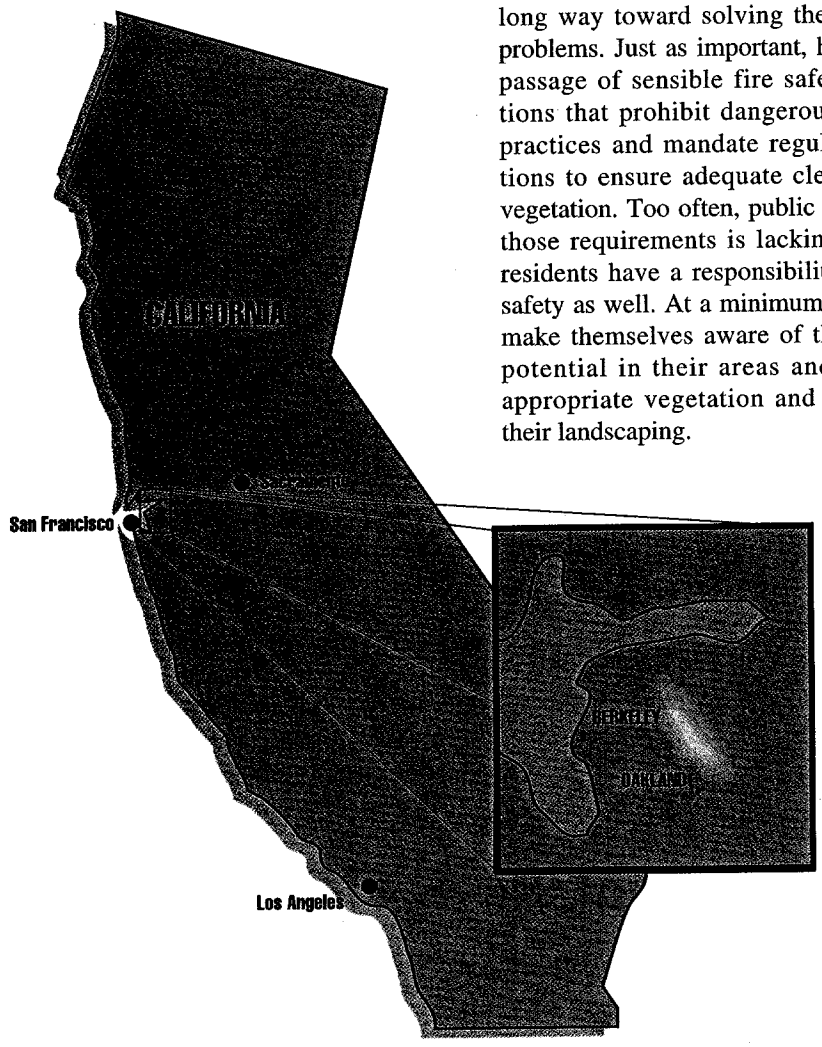
Fire protection agencies face special problems in wildland/urban interface settings. Established procedures for controlling wildfires include sacrificing some acres by preparing a perimeter fire break and "backfiring" to remove adjacent fuels. This procedure works against the need to protect individual homes. Committing major resources to protecting individual homes can lessen the ability to control the wildfire.

Another serious problem in wildland fires is that wildland fire-fighting tactics differ from structural fire-fighting tactics, and experts in one type of fire may not be trained or equipped to handle the other type. The first responding units in a wildland/urban interface fire are sometimes from agencies primarily concerned with wildland fires. However, they can also come from agencies whose main experience and expertise is in battling structural fires.

It is not unusual for people in major cities like Oakland and Berkeley to have difficulty believing that a major wildfire can happen in their area. Most city dwellers consider their surroundings to be more urban than rural. Since most urban fires are likely to be structural, people put their emphasis on preparing for those fires and forget the dangers they'll face in a fast-moving wildland fire.

To compensate for these special problem areas, some areas in California are legally designated as hazardous fire areas where special fire protection measures are required. The law defines a hazardous fire area as any land covered by grass, grain, brush, or forest, privately or publicly owned, that is so inaccessible that a fire there would be abnormally hard to suppress. In practice, however, areas where buildings can be accessed by paved roads aren't considered to present abnormally difficult fire suppression problems, and so they aren't considered hazardous under the law. All the residences in the Oakland Hills fire were accessible by paved roads, however narrow and winding, so they were not designated as hazardous fire areas.

Cross-training of fire fighters can go a long way toward solving these tactical problems. Just as important, however, is passage of sensible fire safety regulations that prohibit dangerous building practices and mandate regular inspections to ensure adequate clearance for vegetation. Too often, public support for those requirements is lacking. Finally, residents have a responsibility for their safety as well. At a minimum, they must make themselves aware of the wildfire potential in their areas and seek out appropriate vegetation and design for their landscaping.



# Factors Affecting the Wildland Fire

**Severe wildland/urban interface fires are seldom due to one or two physical factors. Generally, a combination of factors work in tandem, spawning and nurturing the catastrophe. Those factors in any given fire are rarely unique.**

J. SMALLEY/PICTURE CUBE

J. SMALLEY/PICTURE CUBE

OAKLAND PUBLIC LIBRARY

The elements at play in the Oakland and Berkeley Hills included the usual high temperature, low-humidity, and high-wind conditions typical of all such fires; a mix of easily ignitable duff—or forest-floor material; shrubs and trees; inadequate vegetation clearance; and wood-frame homes, some with wood shingle roofs and overhanging wood decks. Together they combined to produce a firestorm of such great magnitude that it could not be stopped.

## Vegetation

The fields of native oak trees that once occupied the Oakland/Berkeley Hills began to be harvested as the population in the area grew and prospered in the late 1800s. In their place were planted millions of eucalyptus trees thought to be a fast growing, hard wood, perfect for use as railroad ties and furniture. Unfortunately, this was not the case and large stands of eucalyptus trees are common in the Hills. Farmers also planted the trees to take advantage of their sturdiness as windbreaks. The wind they protected against spread their seeds throughout the Hills, so that now the eucalyptus covers the area in thick, large stands. Man began to encroach more and more into the Hills and eventually began to build homes there and further brought with him an assortment of additional vegetation.

Besides having a high resin content like the Monterey pine and chaparral, the eucalyptus has long, dry, shaggy bark that can ignite easily. Further, its lower limbs often barely clear the ground and provide a "ladder-fuel" arrangement that can spread fire (by convection currents) quickly up to the crowns, which ignite, greatly increase the intensity of the fire, and rapidly spread it beyond established fire department perimeters. The eucalyptus trees were the most prevalent of the tall vegetation in the fire area, and were estimated to have released over 70 percent of the energy produced by the combustion of the vegetation.

Monterey pine, chaparral, grass, and ornamental species such as junipers and cedars were also common in the mix of vegetation in the Hills. All but the grass have high resin content and can ignite readily. Each has the ability, once ignited, to produce fire intense enough to ignite other combustibles and are capable of producing airborne embers that are carried far from the burning site.

The Monterey pine, also characterized by its low-growing limbs, is present throughout the Hills in thick stands. Not only can the Monterey pine "crown" easily, it will also sustain a crown fire, which again can out pace fire suppression crews. The juniper and cedar are mostly present as ornamental vegetation around many homes. A dry-climate species, the juniper also ignites easily and burns intensely. Cedars are similar. Placement of these and other ornamental vegetation adjacent to combustible portions of the homes was a significant ignition scenario in this fire.

The chaparral is native to California and grows on more acrid sites. Its leaves and needles hold low levels of moisture, and it has a widely known and well-deserved reputation for ready flammability and fast rate of fire spread.

The burning of the chain of fuels in wildland fires usually begins with the ignition of grass, which is a light-weight, easily ignited fuel.

Grassy areas respond more quickly to precipitation changes than forested areas do. In the fire area, a sharp fluctuation in precipitation occurred in the spring and summer of 1991. March had been a rainy month, providing the moisture necessary for the grass to grow. But, the summer was hot and dry, making the once-lush grass, which covered wide stretches of the land, a rich source of dry fuel. Dry grass enables a fire to move quickly over the land, but it is when the grass fire comes in contact with "heavier fuels" that the chain continues. While grass fires don't easily ignite tree canopies, they do ignite the ladder fuels, and the flames then quickly move up to the intermediate limbs, eventually engulfing the tops of the trees.

Another item that played an important role in the continuity of the fuel chain in this fire was the assortment of brush, which is also a heavier fuel and tends to

smolder, burn longer, and spew off embers. In the Hills there was an abundance of scrub brush known as French broom. This fuel also helped increase the intensity of and further spread of the fire.

Then there are the trees themselves, very heavy fuels which sustain burning for long periods of time. When fire climbs the fuel ladder to the tree crown, it easily ignites adjacent tree tops with heat radiated and convected to them. Those areas of the Hills that experienced a crown fire showed the area had an intense fire. Heavier fuels, characteristically, once ignited, can burn for days until consumed or extinguished through a labor-intensive effort.

Further contributing to the available fuels of this fire were the leaves and branches of the eucalyptus trees and ornamental vegetation in the fire area that had been killed by an unusual freeze the previous December. This made the trees easy to ignite, which added to the already abundant and volatile natural fuel mixture in the area.

Regardless of the way in which this just described mix of fuels becomes ignited, it is not only the intensity of the resulting fire that causes the rapid spread, but also their ability to cause "spotting" that makes wildfires so dangerous. Spotting is the carrying of burning leaves and embers by the wind or the convection column from the fire to unaffected areas, which then ignite combustible roofs, ornamental shrubs and bushes, and other vegetation. Strong winds and the in-rush of air needed for the fire's combustion process are the driving forces behind spotting. The long leaves of eucalyptus trees are especially susceptible to spotting. Their shape and light weight give them airfoil characteristics. They float along easily in a wind. Spotting was a major factor in the spread of this fire, and a major reason initial fire crews could not contain the fire. These numerous secondary fires caused by spotting can combine into a massive firestorm and/or spread fire suppression forces so thin, over a such wide area, that they are ineffective.

Clearances. One of the fundamentals of residential fire protection in wildland areas is the creation of safety zones, or fire breaks, around individual homes. Reducing the amount of fuel immediately around the home helps prevent fire spread to the structure or from the structure. In the Oakland Hills area, however, many homeowners did not take that basic precaution. The result was that embers ignited vegetation, which in turn ignited homes, and massive embers from burning structures were driven by the winds to other areas where they, too, ignited the fuel chain that led to destruction.

Juniper and other vegetation were in some cases right up against and touching homes. Eucalyptus and Monterey pine trees touched each other and spread over the roofs of houses. Further, shrubs, small trees, and other vegetation were allowed to grow under the overhanging wood decks of some homes, providing a ready path for fire spread to the buildings. Steep slopes also accelerated the fire spread.

The Hills residents who thought they were far away from the rising smoke column began to be bombarded by a shower of burning embers that ignited the vegetation around their homes. Many tried to extinguish those fires with garden hoses to no avail.

Evidence of the benefit of adequate clearance was abundant in the aftermath of the fire. In some cases, homes facing one street survived the fire, while homes also facing the street on the opposite block were destroyed. That is because the combined backyard distance, when not filled with an overgrowth of vegetation, slowed the fire enough for effective fire suppression. Among the common factors that surviving homes shared was a large, clear yard.

Large thick stands of the trees can also benefit through proper clearances. Thinning of the stands to reduce the likelihood of heat radiating from a fire and igniting adjacent trees has proven to be an effective method to slow the spread of a wildland fire.

## Residential construction

Combustible construction materials of the homes in the fire area also played an important role in the devastating effects of the fire. Specifically, the combustible materials used for porches, siding, and roofing finish were identified.

Roof construction in the Oakland Hills area varied and included asphalt shingles, ceramic tiles, and wood shingles. Despite the variety, the vast majority of the homes had combustible roofs. Roofs are not all created equal. Some offer more protection from fire than others. Class A roofs protect against fire brands weighing more than four pounds. Class C roofs offer much less defense, withstanding brands weighing no more than one third of an ounce, or about the size of a kitchen match. Untreated wood shingle roofs offer even less protection. New treatments such as pressure treatment can improve the ignition resistance of wood roofing. Yet, even roofs whose wood shingles have been dipped in fire retardant (another current method) can lose their protective treatment due to weathering. To maintain their protective coating, these shingles should be treated virtually every year, which is, of course, impractical.

The roof is the most vulnerable part of a building in a fire. That vulnerability is dramatically increased if the roof is covered with untreated wood shingles. Over time, rain, weathering, and the sun cracked the shingles and curled them up so they became effective ember catchers. In more than one case, a home with a wood shingle roof was severely damaged or burned to the ground, while homes on either side of it with clay tile roofs were relatively undamaged. Many of the roofs were flat or sloped with overhanging eaves. Overhanging eaves pose a danger because they are exposed on the underside to burning vegetation. Further, flat roofs were able to collect fallen leaves and needles, and burning embers. Roofs on the three-story, wood-frame Parkwood Apartments were flat and illustrated such an ignition scenario when many of the roofs began to burn intensely.

Some roofs were built of clay tile and terminated at the edge of exterior walls. This type of roof covering performed much better in the perimeter areas because fire fighters could extinguish embers before the roof could become ignited.

Virtually every major wildland/urban interface fire in recent years has spread faster than it otherwise might have or has increased the amount of damage because of wood shingle roofs.

There are five other noteworthy points about residential construction and this wildfire:

First, most of the townhouses in the Hiller Highlands subdivision were attached. Vegetation spread throughout many of the open areas and touched some of the buildings. The fire took about an hour to move through the community and destroy every building in sight. But, largely due to the spacing of the units, the burning was more characteristic of an urban conflagration than a typical wildland/urban interface fire. Once a unit or several units were ignited, the raging fire easily negated the one-hour fire walls separating the units. Soon, blocks of the building burned, and that, too, affected the conflagration's spread.

Second, the lower floor of the Parkwood Apartments included a concrete-reinforced garage for cars. That concrete structure survived the fire well, and the cars parked inside incurred little or no damage, showing the benefit of fire-resistive construction.

Third, the fire provided further evidence that double-pane windows appear to resist breakage and reduce the transmission of radiant energy in a fire, especially in the perimeter areas of the burn. Such windows in dwellings in the Oakland Hills for the most part helped protect the interiors of the homes. Even in areas of maximum fire intensity, they showed their protective potential. In one case, even when the outer panes of a window cracked due to intense heat, the interior panes remained intact.

Fourth, homes on steep slopes were extremely vulnerable. Due to preheating of vegetation, the fire ran up steep slopes like flames up an upturned match. Some of the slopes in the fire area were at a 58 percent, or 30-degree, pitch. That made it as difficult for fire fighters to traverse as it was easy for the fire to travel. Further, building on a slope often means there is an open area under the house. This open area poses a major exposure to flame fronts and radiant energy, and provides a clear path for fire spread to the structure itself. In this fire, there was another critical factor in building on slopes. Once the fire reached, ignited, and consumed the home, structural collapse occurred, allowing burning automobiles to roll from garages and down the slopes. These automobiles blocked the roads for suppression crews and evacuating residents.

Fifth, the contribution of wood framing to the overall spread of the fire was insignificant compared to the role of easily ignitable vegetation, combustible roofing and siding, and burning brands. Failure of wood-framing members led to structural collapse, but only after a long and intense exposure that far exceeded conditions humans could have survived.

## The Weather

Weather contributes as much to the life of a wildfire as the fuels do. Temperature, lack of precipitation, and humidity provide the conditions for a fire to start, and wind nourishes the blaze, spreading it through spotting or by causing direct flame impingement on combustibles.

Like the vegetative fuels themselves, the different weather characteristics work together to form a system that is either hospitable or inhospitable to wildfire.

Moisture. The moisture content of fuels is a critical variable. Naturally, the drier the fuel, the more susceptible it is to fire. The moisture in fuels comes from rainfall and relative humidity. Average annual rainfall along some parts of the northern California coast can be as low as 20 to 30 inches, although other areas in the state can experience as much as 150 inches.

Rainfall in the Oakland and Berkeley Hills area had been particularly low before the fire. For five years prior to 1991, the area had experienced drought conditions. Coupled with the lack of precipitation was especially low relative humidity—the ratio of the amount of moisture in a volume of air to the total that the air can hold at a given temperature and atmospheric pressure.

Relative humidity and temperature are interrelated. As the temperature rises, relative humidity drops. If the temperature rises by 20oF, the relative humidity will drop by about 50 percent. Relative humidity controls the moisture content of fuels, and therefore their susceptibility to fire. Fuels with 20 percent moisture can catch fire; light fuels with 2 percent moisture can burn like gasoline. Relative humidity in the Oakland and Berkeley Hills on the day of the fire was 16 percent, while the temperature was 92oF, a record high that surpassed previous highs by 6 degrees. The combination of drought and low relative humidity dried out the vegetation, eliminating whatever potential it might have had to resist or slow down flames. Any open flaming held the potential of causing a disaster.

Wind. Of all the weather elements affecting wildland fires, wind is the most variable and least predictable. The shape of the terrain and local heating and cooling affect wind behavior. In turn, wind affects fires by carrying away moisture-laden air, hastening the drying of vegetation, adding oxygen to a fire, carrying burning embers that ignite other combustibles, and pushing flames in the direction of virgin fuels. Wind, in short, strongly influences the direction of spread of a wildfire. Nearly 90 percent of the large southern California wildfires documented in the last three quarters of a century have taken place between September and December — the season of the Santa Ana winds. Those winds come less frequently to northern California, but they do occur there.

Dry easterly winds that average 8 to 25 miles per hour, and dry northeasterly winds that average 15 to 30 miles per hour are prevalent in northern California from July through September. That peri-

od is one of critical fire danger. So-called "Diablo" winds occur in the area in May and October. These winds occur when an inversion layer builds up in the Bay area and forces air moving west from the San Joaquin Valley to speed up as it moves down the west, or lee, side of the hills. When it can go no further laterally, it moves up and over the ridges and then down. As it flows downward, it increases in temperature.

There was virtually no wind on Saturday, October 19, the day before the conflagration, just a five-mile-per-hour breeze from the northeast. Nevertheless, the California Department of Forestry and Fire Protection (CDF) issued a Red Flag warning that day and the following day. The reason was that a strong high-pressure area in Oregon and the Great Basin on Saturday was threatening to send strong northerly winds to the Hills area and lower the relative humidity. Actually, precursors of those winds had moved into the area a week before and replaced the moisture-laden air that normally would have swept in from the Pacific.

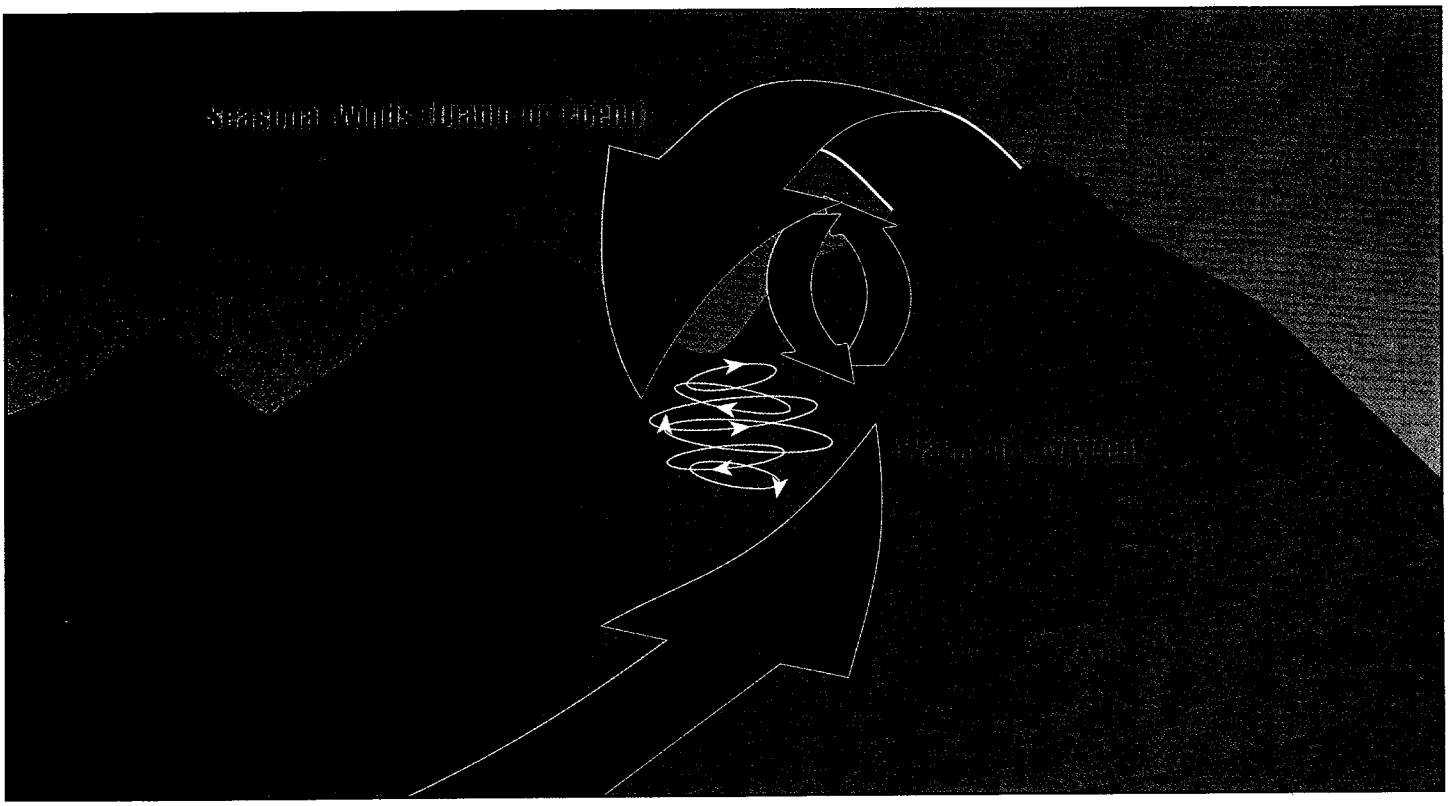
The Red Flag program deals with the extreme end of the fire rating system—when the CDF foresees extreme conditions they put up red flags and broadcast warnings so fire officials can take extra precautions. As the CDF anticipated, the Diablo wind phenomenon occurred October 20. Early that day, the winds shifted to the northeast and the relative humidity dropped. Wind velocity increased to the high teens and low twenties. By the time the fire rekindled, the wind in the Oakland Hills was blowing at 17 miles per hour, with gusts to 25 miles per hour. Some reports of conditions later in the day said winds were gusting to 38-58 miles per hour.

The Diablo winds are "foehn" winds that force the convection currents down against the natural flow that normally blows up the hills. The result in this fire was wild turbulence that sent embers in several directions. The phenomenon was a swirling effect much like a tornado, picking up embers from one place and depositing them in another. From the perspective of the fire fighters on the scene, the fire was in front of them one minute, and then the next minute it was behind them. The winds preheated everything in their path. These conditions created a totally unmanageable situation rife with terror for residents caught up in it and struggling to find a way out of the area.

Another phenomenon that led to rapid spread of the fire was development of a thermal inversion layer. The smoke and heat from a fire will rise only until their temperature equals that of the surrounding air. Then, the smoke and heat flatten out and spread horizontally. The thermal inversion layer during the Oakland Hills fire was at 3,500 feet. The layer trapped heat from the fire and spread it out, adding to the preheating of vegetation and structures in the area.

By approximately 7 p.m. on Sunday, the winds slowed to about five miles per hour. They also shifted and began to blow over the areas already burned. The combination of decreased velocity and change in direction to an area of virtually no live fuel helped fire fighters bring the fire under control.

## HIGH WINDS



KTVU-TV/OAKLAND

**Origin and spread. The area where the fire started was a "box canyon" with steep slopes and contours that had formed over the years from wind and water drainage. Once ignited, fuels within a canyon are preheated, can more easily ignite, and are more apt to further ignite adjacent combustibles.**

Strong upslope winds are also common in canyons. Winds are drawn in from the bottom (especially on warm days) which further preheat and dry fuels. The "walls" of the canyon then contain the heat from a fire. As a result, fires in canyons are an efficient mechanism for intense burning.

The fire in this canyon might have erupted a day earlier than it did had the day not been unusually calm for that time of year. On Saturday, October 19, a fire of suspicious origin started near 7151 Buckingham Drive; an area near the top of the Hills near Grizzly Peak Boulevard. But the almost pleasant, five-mile-per-hour breeze was too gentle to push the flames very far from their point of origin. Sixteen engine companies, four patrol wagons, and a helitac unit from area fire departments aggressively attacked the 5-acre fire and brought it under control in about three hours. Fire fighters relied heavily on wet lines around the perimeter. Only one section of fire-line construction was undertaken. Fire fighting forces soaked the rest of the perimeter with water from hose lines and helicopter drops.

Within and outside the burn there was dense coverage of Monterey pines, and duff under those pines was about a foot deep. Further, the heat from the fire produced greater-than-normal needle cast from the pine trees, which added fresh kindling to accumulated duff about the fire area. It is known by wildland fire fighters that fire burns freely in the top layer of duff in such fire scenarios, but smolders deep within the duff because of the lack of oxygen. Water extinguishes the surface flames but combines with ash and charcoal to form a crust; the smoldering continues under the crust, sometimes for days.

When the fire fighters thought they had extinguished the fire early Saturday evening, they left the scene. Early Sunday morning, they returned to "mop up."

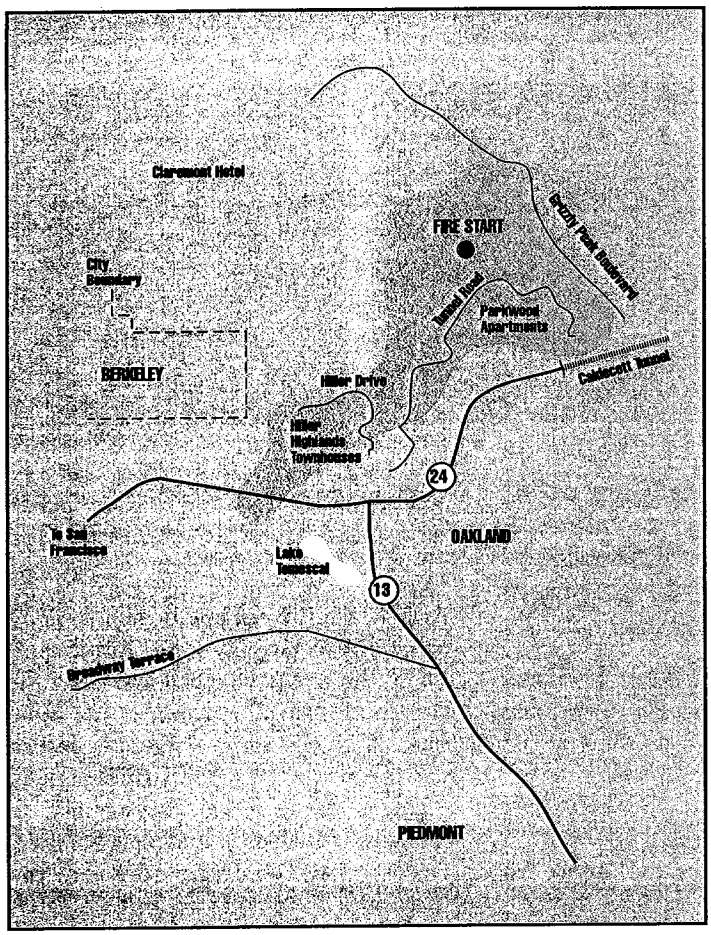
Overnight, however, the heat buried in the duff at the fire site intensified. So too did the local winds. By 10:45 a.m. Sunday, while fire fighters were on the scene mopping up, sparks burst out of the duff. They were quickly picked up by convective currents and carried by strong winds out of the northeast portion of the fire area to nearby vegetation. The winds (17 miles per hour, gusting to 25 miles per hour) acted like bellows on the now growing fire. By 11:15 a.m., the fire blew out of the canyon and within minutes it was out of control.

At first, the fire ran uphill from its point of origin to Grizzly Peak Boulevard. Then, the winds changed and blew the fire in several directions at the same time. A classic foehn wind also pushed the fire downhill toward Buckingham Place as fast as it was going uphill. In minutes, the winds shifted again and the fire spread eastward toward the Parkwood Apartments near the Caldecott Tunnel. Another wind shift sent the flames southwest toward the townhomes in the Hiller Highlands. Pine trees in the area crowned and other vegetation burst into flames. Soon homes were threatened and fire fighters scrambled to contain the fire. Then, spotting spread the fire across Highway 24 and pointed it toward Lake Temescal. Meanwhile, another flame front rushed northwest toward the Claremont Hotel and into the city of Berkeley.

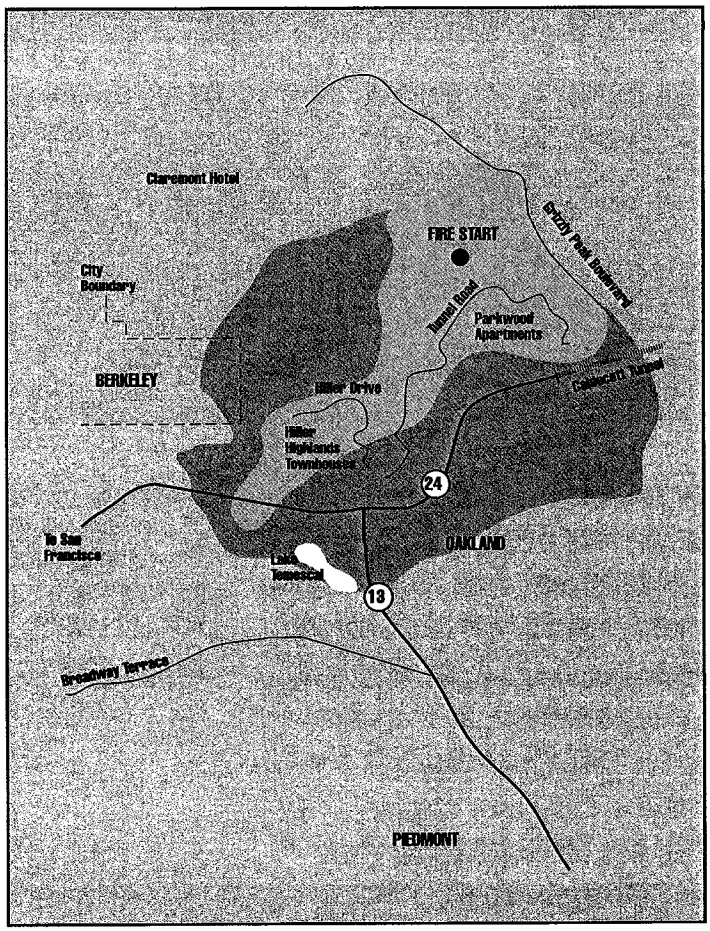
The spotting soon turned the fire into numerous large fires. The winds caused a downward acceleration as the fire descended along the ridge between Marlborough Terrace and Hiller Highlands consuming everything in its path. The fire burned with such intensity that it consumed 790 structures within the first hour, and spread about 1.67 meters per second.

The fire also swept around the mouth of the Caldecott Tunnel into the area south

## 11:30




## 1:00




of Highway 24. Parts of the Upper Rockridge area ignited due to winds and spotting. By noon, the fire had burned about 40 percent of the area ultimately to be affected. Included at this time were the Parkwood Apartments and the Hiller Highland townhomes. But as the fire spread south and west, it slowed somewhat because the land there was flatter and there was more open space. By 5 p.m., cooler temperatures and decreasing wind velocity halted the fire's advance, but the intensity of the fire, much of it coming from thousands of burning structures, would require many more hours of burning before it would subside.

## Intensity

The fire that raged in the Hills was terrifying. It reached temperatures as high as 2,000 degrees F, hot enough to boil asphalt. Temperatures reached crematorium-level. Still, it's important to keep in mind that the Oakland Hills wildfire was not particularly intense and hot as wildfires go. Wildfires of this type, with the mix of fuels primed to burn and the high winds to nourish and spread the flames, can easily reach 2,000 degrees F and spread faster than a person can run.

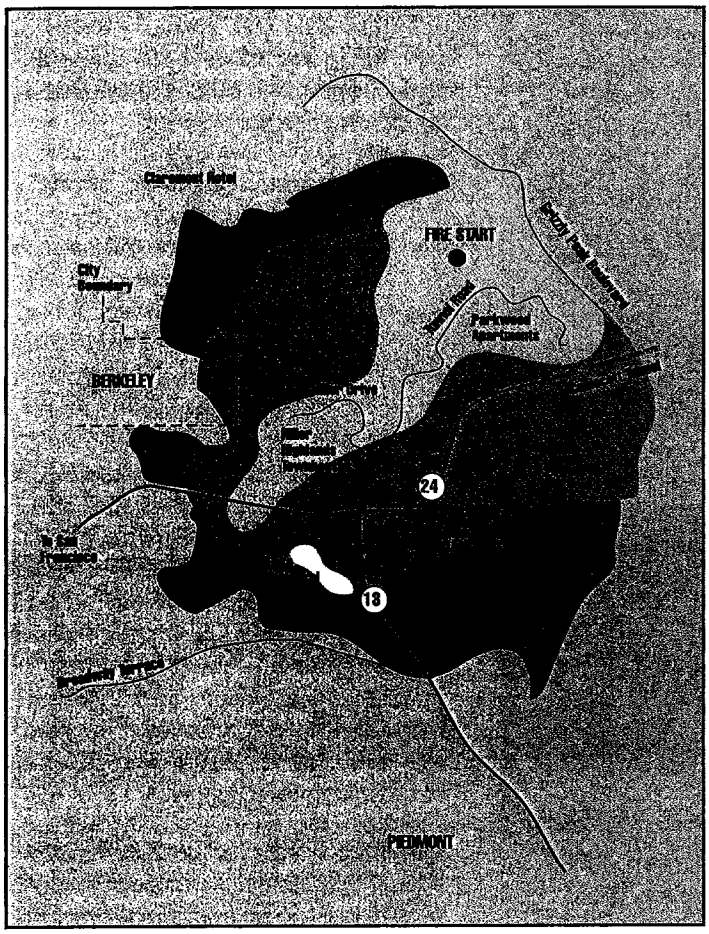
The Oakland Hills fire, as many other wildland/urban interface fires, developed firestorm conditions. Within 15 minutes of ignition of the first structure, the fire developed into at least one and possibly two firestorms.

Firestorms develop when the heat, gases, and motion of a fire build up to the point where they begin to create their own weather and wind, independent of the external conditions. Firestorms pull air into the base of the fire, the fire begins to feed itself, and towering convection columns result in long-distance spotting and tornado-like vortices.

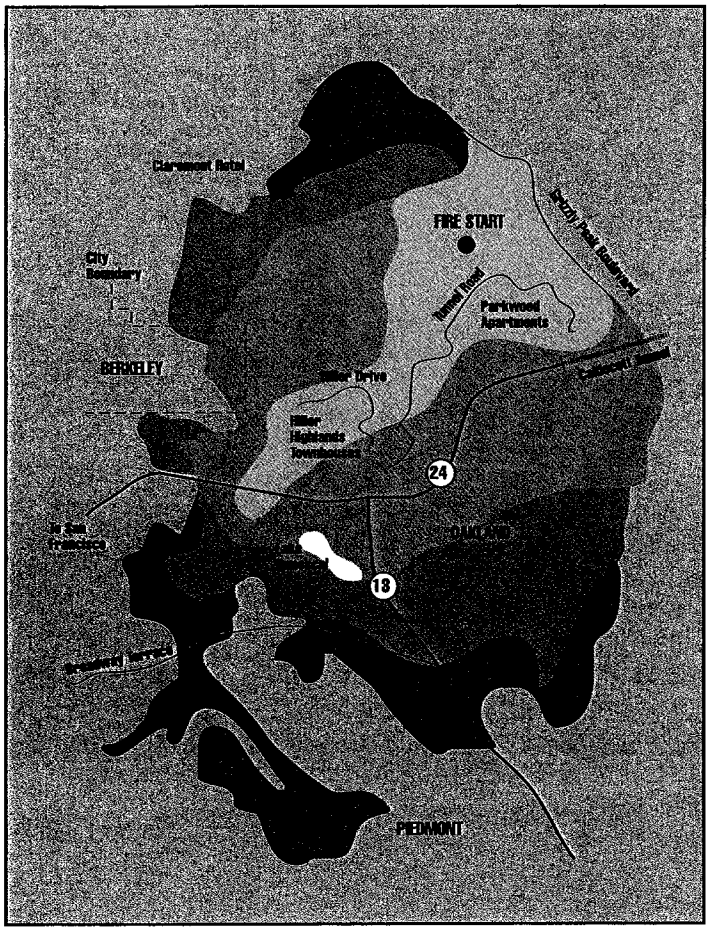
However, before reaching the firestorm level, a fire passes through another phase. The fuels combine with wind and temperature to build a fire into a conflagration, typical of the kind that occasionally devastates cities. Examples include the Chelsea, Massachusetts, conflagration in the late 1970s and the Great Chicago Fire of the last century. Conflagrations need the right weather and climatic conditions to continue building in intensity. When the intensity reaches conflagration and then firestorm proportions, the fire can develop a fire front that will actually move away from the direction of the wind.

The Oakland Hills fire achieved all three of these conditions. The hot, dry, high-speed winds, and dry, overgrown, closely spaced vegetation triggered a conflagration that built up to firestorm intensity and eventually developed several fire fronts. The combination of spot-

3:00




5:00




ting and wind-driven flames spread the fire in several directions at once. But as the fire swept west, it slowed when it reached flatter terrain and less open space. Still, the topography in other areas, such as Broadway Terrace, kept the fire burning fiercely. By 5 p.m., cooler temperatures and a dramatic decrease in wind halted the fire's progress. In effect, nature gave the fire back to the fire fighters so they could bring it under control. In the 10 hours the fire roared through the Oakland and Berkeley Hills it ignited one building every 11 seconds.

## Response

Public-protection-agency response to the fire was massive and swift. But the fire was, too. Fire behavior was so extreme that fire fighters could not save the residence at 7151 Buckingham Boulevard, near the point of its origin. They were, however, able to save the house across the street at 7200 and the house at 7235. They fought valiantly, holding positions until the last possible minute. The wind was so strong that it bent 500-GPM hose streams (at 100 psi) 90 degrees. Seventy-five-GPM streams were completely ineffective. Air attacks were also ineffective, at least during the first three hours of the fire due to strong winds, the continuous fuel chain, and heavy smoke that obscured visibility. Residents, off-duty teachers, and other civilians helped fire fighters, and the Oakland and Berkeley departments used wildland tactics like bulldozing fire breaks where that seemed advantageous. Those tactics only helped along the east and west flanks of the fire.

Fire fighters' first reaction to the fire was to retreat to perimeter areas, attack the fire, and summon help. While additional alarms were being sent, however, the initial crews could not establish effective perimeter areas because of the rapid spread of the fire. Additional units responding to the area found adjacent areas burning too, and began to engage those fires. However, they also found that the fires were overrunning their positions. That was the early picture being relayed to the incident command structure from all responding units. Such unprecedented and rapid fire spread made it impossible to establish a coordinated attack.

Coordination of the attack by the incident command was also hampered by the inability to directly communicate with mutual aid fire departments arriving from around the state. There was plenty of fire for all arriving units, however, so they began to stake out areas for a defensive stand. The efforts of mutual aid companies were complicated however by the lack of compatibility of their hose connections with Oakland's hydrant system.

## CONSENSUS

**From the experience of the earlier stages of the fire, in which flying brands started new centers of conflagration blocks ahead of the burning buildings at which the firemen were working, it is the consensus of opinion of those at the fire, including chief officers and firemen, that had the wind not changed the fire would have swept through the entire East Bay region.**

Excerpts from the Report on the Berkeley California Conflagration of September 17, 1923 by the National Board of Fire Underwriters

Command and coordination of fire units improved as time went on, but they were never ideal. As weather conditions improved, it became possible to establish perimeter areas. Fire crews were still subjected to the full intensity of the fire, but they were now able to effectively suppress ignition of homes. Crews could break the chain of combustibles that had earlier led to the total destruction of homes. Hose streams became effective in extinguishing burning vegetation, wood siding, and spot fires on roofs. Still, they were helpless in extinguishing the rapid propagation caused by the ignition of homes with wood shingles.

There is little doubt regarding the effective role fire fighters played in the reduction of loss of life and property in this fire. The fire scenario they first encountered stacked the cards against them, yet in spite of this they fought the fire assuming they would not survive. Their valiant efforts began to pay off as the winds subsided and the fire spread slowed down.

One fire fighter died while shielding a woman from a live power line that fell on both of them. A police officer was killed while trying to lead residents of the Hiller Highlands neighborhood to safety when they were overrun by the fire.

## Communications

The Incident Command System (ICS) developed by the Southern California Fire Service and the U.S. Forest Service in the 1970s allows for unification and coordination of multiple jurisdictions responding to a fire.

E. LEDESMA, SIPA PRESS

The coordination of the activities of this many responders was extremely difficult due to the intensity and rapid spread of this fire. Coordination was worsened because the communications system was quickly overwhelmed by the volume of telephone and radio traffic generated by responding elements and the public, who were pleading for information.

During the first 12 hours of the fire, communications after fire spread, were the biggest problem that public agencies faced. The result was uncoordinated action, losing requests for resources, and an inability of field commanders to get an accurate picture of overall suppression efforts and resources committed or available. Field commanders resorted to self-assigning their units where they thought they were needed.

The Oakland Dispatch Center had no telephone lines reserved for outgoing calls. As available incoming lines were flooded with calls, dispatchers could not make outgoing calls. Radio frequencies, including the mutual aid frequencies, were saturated. Some field elements tried reaching dispatch on cellular telephones.

The steep hills interfered with radio transmissions, especially those from hand-held radios. Finally, communications between Oakland and Berkeley were hampered because the direct-dial tactical line (TAC) that links East Bay fire departments was down.

Despite the many hindrances, fire fighters did their best to control this blaze. In the end, however, the fire followed its own course. There really was little fire fighters could do until the winds subsided.

## Water

Virtually no water-supply system might have been adequate for a wildfire of this magnitude. Eleven pressure zones were in the district, nine of which were affected by the fire. There were one or more reservoirs per zone, each with between 400,000 and one million gallons of water. Pumping stations linked the reservoirs, and draw-downs from the reservoirs activated them. However, there was no auxiliary power supply.

The entire system had been designed for normal operations. Emergency reserves were in place to minimize temporary disruptions, and fire fighting reserves were among them. The fire fighting reserves were designed for "normal" fires. This was no normal fire.

OAKLAND TRIBUNE

The rapid spread of fire caused numerous power failures. As houses incinerated, their water service lines ruptured. The result was a drain on reservoirs, since the water kept flowing. For example, ruptured water lines at the burning Parkwood Apartments complex drained reservoirs in that zone. That led to abandonment of suppression efforts in other areas of the zone because hydrants ran

dry. In one area, water tenders and other fire engines transported water to fire companies on the scene.

Eight pumping stations and 10 residential reservoirs were lost in the first half-hour of the fire due to power disruptions to pumping stations. By 5 p.m. on Sunday, the first day of the fire, 10 key reservoirs were dry. It is estimated that more than 20 million gallons of water were used to extinguish this fire.

Oakland's fire hydrants have one or more standard three-inch-thread outlets. Other California cities and towns have hydrants with two-and-a-half-inch-thread outlets. Except for those departments in cities immediately adjacent to Oakland, to whom Oakland had previously supplied the appropriate adapters, responding fire departments could not connect to the hydrants. Those few departments that did have the required adapters usually left them behind when they were overrun by the fire, and therefore did not have them when they got to their next position.

Even if the water supply system had been greater, there had been an emergency power supply, and the hydrants all had the two-and-a-half-inch threads, officials question whether it would have made much difference in a fire as violent and widespread as this one.

## Narrow roads

Another major hindrance to fire fighting was the system of narrow, winding roads in the fire area, many of which ended in cul-de-sacs. Fire apparatus could not pass each other or the cars filled with fleeing residents. Traffic jams developed, especially near the large apartment complex. Many apartment residents abandoned their cars in frustration so they could run to safety. The abandoned cars, in turn, served as roadblocks to fire fighters and other residents. Downed power lines further impeded evacuation down the narrow roads. Some apparatus and private vehicles were trapped for hours on these roads.

Eleven of the fire victims died as flames caught up with them while they were trapped in a traffic jam on Charing Cross Road. Eight others died on narrow streets in the same area.

R. WARWICK, OAKLAND TRIBUNE

M. MACOR, OAKLAND TRIBUNE

## Mutual aid

Mutual aid for the Oakland Fire Department is secured through the Alameda County Fire Mutual Aid Plan. Inter-regional resources are mobilized through the State Fire and Rescue Coordinator of the Office of Emergency Services.

Within an hour after the fire erupted, Oakland requested mutual aid in the form of air attack from the California Department of Forestry. The city also requested one engine company each from Alameda, Alameda Naval Station, Emeryville, Lawrence Berkeley Lab, and San Leandro. It then asked Contra Costa and San Francisco for 10 engine companies each. Berkeley requested one engine company each from Albany, Emeryville, and Lawrence Berkeley Lab, and two strike teams from Alameda County. Between 11:40 a.m. on October 20 and 5 p.m. on October 23, fire officials placed 17 separate requests for mutual aid.

In total, the Oakland and Berkeley fire departments were assisted by 88 engine strike teams, 6 air tankers, 16 helitac units, 8 communications units, 2 man-

agement teams, 2 mechanics, and more than 700 search and rescue personnel. Additionally, 767 law-enforcement officers supplemented the efforts of the two cities' police departments, and the California Office of Emergency Services, Federal Emergency Management Agency, the Red Cross, and the Salvation Army pitched in to help.

## Utilities

When the power lines were knocked down by the fire, electricity was not available to the pumping stations set up to refill reservoirs. Also, as the fire ravaged homes it also destroyed gas lines. The ruptured lines sent plumes of flame upward from the meters. While the burning gas may or may not have contributed to fire spread, officials were not able to turn off the lines for several hours after the fire began.

## Evacuation

Evacuation of the fire areas was a major problem. Imagine the situation: Swirling winds blowing embers from all directions at once, making no area really safe; thick clouds of smoke taking away visibility; congestion as residents fleeing in cars and on foot clogged narrow roads that fire apparatus was trying to traverse. It was a nightmarish scene. Evacuation was impeded by narrow, steep roads, high winds, and heavy smoke. In fact, the smoke made it difficult to locate the fire. Fleeing residents did not know which way to go, and fire fighters had a hard time directing them because they could not see beyond their immediate areas. The rapid fire spread made it hard to distribute evacuation personnel effectively.

During the early stages of the fire, officials opted for fire control rather than evacuation. However, residents turned to fire fighters for evacuation assistance. Police using loud speakers moved through the area. Little time was available for anyone to instruct residents on how to evacuate, what to take with them, or how to secure their homes before they left. Eventually, after sensing the growing magnitude of the fire, many residents left on their own without waiting for assistance.

On the other hand, the fire fighters had to force some residents to evacuate. Other residents returned to the area to check on friends, relatives, valuables, and the status of their homes, and fire fighters had to re-evacuate them. Some civilians, posing as volunteers, entered the fire area and looted homes.

Evacuations were conducted on a personal, one-on-one basis. Oakland chose not to use the Emergency Broadcast System, feeling it was inefficient. The lack of a common radio frequency at the operational level between Oakland fire and police officials hampered evacuation coordination.

The majority of the fatalities occurred to individuals who had little warning of the pending disaster. As a result, their positions were overrun by the rapidly spreading fire. One fire fighter and a police officer sacrificed their lives trying to save residents. The police officer gathered several individuals into his squad car hoping that they would survive the fury of the fire. Unfortunately, their escape route was blocked and the fire moved past them.

## RISKS

**The risk of fire in the East Bay urban-wildland interface zone is greatest during the warm dry months of the May to October fire season. It is during this period that warm dry winds out of the north or northeast are more frequent, creating a situation conducive to rapidly moving, high intensity fires. The open space portion of this area consists largely of steep (20%-60%) east and north facing slopes which are predominantly covered by brush and areas of eucalyptus stands. Over the years there has been significant buildup of dead or nearly dead brush which will burn rapidly during the high fire danger period. In the eucalyptus stands there has been accumulation of dry, dead leaves and bark which also poses a significant fire hazard. Following the 1972 eucalyptus freeze, some seven miles of fuelbreak was constructed through these stands, however, maintenance has been minimal during the intervening years allowing for the fuel buildup.**

**On the urbanized side of the interface zone, many of the homes which have been built along the crest of the west facing slopes have shake and shingle roofs and are surrounded by brushy vegetation which has been allowed, in many cases, to grow up to the homes and under decks. Where clearing around homes occurs, it is rarely the thirty foot minimum clearance required by State law, and even more rarely, the hundred foot clearance which should be maintained in fire risk hillside area. Additionally, many of the streets in the area are narrow and winding, hampering access for fire apparatus and escape routes for residences.**

Excerpts from the 1982 Report of the Blue Ribbon Fire Prevention Committee for the East Bay Hill Area Urban-Wildland Interface Zone.

# Discussion

KTVU-TV/OAKLAND

**Fire is part of the natural ecology of forests and wildlands. It's predictable, and even cleansing. For thousands of years, wildfires have periodically raged through wooded areas like the Oakland and Berkeley Hills, clearing out combustible vegetation and making room for new growth. In fact, centuries ago, Native Americans populating the Oakland Hills, which then did have oak trees, practiced burning in the area to improve hunting.**

Throughout time, fire has been an important factor in nature's rejuvenation and man's efforts to modify the natural environment. Today, large numbers of people and the homes they have built in these lush, beautiful areas have added a component that makes wildfires far more grave than they were 300 years ago. The human presence is not likely to diminish. For a large number of people, moving out of the city and into areas like the Oakland and Berkeley Hills provides a desirable counterbalance to the crush of city life. Sometimes these people make unsafe choices when they make such a move.

Some of these unsafe choices, as fire and forestry officials have pointed out for years, include mismanaging vegetation by ignoring "ladder fuels," not cleaning out brush and allowing vegetation to grow up to and over dwellings, building homes with wood shingle roofs and untreated combustible siding, constructing combustible decks on pilings buried in steep slopes, and depending on narrow roads that can hardly accommodate two-way car traffic for access and egress, making it virtually impossible for large vehicles like fire apparatus to pass.

People need to be aware of the natural fire risks in wildland areas. Fire officials and others can offer guidance in construction, landscaping, and other factors that reduce those natural risks. Many suggestions like these are included in the Recommendations section of this report, and in reports the Wildland/Urban Interface Initiative has produced on previous fires, such as the Black Tiger Fire of July 1989 near Boulder, Colorado; the Stephan Bridge Road Fire of May 1990 in Crawford County, Michigan; and "Firestorm 91," a study of a series of fires that occurred during October 1991 near Spokane, Washington. Further, there are publications similar to the California Department of Forestry, "Fire Safe—Inside—And Out," that provide detailed information on lowering the risk from wildfires.

Based on data gathered from those and other fires, and on the experience and advice of fire officials, foresters, other public officials, builders, architects, and average citizens, NFPA has published NFPA 299, *Standard for Protection of Life and Property from Wildfire*. The standard was developed through NFPA's broadly participatory consensus standards-making process, and presents fundamental planning and design criteria for fire agencies, planners, architects, developers, and government on development in wildland/urban interface areas.

Fires like the one in the Oakland and Berkeley Hills will continue to burn wildland areas periodically, but future wildland fires need not be as devastating. Residents in interface areas can take steps to make themselves and their homes safer.

For the person who intends to build in interface areas, the first step is to choose the house site wisely. Flat sites are better than hills because fires move uphill rapidly. Also, narrow, steep, or winding roads slow and sometimes block fire apparatus and make evacuation difficult.

Next is the house itself. The roof is the most vulnerable part of the house in a fire. Noncombustible roof coverings are a must. So, too, are noncombustible siding, decking, and trim. The chimney should extend above the roof line and be topped with a spark arrester. Eaves should be boxed and vents should be screened. No part of the house should rest on poles or pilings.

The yard can and should act as a fire break. Decorative masonry walls free of vegetation are an effective barrier. A 30-foot safety zone around the house, free of flammable vegetation, is preferred.

Special attention should be paid to the ladder fuels. Low-lying branches must be cut off and hauled away and grass must be low in that area. Hardwood trees are a good addition because they are less flammable than conifers. All trees need to be at least 20 feet from each other and any structure. Limbs should be pruned to a height of 15 to 20 feet from the ground, never over the roof, and not within 15 feet of or directly above a chimney. Shrubs are best planted at least 15 feet from the house.

Maintenance is important. Structures should be kept free of vines and roofs should be clean, i.e., no leaves, pine needles, moss, or twigs. Keep leaves and needles more than 30 feet from the house. Residents should mow grass closely when it has stopped growing, and collect the clippings.

Not every dwelling in the Oakland and Berkeley Hills was burned to the ground. Several survived with minimal damage. Here is what they had in common:

1. Class A or Class B roof coverings. Many were clay or concrete tile, or covered with mineral-surfaced asphalt shingles. Some had a mineral aggregate overlay, and a few had metallic tile roofs. These roof coverings were especially important at perimeter areas where fire fighters could extinguish small roof fires before they ignited the dwelling.

2. Stucco exterior walls. They are noncombustible. Again, the delay in the ignition of the home brought about more effective extinguishment.

3. Small double-pane windows. Just as they keep out the cold air, they resist breakage when subjected to fire and reduce the transmission of radiant energy.

4. Few overhangs or projecting elements like roofs exposed to burning vegetation.

5. Adequate clearances, or fire breaks. Where there were cleared, clean separations between houses and vegetation, or between houses themselves, fire did little damage.

J. SMALLEY/PICTURE CUBE

# Recommendations

KTVU-TV/OAKLAND

**The wildfire in the Oakland and Berkeley Hills in October 1991 was the worst in California's history. It killed 25 people, injured 150 others, and destroyed more than 3,000 structures. Yet, for all that horror and tragedy, it was a relatively small fire by wildfire standards. The area it burned was two-and-a-half-miles square. Had the winds not subsided Sunday evening, this fire could have been much worse.**

The Oakland/Berkeley Hills was a picturesque setting for thousands of residents who called the area home. But in fact, the area was ripe for a major disaster and on October 20, 1991, it finally happened. The long history of fires in the area should have been warnings that we must be vigilant regarding the identified factors constant in most of these prior fires. But we were not. Slowly over time the Hills were allowed to integrate the factors that led to a build-up of a substantial fuel load about the homes. But then, when the predictable yearly "Diablo" winds that quickly dry out the normally plush vegetation don't produce disaster, perhaps we begin to believe that disaster cannot occur. We might, in fact, even forget that we are in a wildland/urban interface area. But this was not the case for the Hills nor is it the case in many similar settings throughout the United States.

No one can predict exactly when or where the next fire will be, but nature gives us clues. Prolonged drought conditions, high temperatures with low relative humidity, and extreme winds blowing hot, dry air are among the warning signs of potential disaster. Fire officials everywhere recognize these signs and base their declarations of "fire season" on them as well as local fire history. The public must learn to recognize those signs as well.

Just as every wildland/urban interface fire is the result of a combination of factors rather than a single event, prevention of those fires and protection against them requires the cooperation of everyone in the community. Urban/interface residents must learn to adopt firesafe habits and firesafe lifestyles.

Those who choose to move to interface areas have an obligation to use good judgment in construction of their homes, in choosing their landscaping design and materials, and in maintaining their homes and the vegetation around them in a firesafe condition. Once a wildfire starts, the survival of individual dwellings will depend, in part, on the preparations that were made for such a catastrophe.

Legislators at the local and state level have an obligation too. Theirs is to make sure that well-known and proven fire protection methods and practices are in place in their communities. Legislators are in a unique position to ensure public safety before a disaster rather than after it has occurred. That can mean enacting unpopular regulations at times.

Tragic losses of homes in the wildlands are usually preventable. However, combined efforts of the community organizations, fire services, federal, state and local governments, and individual homeowners are necessary to minimize losses.

The Oakland/Berkeley Hills fire has resulted in a greater local and statewide awareness of the problems associated with the wildland/urban interface. Nevertheless, a continuing and expanded effort must be undertaken to inform the nation of the potential hazards involved in interface areas, to inform them of how they can assess the hazards in their area and to assist them in eliminating the hazards. Clearly, this effort cannot be accomplished by just the individual efforts of one of the listed groups.

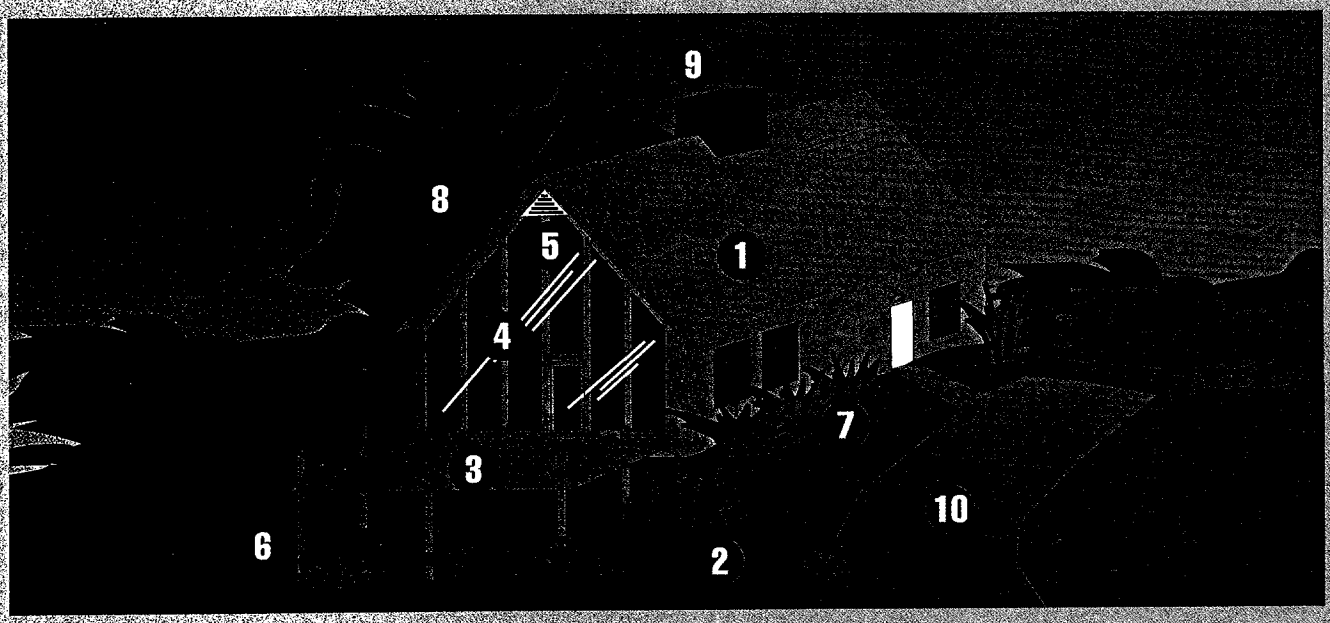
## The fire service

Wildfires require different tactics than structural fires do, and experience fighting one kind of fire is not readily transferrable to another. Yet, the very nature of an interface fire requires knowledge of both types of fire fighting.

The fire service should ensure that all personnel receive regular cross-training in fighting both wildfires and structural fires. That cross-training should be a required component of the regularly scheduled training activities in each

## LOOK FOR TROUBLE SPOTS

1. Untreated wood shake roof
2. Home located on a slope
3. Wood deck facing slope
4. Large glass windows facing slope
5. Unprotected louvres in front
6. Firewood stored too close to home
7. Inadequate weed clearance
8. Tree limbs overhanging roof
9. Chimney spark arrestor missing
10. No access for emergency vehicles




department that may be called on to respond to a wildland/urban interface fire.

Urban departments, in particular, should recognize the need for such tactics as working inside the perimeter with hand tools to break up charred crust, churn up vegetation, and mix water with vegetation to ensure fires are totally extinguished. This procedure is commonly referred to as "mop-up."

No single fire department will likely be able to handle a wildland/urban interface fire on its own. Local departments will need the assistance of sister departments and agencies in their areas, and perhaps even outside their areas. Close coordination of the efforts of other responding departments is essential for effective fire fighting, life safety operations, and the safety of the fire fighters themselves.

Further, the fire service in interface communities should develop a specific mutual aid plan for coordinating resources to attack wildfires. Plans should cover fire fighting strategies, reporting protocols, command and functions of the Incident Management System, staging areas, deployment of personnel, supporting activities, and demobilization.

Drafting detailed mutual aid plans is only a first step. The next crucial step is regular practice in carrying out those plans.

The fire service should schedule regular and frequent mutual aid exercises so that when the next fire occurs that requires mutual aid personnel they will be prepared to work together. Good communications facilities, systems, and procedures are essential for the coordination of fire fighting resources. Communities should plan those systems for a worst-case scenario—because all too often in a wildland/urban interface fire the worst case happens. The Oakland and Berkeley Hills fire overwhelmed the established communications system and resulted in a lack of coordination of all responding forces.

Communities should establish communications systems that allow allocation of radio frequencies by function, operational division, and support service. The system should be compatible with other local departments' systems and with county and state systems. And, the systems should be able to transmit to all areas, regardless of topographical features such as hills. The public apathy about fire in general, and wildland/urban interface fires in particular, is understandable. People have other things on their minds, like raising families and making a living. The fire service has to break through that apathy to educate people, including public officials, about the potential dangers they face and how to prepare for them. The fire service should fund and plan regular public education campaigns, including the distribution of pamphlets, visits to homeowners, and even public meetings, to make homeowners aware of wildfire risks and the steps citizens can take to minimize those risks. In particular, they should explain practical fuel-management steps that residents should take and make reg-

## HIGHLY FLAMMABLE PLANTS

These plants are among those known for the amount of dead fuel that accumulates in them, and the high oil, high resin, or low moisture content of their leaves and branches. If you're planting a new landscape, most shouldn't be used. Native plants can be planted sparingly if spaced widely. All plants are flammable if not pruned periodically, and the risk attached to any one plant can be greatly diminished with maintenance.

**Trees:** Acacia, Arborvitae, California bay, Cedar, Cypress, Douglas fir, Eucalyptus, Fir, Juniper, Palm, Pine, Spruce, Yew

**Grasses, shrubs, ground covers:** California buckwheat, California sagebrush, Dry annual grasses, Juniper, Laurel sumac, Manzanita, Pampas grass, Rosemary, Scotch broom, Scrub oak, Spanish broom, Sugar bush, Toyon

## WHAT YOU CAN DO

### Rearranging Your Plants

- Eliminate fire ladder configurations.
- Make sure the landscape within 30 feet of the house is adequately watered and well maintained. Keep vegetation next to the house under 1-1/2 feet. Trees put the house at greater risk than low-growing shrubs and ground covers.
- Create a transition zone 30 to 50 feet from the home. Remove most major plants (leave enough shrubs to stabilize a slope). You can hydroseed with so-called native grasses and wildflowers or plant low-volume herbaceous perennials like gazania, poppy, and common yarrow. Keep watered and green year-round, or let dry out and cut back.
- Arrange plants 50 to 200 feet from house into islands (make distance between shrubs three to five times plant height).
- In heavily wooded areas, cut out weak or diseased trees; thin healthy ones if more clearing is needed.
- Get rid of stumps to prevent stump sprouting except when slope stability is a concern.

### Annually:

- Clean up leaves and other plant litter.
- Cut grasses to about 4 inches when they turn brown.
- Remove brush that grew with the winter rains.
- Clean off all vegetation from the roof. Clean gutters several times during the year.
- Keep plants near the house watered.
- Work with neighbors to clear common areas and prune heavy vegetation between houses.

### Every few years:

- In early spring, prune or mow down low-growing ground covers. Fertilize and water afterward.
- Periodically cut back native vegetation plants severely.
- Budget for pruning, maintenance of trees you keep.
- Thin crowns of clustered trees (keep 10 feet apart).
- Trim limbs up off the ground 20 feet or more.
- Cut branches back 15 to 20 feet from the house.
- Prune out all dead branches; remove all dead plants.
- Along the driveway, clear out overhanging tree branches and prune back bushy shrubs for fire truck access.

ular visits to interface communities to check for overgrown, closely spaced vegetation that may brush up against dwellings and other fuel-management problems. Public officials should fund those efforts to the fullest. Finally, the fire service should intensify its training efforts on conducting fire prevention inspections, tailoring those efforts to the hazards prevalent in wildland/urban interface areas.

## Legislators

Although the public determines acceptable levels of risk from fire in wildland areas, lawmakers react to the perceived needs of constituents and enact the regulations controlling that level of risk. Therefore, it is generally up to homeowners and fire protection agencies to articulate and justify acceptable and unacceptable levels of risk. When losses occur, they usually focus attention on the risks, but preventive actions are preferable. Legislation for such actions may be necessary for homes that are to be located in high hazard areas.

Lawmakers should take the initiative to examine existing laws, regulations, and standards from other jurisdictions that are available for local use in mitigating fire hazards associated with wildland fires.

Lawmakers are encouraged to adopt NFPA 299 as one part of the protection provided for new construction in the wildlands.

Authorities should provide strong building regulations restricting untreated wood shingle roofs and other practices known to decrease the fire safety of a structure in the wildlands. In the past, untreated wood shingle roofs have repeatedly been shown to be a major contributing factor in the loss of structures to wildfires, yet today some residential subdivisions actually encourage, and some cases even require, wood shingle roofs for aesthetic reasons.

## Planners

This event has also focused on the need to have construction standards for homes in the wildlands. The published version of NFPA 299 provides important guidance in this area, but it is fully effective only when adopted by local lawmakers.

In the absence of clear and meaningful regulations for the common good, the practices of uninformed developers may create potential hazards. Fire protection features, or their costs, may not be appreciated by uninformed buyers. However, decisions made at the early stages of a development will affect a home's fire safety for many years in the future.

All developments should have more than one ingress-egress route and employ looped road networks. Roads should be wide enough for simultaneous access for emergency vehicles and the evacuation of residents. In consideration of the long wheelbase of tankers and other emergency vehicles, roads should be constructed with an adequate curve radius. Homes along dead-end roads and long driveways provide extra privacy for residents but also provide the potential for fire apparatus to become trapped by spreading fire. These roads and driveways should allow access by large emergency vehicles.

Developers should reconsider their frequent use of combustible exterior building materials, or at least offer options for more fire safe materials for potential buyers who may not yet understand the differences.

Developers should also consider the long-range implications of siting unprotected homes on slopes or where water supplies for fire fighting are low or nonexistent.

Developers can provide a valuable service to new buyers, who may initially be distracted by other moving details, by creating appropriate fuel breaks or greenbelt areas.

## General public

The people who choose to live in the scenic wildlands have the responsibility of taking necessary precautions when facing predictable hazards. Informed homeowners would be better prepared for surviving a wildfire, but some homeowners in the area of the Oakland/Berkeley Hills admitted to a lack of knowledge about the wildfire risks where they lived.

Potential homeowners should determine the wildfire hazard potential of the immediate area before buying or moving into any home. This information can be obtained from the local fire department. NFPA 299 provides guidelines for rating the wildfire potential of an area.

Homeowners should contact federal, state, and local fire and forestry agencies for educational programs and materials to address the fire hazard in general. Information should also be shared with children. Information and publications covering numerous wildland home fire safety details are available free from many sources, but until individual apathy is overcome the homeowner may not be motivated to take proper precautions. Here, the fire services can function as fire protection resource centers for the public.

It is the responsibility of the individual property owner to provide a defensible space around structures to help protect them. Extra measures to provide additional space are required for structures built on steep slopes or above canyons, and near combustible materials, and exposures.

When homeowners become aware of the wildfire risk of their own areas, they should join forces with other interested individuals and groups to urge lawmakers to respond with legislative assistance to require appropriate fire safety measures by all of those who live in the affected areas.

These are but a few of the recommendations that have been proposed following the fire. There are many others and concerned parties are encouraged to access the others. But regardless of the specific recommendation, they have one common thread—prevention of devastating wildland fires is not one group's responsibility. It is all our responsibility.

# Today

**One year after the fire there have been several changes in the Oakland and Berkeley Hills. Thirty percent of those who lived there during the fire have chosen not to move back and rebuild. Nevertheless, 51 homes have been rebuilt, many of them larger than before. The area now has a Firestorm Memorial Garden at the intersection of Tunnel Road and Hiller Drive, and a community newspaper, The Phoenix Journal, has risen out of the ashes to keep community residents informed of activities in the area.**

KTVU-TV/OAKLAND

**Other activities include the following:**

- The California Public Utilities Commission is considering a $36 million project to bury utility lines underground.
- East Bay Municipal Utility District has used computer analysis to investigate the potential of several enhancements to the water supply. Among possibilities: more tanks in the Hills, bigger pumping plants, more connections between different parts of the system, and installation of a permanent backup system. Steps already taken include installation of a permanent emergency generator at Claremont Center, which powers pumps that fill the first two reservoirs in the hillside system. Also, there are now portable power generators on both sides of the Hills and a policy of keeping reservoirs full during high-fire-hazard weather. Despite these actions, officials maintain that it would be impossible to supply all the water needed during a firestorm such as took place October 20, 1991.
- Oakland is negotiating with the Federal Emergency Management Agency for a $1 million grant to widen Charing Cross and Drury Roads.
- Oakland officials are considering using $300,000 from a bond issue to put adapters on all 6,500 hydrants in the city.
- There is a new program to control vegetation in the Hills.
- The Oakland City Council has passed an ordinance requiring Class A roofs in the entire fire-hazard area above Highway 13. Berkeley has a similar ordinance.
- Berkeley has approved a $55 million bond issue to improve the water system to include a salt water backup supply.
- A hazardous assessment district was created in Berkeley to fund the fuel-management district, which is comprised of 8,300 properties.
- Fifty-three lawsuits have been filed in Alameda County as a result of the fire.

**For additional information, contact your local fire department or forestry agency, or contact the following organizations.**

**National Association of State Foresters**
444 N. Capitol Street, NW
Washington, DC 20001
202-624-5415

**National Fire Protection Association**
1 Batterymarch Park
P.O. Box 9101
Quincy, MA 02269-9109
617-770-3000

**United States Department of the Interior**
Interior Building
18th and C Street, NW
Washington, DC
202-653-8800

**United States Department of Agriculture**
**Forest Service, Fire and Aviation Management**
P. O. Box 96090
Washington, DC 20090-6090
703-235-3220

**United States Fire Administration**
16825 South Seton Avenue
Emmitsburg, MD 21727
301-447-6771

**Boise Interagency Fire Center**
**Publications Management System**
3905 Vista Avenue
Boise, ID 83705
208-389-2512