FIRE-SCIENCE-BASED OVERVIEW

1. Wildland Fire Management in the Santa Monica Mountains

2. The Home as Emergency Fire Shelter

3. "Optional" Fire Shelters during Possible Worst-Case Scenario Entrapment Situations of Campers within Major Wildland Campsites

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This unpublished "draft" document attempts to provide a fire-science-based basic understanding of past wildland fire management attempts in the Santa Monica Mountains and fire safety related issues inclusive of homes as emergency fire shelters. The knowledge gained is then expanded to evaluating clearance distances that may be necessary for "optional" emergency fire shelters and the type of "optional" shelters required/recommended during possible worst-case scenario entrapment situations of campers within major campsites in chaparral ecosystems. Such safety zones for survival are largely not feasible, and fire-safe-maintained campground sites with clear escape routes rather than relying only on optional fire shelters of campsites located in fire hazardous areas is still the best option.

For a well-trained firefighter a safety zone is defined as providing freedom from danger, risk, or injury. However, these standards cannot be achieved in many situations for campers and hikers as they are not as physically fit as firefighters, generally not properly dressed, and not trained to evaluate, confront or avoid dangerous situations. Therefore they face much greater risks to exposure. Minimum standards for the general public are therefore different from that for well-trained firefighters that are properly prepared and dressed for fighting wildland fires.

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I. Fire and Chaparral in the Santa Monica Mountains[1]

Chaparral is a plant community in California that has adapted over many years to summer drought and frequent fires. In other words, it is fire-dependent and needs fires to sustain and rejuvenate itself. Two distinct sub formations of chaparral called “hard chaparral” and “soft chaparral” are clearly distinguished in ecological literature and are generally referred to as chaparral and coastal sage scrub communities. This distinction is important for fire management, watershed and hillside management, as conservation efforts as well as escaping safely in a wildland fire scenario.

The coastal sage scrub community or “soft chaparral” is rapidly becoming an “endangered” habitat because it is commonly found in California's coastal zone, where most urban expansion is taking place. It is generally restricted to the most xeric sites at lower elevations because of orographic effects, and at higher elevations because of shallow soils. The dominant species that compose the coastal sage scrub community are of smaller stature than those in the chaparral plant community and provide a more open habitat that encourages more herbaceous species including sages, California sagebrush, and Deerweed. In comparison to hard chaparral species, which tend to start growth in winter, coastal sage species tend to start growth soon after the first significant winter rains.

From the fire management and suppression viewpoints these are important considerations. Since coastal sage scrub, because of its shorter life span and greater mixture of herbaceous species, can already become highly fire-prone within 7-10 years after a previous fire, the highest fire frequencies are found in the coastal sage scrub communities. This is well-documented in the lower elevations along Pacific Coast Highway (PCH) where fires overlap, specifically in the lower Corral Canyon watershed characterized by coastal sage scrub cover.

Woody chaparral, if not degraded by too frequent fires and human activities that provide an intermix of more highly flammable herbaceous species, does not become highly fire prone for about 15 to 20 years. Historically, such young chaparral, because of its low dead-to-live fuel ratio, acted as effective fire barriers and helped set boundaries for past fires in the Santa Monica Mountains, as the flanks of the fire were easier to contain then, even under Santa Ana fire weather conditions.

Wildfires in Southern California can occur at almost any time of the year but are most prevalent during the dry season. Extreme fire danger conditions normally exist from September through December or until the winter rains end the dry season. Fires are most likely to occur during strong Santa Ana winds; these winds, also known as Santana, foehn, devil, or fire winds, blow from the north to northeast out of the Great Basin of Utah, Colorado, and surrounding Northern States. As the air is compressed and forces southwestward to lower elevations, it becomes hot, dry, and gusty. When Santa Ana winds meet the local mountain winds, unpredictable fire patterns are often set up, making erratic fire fronts and spotting ahead of fires a common occurrence. Within the onset of the Santa Ana winds, humidity often drops rapidly while the air temperatures rise quickly. These are called typical “Red Flag” fire weather conditions that lead to greater possibilities of brush fires spreading rapidly, and uncontrollable wildland fires. As, for example, described in the City of Malibu *Residents Handbook for Emergency Survival* (referred to as *Malibu Survival Guide*), these conditions generally exist when the wind exceeds 25 mph and the relative humidity is below 15%. Southern California averages about 15 Red Flag days every year.[2] Public parks, campgrounds, and hiking trails within fire prone watersheds throughout the mountains are closed to the public during all Red Flag alert days.

Under Santa Ana fire weather conditions, wildfires are extremely difficult to control unless the fuel supply (vegetation and structures) is exhausted or the wind subsides.

In the interior mountain ranges of Los Angeles County, fire frequency and numbers of acres burned are high in the summer months because of high summer temperatures and occasional lightning strikes. In the coastal Santa Monica mountain range, fire frequency is lower in the summer, and lightning strikes are almost unknown as causes of fire. The number of acres burned during this time period is also lower than in the interior ranges because the Catalina eddy, a marine breeze characterized by cool, moist air, penetrates the local mountains, primarily during June and

1 Radtke, Klaus W.H. *Living More Safely in the Chaparral-Urban Interface*. Gen. Tech. Rep. PSW-67, Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1983. 51 pp.

2 City of Malibu. *Malibu Survival Guide: Residents Handbook for Emergency Survival.*

July.[3] This cool air is responsible for the abnormal air circulation pattern of upslope instead of downslope winds during the evening and into the night. In both the inland and coastal regions, the great toll of acreage burned from late September through December is the result of the Santa Ana wind, which has its highest frequency from September through February and is almost absent in July and August. As Malibu has experienced time and time again, during drought years, wildland fire starts with homes endangered and quickly lost can even happen in January and February during the supposedly "rainy season," especially within coastal sage scrub. For example, on January 8, 2007, at approximately 5:00 p.m., a fire starting in the vicinity of Malibu Bluffs Park near the ocean, south of Pacific Coast Highway, quickly expanded into the Colony area, burning down four houses on Malibu Road. Los Angeles County Fire Department officials traced the fire start to a discarded cigarette stub.

The amount of fine, dead fuels (generally under 1/4 to 1/2 inch in size) determines the rate of fire spread because such fuels dry rapidly, ignite quickly, and preheat live fuels to the ignition point. So, when a wind-driven fire makes a run through flammable vegetation, it will first be nourished by and consume fine dead fuels. When fine dead fuels are removed through diligent, year-round maintenance, a fire cannot spread through such areas. Direct impacts on fire-safe built structures such as fire-safe homes are therefore minimal and of very short duration from the heat and flame sources originating beyond the fire-safe zone. Firebrands then become the biggest cause of concern, especially if a structure is unattended.

Live fuel moisture is also an important fire-safe characteristic because plants with high fuel moisture ignite less readily. Within the interior Santa Monica Mountain range (generally characterized by woody chaparral), the late summer and fall Santa Ana fire winds coincide with low live fuel moisture of plants. Within a few hours the dry, hot winds can reduce fuel moisture of fine dead fuels to the critical level of ready ignition and can further decrease live fuel moisture by a few percentage points over several days.

The major flammable native vegetation found in the Santa Monica Mountains, namely grassland, coastal sage scrub, and chaparral, have a direct bearing on fire starts, fire frequency and fire intensity because of their different fuel loads and ease of ignition. For example, the flash fuel annual grasses seldom exceed 5 tons of fuel per acre, whereas mature, woody chaparral can greatly exceed 30 tons per acre. Grassland fires may be more frequent and provide a quick heat release but are also more easily extinguished; however, they often carry the fire into the coastal sage scrub and chaparral. In any event, the fuels dictate the ease of fire starts and spread rates and this has a direct bearing on fire frequency. When the grasslands were grazed by sheep, reducing their fuel loads, the highest fire frequency was found in coastal sage. With reduction in grazing, fire in annual grasslands, especially along roads and rights of way, along with downed power lines, have become the major source of fire starts.

The predictable direction of fire spread in the Santa Monica Mountains during Santa Ana wind conditions is south to southwest. This spread pattern is primarily influenced by the winds and secondarily by topography. Because canyons in the eastern part of the Santa Monica Mountain range run in a south-to-south-westerly direction or parallel with the fire winds, fire is channeled up the canyons, spreads out as it reaches the ridges, contracts initially as it is funneled downhill through the canyons, and may fan out in either direction as it reaches the beaches. The western portion of the Santa Monica Mountains does not have this pronounced linearity of canyons and fire winds, however. Fires are therefore more influenced by the direction of the wind and are more irregular in shape. One of the most important topographic effects to remember is that fire spreads much faster uphill than downhill.

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[3] Radtke, Klaus W. H., Arthur M. Arndt and Ronald H. Wakimoto. *Fire History of the Santa Monica Mountains.* In Gen. Tech. Rep. PSW-58. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; pp. 438-443. 1982.

II. Wildland Fire Heat Sources and the Basics of Fire Behavior[4,5]

Understanding the basics of fire behavior will prove helpful to homeowners, campers, as well as hikers. They will be able to better judge fuels in terms of flammability, heat intensity, heat duration, and fire spread.

A fire can be visualized as 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, sustaining combustion requires a continuous supply of oxygen.

Wildland fire management attempts to predict and control fire behavior by managing vegetative fuels to control flame length, rate of spread, heat intensity, and the potential for spot fires**.**

Understanding the different heat sources of a wildland fire is critical to siting of fire-safe homes and using them as stand-alone fire shelters, as well as understanding the need for and protection other emergency fire shelters may offer.

Heat transfer is by convection, radiation and conduction. 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. It is responsible for most wildland fire-related injuries and fatalities. With light wind and on level terrain, the convection heat column is almost vertical. Reducing the duration of heat and length of flames produced by nearby vegetation can be critical to protecting yourself and 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-long convection heat flames can occur in 6-foot-tall mature chaparral at wind speeds 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 non-maintained continuous woody fuels with a high dead-to-live fuel ratio increases to 35 feet and for 6-foot-tall fuels to more than 100 feet.

Radiation heat is the 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.

Again, it can be predictably managed if you are in control of your situation as the following landscape examples illustrate. For a point source of radiation, the heat intensity decreases with the square of the distance. This means that a burning tree 40 feet from a roof or picture window transfers only one-fourth of the heat to the house compared with a tree burning within 20 feet, and one-sixteenth the heat compared with a tree burning within 10 feet. A line source of radiation such as a burning hedge of junipers or cypresses is even more critical than a single point source because the house receives a broad expanse of heat from all points along the line. In this case, heat intensity varies with the distance instead of the square of the distance, so that the heat intensity at a home located

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4 Radtke, Klaus W. H. *A Homeowner's Guide to Fire and Watershed Management at the Chaparral/Urban Interface.* Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture and County of Los Angeles. **1982**. 33 pp. Reprinted as *A Homeowner's Guide to Watershed and Fire Safety* by Los Angeles County Fire Department (Forester and Fire Warden 1982-1995+. 33 pp.
Radtke, Klaus W. H. *A Homeowner's Guide to Fire and Watershed Management at the Chaparral/Urban Interface.* **Revised 2004**. City of San Diego Water Department in cooperation with the City of San Diego Fire Recovery Network and the Conservation Action Committee. 2004. 45 pp.

5 Knowles, Robert. Booklet on blaze protection ordered reprinted (L.A. County Board of Supervisors orders reprinting of 25,000 copies of *A Homeowner's Guide to Fire and Watershed Management* ...after last Saturday's disastrous fires in Malibu). *Los Angeles Herald Examiner*. October 13, 1982.

within 40 feet of the burning hedge is still one-half that at 20 feet. This is a powerful incentive not to plant potentially flammable hedges or hedge-like “groundcovers” near structures, as well as keeping flammable shrubs and trees as far away as possible from your house so that can also act as an emergency fire shelter.

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. 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. Other factors being equal, a fire burning on level ground will spread twice as fast when it reaches 30% slopes. The rate of spread will again double as the slope reaches 55%. Heat energy release rates will be correspondingly faster and greater as indicated by greater flame length per foot of fire line. You cannot outrun a rapidly moving uphill fire. So, be prepared, stay calm, and evaluate your situation before this happens.

The duration of heat transfer 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 are reduced and the fine dead fuels removed, the duration of the flame and its associated heat can often be shortened to seconds. Thus, a non-maintained yard tree, which may take many minutes to burn, may represent a greater hazard to a home than nearby discontinuous, well-maintained chaparral.

The different major wildland fuels found in the Santa Monica Mountains, such as grasses, coastal sage, scrub, chaparral, and trees, have various ignition requirements. Heat and ignition are greatly influenced by fuel particle size distribution, live-to-dead ratio of these particles, and moisture content of live and dead tissues. The physiological condition of the living tissues greatly affects live fuel moisture. A vigorous growing plant has high living tissue moisture and a plant under stress or in poor vigor has relatively lower living tissue moisture. For example, growing green grass has a living tissue moisture content greater than 100 to 150 percent of dry weight. Dead tissue moisture content is determined by the ambient air temperature and therefore changes rapidly. Dry grass has the lowest heat requirements for ignition and is therefore easily ignited; it has the longest fire season and also the highest fire frequency. Coastal sage scrub, because of its summer dormancy, its high amount of fine dead fuels, aromatic oils, and the relatively short life cycle of individual species, is next in heat requirements for ignition and in fire frequency. Woody chaparral shrubs in coastal areas have higher fuel moisture than the same vegetation inland and normally do not become dangerously dry until late summer or fall. However, even among these plants, several species, such as Chamise, have greater amounts of fine fuel (such as needles) and tend to have more flammable compounds (such as oils) during the annual dry season.

III. Understanding the Purpose and Effectiveness of (Emergency) Fire Shelters

As the number of civilians moving to the wildland-urban interface and enjoying the outdoors increases, the number of wildland fires associated with disasters and injuries both among civilians and firefighters also increases.

The most common cause of thermal injury is direct contact with flames. Although a significant amount of radiant heat can be created in wildland fires, firefighter clothing is usually enough to offset serious burns. Temperatures may be extreme at the fire front but they are of short duration. The worst burn events typically involve civilians who are inexperienced with wildland fire behavior or with rapid, unanticipated changes in fire behavior and do not have the proper equipment and clothing to protect themselves from such extreme exposure. Immediate death is primarily due to incineration. Of the 133 firefighter fatalities during 1990-1998 studied by Mangan,[6] the most common cause of death with 29% was turnovers. It occurs when a firestorm burns over the individuals in the path of an advancing fire front. Volunteer firefighters experienced the most fatalities with heart attacks being the most common.

Another type of burn is the inhalation burn. Mostly seen in firefighters, this is when the patient has inhaled superheated air. One good indication that the patient may have a supraglottic (above the glottis) heat injury is swollen lips. In this case, advanced airway interventions may have to be done soon. If the patient has severe shortness of breath, he may have to be treated with high-flow oxygen. Protecting the airway from extremely hot air is always a firefighter's primary concern. Breathing through a wet shroud or bandana exposes the airways to hot, moist air, which can be more harmful than hot, dry air. Avoid breathing through wet cloth but protect your face. A wet bandana or wet cloth can be used to cover the nose and mouth to reduce inhaling smoke after the flame and heat of the fire have passed.

As explained by Robert Frantz in the book *Disaster Medicine*,[7] contact with superheated air brings the risk of respiratory tract injury. Respiratory tract injury should be suspected with burns around the face, neck, and upper body. Physical findings that have a high correlation with upper respiratory burns include facial burns, nasal hair singeing, facial edema, stridor, and early respiratory distress. Serious respiratory burns are most often seen in those casualties whose history includes being trapped in the burning area. These people have no choice but to breathe the smoke and hot air. The level of injury is directly correlated with the amount of time spent in the burning area and the actual temperature of the air being breathed.

Fire tents–As understood by firefighters, an emergency fire shelter is a stand-alone, compact, aluminum foil and fiberglass tent-like structure employed by firefighters as a last resort in a wildfire life-threatening situation to protect them from burning from radiant heat sources. The fire shelter is basically a one-person pup tent, minus the floor, made from fiberglass cloth covered with a reflective aluminum coating. It takes a minimum of 15 to 20 seconds to deploy a shelter under ideal conditions, longer in turbulent winds and when an area has to be cleared. As explained by Anderson the new post 2003 generation fire shelter protects primarily by reflecting radiant heat and trapping breathable air.[8] It has two layers. The outer layer is aluminum foil bonded to woven silica cloth. The foil reflects radiant heat and the silica material slows the passage of heat to the inside of the shelter. The aluminum can reflect up to 95 percent of the fire's radiant heat but generally does poorly against moving, windborne (convection) heat. Unlike radiant heat, convective heat (from flames and hot gases) is easily absorbed by the fire shelter, allowing the temperature of the material to rise rapidly. At 470° F such fire shelters generally fail as glue holding the outside together melts. People can survive inside temperatures up to 175-190° F. But for how long?

Initially it is difficult to understand how anyone can survive breathing dry hot air in a fire shelter until one

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[6] Mangan, R. "Wildfire Fatalities in the United States 1990-1998" *United States Department of Agriculture, Forest Service.* 1999. As quoted with permission by Robert Frantz in Chapter 20 "Fire Storms and Wildfires" in the book "Disaster Medicine."

[7] Frantz, Robert E. "Firestorms and Wildfires" (Chapter 20) in *Disaster Medicine* authored by Hogan, David E. and Jonathan L. Burstein.

[8] Anderson, Leslie. Project leader. "The new generation fire shelter." NWCG PMS 411. Boise, ID: *National Wildfire Coordinating Group, Fire Equipment Working Team, National Interagency Fire Center*. 2003. 30 pp.

understands that air, fortunately, is a poor conductor of heat and the upper airway is very efficient in thermal or heat exchange. As further explained by Robert Frantz, for this reason a person can breathe air at a temperature of 199° F (92° C) for 30 minutes and of 482° F (250° C) for 3 minutes without serious injury. Although most of the injuries to the respiratory tract are therefore generally mild and they involve only the upper airways, anyone with a significant history of exposure should receive a medical evaluation as soon as possible. Thermal injuries to the respiratory tract can be insidious, with a delayed onset of respiratory distress after contact with superheated air. Significant respiratory distress may be present as late as 24 hours after the exposure. Thermal airway injury is always associated with edema, which can rapidly occlude the airways.

In stark contrast to the higher temperatures generally required for respiratory tract injuries, soft body tissue thermal burns can already occur when the skin is exposed to temperatures above 115° F (46° C). At temperature exposure greater than 120° F for three seconds, a child's skin is burned severely enough to require surgery.[9]

While emergency fire shelters reduce the risk of death and injury for firefighters, they are not fail-safe, and carrying a fire shelter should never be considered an alternative to safe firefighting.

But what about smoke inhalation during wildland fires? While lightweight breathing devices occasionally carried during prescribed burn operations can protect from smoke inhalation, they are not generally carried during wildland fires. In reviewing the literature about smoke exposure among wildland firefighters, Reinhardt and Otmar (1997)[10] found that overexposure to carbon monoxide and respiratory irritants is likely among firefighters when direct control of fires is required and smoke production is intense. Such over-exposures are brief events but sometimes poor atmospheric dispersion or rigorous work schedules cause hours or even days of unhealthy working conditions. During such exposures increased respiratory health problems have been measured in wildland firefighters. Small but statistically significant reductions in lung functions have been observed, across both work shifts and seasons. Specifically, smoke exposure is likely to be the highest during initial attack, during direct attack on fires in high winds (as the smoke lays low on the ground), and large fire situations that suffer from poor atmospheric dispersal. Hazards in smoke seems to be limited to respiratory irritants and carbon monoxide. Ambient wind speed is a key factor in controlling smoke exposure potential, with smoke exposure proportional to wind speed at both wildland fires and prescribed burns. Prescribed burns may increase exposure because of the higher moisture in the fuels.

Fire trucks/vehicles–Since the 1950s mechanized fire equipment such as fire engines have been more widely used in wildland fire suppression, and by necessity often became emergency shelters. Because of firefighter deaths as well as “close-calls” when using fire trucks as emergency fire shelters, research is being conducted continuously to evaluate their effectiveness during a burn over (where a fire escapes beyond the fire lines). Such a vehicle entrapment study was conducted by the Missoula Fire Laboratory in 1996 with the Los Angeles County Fire Department and other fire services throughout the country as collaborators.[11] Some of the research results important for survival in a real-world fire entrapment are listed below:

a. In most fuel types (besides grass and light brush), the temperature and radiant heat flux generally increase with the height above the ground. This is consistent with the principle that heat rises. This observation has special relevance considering the height of an engine cab compared to the height of a fire shelter.

b. Heat from the passage of the fire front appears to be retained in the vehicles longer than in the fire shelter or other items of PPE (Personal Protective Equipment), indicating that the metal in an engine may act as a “heat sink.”

c. Moving just a few feet back from the oncoming flaming front—especially on a road cut on steep slopes—appears to significantly reduce the effect of temperature and radiant heat flux on both the individual firefighter and fire

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9 http:/emedicine.medscape.com.

10 Timothy E. Reinhardt and Rogar D. Otmar. Smoke Exposure Among Wildland Fire Fighters- A Review and Discussion of Current Literature. USDA Forest Service Pacific NW Research Station General Tech Report PNW-GTR-373 Feb. 1997.

11 Mangan, Richard, Project Leader. “Surviving Fire Entrapments. Comparing conditions inside vehicles and fire shelters.” *USDA Forest Service Technology and Development Program.* Missoula, Montana. *Fire.* September 1997.

engine.

d. During the moderate-intensity, short-duration exposure of the Los Angeles County tests, exterior components of the engines either caught fire or experienced some melting (See Figures 27 and 28 of the Mangan report referred to in the above footnote). Under higher intensity or longer duration exposures, the fire engine could catch fire and continue burning when conditions outside would be harmful to a firefighter attempting to leave the engine.

e. When a fire comes up a steep side slope, it appears to go over and under the engine, creating an eddy on the back side that draws heat and flame. A firefighter taking shelter behind an engine parked on a steep slope would not be protected from heat or flame. This effect was demonstrated in October 1996 when an engine was burned over during the Calabasas Fire in Malibu.

f. When the outside doors of an engine cab are subject to high radiant heat loads, the petroleum-based plastics and sound-deadening materials in the door panels and dashboard volatilize. The smoke generated by this volatilization may cause both short-term and long-term health effects on firefighters without respiratory protection, and will create conditions that force them from the cab into the fire area.

g. Under high heat loads, tempered glass in the cab's windows may break out. This may occur when the difference in temperature inside the cab and the temperature outside is only 4° C. Consideration should be given to using safety glass for greater levels of protection.

h. The temperature difference between the 1-inch (3-cm) and 12-inch (30-cm) levels in the fire shelters reinforces the need to encourage entrapped firefighters to get on the ground and to keep their face and mouth as close to the ground as possible, protecting their respiratory system.

Based on such results, it is prudent for firefighters operating fire trucks to also carry emergency fire shelters that they employ inside their trucks to escape the heat and toxic smoke, or deploy it outside along a road cut or other surrounding areas that protect from convective, radiant, and conductive heat sources.

Open ground fire safety zone–All firefighters that are working on or near a fire line, or hikers and campers suddenly exposed to a wildland fire line, must be able to identify a survival safety zone and need to know how big is “big enough.” Such a zone is defined as providing freedom from danger, risk, or injury. Research conducted by Butler and Cohen indicates that an open ground safety zone should be large enough (and therefore cleared of all flammable vegetation) so that the distance between the person and the flames is at least four times the maximum flame height.[12] The research compared the causes of fire fatalities and near fire fatalities of firefighters wearing largely protective Nomex clothing in severe fire conditions even in those cases where crowning in forest fires could produce flames in excess of 200 feet.

The authors further stated that radiant energy travels in the same form as visible light, that is, in the line of sight. Therefore, locating safety zones in areas that minimize firefighters’ exposure to flames will reduce the required safety zone size. For example, topographical features that act as radiative shields are the lee side of rocky outcroppings, ridges and the tops of ridges, or peaks containing little or no flammable vegetation. Since safety zone size is proportional to flame height, any feature or action that reduces flame height will have a corresponding effect on the required safety zone size. Some examples are burnout operations that leave large “black” areas, and thinning or fuel-reduction operations that reduce fuel. The authors emphasized that the research results only address the results of radiant heat, and convective heat transfer from gusts, fire whirls or turbulence could increase this required zone.

The Stanford Research Institute's 1973 report, in analyzing fire protection strategies for the Santa Monica

[12] Butler, Bret W. and Jack D. Cohen. “Fire Fighter Safety Zones: How Big is Big Enough.” *Fire Management Notes*. Volume 58. N. 1. Winter 1998. pp. 13-16.

Mountains,[13] quotes the yet unpublished report by Green (1973) that lateral firebreaks (those containing the flanks of the fire) must be at least 200 feet wide to provide adequate safety for suppression crews (as it provides a 200-foot distance from flames in emergencies).[14] According to the above quoted research by Butler and Cohen, flame length would have to be limited to 50 feet in length to provide adequate protection during extreme fire events. However, fire behavior modeling by many different authors since then has indicated that flame length can greatly exceed this length under extreme fire weather conditions, especially in steep topography with flames being pushed uphill by convection currents.

Wilson[15], in investigating the common denominators of fire behavior on fatal and near-fatal forest fires in the U.S. from 1926 to 1976 involving firefighters, found unexpected factors. He stated that firefighters were surprised to learn that fatal and near-fatal incidents often occur in fairly light fuels, on small fires or isolated sectors of large fires, and that fire behavior is relatively quiet before the incident. The general belief is that the high intensity crown fire in timber or heavy brush is most likely to trap and kill firefighters. Yet, with rare exceptions, such as the Sundance Fire of 1967 in Idaho, the Blackwater Fire of 1937 in Wyoming, and the King's Canyon Fire of 1967 in Western Nevada, most of the fires in his study were innocent-appearing just before the accidents.

Wilson then asked himself the question. Why, then do such tragedies and near-fatalities occur under so-called “easy” fire behavior conditions? He answered it by stating that fire spread and intensity can change much more quickly in light fuels than in heavier fuels. Fine fuels tend to be more quickly responsive to changes in atmospheric conditions than heavier fuels. Second, hot, dry Santa Ana (or foehn-type) winds dry out the lighter fuels with the result that any change of wind, slope, or other environmental factor may lead to a drastic and unanticipated change in fire behavior. Since dry fuels burn with little or no smoke, the obvious signs of change in fire behavior, such as smoke and crackle of flames, are only noticeable once the situation has become critical. Wilson then concluded that there are four major common denominators of fire behavior in fatal or near-fatal fires. These often occur:

1. On relatively small fires or deceptive quiet sectors of large fires.
2. In relatively light fuels such as grass, herbs, or light brush.
3. When there is an unexpected shift in wind direction or wind speed.
4. When fire responds to topographic conditions and runs uphill.

But Wilson also cautioned that, with a sudden change of wind, the fire may change direction regardless of the topography.

A common-sense approach for hikers when caught in the open without a shelter and with a fire approaching is to look for a road cut or ditch (firefighters have even survived in deep wheel well ditches or deep ruts on dirt roads). Lie face down in the ditch or road cut on its uphill side at the base of the (hopefully tall) bank and cover yourself with anything that will shield you from the heat of the fire. If you do not have protective clothing, cover yourself with dirt as much as you can as it is a good insulator. If there are no road cuts, look for large rock outcroppings and shield yourself from the approaching radiation heat behind these rocks. However, if you have time, remove all fuel from around the rocks. If time is more limited, first remove all finer dead fuels as these will carry the fire and provide a quick heat release that may be fatal. Even hiding in the depression under large fallen logs and covering exposed parts of your body with soil will help protect you. However, be aware that you may share such shelters with rattlesnakes and other critters. Also carry lightweight heat-reflecting blankets with you wherever you go.

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[13] Stanford Research Institute. Decisions Analysis of Fire Protection Strategy for the Santa Monica Mountains: An Initial Assessment. Prepared for Forest Service. US Department of Agriculture. Pacific Southwest Forest and Range Experiment Station, Berkeley, CA. Stanford Research Institute. Menlo Park, CA. Oct. 1973. 159 pp.

[14] Green, Lyle. R. Developing Fuel-Breaks for Wildland Fire Control in California. Review draft of the U.S. Forest Service, Riverside Fire Laboratory. June 1972.

[15] Wilson, Carl C. “Fatal and Near-Fatal Forest Fires. The Common Denominator.” In: *The International Fire Chief* 43(9). 6 pp. March 1976 (portions of this paper were first prepared for the National Advanced Fire Behavior Course, Sunriver, Oregon, April 1974 and for the National Fire Behavior Officers Training Course, Marana, Arizona, March 1976).

IV. Wildfire Management Policies and the Home as Emergency Fire Shelter

Every home constructed in fire-prone areas should be so sited, constructed, and maintained that it could be considered a shelter-in-place for natural disasters inclusive of wildland fires. Such was the case with the Spanish haciendas that had fireproof tile roofing and fireproof exterior walls and extensive fire-safe landscape buffers around their structures. However, after WWII when construction expanded rapidly into the wildland-urban interface areas, such lessons were quickly forgotten and homes were often sited in high-risk-fire topography and quickly built with the easiest available material: wood. Quite predictably, wildland fire disasters grew bigger and bigger and burned more and more homes even in seemingly fire-safe areas, as firebrands carried the wildland fire from wood roof to wood roof, burning thousands of homes even within the city, as was the case in the 1991 Oakland Tunnel Fire. When the November 6, 1961, Bel-Air Fire burned or severely damaged over 500 homes, the fire was ranked only second in the Western states to the San Francisco Fire that followed the earthquake of 1906, as the insurance loss was estimated at $24 million. Because of the high risk and exposure to insurers, private fire insurance had pretty well dried up by 1968 and the insurance companies were then forced by the State of California to form a FAIR PLAN umbrella insurance pool that spread the shock losses of brush fires among all insurance companies. Because of its generally low cost relative to the risk insured, it was a key incentive to continue development in high risk fire areas often without meaningful fire-safe changes in land use, planning, and construction, as FAIR PLAN subsidized insurance for homeowners living in such areas. Consider that two-thirds of the homes destroyed by wildfire since state-wide public records were kept in 1923 have been burned since 1980.[16] The new density of hillside housing has shifted from a policy of the home as an emergency fire shelter to wholesale evacuation and with it a greater loss of homes during fires (K. Radtke, unpublished research).

Research was conducted as far back as the early 1980s in the Santa Monica Mountains[17] by UCLA researchers pertaining to residents' beliefs regarding fire hazards, their adjustments to the threat of fire, and the expectations regarding the level of fire services provided to them. Results indicated that they were well aware of the hazards, were uncertain of what technological safeguards are likely to be the most effective, and may have unreasonable expectations regarding their individual protection via fire service organizations.

However, it is not too difficult to build and maintain a fire-safe designed home. First, it must be located in an area where it is not exposed to convection and radiation heat sources. This means that it must be set back from slopes, not located side-slope, not located in fire chimneys such as narrow canyons, not in saddles, and not in or at the confluence of narrow canyons. Given the steep topography of the Santa Monica Mountains and the insistence on their property rights when people want to build on otherwise wildfire-exposed lots, such constraints are often hard to meet. However, building with truly fire-safe construction and designing homes that don't catch convection and radiative heat sources but rather let them slide over the houses where possible can often greatly mitigate some of the siting problems. Add to this the proper clearance of all flammable materials around the house while working with your neighbors to do the same, and you have created a pretty safe fire shelter for yourself and them. But keep your diligence up on a year-round basis.

Many of the even more recent fire losses in the Santa Monica Mountains were still related to causes such as fire-trap constructed homes (wood roofs, wood decks), homes so located and built as to being exposed to convective and radiative heat sources (fire catchers), flammable accessory structures, wood fences, railroad ties, improper clearance of native and ornamental vegetative fuel sources, accumulation of other flammable materials around the homes, and ease of fire entry. When even seemingly fire-safe construction, such as newer homes with stucco siding, enclosed eaves, and fire-safe Class A roofs, catches on fire there must be reasons. Totally overlooked Achilles heels of such homes are wooden decks, the vents required at the base of their stuccoed walls, and the still-permitted use of wood along the outside of homes such as wooden railroad ties for steps to reduce the overall cost compared to fireproof steps such as stone or concrete. The vents are soon forgotten or overlooked and soon covered with landscaping. When the railroad ties slowly ignite or such vegetation burns on unattended homes (such as fire-

16 Davis, Mike. Let Malibu Burn: "A political history of the Fire." *L.A. Weekly* 1996. Internet Report Oct. 24, 2007.

17 Loeher, Larry. Fire Hazard: "The Dimension of Resident's Attitude." in *Living in the Chaparral of Southern California-an Integrated Approach to Public Safety*. Proceedings of the Conference and Public Workshop sponsored by the National Foundation of Environmental Safety and the National Park Service. 1985. pp. 51-55.

evacuated homes), firebrands or flames have plenty of time to creep into the wooden frame covered by the stucco and slowly ignite the house from the inside. An initial tell-tale sign of this is often a warm or hot exterior or interior wall of the house, soon perhaps a smoky room, and finally often smoke coming from the chimney on a hot day.

This author, as one of the board members of the then National Foundation for Environmental Safety, conducted many homeowner inspections free of charge in Los Angeles County's wildland areas during the 1980s-1990s, often after homeowners had passed their yearly "brush clearance" inspections and thought they were safe. Wildfires and their causes as well as home losses were also investigated when time permitted and fire safety seminars were held throughout California.

To his dismay, the author found that most of the homes inspected were not really fire-safe, as flammable landscape vegetation, flammable household items, or flammable accessory structures were never really addressed during brush inspections. To his knowledge, none of the residences of homeowners that diligently followed his advice were lost in wildfires even when they were located in the center of a firestorm such as in central Las Flores Canyon during the 1993 Old Topanga Fire. The owner of the property wanted to build a home on a lot inherited from his parents where their previous summer home had burned down during the 1943 Las Flores Fire. He attended the Symposium Chaparral—Fire & Man this author had organized with the Los Angeles County Fire Department Forestry Division and other agencies such as U.C. Berkeley extension services at Tapia Park in Malibu in June 1978. Because of potential fire exposure to steep slopes in a fire-funnel canyon, the owner of this particular home built a compact one and a half story overall fire-safe-designed side-slope home with stucco siding, a low pitch Class A tile roof so as not to be exposed much to convective and radiative heat sources, and added a stand-alone garage. Because windows and the code-required vents near the roof and at the base of the stucco walls presented dangerous places of fire entry, he then hand-fabricated 1/2-inch-thick plywood shutters with handles to fit the windows and also constructed small wooden shutters to fit every opening or vent within the stuccoed walls of the home and garage as the house was being completed (see 1982 *Homeowner's Guide*... p. 15; 2004 *Homeowner's Guide*... p. 19). The fire-safety emergency devices were put in place whenever a fire potentially threatened the neighborhood. He then also taught his neighbors the lessons he had learned. During the 1993 Old Topanga Fire, when a firestorm overran the house, small wooden vent covers at the rear of the house facing the slope and upstairs wooden shutters placed from the interior saved the house when one of the windows broke and the vents were charred black during the burnout period of the low-growing coyote brush on the steep and long slope located within 15 feet of the rear of the garage. This was reported by the *Los Angeles Times* on November 5, 1993 and other news media at this time. Others in the neighborhood had installed roll-down metal fire shutters along fire-exposed windows. Being educated to the potential fire danger and knowing what to do and following through paid off in all instances investigated.

Further research has indicated that home losses can be effectively reduced by focusing mitigation efforts on the structure and its immediate surroundings. Those characteristics of a structure's materials and design and the surrounding flammables that determine the potential for a home to ignite during wildland fires (or any fires outside the home) from direct flame impingement as well as the ever-present firebrands are being referred to as home ignitability[18]

The Stanford Research Institute report (1973) quoted earlier, is a think-tank" report based largely on raw data provided by the City and County of Los Angeles Fire Departments and the U.S. Forest Service. In carrying out a comprehensive economic analysis for protecting the Santa Monica Mountains from wildfire, the report proposed and analyzed the following three alternatives:

1. To reduce the number of wildland conflagrations.
2. Given the number of wildland conflagrations, to reduce their extent.
3. Given the number of wildland conflagrations, to reduce the damage (to structures).

The fire-adapted vegetation in the mountains and the fire weather patterns make wildland fires inevitable. Reducing

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[18] Cohen, Jack D. "Reducing the Wildfire Threat to Homes and How Much?" Paper presented at the Fire Economics Symposium in San Diego, CA. April 12, 1999.

the number of wildland fires and reducing their size would require lateral fire barriers such as firebreaks of at least 200 feet in width or wider fuel breaks that require a large labor input for maintenance of even greater width. Attempting to stop the frontal advance of wildland fires to the beach would require horizontal (E-W) firebreaks of at least ½ mile in width. But even then, there would be no guarantees that wild-driven wildland fires could be stopped because of spotting of firebrands. As such, alternative 3 was the only one economically feasible with benefits to society overall. It uses the fire loss data of the 1961 Bel Air Fire in predicting future fire losses in the Santa Monica Mountains. In using the least-cost plus-loss planning method, the conclusion was that, with then approved (fire-retardant) roofs and "brush" clearance of 100 feet, the average home destruction rate could be limited to 7 homes per year for the whole Santa Monica Mountains stretching from Ventura County to Griffith Park.

To accomplish this, the three final recommendations were:

> 1. Public Education - Fire agencies should emphasize that occasional large-scale fires are inevitable in the Santa Monica Mountains and urge that steps be taken to minimize the loss when the conflagrations occur.
> 2. Insurance Surcharge Rates - The brush surcharge rates should be set to reflect expected losses. If present rates do not meet this criterion, they should be revised.
> 3. Planning for Fire Protection – Fire protection agencies should use the least-cost plus-loss economic planning methods as illustrated in the report; fire research and planning groups should continue to develop them.

The report also noted that brush clearance is inadequately enforced and only applies to "brush" and that flammable landscape vegetation that often replaces flammable brush is not required to be cleared. The report then suggested that research should also be directed towards the role of ornamental shrubbery in the spread or containment of fires. It also stated that additional steps should be taken to protect individual homes from fires aside from the first step of installing fire-retardant roofs (whose meaning has now been replaced with the more stringent requirement of nonflammable and preferably Class A roofs as well as Class B roofs) and clearing the "brush" should include:

1. Reducing overhanging roofs and closing other openings to the house to prevent flying embers from entering it .
2. Installing fireproof shutters, especially on the sides of the house that get direct fire exposure.
3. Having auxiliary pumps for swimming pools.
4. Eliminating flammable objects from the yard.
5. Improving access driveway standards.
6. Initiating programs to train able-bodied citizens to defend their houses during periods of moderate fire exposure.

If all the above listed items would have been diligently followed up and enforced, the report estimates that fire losses could perhaps have been reduced to that approaching the average of 7 homes per year. However, the Stanford Research Institute report did not foresee the continuous permitting of homes (inclusive of the proliferation of accessory structures and barns, flying decks, wooden balconies and wooden fences) in high fire risk areas. The siting and density of such homes added structural fuel components that increased the spread and reduced the containment of fire. Also, the role of topography was not yet addressed in "brush" clearance requirements, and (as even shown today in most brush clearance publications) most fire department pamphlets still show the house situated on level land with proper ingress and egress that includes the building pad as well as a flat 100-to-200-foot clearance distance with no surrounding homes. The real problems faced by homeowners struggling with living in steep mountainous topography with often limited ingress and egress and with other homes nearby is often an instant disconnect when they are provided with such unrealistic guides.

Lee and Bonnicksen,[19] in evaluating brushland watershed management policies in southern California, came to their somewhat surprising findings that increasing monetary losses in wildland fires appear to have resulted from the increases of property values at risk and not from the increases in number of acres burned. This holds also true for

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[19] Lee, Robert G. and Thomas M. Bonnicksen. "Brushland Watershed Fire Management Policy in Southern California: Biosocial Considerations." California Water Resources Center. University of California. Contribution No. 172. August 1978. 73 pp.

wildland fires in the Santa Monica Mountains and indicates that the Stanford Research Institute report (1973) that recommended its alternative 3, reducing the damage (to structures) through fire-safe construction and clearance of flammable vegetation, is still the most cost-effective bio-social consideration.

Further requests for studies on solving the fire problems in the Santa Monica Mountains, often urged by the public, elected officials as well as fire chiefs such as County Fire Chief Houts himself, continued for quite some time and became more urgent with every uncontrollable large-scale fire. One such study by Lowden and Degenkolb (1972)[20] recommended the development of a strong fire research program within the Los Angeles County Forester and Fire Warden Department. One such program was then initiated soon thereafter with cooperative research programs between the County of Los Angeles and the U.S. Forest Service Riverside Fire Laboratory, and expanded in 1976.

The 1976 5-year research and development program called Vegetation Management Alternatives for Chaparral and Related Ecosystems, headquartered at the Riverside Fire Laboratory, was initiated by the U.S. Forest Service Pacific Southwest Forest and Range Experiment Station and the Pacific Southwest Region, Forest Service, U.S. Department of Agriculture. (A comprehensive report of its findings, recommendations and management guides produced was published in 1986).[21] The County of Los Angeles, through the Los Angeles County Forester and Fire Warden, continued to be one of the grant-receiving cooperators with Klaus Radtke continuing as its cooperating scientist. Several then state-of-the art publications were produced by this author and others during the five-year period such as his *Living More Safely at the Chaparral-Urban Interface* and *A Homeowner's Guide to Fire and Watershed Management...*, published at the insistence of the Forest Service. However, many of the recommendations were not seriously addressed and were started to be implemented only reluctantly by local agencies before the wildfires of 1978, 1982 and 1993 that burned 230, 85, and 333 homes respectively, and 202, 11, and 112 structures that included barns, sheds, detached garages, etc.

Research was hampered and then generally shut down within the Fire Department because of concerns raised by a post tax-cutting-related audit (Proposition 13) that attempted to streamline the department. This audit, among other more items, recommended that up to 25% of fire department rank and file jobs be filled by civilians (with great salary and retirement savings), as they are not directly involved in firefighting but that the wildfire prediction research carried out within the Forestry Bureau (by Radtke) be prioritized.

Since, in response to this audit, the efforts of foresters in fire-related work were further marginalized, cooperative wildfire-related research within the Fire Department was largely continued “under the radar” by this author. Non-published research still focused on assisting firefighters with evaluating potential home losses given a fire start in the area and supporting a then-controversial triage system for predicting home losses in a fire, defending defensible homes with limited resources available, and bypassing predictable indefensible homes in a fire conflagration.[22] Some studies focused on predicting a fire's path given a fire start and recommending its containment (largely along flanks in a large-scale fire) based not only on man-made barriers such as firebreaks and roads but also types and age classes of native woody chaparral vegetation.[23] Efforts were also made to disseminate public safety information when feasible.[24]

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[20] Lowden. Merle S., and John G. Degenkolb. Fire in the Malibu. U.S. National Bureau of Standards. 1972. 16 pp.

[21] Conrad, C. Eugene, George A. Roby, Serena C. Hunter. “Chaparral and Related Ecosystems: a 5-year Research and Development Program.” Gen. Tech. Rep. PSW-91, Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1986. 51 pp .

[22] Radtke, Klaus and Martin Gubrud. “Evaluation of Roof Types from Infrared Aerial Photographs.” Unpublished document prepared under Cooperative Research Agreement 21-436 between the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture and the County of Los Angeles and its Department of Forester and Fire Warden. On file, County of Los Angeles, Department of Forester and Fire Warden, Los Angeles. July 11, 1980. 14 pp.

[23] Radtke, Klaus. 1982. The Oat Fire of October 31-November 1, 1981. Unpublished report prepared under Cooperative Research Agreement 21-436 between the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture and the County of Los Angeles and its Department of Forester and Fire Warden. On file, County of Los Angeles, Department of Forester and Fire Warden, Los Angeles; 22 pp. 1 map.

[24] Radtke, Klaus. An Urban Viewpoint of Wildland Fire Problems. In: Proceedings of the 1980 national conference of the Society of American Foresters. Oct. 5-8, 1980. Spokane, Washington. Society of American Foresters; 1981: 117-122.

The summary of one such report, filed away somewhere in County files, reads as follows:[25]

> Six fuel management alternatives were proposed to meet the objectives of reducing large-scale fire conflagrations as well as the damage to property and watershed values. It was shown that the best long-range fuels management alternative for the Santa Monica Mountains may be Alternative F.
>
> Alternative F presupposes that all agencies adhere to a land use plan that incorporates fire-safe zoning ordinances and building codes that are vastly improved. This land use plan must also recognize the interrelationship of fire and watershed management (of vegetation and topography) and must not favor one over the other. Lack of multiple purpose management may be witnessed throughout the mountains when local brush clearance ordinances are strictly enforced by the fire services on steep terrain to which they may not be applicable. Additionally, the land use plan requires that public agencies update their ordinances to assure that they are not in conflict with one another (and public safety).
>
> Alternative F also presupposes that homeowners are made aware of the fire and watershed management problems in fire-prone mountainous areas so that they can effectively manage their land as well as their home.
>
> Prior to the establishment of large-scale mosaics of different vegetation classes in woody chaparral (which could be largely accomplished through effective wildland fire management), intensive research has to be completed throughout the mountain range on fire behavior, fire corridors (fire topography), fire climate, and vegetation. This information must then be assimilated to create an effective fire barrier system for the Santa Monica Mountains which could act as backbone for the mix of fuel management methods that is going to be used by the different agencies. The additional value of such studies is that it provides quantitative data to answer many related questions that arise in effective fuel management.
>
> Fast-moving fires of low to moderate intensity (as measured in environmental terms) in annual or soft chaparral may be a fact of life which public agencies have to accept given the restraint on aggressive firefighting due to past haphazard development. Any management alternative should be careful not to increase these vegetation types at the expense of chaparral so that large-scale fires and their frequency are not changed or increased from one vegetation type to another.

After 1982, Radtke, in private practice, continued to oppose non-fire-safe development in the Santa Monica Mountains[26] and supported fire-safe community standards that must include safe and adequate ingress and egress.[27] In 1984, with Judge Baker of the National Foundation for Environmental Safety as moderator, a professional seminar was held at the Malibu Civic Center's Library attended by Fire Department personnel from Los Angeles County, Los Angeles City, and Ventura County Fire Departments as well as research professionals and interested homeowners. The meeting highlighted unpublished research carried out under the Chaparral Research and Development Agreement. Fire history, vegetation type, and age class maps were displayed on overlays and historic fire corridors were outlined. It was shown how the lessons gained from such research could predict fire patterns given a fire start and where and how fires could be fought effectively under different fire weather regimes because of less resistance to containment. Such knowledge gained by fire chief officers led, for example, to the containment of the eastern flank of the 1993 Old Topanga Fire along Topanga Canyon Road.[28] However, such knowledge gained has to be continuously updated to be applicable to current field conditions.

There are firebreaks within the Coastal Sage Scrub areas of, for example Corral Canyon, that have not been

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[25] Radtke, Klaus. "Fuel and Fire Management in the Santa Monica Mountains." Unpublished document prepared under Cooperative Research Agreement 21-436 between the Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture and the County of Los Angeles and its Department of Forester and Fire Warden. 1980. 54 pp.

[26] Radtke, Klaus. Re: Rancho Malibu Estates (Vesting Tentative Tract Map No. 46277. Document addressed to Los Angeles County Board of Supervisors raising concerns about this unsafe development. Geo Safety, Inc. 10 pp.

[27] Radtke, Klaus. Public Hearing on the Adoption of a Permanent Community Standard District, Malibou Lake. Document addressed to Los Angeles County Regional planning Commission. Geo Safety, Inc. 3 pp.

[28] Personal communication in 1994 at Fire Camp 2 by the chief in charge of this section.

maintained in the recent past and are slowly being revegetated naturally. If not maintained, the lower faces of such firebreaks will become vegetated with a mixture of highly flammable annual weedy species and highly flammable Coastal Sage Scrub components. One may ask when and why were such firebreaks established in the first place and why have they not been vegetated with "nonflammable" or "low fuel" vegetation. The following quote taken from the introduction to a 1938 research publication pertaining to test plots established in the Santa Monica Mountains by the Department of Los Angeles County Department of Forester and Fire Warden for revegetating firebreaks answers these questions:[29]

> "The many miles of firebreaks constructed during the past two decades produced an annual maintenance problem of major proportions. Firebreaks were constructed primarily to assist in rapid influx of firefighters to the conflagration, as a front line of defense from which to set backfires, and to retard the spread of fire if burning against the wind. The firebreaks, in order to be effective, must be free of vegetation in order to rob the area of fuel. Following initial construction, annual weeds and grasses appear as though from nowhere, which had to be removed by hand and on more favorable slopes by motive power. Areas where cleaning may be performed by caterpillars make up a very small percent of the firebreak."

Extensive test plots with more than 30 species of succulents were established in the 1930s throughout the southland in cooperation with the L. A. County Department of Forester and Fire Warden, the U. S. Forest Service, arboretums and nurseries, as well as the University of Berkeley. One such plot was also established after the 1935 Fire adjacent to Latigo Canyon Road about one mile north of the Lechuza Fire Patrol Station. Results indicated that the plants would be eaten by deer and rodents if not fenced, would largely freeze in the higher elevations, would require supplemental watering, and could not compete with the native vegetation as they were more suited for the immediate coastal areas.

As the wildland-urban interface extended more and more into the mountains and mingled often highly flammable structures and flammable landscape vegetation with highly flammable native vegetation, the options for maintaining and using firebreaks for backfiring and effectively fighting wildland fires diminished greatly. While lateral firebreaks have proven effective in the past to contain the flanks of even wind-driven fires, the emphasis is now on mass or forced evacuation during wildland fires. Unfamiliarity with the area by out-of-town firefighters, structural firefighters exposed to wildland fire fighting in unfamiliar territory, and the lack of effective firefighting due to crowd control and evacuation has already affected fire patterns of recent fires, will undoubtedly increase the acreage burned in the area, and has increased structural losses. The latter has been well documented for the Santa Monica Mountains. Homes unattended by either homeowners, friends or residents, or firefighters have a much greater probability of burning than attended homes as many homes slowly ignite and become fully engulfed after the fire front has passed.

The opening of the coast road and highway from Santa Monica to Oxnard at the close of the Rindge Ranch area by the early 1930s started a real estate boom that also saw development in the riparian areas of lower Corral Canyon. For example, the 1950 Los Angeles County Forester and Fire Warden base map identifies only one structure located along a permanent road leading more than 750 feet along the creek from the highway into the canyon as the Parmalee residence.**[30]** However, the 1950 Malibu Beach Quad map[31] based on aerial photos, shows 3 structures within the riparian area of lower Corral Canyon with a permanent road extending now to 1,500 feet through and along the creek unto the canyon. Dirt roads branching off from it lead west, then east up to and across the Coastal shelf and north along the riparian boundary and up a short distance into the hills towards a relatively flat area.

When the western flank of the 1943 Woodland Hills Fire burned across the Corral Canyon area, it did not reburn a thin strip of riparian vegetation within lower and central Corral Canyon. While this often gives residents the false hope that they can also by luck, divine intervention, preparedness, or firefighter intervention survive the next fire, this is often not the case unless they have a truly fire-safe home built in an area where it can be easily protected or

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[29] Gerhardy, Carl O. "Succulent Plantings at Lechuza Plot, Santa Monica Mountains March 1936." *Department of Forester and Fire Warden, Los Angeles County*. December 23, 1938.

[30] Los Angeles County Forester and Fire Warden. 1950 base map. Santa Monica Mountains. Scale 1" = 2,000 feet.

[31] USGS (United States Geological Survey). Malibu Beach 7.5 minute quadrangle topographic Map. 1950.

can serve as a stand-alone fire shelter. These lessons were then learned (but generally soon forgotten) when the 1958 Liberty Fire, in burning 74 homes in its path, also burned 17 homes in the Corral Canyon area.

Rebuilding and new construction becomes easier after the vegetation is cleared by fire, and the 1967 Point Dume quad[32] map now shows an additional structure further along the dirt road that leads to north into the canyon, as well as at the terminus of the dirt road leading west out of the canyon that is now connected to Corral Canyon Road. The photo-revised 1981 Point Dume Quad map[33] now only shows the original (now uninhabited?) three (rebuilt) structures from the 1950 quad map. The unimproved roads west to Corral Canyon no longer exist, and the access road from the highway is also eliminated. Such roads became overgrown with native as well as weedy, exotic vegetation such as Black Mustard. When walking the area, remnants of Rindge Ranch range fencing were still in evidence along the hillsides.

[32] USGS (United States Geological Survey). Malibu Beach 7.5 minute quadrangle topographic Map. 1950 (photo-revised 1967).

[33] USGS (United States Geological Survey). Malibu Beach 7.5 minute quadrangle topographic Map. 1950 (photo-revised 1981).

V. Australian-type Emergency Fire Shelters/Fire Bunkers

After the Australian Victoria Fire of February 6-7, 2009, in which over 170 people were killed largely trying to escape fire infernos by car, private contractors proposed fire-proof “live-in fire bunkers” as stand-alone structures adjacent to homes. Some of these private bunkers were often designed to withstand the extreme heat of over 1,700° F generated by direct flame impingement in a fire inferno characterized by heavy woody fuels with long burnout or fire reburn periods that could extend into hours. Many of the destroyed homes were located in the midst of Eucalyptus forests with minimal fire clearance and minimal fire-safe designs or construction. Eucalyptus forests are known to be some of the most explosive and volatile wildland fire fuels in the world and, once ignited, fires cannot be stopped in them.

Such bunker shelters can be considered an extreme case of a “live-in” fire shelter where all common sense and fire science evidence about living more safely within the wildland urban interface has been thrown out the window, thereby expecting a predictable design for disaster. To this author's knowledge, no freestanding private nor public wildfire emergency shelter bunkers have been designed and/or approved by any public agency in fire-prone wildlands in the U.S. It must be emphasized that fire bunkers are not a safe nor meaningful alternative to proper siting of buildings or campsites, meaningful fuel modification, and construction of fire-safe homes.

However, because of the fire politics of such fire bunkers in Australia, and the life safety concerns about the proliferation of private contractors that advertise fire bunkers that often do not address or evaluate the threat level and occupant load required, the Australian Building Codes Board (ABCD) is preparing to add a new building classification namely Class 10c – Private Bushfire Shelters.

In the preface to the standards, ABCD immediately issued a disclaimer stating “The guidelines do not constitute and must not be relied upon as legal or other professional advice. You should seek legal and other specific professional advice tailored to your needs and circumstances.”[34]

In its media release on *National Standards for Private Bush Fire Shelters*, ABCD clearly states and cautions “However, the standards and private bush shelters are not stand alone solutions to protect people in bushfires. As the Board has made clear in the past, building standards need to be part of a wider set of measures to deal with mitigation of bushfire risk, including effective coordination of efforts by authorities and communities, predicting fire spread, better education of homeowners, clarity in community notification procedures and sound planning and fuel management strategies.”

The overall Australian emphasis here is on PRIVATE FIRE SHELTERS and NO LIABILITY TO PUBLIC AGENCIES, as no public agency will and can endorse private or public fire shelters.

[34] ABCD -Performance Standards for Private Bush Fire Shelters 2010 (Internet Research).

VI. Camp Sites within Fire-prone Coastal Sage Scrub or Chaparral Watersheds

What about camp sites in fire-prone Coastal Sage Scrub or Chaparral areas? The Butler and Cohen research results described earlier indicate that, in order to prevent injury from largely radiation heat to firefighters caught in the open with protective clothing, an open ground safety zone should be large enough (and therefore cleared of flammable fuels) so that the distance between the person and the flames is at least four times the maximum flame height. Such a zone was defined as providing freedom from danger, risk, or injury.

The above guidelines, not even taking unpredictable wind patterns and convection heat sources in account, would require a total (!) fuel clearance zone of at least 50 to 200 feet with campers huddled in the middle of campsites with protective gear (!). Furthermore, clearance distances must be so shaped as to provide a buffer of at least 50 feet to the closest grassy vegetation and about 200 feet from the drainages or any heavier, continuous fuels. It must be acknowledged that few campers would be wearing proper fire-protective clothing if a wildland fire develops and they could be required to find shelter within a few minutes. Tents must also be considered potential fuel and could further compromise the minimum required safety zone if they catch on fire.

Highly flammable vegetation could have a flame residence time of as little as 5 to 15 seconds for grass, perhaps several minutes for pockets of degraded coastal sage scrub, and perhaps about five minutes or slightly more for the brush in canyons. This, and also the smoke created, depends of course on such factors as fire weather conditions, the fuel itself, live and dead-to-live fuel moisture, and wind patterns.

Direct fire line exposure of campsites to flame and heat is life-threatening, as one can succumb to radiation and convection heat sources before the flames from the fire front overrun the sites. However, as discussed previously, short-term smoke exposure in wildland fires is not life-threatening but can have short-term health effects. With no wind, the fire's smoke column rises straight up in the air while in strong winds it lays down on the landscape and becomes heaviest in canyons and draws. Level plateaus will be exposed to less smoke under such conditions than canyons and draws. However, lower canyon areas, often heavily vegetated with riparian vegetation, may be a smoke sink while burning. Native coyote brush, often found intermixed in disturbed riparian areas, has approximately 10% crude fat or oil content as measured by oven dry weight. This is similar to Chamise, considered the most flammable chaparral species. Plants with a high oil content such as Coyote Brush, Chamise, sages, and landscape plants such as Rosemary, needle-like conifers, and many Eucalyptus species, when burning give off much more smoke than plants with a low crude fat content. These plants often explode when they reach the ignition point, giving off thick, dark smoke in the process. Plants with a low crude fat content but with a high moisture content give off more smoke that is lighter colored than similar plants burning under dry conditions.

Exposure to smoke from poison oak is generally not a concern in grassland or Coastal Scrub communities but could be a concern in nearby canyons and north slope chaparral plant communities.

From personal experience this author knows that camping in the Santa Monica Mountains—as he has occasionally done since 1960—or “hiking through the brush” may expose one not only to an occasional wildfire threat when the fire ignition conditions are high, but also to other natural hazards on a daily basis. While he would not hike or camp in these mountains during days of high fire danger, other dangers he encountered were flash floods in narrow canyons, mudslides, rattlesnakes, and black widow spiders on the ground, grass and brush (was bitten by one once). There was also an abundance of bees largely when the sages were in bloom in the coastal sage scrub in early winter and the woody chaparral species in mid-winter and spring. Encountering ground wasps is normally also an unpleasant experience. Heat exhaustion or heat stress that could include symptoms such as fatigue, dizziness, weakness, nausea, vomiting, headache, muscle cramps, or even impaired judgment could happen on hot days and could ultimately lead to heat stroke, a life-threatening situation.[35] Earthquakes may also be an occasional rare and unnerving experience.

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[35] Frantz, Robert E. “Firestorms and Wildfires” (Chapter 20) in *Disaster Medicine* authored by Hogan, David E., and Jonathan L. Burstein.

With the above concerns in mind, no open ground safety zone “fire shelters,” even where feasible, would generally be meaningful alternatives for the overall fire safety of camping in well-maintained public campgrounds. Open ground safety zone “fire shelters” have the built-in potential of becoming a design-for-disaster during unpredictable and rare circumstances of sudden, unexpected life-threatening fire behavior within or in close proximity to campsites.

Many fires have and are continuing to provide insight into the potential for loss of life. For example, hazardous conditions were dramatically shown in videos made during the early phases of the October 20, 1991, Oakland Tunnel Fire.[36] The fire had reignited in a small pine needle burn thought to be extinguished the previous day, Saturday, by the local fire department. The next morning the weather changed with gusty winds picking up that quickly reignited the fire hidden in the duff below the pine needles, and carried spot fires onto adjacent slopes covered with flash fuels and then onto highly explosive pine and eucalyptus trees. The exploding trees crowned and the resulting firestorm flames, stretched by high winds, along with the rain of firebrands, engulfed street after street largely lined with wooden homes. Since it was a Sunday morning many people were at home. As the large, seemingly fire-safe Parkwood apartments complex became engulfed with flames, the single exit from it became clogged with cars and fleeing pedestrians. Piles of woodchips had been stored near the exit there as they were being spread out within the landscaping. As the pedestrians were trying to flee, they were showered with blinding wood chip firebrands as well as wood chip debris. Close by at Charing Cross Road, tragedy had already unfolded in an area where the paved sideslope-situated street narrowed to about twelve feet in width with a long and narrow draw vegetated largely with weedy grasses and native coyote brush pointing uphill towards it. Some cars attempting to escape the fire jammed up along this narrow stretch of road and able-bodied residents jumped out of their cars, fleeing along the road. Oakland Police Officer John Grubensky was directing the fleeing residents to hurry along the road to safety until the convection and radiation heat rushed over him and engulfed his body. The last person to escape alive remembered seeing that his pants legs were already on fire as he was encouraging her to run past him. He and five other civilians were found burned to death in this location and others were found nearby. While this tragedy had been unfolding, residents in homes on a nearby street cried out for help as some of them were being incinerated within their homes, with firefighters unable to help because the fire was too intense.

Two years later, on November 2, 1993, during the initial phases of the Malibu-Topanga Fire, another predictable but preventable design for disaster resulted in the incineration of two elderly mountain residents. They lived in a non-permitted temporary makeshift firetrap trailer home without utilities such as water and electricity. It was accessible during the dry season by a narrow dirt road that led through the chaparral and across several small draws. The situation was known to fire personnel of close-by Fire Camp 8, other County Department personnel as well as nearby wildland residents. Some had befriended the couple and assisted them as needed and hoped to be there for them in emergencies. After the fire broke out the wife, working in Santa Monica, heard about it and rushed home in the afternoon through traffic, roadblocks and fire lines to evacuate her invalid husband. She was forced to drive up into the mountains apparently along the longer route across the Las Flores Canyon bridge before it caught on fire because Rambla Pacifico had long been closed by a landslide. After evacuating her husband and attempting to drive back along the dirt road, her car was overrun by fire close to the safety of stand-alone fire-safe homes at the end of the dirt road and near Fire Camp 8. The most accessible home at the beginning of the dirt road was empty and locked because the residents were on vacation and others had apparently been evacuated.

In the area where the fatalities occurred, the 1993 fire had burned through an incomplete burnout within the Piuma Fire of October 14, 1985. The burnout was characterized by standing dead fuels characterized by a higher dead-to-live fuel ratio than would normally be found in 8-year-old woody chaparral regrowth. Additionally, because of further disturbance, the degraded woody chaparral had a high herbaceous flash fuel component.

One must also not forget the lessons learned from the tragedy that occurred during the Griffth Park Fire of October 3, 1933 in Los Angeles County. It killed 25 park workers and injured and often severely burned an additional 130

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[36] Klaus Radtke—the incidents described are based on personal knowledge gained from research conducted, inclusive of site investigations and review of documents, photographs and videos (1991 [Oakland] Tunnel Fire) and personal association with the victims years prior to the fire (Old Topanga Fire).

hired by the County to combat unemployment with park work. The *Evening Outlook* newspaper in Santa Monica described the developing tragedy as follows: "Deep in the canyon a small area was in flames. There was little or no wind. The flames and smoke from the burning scrub oak growth at the canyon's floor were shooting straight up."[37] When suddenly strong winds came up and ignited the narrow box canyon the young men raced up the steep canyon walls after they were trapped by the walls of flames. As described by survivors, the scorching heat first dropped many of the victims before they were overrun by the flames. When the tragedy became known thousands stormed morgues in dread fear loved ones lost their lives in the canyon inferno." The next day the *Evening Outlook* reported that the quickly formed board of inquiry stated that ill-timed backfiring had cut off the workers in the canyon.[38]

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We must keep in mind the proverb "That what can never happen always happens first."

[37] *Evening Outlook*, Santa Monica, California. Wednesday, October 4, 1933.

[38] *Evening Outlook*, Santa Monica, California. Thursday, October 5, 1933.