California Coastal Commission

Natural History of Fire & Flood Cycles

Prepared by *Jack Ainsworth & Troy Alan Doss* as a presentation to the Post-Fire Hazard Assessment Planning and Mitigation Workshop at the University of California, Santa Barbara, August 18, 1995

"...many people do not understand the ecological and scientific concepts behind fire. For many, fire remains a fearsome, destructive force that can and should be controlled at all costs. Smokey Bear's simple, time-honored "only you" fire prevention message has been so successful that any complex talk about the healthy, natural role of fire gets lost, ignored or denied by broad internal and external audiences."

from the ***Federal Wildland Fire Management Policy & Program Review Draft Report - June 9, 1995***

The July/August 1995 issue of *Sierra* magazine featured an article entitled "Only You Can Postpone Forest Fires". Although the message of this title may falsely incriminate Smokey Bear for the current pyrotechnic state of America's wildlands, it does imply an important fact; our wildland vegetation burns. It burns periodically, and must burn in order to survive. In much of California, the problem is not so much the fact that it burns but that all too many people chose to build within it, surrounded by what many consider to be a sea of gasoline. A combination of ignorance and several million years of evolution have combined to create a deadly situation along the serene and scenic battlefront commonly referred to as the '*wildland/urban interface*'. The situation has been further exacerbated by over a hundred years of fire suppression where man has tried to control nature, usually with disastrous results.

Fire is an essential part of most wildland ecosystems. In Mediterranean climates around the world, plant species have adapted to a point that they would not exist without the presence of fire. Wildland fires spawn a period of rebirth and vigor in post-fire environments by removing dead materials and by releasing nutrients back to the environment that are locked up in mature plants and organic litter. Many fire prone habitats exist around the globe, however, this paper will focus on the

Mediterranean climate of Southern California, and its associated plant communities. Further emphasis shall be placed on the Santa Monica Mountains region where the fire/flood cycle has existed for millions of years, and where impacts of living in the wildland/urban interface have been so clearly illustrated following the Green Meadow and Old Topanga Firestorms of 1993. However, it should be noted that the fire/flood cycle is not unique to the Santa Monica Mountains, and that much of California and the West is under the influence of this cycle as well, although some differences will occur due to habitat type, and the environmental conditions and other factors present.

Fire in the Landscape

Natural Causes of Fire

The presence of fire in the landscape has been one of the major evolutionary factors determining the composition of flora throughout the state and around the world. Natural causes of fire range from lightning, sparks from falling rocks, volcanic activity, and the spontaneous combustion of plant materials and other organic matter (Barbour, Burk, & Pitts 1980). However, of these, lightning is the most influential factor in almost all regions of the world as lightning strikes the earth an average of 100 times a second totaling over 3 billion strikes a year (Barbour, Burk, & Pitts 1980). Generated by summer thunder storms, lightning is responsible for much of the wildland fires that occur throughout the western United States each year, and have been the cause of such notable fires as those occurring in Yellowstone and Yosemite National Parks in 1988 and 1990 respectively.

Lightening is the result of storms created by the convergence of a warm moist rising air mass with a cool high air mass as the warm air mass attempts to pass over a mountain range. This convergence is typical along the Sierra Mountains, and desert ranges inland, and also occurs, but to a lesser extent, along the coastal ranges. In California, lightening caused fires typical occur above 5,000 feet in altitude, but are recorded to have occurred at much lower elevations (Burcham 1987).

Man and Fire

Man has also played a role in the pattern of fires in the landscape, dating back possibly as far as 30,00 years ago with the arrival of the first Americans. Early Spanish explorers and missionaries documented the use of fire by Native Americans who used fire clear areas for the germination of oaks, for the production of acorns, and to create and maintain grasslands for hunting. Many Native American stories speak of the use of fire, and these stories indicate that wildfire was also a concern of Native Americans and that fire was used in a careful and respectful manner (Burcham 1987). Latter, European settlers used fire to clear brush so land could be used for agricultural purposes. Through the use of fire, patterns or burn mosaics may have been created, which, to a certain extent, may have operated as a fuel break due to the reduction of dead fuels. These inadvertent fuel breaks would have been very important to early Americans due a limited ability to control blazes of any substantial size.

Types of Wildfires

Three main classes of wildfire exist depending upon location in the fuel matrix and intensity. These are *surface*, *crown*, and *ground* fires. *Surface fires* are typically low intensity, rapid fires that seldom reach high temperatures. These fires consume light fuels and present little danger to basal portions, root stocks, and tubers, in the soil (Barbour, Burk, & Pitts 1980). *Crown fires* occur in the upper sections of trees and are typically the result of a surface fires. During such fires surface materials and trees alike are ablaze. Ignited branches and embers fall to earth further spreading the fire. *Ground fires*, although occurring less frequent than other forms of fire, are typically very intense blazes that remove vegetation and organic matter down to bare mineral earth. The heat and intensity of such fires can destroy roots, tubers, and rhizomes, located beneath the soil surface and may devastate entire plant communities (Barbour, Burk, & Pitts 1980).

Response of Vegetation to Wildfire

Various plant species depend upon fire as a means to reproduce, while others have adapted to survive in the presence of fire. However, the process by which species have adapted varies greatly. Species such as Monterey, Bishop, and Knobcone pines have adapted to produce pine cones which hold seeds locked by a resinous coating that is melted away by fire (Baker 1971). Following a fire the seeds are released and benefit from improved growing conditions such as available sunlight, a seedbed of bare mineral soil, and nutrients released from organic matter cleared by the fire. Other species of plants produce seeds which lie dormant in the seedbed and will germinate only after a fire heat-treats their seed coat and removes duff from the top soil.

In the case of Coast Live Oaks, *stump sprouting*, or the generation of new stems and growth from brunt trunks and branches, occurs following a blaze. In similar manner species such as Our Lord's Candle, *Yucca whipplei*, produce new growth from the root crown of a burnt plant in a process known as *crown sprouting*. Although all plant communities have developed a response to fire, the chaparral community associated with the Mediterranean climates of the world may be the most fire responsive.

Patterns of Fire on the Landscape

The pattern of vegetation on the coastal ranges is influence by factors such as exposure, geology, and of course fire. In the Santa Monica Mountains these patterns are clearly observed from Agoura Hills to Point Mugu. Rarely are slopes covered entirely with a pure stand of chaparral, grassland, oak woodland or other vegetation type in which all the vegetation is of the same age or vegetation group. Exposure, climate, and geology dictate what will grow where, and fire acts as agent to clear old growth and germinate new vegetation. In the Santa Monica Mountains, coastal sage scrub is the dominate vegetation type on the seaward slopes due to a strong marine influence, whereas chaparral tends to prevail in the northern land ward section of the range. Oak and walnut woodlands, as well as grasslands, can also be found in the interior sections of the mountains adjacent to or intermixed with chaparral vegetation and in the riparian corridors in located at the bottom of canyons which drain into the sea.

Soils and exposure create different growing conditions on southern and western facing slopes, than exist on northern and east facing slopes. In areas covered by oak and walnut woodland, slopes facing southwest may tend to be dominated by oaks, whereas the northeastern slopes will contain a mix of oaks and walnuts which appear to prefer moist shale types of soils. On the coastal sections of the mountains, southwestern slopes will tend to have shrubs such as Buckwheat, Toyon, or Rhus, whereas adjacent northeastern facing slopes may tend to be dominated by Black and White Sage, and other herbaceous shrubs which need more moisture than their xerophytic neighbors across the canyon. It should be noted that a mix of both vegetation types, coastal sage scrub and chaparral, may be found within opposite canyon walls due the presence of micro climates under the canopies of larger shrubs or trees, or in the shade of rock outcroppings.

Although a combination of soil, geology, exposure and climate may be the chief factors controlling vegetation type, fire plays an important role in the life cycle of these plant communities. When driving through California's coast ranges the pattern of fire can be observed as most landscapes are either burning, or in a pre-burn or post-burn state. This pattern can be observed where thick fields of wildflowers cover slopes adjacent to thick stands of chaparral, where a carpet of green grasses and flowers lay beneath a stand of branch sprouting oaks, or where a mosaic of grasslands, wildflowers and coastal sage scrub cover a hill top above a confer forest.

Chaparral, a Fire Ecology

Mediterranean/Chaparral Climate

Chaparral habitat covers only about 8.5 percent of California, and only ranges in elevation from near sea level to over 5,000' in Southern California, and up to 3,000' in Northern California. Yet, it is considered by many to be the most characteristic vegetative community of the state (Hanes 1987). This is especially true in Southern California. Chaparral communities experience long dry summers, and receive most of their annual precipitation, 10 to 32 inches per year, from Winter rains (Radtke 1983). Although chaparral is commonly referred to as one community there are two distinct types; hard chaparral and soft chaparral, more commonly referred to as chaparral and coastal sage scrub respectively.

It is commonly believed that fire has been an important component of chaparral communities for at least 2 million years; however, the true nature of the "fire cycle" has been subject to interpretation. In a period of 750 years, it generally thought that fire occurs once every 65 years in coastal drainages, and once every 30 to 35 years inland (Barro and Conard 1990). Many wildland blazes of the interior mountains of California are the cause of lightning; however, in the coastal ranges of the state, where coastal sage scrub is a dominant community, the "Catalina eddy" and marine influence create conditions where summer lightning rarely occurs (Radtke 1983). Despite the marine influence associated with the coastal range, lightning, or other nature causes, may still have played a major role in the creation of early to mid summer fires. Yet, with the advent of fire suppression, fires in this region now occur predominately between late fall and early winter, coinciding with the Santa Ana winds. These fires differ in intensity from the interior summer blazes as Santa Ana conditions result in lower than normal humidity levels and produce high wind speeds which further intensify a wildfire to a point where it produces its own weather conditions creating what is commonly referred to as "*firestorm*". These fires are often too intense to control until fuels are either consumed, weather conditions change, or the fire reaches the sea.

Role of Fire in Chaparral Habitat

The vegetation of chaparral communities has evolved to a point it requires fire to spawn regeneration. Many species invite fire through the production plant materials with large surface-to-volume ratios, volatile oils, and through periodic die-back of vegetation (Barbour, Burk, & Pitts 1980). These species have further adapted to possess special reproductive mechanisms following fire. Several species produce vast quantities of seeds which lie dormant until fire triggers germination The parent plant which produces these seeds defends itself from fire by a thick layer of bark which allows enough of the plant to survive so that the plant can crown sprout following the blaze. In general, chaparral community plants have adapted to fire through the following methods; a) fire induced flowering; b) bud production and sprouting subsequent to fire; c) in-soil seed storage and fire stimulated germination; and d) on plant seed storage and fire stimulated dispersal (Barbour, Burk, & Pitts 1980).

Response of Chaparral to Wildfire

Whereas a yellow pine forest may take hundreds of years to recover to its pre-burn state, it may take only ten years for coastal sage scrub to recover following a fire. The recovery of a coastal sage occurs through a successional process in which various sub-communities of coastal sage are present at different time periods following the fire. During the first two years herbaceous annual species dominant the landscape. Fire treats the seeds of these species which flourish in an environment cleared of litter, high in available nutrients, and bathed in sunlight. It is during these years that spectacular displays of wildflowers abound. Species such as California Poppies, Blue Dicks, Mariposa Lily, Fire Hearts, Lupines and many others carpet the post-burn environment.

Among this colorful display is a rebirth of more typical perennial chaparral species such as Chamise, Coastal Sage, California Buckwheat, Poison Oak, and Bush Sun Flower. These and other species, such as Ceanothus, Manzanita, Laurel Sumac, and Sugarbush, begin to germinate from seed as the fire has scarified their seeds coats. Coast Live Oaks, and Laurel Sumacs also begin to recover through the process of crown sprouting and stump sprouting.

Two to three years following the blaze the fire annuals begin to disappear. They have produced vast quantities of seeds which are now stored in the soil until the next blaze comes along. The herbaceous community has succumbed to various factors such as a lack of fire scarified seeds, limited available sun light, due to a new canopy of perennial growth, and as the result of toxins, *allelopathogens*, released by perennials such as Chamise to reduce competition with other species. Many of the herbaceous species, such as Lupines, have laid the path to recovery by processing, or *fixing*, nutrients like nitrogen into a form which can be used by subsequent and more dominant perennial species. Other nitrogen fixing species like Deerweed have recovered as well, and it is at this time that perennial species begin to flower and thus start seed production once again.

Four to ten years following a fire the landscape is once again dominated by Chamise, Laurel Sumacs, Sugarbush, Buckwheat, Monkey Flowers, Live-Forevers, Toyon, and others. The community is reaching equilibrium and will begin the process of accumulating woody, dead, and organic materials rich in flammable oils until the next fire is allowed to burn, or escapes to the Santa Ana winds.

Fire / Flood Cycle

Erosional Processes in Chaparral Watersheds

Erosion is a prevalent process in chaparral habitat. Slopes ranging from 25 to 70 degrees in steepness are typical in chaparral habitat (Radtke 1983). This is due to the fact that chaparral habitat is typically associated with mountain ranges which are young and geologically active. Close to 25% of chaparral watersheds exceed what is referred to as the *angle of repose*, or the angle between the horizontal and the maximum slope that a particular soil or other material assumes through natural process (Radtke 1983). These slopes are shaped by gravity as materials not firmly attached to the slope slide and fall unless held in place by plant materials or other factors.

The Santa Monica, San Gabriel, and San Bernadino Mountains, as well as most of the coastal ranges, are extremely young and extremely geologically active. Writer John McPhee, in his essay *Los Angeles Against the Mountains,* suggest that the mountains of Southern California appear to be crumbling faster than they are rising due to the steepness, nature of rock and soils associated with these ranges, and the constant battering the ranges receive from earthquakes. McPhee relates the story of a group of scientists from Spain whom after observing the rate of decay of the San Gabriel Mountains felt sorry for their local counterparts who would be out of work due the rate of disintegration on the mountain front (McPhee 1989). The fact is, most of Southern California's mountain ranges are rising faster than they are crumbling.

Gravity, more than water or wind, may be the most important cause of erosion in chaparral habitat. On slopes steeper than the angle of repose a process known as dry creep and *dry ravel* occurs, which is basically the down slope movement of materials due to gravity. During dry years this process can exceed erosion rates that occur during the wettest season of the year (Radtke 1983). In parts of Southern California, the process of dry ravel, independent of fire, accounts for over half of all hillside erosion (Anderson and others, 1959; Krammes, 1965; Rice, 1974; Howard, 1982). Over 25% of the watersheds of Santa Barbara, Los Angeles, and San Bernadino Counties are effected by this process (Rice 1987). The occurrence of dry ravel is probably unknown to most people, even those that live in the wildland/urban interface, as this process occurs on steep slopes away from structures, or unobserved under a canopy of vegetation. However, the presence of dry ravel becomes apparent following a fire as the formation of *riles* formed by dry ravel and *dry creep* appear on the barren slopes of post-fire watersheds. On going studies in the California chaparral wildlands demonstrate that dry ravel and, to a lesser extent, the formation of extensive rill networks account for most of the increased sediment production following a fire (Wells, 1986). This process may even be more prominent in the post-fire environment due to creation of *hydrophobic* soil layers during a blaze.

Hydrophobic Chaparral Soils

During a fire temperatures at ground level may reach six to seven hundred degrees centigrade. Oils, resins, and waxy fats stored in plants and their litter are released as they vaporize due to the intense heat (McPhee 1989). Soil is a excellent insulator, and temperatures just several centimeters bellow the surface remain much cooler, allowing the vaporized substances to recondense forming what is referred to as a *hydrophobic* layer, a condition also known as *nonwettability*. This layer is impermeable and prevents water from reaching all but the first few inches of soil, but at the same time slows the process of evaporation in the root zone. The extent and depth of a hydrophobic layer will depend upon the type of soil present. In the case of clay soils, which are fairly dense, they tend to resists this condition; however, sandy and sandy loam soils appear to be far more susceptible to hydrophobic conditions (DeBano 1987). If a drop of water is placed on an pre-burn sample of sandy loam soil, the water will all but disappear. Yet, if a water is placed upon a post-burn sample, the drop will ball up and may remain there for hours. The depth at which these layers form is further the result of such factors as fire intensity, and the content of soil moisture (DeBano 1987). The firestorms of Southern California typically occur just prior to the winter rains. Water quickly saturates the thin layer of permeable soil above the hydrophobic zone not being slowed by a vegetative canopy. Slower infiltration rates result in an increased intensity of surface runoff and erosion.

Debris Flows

Post fire erosion rates may be more than 50 - 100 times greater than on a well vegetated watershed (Radtke 1983). Work by Davis (1977) suggests that many post fire flows are debris flows. In the watersheds that Davis studied he found bulking ratios in runoff ranged from 0.5% to 2.5% by volume for normal flows to 40% to 60% by volume for post fire flows. The process by which debris flows develop in the post fire environment are the acceleration of dry ravel and formation of rill networks. The rill networks develop rapidly and deliver runoff water to the stream channels where large amounts of debris, delivered by both processes, are stored (Wells, 1987). The result is a rapid mobilization of channel deposits into debris flows (Wells, 1987). These debris flows usually occur in small watersheds in response to unusually small amounts of rainfall. However, large debris flow events can occur when a extreme storm event occurs after a severe fire.

Work done by Florsheim and others (1991), following the 1985 Wheeler Fire near Santa Barbara, suggest that normal fluvial transport of these sediments is more likely, and moderate storm events that could mobilize sediments are far more likely to occur than large magnitude, high intensity storm events that would generate large destructive flows. In any event, what is clear is that the post fire landscape is subject to significantly increased erosion rates capable of producing large destructive debris flows. Increased post fire erosion rates can be expected for a period of 8-10 years. During this recovery erosion rates might be 9 to 10 times greater than those before burning.

Post Fire Landslides

Most chaparral in Southern California grows on geologically young mountains where the steep slopes range from 25 degrees to 70 degrees (Radtke 1983). About 25 percent of the chaparral watershed exceeds the angle of repose, that is the angle between the horizontal and the maximum slope that a particular soil or other material assumes through natural processes.(Radtke 1983). On vegetated slopes anchored by deep rooted plants the angles of repose can be much steeper. Specific factors that can cause or contribute to landslides are; 1) weakness of the slope material; 2) steep or undermined slopes; 3) unfavorable geologic structural conditions; 4) prolonged precipitation; 5) absence or sparsity of vegetative cover; and 6) ground shaking (Gray 1985). Landslide occurrences in the chaparral landscape are strongly related to the angle of repose for different soils , taking into account cover, root depth, and root strength. Soils slips and landslides account for almost 50% of the total erosion in a watershed (Radtke 1982). Unlike dry creep, these soil movements normally occur when the soil is saturated. Although hydrophobic soils, dry ravel and formation of rills and the debris flows associated with these processes account for the majority of post fire erosion, landsliding activity may also increase as a result of fire.

Increases in landslides during the rainy period following a fire could be caused by well-spaced storms that permeate the nonwettable layer and completely recharge the water holding capacity of the soil (Radtke 1983). Once the soil moisture is recharged, a high intensity storm could quickly supersaturate the soil, thereby accelerating wet creep, starting slumps slides, and greatly increasing overland flow (Radtke, 1983). However, post fire landsliding during the first few years following a fire may be greatly reduced on nonwettable soils if high intensity storms follow each other in close order, thereby reducing rainfall penetration through the nonwettable layer. The soil below the nonwettable layer would remain dry, eliminating landslides, but greatly increased overland flow would result in highly visible rill and gully erosion and would increase channel scour (Radtke, 1983).

Another possible contributing factor to increased landsliding in the post fire environment is stream channel scour and erosion. This process may remove or over stepped the channel banks contributing to landsliding of over steepened slopes along the creek channel, or possible reactivate previous landslides by removing the toe of the slide.

Development in the Chaparral Community

Santa Monica Mountains

The Santa Monica Mountains provide an excellent case study of the dangers of living in the wildland/urban interface. Physically, the Santa Monica Mountains are not that different from much of California's coastal or Peninsular Ranges, except for their proximity to the greater Los Angeles basin. Extending 46 miles from Point Mugu in Ventura County to Griffith Park in the heart of the City of Los Angeles, the Santa Monicas bisect the second largest metropolitan area in the United States. It is the adjacency of the mountains to Los Angeles, as well as breath taking views and a sense of living in a rural environment, that make them such an ideal place to take up residency. A mixture of oak woodlands, riparian corridors, and coastal sage scrub vegetation add to the scenic qualities and rural feeling of the mountains. An article in the February 13, 1994, edition of the Los Angeles Times assessed the paradoxical nature of development in the Santa Monica Mountains in the following way:

"*Southern California's stored hillsides nurture native vegetation that is literally explosive. Many types of Chaparral plants reproduce only after a wildfire has moved through. But these hillsides also provide what much of the area can't: a rural feel, scented air, scenic views of ocean and city. They are the most desirable, expensive real estate in California. And they burn*".

The major plant communities of the Santa Monica Mountains are chaparral and coastal sage scrub, also referred to as hard chaparral and soft chaparral respectively (Radtke 1983). Oak woodland, and coastal grasslands also exists here, yet it is among chaparral and coastal sage scrub habitats where most of the wildland/urban interface occurs, and where the greatest danger of wildland configuration is present.

Old Topanga Firestorm of 1993

At approximately 10:45 a.m., on the morning of November 2, 1993, the second of two arson suspected fires began to burn substantial portions of the Santa Monica Mountains. At this same time 21 wildfires were burning throughout the Southern California area. The Old Topanga Firestorm erupted near the southern limits of the City of Calabasas and consumed approximately 18,000 acres of watershed, took the lives of 3 residents, and damaged or destroyed over 408 single family residents (SFR) on its march towards the Pacific Ocean. Over 208 SFRs were lost in the City of Malibu alone.

This was not the first fire to destroy homes in the Santa Monica Mountains, nor to occur in the area impacted by the Old Topanga Firestorm. The Hume Incident of 1956 burned approximately 1,940 acres, the Piuma Incident of 1985 burned approximately 5,160 acres, and the Wright Incident of 1970 destroyed 27,925 acres, and all occurred within or adjacent to the boundaries of the Old Topanga Incident (CLAFD 1994). Wildfires in the Santa Monica Mountains occur in almost predictable corridors which begin in the northern sections of the mountains and burn until they reach the Pacific Ocean, referred to by many as the "Great Pacific Fire Break". Some have said that the Old Topanga Firestorm was one of the most predictable fires in the history of development in the mountains; however, the same shall be said again in different areas of the mountains following future conflagrations.

Most of fires in the Santa Monica Mountains have been fueled by a combination of prolonged fire suppression resulting in an accumulation of dry woody chaparral fuel and the annual Santa Ana Winds. On November 1, 1993, a high pressure zone moved in over the Great Basin, while at the same time a low pressure system moved in off the coast of Southern California. This situation created the Santa Ana Winds which drove the Old Topanga Firestorm. On November 2, 1993, a "Red Flag" warning was issued as temperatures in the high 80s, and winds from 20 to 40 miles an hour were predicted. The high temperatures and winds combined to produce a relative humidity of only 7 to 13% which began to drop as the Santa Ana began to build (CLAFD 1994).

Those who have survived previous fires, such as the 1970 Wright blaze, and the Piuma Incident of 1985, have stated that the Topanga blaze burned with a previously unseen intensity, and within the first hour of the blaze the Incident Commander predicted that the fire would "go the beach" a distance over 5 miles away (CLAFD 1994). The fire spread from 1 acre to 200 acres in ten minutes, and within one hour the fire had consumed over 1,000 acres of chaparral. The blaze produced a column of smoke which rose six miles into the sky, which in turn created a huge vacuum, and in affect its own weather pattern (CLAFD 1994). The Old Topanga Incident had become a firestorm.

The fire would continue for 3 days, aided by changing weather patterns and an abundance of dry fuels, including not only chaparral but single family residences and the ornamental landscapes that surrounded them. The fire resulted in the largest deployment of fire fighters in the history of California involving 165 engine strike teams, 25 single resource engines and Emergency Support Teams, 129 hand crews, 31 air tankers, 23 helicopters, 13 dozers, 50 water tenders, 8 food dispensers, over 7,000 fire fighters and support personnel, and the support of 458 agencies from 12 states (CLAFD 1994). The fire cost over $1.3 million in terms of fire suppression, destroyed approximately $230 million in private and public property, and has lead to the spending of millions of dollars in post fire flood and erosion control mitigation (Carter, Bean & Weissler 1994).

The Floods of 1995

The first winter rain season following the Old Topanga Firestorm created more worry than disaster. Although mudslides, debris flows, and flooding did occur, the extent of damage was manageable, albeit costly in terms of public works projects. However, despite the absence of massive flooding and debris flows, sedimentation was accumulating in the drainages below the slopes cleared of mature vegetation. Through various erosional processes, such as dry ravel, and the stage was being set for a disastrous chain of events should a heavy rain season appear within the next few years. That season came in the winter of 1995 as an El Nino weather pattern formed in the Pacific Ocean producing heavier than usual rains throughout the State of California and the West.

As the years prior to the Fires of 1993 involved a prolonged drought, many of the watersheds stripped of vegetation had been eroding due to dry ravel, a process which was further enhanced by barren slopes with hydrophobic soils. Many of the major riparian corridors within the burn area of the Old Topanga Firestorm were loaded with sediment and only required the right flow of water to set off the second part of the fire/flood cycle. The first heavy rains hit the Santa Monica Mountains in late January and continued through February and well into March of 1995. In January a storm of only 2 year intensity hit the Las Flores Canyon, Carbon Canyon, and the Malibu/Cold Canyon watersheds. The damage from this storm alone was several million dollars, and it completely flooded the area surrounding Malibu City Hall, closed the Pacific Coast Highway (PCH) in several locations for days, as well as most of the few remaining access route in and out of the city. In March of 1995 a storm hit the mountains dumping over 3 inches of rain in 2 hours upon the Topanga Canyon, Tuna Canyon, and Pena Canyon watersheds. The result of this storm was a debris flow which covered PCH with over 12 feet of mud and debris and closed the major route in and out of Malibu for over 3 days, as well as damaging or destroying several residences and associated structures.

Many historic and ancient landslides throughout the Santa Monica Mountains were reactivated by heavy, and more importantly, constant winter rains. The Rambla Pacifico landslide, which in 1984 destroyed 11 homes and closed the easiest access route to PCH, again began to move at a rate of approximately 60 feet per year on average on its northern lobe, and 30 feet per year at its southern lobe. The increase in speed was largely the result of the undermining of the slide mass by Las Flores Creek, which was flowing along the base of the slide at a rate of at least 4,000 cfs during the storm events of January and February 1995. The movement of the slide now threatens one of three remaining access routes into the area, as well as properties adjacent to the slide destroyed by the fires.

Many other landslides throughout the Santa Monica Mountains have activated as a result of the rains, closing roads for weeks on end. Some roads remained closed into the summer and fall of that same year. These landslides become active as ground water filtrates through soil horizons and onto the slide plains of these unstable slopes. Approximately a hundred properties are now threatened by the active movement of both small and regional slides. Many of these properties have subsequently been impacted by the floods of 1995, and the Old Topanga Firestorm of 1993.

Post Fire Mitigation Efforts

Development in the Urban/Wildland Interface

Over 1,000 homes were destroyed by fire in six Southern California counties between October 25 and November 10, 1993 (FEMA-OES 1994). During the Old Topanga Firestorm alone at least 3,500 homes were directly threaten with destruction. The Oakland/Berkeley Hills Fire of 1991 destroyed 2,449 single family residents, 437 apartment dwellings and condominium units, burned over 1,600 acres, killing 25 people, and injured another 150 people (NFPA 1992). In the summer of 1994, over 50,000 acres and 37 homes were destroyed by fire (Planning 1995). With such staggering statistics it is a wonder to many why one would choose to live in the urban/wildland interface, but many do. Over six million Californian residents live in wildland areas, with another four million along the wildland urban/interface (Planning 1995).

The urban/wildland interface is a wonderful place to live from an aesthetic point of view, and these areas provide a rural environment to many who have given up on the lifestyle of the urban flat lands of areas like the Los Angeles basin. Yet, natural processes are seldom understood or taken into consideration by those who develop or live in the urban/wildland interface. Millions of dollars are spent every year in fire suppression, flood control, and by tax subsidized insurance programs paid for off the backs of the majority of "flatlanders" who don't live with such risks, and by those who can not afford to live in such locations. In a recent letter to the City of Malibu, the National Foundation for Environmental Safety, Inc., stated:

"Man-made calamities should not be continuously confused with 'Acts of God.' The life style of people living in slide, flood, and fireprone communities where periodic and largely foreseeable 'man-made' disasters occur on a seemingly regular basis (such as in many areas of the Santa Monica Mountains and much of Malibu) is supported by the general public in the form of FEMA (Federal) and OES (State) disaster aid and State-mandated subsidies."

These areas are a dangerous place to put a home, and require that many pay with tax dollars and sometimes their lives for a privilege experienced by only a few. Furthermore, it is difficult and costly for government to prevent the spread of development into these areas as any conflict between government and the property owner over the development is such areas may result in a "takings" case, resulting in the further spending of tax dollars. Additionally, past development in the interface has occurred, far too often, with little planning for the inherent risk associated with living in these areas. Small wildland fires may quickly be extinguished, but this only results in the further build up of dead woody materials unless the fuel is removed by hand, or allowed to burn during a seasonal summer fire or as the result of a controlled burn. When large conflagrations occur it may be impossible for fire fighters to much more than observe a blaze, as they are charged with protecting life before property, and this includes their own lives.

Fire Suppression

As development has extended, or exploded as it has in some areas, into the chaparral environment, residents and government agencies have had to respond to the hazards associated with living in the urban/wildland interface. The majority of urban settlers who moved into these wildland areas are ignorant of the environment they are moving into and ill equipped to live in this wildland environment. Too often home buyers fail to realize that fire protection agencies may not be able to save their home from fire, and that agencies charged with building and safety and flood control may be powerless to save them from floods, mudflows, and landslides.

The primary response from government has been to initiation aggressive fire suppression and management in an attempt to eliminate fire from native lands. In spite of these aggressive fire suppression efforts large wildfires continue to consume vast acreages of chaparral in Southern California. After nearly a century of suppression, there has been increasing debate that fire control efforts have altered chaparral fire regimes in ways that magnify the treat of burning, erosion, sedimentation, and flooding at the urban/wildland interface (Pyne 1982). Fire suppression in Southern California appears to be producing older growth stands of chaparral which result in larger more intense fires. Younger chaparral stands (less than 20 years) are less likely to burn due to lower ratios of dead fuel to live fuels and reduced horizontal and vertical continuity of fuels. In northern Baja California where fire suppression has not been practiced to the extent it has in Southern California a mosaic pattern of differing age stands of chaparral appears to have developed resulting in smaller fire events of less intensity. Minnich (1983) comparing the chaparral fire regimes in southern California and Baja California found that in Baja California numerous small fire events fragment stands into a fine mixture of age classes, a process which appears to help preclude large fires. While the pattern of large fires in Southern California appears to be an artifact of suppression.

Fire suppression is extremely effective at the ignition stages of a fire and where climatic conditions are favorable. Therefore, fires occurring in Southern California in the summer during periods of higher humidity, lower wind speeds and temperatures are much more easily controlled. Most of Southern California's major fires occur in the very late summer and fall periods during off shore wind conditions (Santa Ana Winds) which are characterized by high temperatures, low humidity and very high wind speeds. Fires in this type of severe weather conditions are extremely difficult and in many cases impossible to control. This type of weather scenario in conjunction with extensive areas of older chaparral stands result in fire magnitudes so great that entire watersheds are completely denuded of vegetation. This intense type of fire can even consume young moist stands of chaparral.

The extent of burned watershed can magnify flash-flood runoff behavior and high sediment yield in an exponential fashion (Minnich, 1989). Higher regional fire intensities may also result in more extensive hydrophobic soil impermeability and high runoff (Minnich, 1989). These adverse watershed impacts can be moderated by implementing a sustained-yield program of small to medium size planned burns to produce the stand mosaic similar to the Baja California chaparral model.

Prescribed burns adjacent to the urban wildland interface can present some challenging problems. The common complaints voiced by residents of these areas are the annoyance and potential health effects of the smoke, reduced visibility and potential danger of the controlled fire escaping and endangering their residences. Furthermore, air quality regulations, particularly in Southern California, severely limit the time of year these burns may occur. Given these constraints the prescribed burning near the urban wildland interface can be carried out only on a very limited basis. However, even on a limited basis prescribed burning in the urban wildland interface can be a valuable cost effective fire management tool for protection agencies.

The proximity of the Malibu/Santa Monica Mountains to the Los Angeles metropolitan region coupled with it's coastal location, breath taking views, access to undisturbed natural areas, and sense of rural living make this a very desirable area. With proper land use planning, site planning, building codes and vegetation clearance it is possible to significantly reduce the threat of fire in the Chaparral community. However, the problem in the Santa Monica Mountains is there are literally thousands of existing legal undeveloped parcels comprising hundreds of acres of land area that are located in very remote, topographically constrained, and environmentally sensitive areas. These factors make it quite difficult to mitigate the threat of fire and adverse environmental impacts.

There are also a number of very poorly planned subdivisions which were divided in the late 1920s and 30s with lot sizes of less than an acre and many more typically 5,000 to 10,000 sq. ft. in size. These subdivisions were primarily designed for weekend cabin type of use. However, today the expensive homes built on these parcels are occupied on a year round basis. There are approximately 6,000 of these ill-conceived small parcels in the Santa Monica Mountains. These subdivisions have very narrow winding roads which cannot accommodate fire equipment and are for the most part very heavily wooded with both natural and exotic plant species. These types of subdivisions are disasters just waiting to happen.

Proper site design on a large parcel can reduce fire danger to some extent, however, in these small lot subdivisions it is impossible in many cases to significantly reduce the fire hazards given the very steep site topography, lack of adequate water supply, proximity to other structures and limited access for fire equipment.

Given that the threat of fire alone has not provide an adequate basis to prohibit development on these parcels and given the more rigorous requirements placed on regulatory agencies by recent court decisions regarding constitutional takings of private property, these parcels are and will continue building out. Furthermore, as most of us know today regulatory agencies are facing even more severe limitations and restrictive requirements regarding regulation of private property. Therefore, the over simplified argument, which is voiced quite often is "just deny all development of homes on these parcels" is just not realistic or legally justifiable.

In order to reduce the buildout of these subdivisions and remote environmentally sensitive parcels the California Coastal Commission developed the Transfer of Development program in the Malibu/Santa Monica Mountains Area of the Coastal Zone. Simply the Transfer of Development program requires that any time a new parcel is created through the subdivision process, the equivalent development rights on designated small lot subdivision lots or remote environmentally sensitive parcels have to be retired. In theory, the newly created subdivisions are located in areas more suitable for this type of development. To date 924 substandard lots have been retired in small lot subdivisions and some 800 acres of remote environmentally sensitive parcels have been retired. Making the Malibu/Santa Monica Mountains Transfer of Development program one of the most successful in the United States.

Potential Impacts of Post-Fire Mitigation / Aerial Seeding

As fire is a natural part of most California ecosystems, chaparral has adapted to rely on the fire/flood cycle as a means to survive. Fires clear dead materials, open up seedbanks, and release nutrients back to the environment. Floods, in a similar manner, generate a regrowth of riparian growth and transport nutrients and propagates throughout riparian corridors. Post fire/flood systems recover at a fairly rapid rate if allowed; however, often post fire mitigation efforts are used rather than allowing the natural system to recover on its own. Some of the methods used may be more detrimental to the environment than not, a may even add to the potential hazards of fire, flood, and landslide. An example is found in the aerial seeding of rye grass in burned watersheds.

The aerial seeding of watersheds, stripped of vegetation by fire, for post fire erosion control is a common practice in California and throughout the west. However, the impacts of this practice are increasingly in question. It has been suggested that the aerial seeding of non-native rye grasses may in fact create large heavy, and unstable, mats of vegetation on geologically unstable slopes prone to sliding even under natural conditions. Such unstable formations combined with hydrophobic soil conditions could lead to increased surface erosion or landsliding. Furthermore, the successful establishment of a rye cover at a burn site may lead to an increased volume of fine dead fuels, and increase the chance of an earlier burn cycle (Barro & Conard 1987).

It has also been suggested that the establishment of rye grass on the slopes of watersheds dominated by chaparral may result in the inability of native fire annuals to germinate following a fire. These annuals are an important step in the post fire recovery cycle, and these species are very well adapted to providing erosion control in post fire environments. If this were the case a major break in the recovery cycle could occur and may have a serious impact on the ability of the chaparral community to recover and survive. As these chaparral communities provide an important source of wildlife habitat, as well as a valuable service in terms of erosion control, the continued practice of aerial seeding should be further investigated for its overall effectiveness.

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