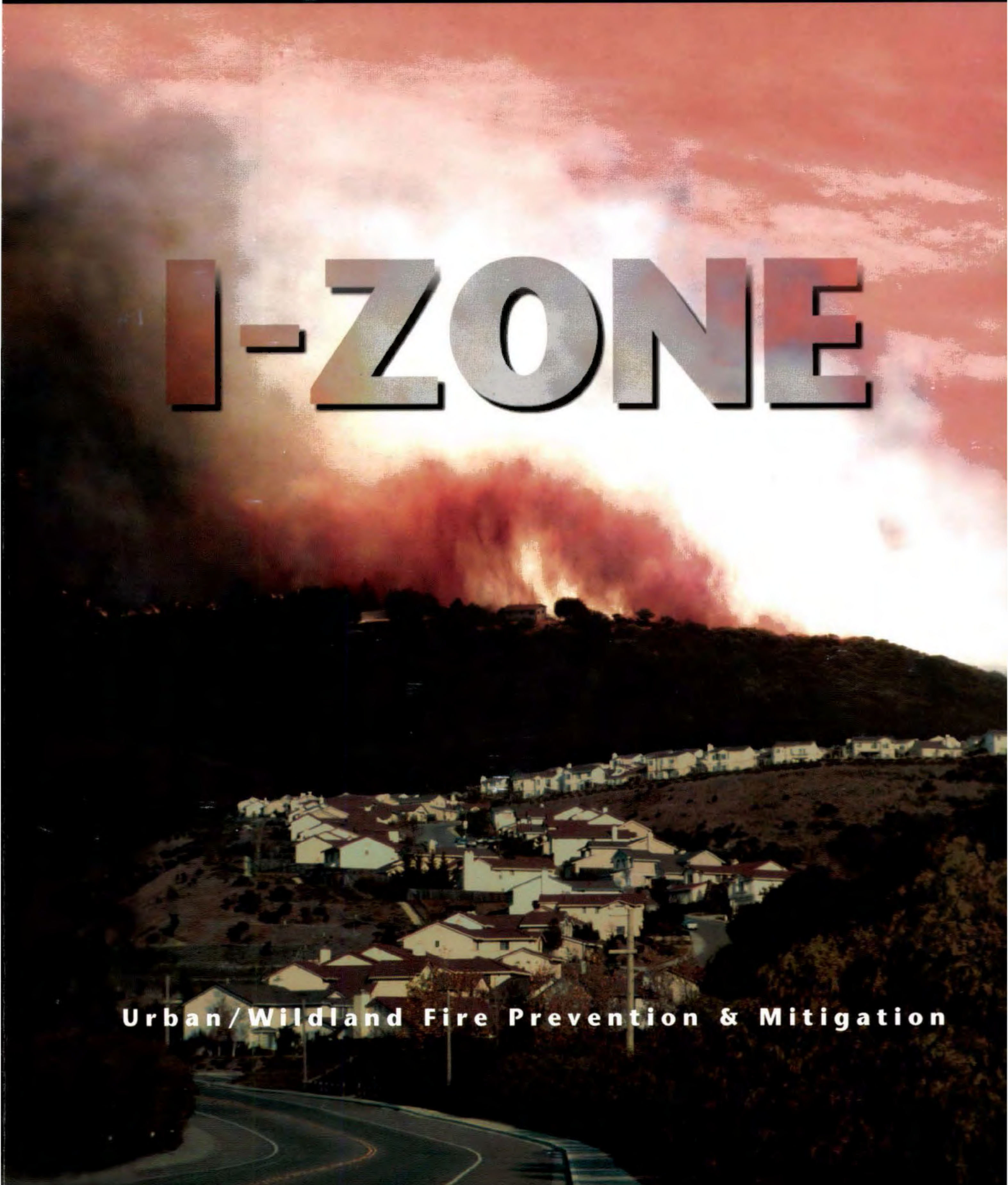
CALIFORNIA'S

# I-ZONE



## Urban/Wildland Fire Prevention & Mitigation

Edited by Rodney Slaughter

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## IV. RISK, RESPONSIBILITY, & PROGRAMS

**Foreward**

The term urban/wildland was first defined by C.P. Butler as, a fire moving from a wildland environment, consuming vegetation for fuel, to an environment where structures and buildings are fueling the fire. What term best describes the interaction between wildland and structural fuels? The answer depends on your perspective and professional orientation. Foresters and wildland fire fighters see the wildland/urban problem with the emphasis on "wildland". While urban fire fighters emphasize "urban" when they define the urban/wildland problem. Regardless of emphasis, both terms, wildland and urban, are loaded with multiple meanings. Wildland is a descriptive word for the natural environment in which fire plays a significant role. Wildlands could describe either conifer forests, chaparral, grasslands, or desert fuels. Many foresters are concerned that the influx of population into wildland areas in-turn threatens the natural resource with people related fires. The term urban, on the other hand, could describe single houses each on a couple of rural acres, an entire subdivision built within a wildland area, or an entire community inundated with wildland vegetation. In this manmade environment fire is managed and limited- though not always successfully.

In either case, everyone in the profession recognizes urban/wildland as a zone between two incompatible fuels. The area or zone between these two fuels are further defined as either interface, intermix, or intermingle. The term urban/wildland, already saturated with meaning, is then suffixed with a zone to become for example, the urban/wildland interface. Compounding the issue, is the three types of interface areas defined by Charles W. Philpot of the U.S. Forest Service. These areas are, the classic interface, mixed interface, and occluded interface. The classic interface occurs when city boundaries and suburbs press against wildland vegetation- as in a subdivision on the outskirts of town. The mixed interface is where homes and other structures are intermixed with wildland vegetation similar to the conifer forest growing throughout mountain communities. The occluded interface is when islands of wildland vegetation occur inside a metropolitan area- like undeveloped pockets of wildland areas preserved within a large developed urban area. So then, the fire problem in say the Santa Monica Mountains, would be called the urban/wildland occluded interface. There are of course, any number of variations in terminology which seek to define a specific fire problem to a specific situation. While these terms maybe meaningful and precise, it is certainly cumbersome to communicate, especially at the scene of an emergency.

Training officer, Jim Bishop with C.D.F. in Butte County, has coined the term the I-Zone to simplify all this terminology. The I-Zone is a generic term whose exact definition would be, where wildland fuels threaten, or are threatened by, structural fuels. This definition includes single structures, subdivisions, and entire communities in any variety of fuel types and fuel loads. The contributing authors were asked to use the I-Zone in place of the more cumbersome term, the urban/wildland interface with all its deviations and variations. Used throughout the text, the I-Zone is the common thread that holds together all the ideas and opinions of the authors.

The purpose of this text is to offer a variety of opinions and perspectives about the I-Zone so that local elected officials, as well as fire planning and building administrators, can make informed decisions about their particular I-Zone problem. The information presented in this text could be used to formulate or support an action plan. The developing International Urban/Wildland Fire Code specifically explains the requirements for mitigating the I-Zone, this text supports that effort by explaining why. This text, however, in no way attempts to answer all questions, nor is it a how-to book. It is presented in such a way that, local government officials and fire administrators have enough information regarding all facets of the problem- so that they too can form an unequivocal argument. To build an effect argument a number of California's subject matter experts were called upon to contribute their expertise. The authors come from a wide range of disciplines including, behavioral science, engineering, law, risk management, environmental management, biology, forestry, as well as fire suppression, fire prevention, and fire research. Collectively, from Anthropology to Zoology, they offer a multi-disciplinary approach to describe and define the I-Zone.

## Acknowledgements

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I must acknowledge that the development of this text occurred during the historic merger between the California State Fire Marshal's Office and the Department of Forestry and Fire Protection. The significance of which, is the roles each agency played over the years to reduce the loss of life, property, and resources. Each agency actualized their goals and objectives in two distinct arenas. The Department of Forestry interacted primarily with the County Board of Supervisors and local government officials, while the State Fire Marshal interacted primarily with local fire jurisdictions and fire administrators. The State Fire Marshal's sphere of influence is in the building and public safety codes, while the Department of Forestry operates in the natural resource codes. The merger of these organizations finally brings urban and wildland expertise together. As such, this text represents the first project of California's State Fire Service. I would like to thank my colleagues from both organizations for their assistance in the development of this text.

Specific organizations that I would like to recognize include; Gary Briese of the International Association of Fire Chiefs, Arlene Barnhart, Bill Baden, and Bob Miller of the National Fire Protection Association, Frank Fendell of T.R.W. Space and Technology, Dr. Jason Greenlee of the International Association of Wildland Fire, Rod Incoll of Australia's Department of Conservation and Natural Resources, Brian Stegavige of Van Couver Fire Services, Gene Wolf of L.A. County Fire, James Radley and Sam Husoe of Orange County Fire, the Western Fire Chiefs Association, the International Fire Code Institute, Lawrence Livermore Laboratories, National Institute of Standards and Technology, U.C. Forest Products Laboratory, The National Wildfire Coordinating Group, The U.S. Department of Agriculture, the U.S. Forest Service, the U.S. Department of Interior, The U.S. Fire Administration, the California-Nevada-Hawaii Forest Fire Council, the California Fire Strategy Team, the State Board of Forestry, the State Board of Fire Services, the State Training and Education Advisory Committee, and the California Fire Chiefs Association.

Closer to home, I would like to thank Chief Ronny Coleman for giving me the opportunity to coordinate this project. To each of the contributing authors, who pushed aside their own frantic workloads so that they could write a chapter, I am extremely thankful. Equally important, I would like to thank Kevin Cahill and his CSU, Chico publication design class for taking-on this text as a class assignment. This group, dubbed the "Fire Dogs" include; Scott Johnson, Thomas Bagely, Kevin Puleo, Thomas Collins, and Matthew Ostling. I hope your creative careers prosper. My office-mates Jack and Phil who have had to put-up with my bizarre and obsessive work habits also deserve a word of gratitude. And, finally I would like to thank Shirley Mae for her love and support.

At the outset of this project the call went out for information. That call was answered with an onslaught of information in the form of text, video, lesson plans, articles, magazines, position papers, bibliographies, ordinances, pictures, products, and programs. Literally, thousands of pieces of information have been collected from a dozen countries, and as many States, scores of organizations, and hundreds of interested people. To acknowledge everyone would be a gargantuan task. However, everyone who answered the call, should feel a connection with the final product.

**Rodney Slaughter**, Editor

# I. MODEL CODE & ENFORCEMENT

To deal effectively with I-Zone fire prevention and mitigation we must first recognize where we've been, where we're at, and where we want to go.

By: **Ronny J. Coleman**

The creation of the United States Forest Service in the early 1900's began to focus upon the fact that forest land was a resource. The initial reason for federal policy being focused on this issue was to preserve this resource primarily for economic reasons. Wildland fire was one form of destruction that deprived timber companies and other entrepreneurs of a source of income, so fire became an event to avoid.

When cities started going from volunteer fire forces to the creation of paid fire departments in the metropolitan areas such as San Diego, Los Angeles, Sacramento and San Francisco, the wildland area was essentially left to its own devices. That is, until the California Division of Forestry (CDF) was created in the late 1920's. This agency was developed in response to a series of fires that occurred during that era. Among these fires was the first really significant I-Zone conflagrations. That fire occurred in the hills immediately adjacent to the City of Berkeley in September of 1923. In that fire 624 structures were lost. Most students of the I-Zone fire problem, are able to identify this particular fire as being the harbinger of things to come.

## Philosophical Shifts

The 1920's and 1930's was a transition period with regard to the philosophical approach to fire. Almost all of those who had grown up in the State from the late 1800's past the turn of the century, regarded fire as part of the natural ecosystem and did not overly concern themselves about its prevention. However, as individuals begin to be given personal responsibility for attacking these fires, the emphasis then began to shift from prevention to suppression. While on the surface, this may appear to be a minor philosophical change, it has major significance when one considers the tremendous explosion in terms of population and land use that occurred in the State of California immediately following this era. The vast majority of California's urban growth was linked to land development and the return of soldiers from World War II. The creation of major military installations in this State brought an exodus of individuals into an environment in which the confrontation between community and nature would have catastrophic effects.

This is not to say that I-Zone fire problems did not exist in other areas of the United States during this period. As a matter of fact, while this country often celebrates the great Chicago fire every year when we celebrate fire prevention week, it often ignores the fact that a small upper state community, Peshtigo, Wisconsin, was devastated by a wildland fire the previous day. Perhaps, the significant reason for its omission from public visibility was the fact that the Chicago fire was an urban conflagration and commanded a great deal of front page coverage, while a forest fire in an obscure corner of Wisconsin was relegated to an insignificant column on the back page. More people died in Peshtigo than did in Chicago. But, more value was lost in Chicago then what was perceived to be lost of Wisconsin forest land.

**Those who fail to remember history...**

Smoke column from the Sierra town of Boca burning (above) at the turn of the century is similar to the fire that threatened Sierra County's, City of Loyalton (below) 100 years later. (Photo Credit: Town of Boca, Nevada County Historical Society, Searls Historical Library, Cottonwood Fire, R. Slaughter)

**...are doomed to repeat it.**

## Areas of Expansion

In the aftermath of World War II, there were several areas of expansion that occurred almost simultaneously. The rapid expansion of population into peripheral areas around metropolitan areas became a primary factor because it resulted in land use and development that heretofore had been devoted to either agriculture or other resource uses. The second expansion had to do with the fire fighting forces themselves.

From the late 1940's till the mid 50's, the California Department of Forestry actually maintained a series of five crews whose entire job was to conduct controlled burns– or rather prescribed burns throughout the State. These teams were specifically financed to help ranchers and farmers maintain some degree of freedom from encroachment by wilderness vegetation on to their properties.

## Fire Safe Regulations

Perhaps the first and most infamous of the early I-Zone fires occurred in Bel–Air in 1961. Rexford Wilson, writing for the National Fire Protection Association, predicted the Bel–Air fire with chilling accuracy. Wilson referred to the area in question as being, "designed for disaster". The characteristics that he witnessed at that time was an expansion of urban development into wildland areas with no consideration for such simple things as access, water supply and/or the elimination of combustible roofs. The citizens of Bel Air paid the initial dues for the entrance into the new era of I-Zone fires with the loss of 500 homes. As a result of these early fires, California Governor's, starting with Governor Edmond G. Brown, placed an emphasis on evaluating the problem and making

Nevada City in 1857, and completely denuded of vegetation, was not threatened by wildland fires. One hundred years later, Nevada City can hardly be seen through the growth of evergreens (Broad Street runs diagonally through center). (Photo credit: Nevada County Historical Society, Searls Historical Library, Nevada City 1995, R.Slaughter)

some recommended solutions. An entire series of reports have been written over the last 35 years, all of which contain 0essentially the same kinds of concerns and even have amazingly similar recommendations.

In 1965, the California Division of Forestry wrote a document entitled, "Operation Fire Safe". This was the beginning of fire safe regulations for the State of California. However, fire safe regulations proposed by the Division of Forestry related only to state responsibility areas and were not universally adopted by all of the communities in California. The autonomy of municipalities and fire protection districts prevented this land mark legislation from having a universal application.

## A Link Between Prevention & Suppression

The cycle of wildland fire has also gone through stages of intensive fire prevention and suppression when wildland fires were considered totally undesirable. Public education campaigns were devoted towards the prevention of wildland fires. While at the same time, funding for fire suppression resulted in massive operations to quickly extinguish and eliminate all wildland fires. We may well have won a battle, but eventually lost the war. The intensity of initial attack created a large number of very small fires, allowing for the accumulation of litter, debris, and understory in many of our forest areas to reach intolerable levels. Harking back to the early days of California, the natural health of the forest depended upon a fire burning through at some portion of the life cycle of the forest in order to prevent a build up of fuels.

This phenomenon is extremely difficult to see in the short term. If we examine the relationship of the growing population in California and the life cycle of much of our forested and brush covered areas, it is evident that the same people who were populating rural areas, were equipped to be able to determine long term effects. One cannot fault the policy makers who developed the strategy of prevention during this era, because it was of a practical political perspective. An entire technology was built up around the concept of suppressing fires as quickly as possible. In the aftermath of World War II, the use of aircraft to combat fires grew by quantum leaps. The development of communications equipment allowed look outs to go into places so that fires could be spotted even earlier, there by initiating earlier fire suppression efforts.

The price continued to be paid, however. In the early 1970's another series of fire storms swept the Southern California area. In the aftermath of these incidents there was public out-cries for a better understanding of why this continues to happen. One of the things that emerged from this 1970 fire series, was the development of FIRESCOPE and the increasing sophistication of our State's master mutual aid system. However, it did not result in a significant increase into the statute and regulations limiting the fire problem or altering the fuel problem. CDF's Fire Safe regulations, that were initiated in the early 60's, were once again taken out, revised, and upgraded. One of the earliest forms of a fire hazard classification system for determining fire hazard severity zones was proposed at that time.

## A Prelude to Ignition Resistant Structures

Probably the most significant event that emerged in the 70's fires, was to focus more attention on the combustibility of structures. Specifically, this era saw a great deal of emphasis on the elimination of untreated wood roofs and more emphasis upon the development of adequate infrastructure in potential impact areas.

In a chart that accompanies this chapter (see sidebar, Fire Time Line), there is a listing of all of the major I-Zone fires that have impacted California from the 1920's onward. You will note by looking at this chart that initially major I-Zone fires were few and far between. Looking back at a land use map of the State of California during these years, we see a corollary phenomena. That is, the cities were also few and far between. The concept of encroachment of one condition upon another was at the time simply not significant. However, as you proceed through this chart and begin to approach the 60's, 70's and onward to today, the period of time between major conflagrations and massive structural loss grows significantly shorter.

Reviewing these fires after action reports shows a great deal of awareness for the basic problem- reducing and maintaining defensible space in wildland fuels and constructing ignition resistant buildings. Essentially, we have not practiced what we have learned about the I-Zone fire problem in the last fifty years. The recommendations shown in the chart of After Action Report demonstrates that we have been repeating the same strategy over and over again. While great strides have been made in some ares, there are areas where these strategies have not been applied. It has always been recognized that the phenomena of high winds, high temperature, low humidity, and exposure of heavy fuels against unprotected structures, makes them literally indefensible. What we have not done is recognize the fact that managing the fuels, managing the physical layout of buildings, and developing ignition resistant buildings is the only defense we have against the significant losses.

**CALIFORNIA's FIRE TIME LINE**

**1920**

Berkeley Hills, 584 structures 1923

Mill Valley Fire, 125 strucutres 1929

**1930**

Malibu 1930

Ventura County 1932

Griffith Park, 28 died 1933

**1940**

San Diego County 1943

Mill Valley 1945

**1950**

Glenn County, 15 died 1953

Humboldt & Siskiyou Co. 13 structures 1955

San Diego, 11 died 1956

Malibu, 50 structures 1956

**1960**

Bel Air, 484 structures 1961

Mariposa County 1961

Santa Rosa, 224 structures 1964

Santa Barbara, 94 structures 1964

L.A. National Forest, 12 died 1966

Paseo Grande, 61 structures 1967

**1970**

773 Statewide fires, 772 structures

San Bernadino, 54 structures 1970

Oakland Hills, 36 structures 1970

Newhall to Malibu, 403 structures

Cleveland Forest, 382 structures 5 died

Santa Barbara, 234 structures 1977

Los Angels County, 30 structures 1978

Sonoma County, 63 structures 1978

Malibu, 230 structures 1978

**1980**

San Bernadino Co., 325 structures 1980

San Bernadino Co., 65 structures 1980

Napa Co., 69 structures 1981

L.A. County, 65 structures 1982

56 Statewide fires, 250 structures, 5 died 1985

San Diego Co., 64 structures 1985

Baldwin Hills, 53 structures, 3 died 1985

12,000 Statewide fires, 114 structures 1987

Alpine County, 26 structures 1987

Pebble Beach, 31 structures 1987

Nevada Co., 312 structures 1988

Shasta Co., 58 structures 1988

L.A. County, 15 structures 1988

**1990**

Santa Barbara Co., 641 structures, 2 died 1990

L.A. County, 50 structures 1990

Mariposa Co., 66 structures 1990

Oakland/Berkeley Hills, 3,403 strucutres, 25 died

Shasta Co., 636 structures, 1 died 1992

Calaveras Co., 170 structures 1992

21 Statewide fires,

SoCal Firestorm, 1,171 structures 1993

Sierra County, Cottonwood Fire 1993

San Luis Obispo, 80 structures 1994

Point Reys National Forest 1995

The I-Zone fire threat for the ridge community Magalia in 1873, was reduced with fewer trees and reduced understory—unlike the same corner in 1994. (Photo credit: Paradise Historical Society, Magalia 1994, R.Slaughter)

Concern is evident on the faces of Governor Pete Wilson and State Fire Marshal Ronny Coleman while they are being briefed on fire operations in Southern California's 1993 Fire Storm. (Photo credit: CDF Communique' Special Edition Dec. 1993)

## Prepare for the Seige

The fire storm of 1993 as well as other major conflagrations that occurred in the 1990's finally provided the impetus for a focused attention on the problem. The combination of huge losses, coupled with extremely expensive fire suppression costs and potential threat to the availability of insurance in California, has brought this issue into the forefront.

The sieges of fire that our cities and towns have experienced are not unlike the history of warfare. As we go back into the history books and examine battles that were fought, strategies that were utilized, and the tools and techniques of warfare we can recognize the fact that a well lead and well equipped army is often the winner and that the loser usually lacked in both competencies. Preparing ourselves to deal with the I-Zone problem is not unlike getting ready for a state of war. We can expect the invasion to occur some day under a specific set of conditions. Those communities that take the time to plan for this particular event will more likely survive than those that don't.

## Summary

It is anticipated that those who participate in this course of instruction will be better organized and better equipped. However, there is no room in this formula for apathy and indifference. The I-Zone fire problem lies on the landscape of California as pervasively as the weather. It is not a question of will we have another I-Zone fire in the future. It is merely a question of when and where it will strike and to what degree the community will be prepared to cope with it.

# A SUMMARY OF AFTER–ACTION RECOMMENDATIONS

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Report Date | 1965 | 1966 | 1970 | 1970 | 1973 | 1985 | 1990 | 1991 | 1993 |
| Fire | Bel Air 1961 | Napa/ Sonoma 1964 | Calif. Fires | Calif. Fires | 1970 Calif. Fires | Calif. Fires | Southern Calif. Fires | Oakland Fires | Southern Calif. Fires |
| Area Affected | L.A. Co. | Napa & Sonoma Co. | L.A. Alameda San Diego | 12 Counties affected | 12 Counties affected | 23 Counties affected | Santa Barbara Riverside San Bernadino L.A. Counties | Alameda County | 6 Counties affected |
| Reporting Agency | County Supervisors Association | Gov. Brown Calif. Disaster Office | Fire Research Group | Calif. Dept. of Forestry & Fire Protection | Office of Planning & Research | Calif. Dept. of Forestry & Fire Protecton | Federal Emergency Management Agency | Federal Emergency Management Agency & CDF | Office of Emergency Services |
| After Action Report Summary | Infrastructure<br><br>Fuel Management/ Clearance<br><br>Building Density<br><br>Public Education<br><br>Interagency Coordination | Outline Hazard Areas<br><br>Public Educaton<br><br>Fire Research<br><br>Planning<br><br>Improved Communication<br><br>Interagency Coordination<br><br>Building Construction | Building Design<br><br>Landscape<br><br>Improved Fire Fighting<br><br>Public Education<br><br>Codes/ Standards | Building Siting<br><br>Landscape<br><br>Training<br><br>Public Education<br><br>Codes/ Standards | Code Enforcement<br><br>Increase Prevention Staff<br><br>Fuel Management/ Clearances | Interagency Coordination<br><br>ICS Training<br><br>Improved Communication<br><br>Rehabilitate Affected Area | Hazard ID & Monitoring<br><br>Construction/ Codes/ Land Use<br><br>Response Planning<br><br>Rehabilitate Affected Area | Fuel Management<br><br>Codes/ Standards<br><br>Improved Infrastructure<br><br>Interagency Coordination<br><br>Public Education<br><br>Training<br><br>Slope Stability | Rapid Response<br><br>Increased Training<br><br>ICS Training<br><br>Improved Communication<br><br>Aircraft<br><br>Interagency Coordination |

# MITIGATION OR LITIGATION

The fire chief may be sued for allowing development in high risk areas, or for failure to allow such development. The chief may be sued for being too restrictive, or for being too permissive.

By **Don Oaks**

The nightmare for the fire chief of the 1990's may not be responding to an interface fire threatening hundreds of homes. The nightmare may be responding to the court summons. Look up litigant in the dictionary, if you find your photograph there, you may be a 1990's fire chief. According to Webster's Dictionary...

**lit•i•ga•tion** (lit´e ga shen) n. 1. the act or process of litigating: a matter that is still in litigation. 2. a lawsuit. SEE LITIGATE

**lit•i•gate** (lit´ e gat´) v. 1. to make the subject of a lawsuit; con test at law. 2. to carry on a lawsuit. SEE LITIGANT

**lit•i•gant** (lit´ e gent) n. 1. a person engaged in a lawsuit

## Law Is Not A Thing

If litigate is a "contest at law"... What is law? We begin to answer that question by stating what the law is not. The law is not a thing... The law is stuff. As "stuff" with few black and white borders, boundaries, and dimensions it is difficult to define. When the law is spoken or written it is less important what is stated, than who stated it and why, when, where, and how it was stated. Context is all important.

Example; "Fire fighter sues equipment manufacturer when ladder fails." The facts indicate that fire fighter Jones was using an Acme ladder when it failed, causing him to fall and sustain a neck injury. Jones contends he was injured because of a design defect in the ladder. Acme argues the ladder was not properly used by Jones and that is was fit for the intended purpose of utility maintenance and shop work. The headlines in newspapers and the captions in professional journals will simplify the issues for convenience. Months, sometimes years will pass. The case will go to trial and then be appealed at least once, often more. A decision will ultimately be rendered and the headlines and captions will read "Fire fighter loses lawsuit against ladder manufacturer. Ladder not defective." Fire fighters will read these statements, bemoan the loss, and assume the next fire fighter injured in a similar circumstance is without likelihood of recovery or remedy.

The fact is the decision was not made on the basis of comparing the simplified positions described above. The decision was probably the result of procedural failures of case preparation rather than the substance and merits of the respective arguments. Even if the procedural problems of not filing within the statutory time frames, bringing the wrong action, bringing the action in the wrong court, naming the wrong defendant or not all of the potential defendants, or any other of the many possible procedural problems, there still exists the probability that the decision was based on an issue or issues much narrower than whether or not the ladder was actually defective.

The courts work diligently to reduce the basis of their decisions to the narrowest issues possible. This often produces a result which seems inequitable at a glance. This is necessary, however, to produce a consistent and predictable foundation from which to formulate the decisions of tomorrow. Remember, "the law is stuff." If it were a thing, the court would analyze only Jones and Acme and make a decision that would be appropriate for them with no mind to yesterday or tomorrow, nor to any other fire fighters or ladder manufacturers.

This law, this "stuff", cannot be separated from the actions and interrelationships of people in society. It cannot be photographed. It cannot be punched into a computer. It cannot easily be described in empirical terms. But it can be, and is, inextricably interwoven in the fabric of our culture and community.

With this law is "stuff" perspective we now analyze the role of the fire service decision maker with regard to I-Zone fires and the law. For convenience we will refer to this decision maker as fire chief though he or she may be one of a variety of individuals (fire marshal, commissioner, planner, agency administrator, or...whatever) or even groups (Board, council, commission, committee, task force, etc.) within the community fire protection delivery system.

The role may be paid or volunteer, elected or appointed, formal or informal. The implications for potential litigation will vary, of course, with each of these variations. Whatever your unique position you must know intuitively that being involved in legal conflict is hazardous to your health and the health of your organization. It may be appropriate to note here that Ambrose Bierce in the Devil's Dictionary 1906, described litigation as "....a machine which you go into as a pig and come out as a sausage." It has also been said that arguing with a lawyer is like wrestling with a pig in the mud. You don't accomplish anything and, after a while, you begin to realize the pig enjoys it.

The theory of economic harm equates to the appropriateness of the action of the fire chief in requiring "reasonable" mitigation mesures as viewed against the construct of the actual or potential damage associated with a resulting I-Zone fire.

## Liabilities

The sausage maker and mud wrestling ring is not criminal law. It is referred to as civil law. More particularly it is civil tort law. Tort is a wrong, sometimes referred to as a harmful touching, against an individual or class of individuals. It differs from a crime in that a crime is a wrong against society as well as individuals with a goal of deterring such activity by punishing wrongdoers. The goal of a civil tort action is to compensate the person(s) harmed.

Torts come in a variety of liability packages: Strict Liability, Intentional Tort Liability, and Negligence Liability. A brief comment on each package and a more thorough discussion of the one big ticket item on the list which is negligence will be provided.

### Strict Liability

Strict liability is liability without fault or culpability. Therefore, no amount of judgement or exercise of due care will prevent liability from attaching to certain activities which create injury. "A case is one of strict liability, when neither care nor negligence, neither good nor bad faith, neither knowledge nor ignorance will save the defendant" (Fresno Air Service v. Wood, 43 Cal. Rptr. 276, 279, 232C.A. 2d 801). Other examples at common law are blasting with explosives or the keeping of wild animals. Today, most strict liability results from statutory proscriptions including those related to nuisance.

### Intentional Tort Liability

Intentional tort liability is for damages resulting from an intentional act. Neither malice, hostile intent nor harmful design is necessary as long as the act itself is intended. It includes trespass, assault, battery, false arrest or imprisonment, intentional infliction of emotional distress, defamation, invasion of privacy, and invasion of civil rights.

### Negligence

Negligence is the unintentional invasion of a person's interest protected by law, where the actor is at fault, and where the actor's conduct is the legal cause of the injury suffered. The fact that one causes injury to another does not necessarily establish liability of the alleged wrongdoer under the law of negligence. Rather, it must be established that the wrongdoer should have recognized a risk of harm to the injured party (or to a class of which he/she is a member), and that the wrongdoer's conduct which led to harm to others was below a standard established by law (Restatement of the Law, Torts, 2nd, American Law Institute, 1965).

## Elements of Tort Negligence

As stated above, the most important of the torts, with respect to fire chief liability, is negligence. There are five elements which must be established in order to prove up the tort of negligence. They are:

Duty
Breach
Actual Cause
Proximate Cause
Damages

Examining each in order, we begin with duty. Duty is to perform consistent with a general or special standard of care. Most often stated as the average reasonable person standard, or, the exercise of that care that the average reasonable person would under the same or similar circumstances. Such duty may be imposed by common law, by statute, or by the voluntary assumption of a responsibility.

Next we have breach, causation, and damages. Breach is an act or omission inconsistent with a duty owed. Causation is routinely divided into two elements. The first is actual cause or cause-in-fact. Actual cause is found where one can say, "but for..." the defendants negligent act or omission, the plaintiff's injuries would not have occurred. The second causal element is proximate cause or legal cause. Proximate cause or legal cause is a social policy consideration. That is, a way of deciding whether society ought to hold this defendant liable under the circumstances, or sever the chain of causation on the basis of foreseeability and intervening events. Simplifying proximate cause is substantially more difficult than pushing toothpaste back into the tube. It has relieved more law students from the burden of two more years of study than any other single question or issue. Do not waste a lot of time on it. Finally we come to the element of damages. Damages are the amount of dollars appropriate to compensate the plaintiff. Such damages must be actual and measurable in dollars.

## Immunity

In order to achieve an overall understanding of tort liability it is important to consider several theories of immunities to, and defenses against the claim.

The first is "sovereign immunity", the historic concept that the king can do no wrong. Therefore the governmental operative as an extension of the king may not be sued. This concept evolved to a position that the king (or the state) could only be sued with the king's permission. Beginning in the early sixties, the erosion of this theory accelerated to the point that now California (Tort Claims Act of 1963) and virtually every other state, has statutory provisions for bringing civil suit against itself— "The rule of governmental immunity must be discarded" as both "mistaken and unjust" (Muskope v. Corning Hospital Dist. (1961) 55 C 2d 211, 11 CR 89,90).

The next theory is governmental versus proprietary. Courts consistently find some degree of immunity for "governmental" activities. That is, those traditionally provided by government, such as, police and fire service. However, activities associated with those functions that could be provided by the private sector are likely to result in liability for the performing governmental agency if harm results. This is a difficult area to predict outcomes due to the inconsistent characterization and definition of governmental activities by today's courts.

A more dependable theory is that of "ministerial" versus "discretionary." Here the California courts will regularly find liability where the activities causing the harm are determined to be ministerial. That is, routine, non judgmental, implementation, following direction type of activities. Where, on the other hand, the activities are associated with setting policies, making decisions, exercising judgement and discretion, providing direction, or allocating resources, the courts regularly do not find liability.

Where no immunity is available the fire chief may employ one or more of a variety of defenses. For example, the "assumption of risk" suggests the person harmed knew, or should have known, the risk created by the defendant's activities and made an election to participate, observe, or in similar fashion, expose themselves to the type of harm which resulted. Another example is "contributory negligence." Here the defendant may admit a degree of negligence resulting in harm to the defendant but claims the defendant's own negligence was a factor in the resulting harm and there the plaintiff should not be held liable.

### Comparitive Negligence

In California a corollary of contributory negligence is the theory of comparative negligence. Here the outcome is not an all or nothing result as in contributory negligence, but rather a division and allocation of compensation proportionate to the respective party's negligence. The implications of application of these theories produce a complex tapestry of resulting liability. Little wonder, then, that the standard response of an attorney to a question of liability is "it all depends." For example, property owner buys or builds in a steep, heavily overgrown canyon under a building permit approved directly or indirectly by the local fire chief. Fire burns home. Is the fire chief negligent? The answer is it all depends. If negligence would otherwise be found, is chief immune? It all depends. If not immune, are any defenses available? It all depends.

Let us look at this situation with a little more specificity and include some typical assumptions. Remember, however, that the outcome is theoretical and any change in any component of the equation might produce an opposite result.

Beginning again, property owner builds in high hazard canyon. Fire chief permits the construction by simply not being an active part of the planning process. Home subsequently burns as the result of fire originating offsite in heavy brush and transmitted to home via wood shakes. Fire chief responds to criticism after fire by denying responsibility and indicating planning and zoning department approved the location for building site and building department approved the construction. Our analysis begins by viewing each element of negligence in the context of the operative facts and circumstances of the example.

### Duty

Duty of average reasonable fire chief to be aware of risks to community, educate and persuade the community with respect to fire risks and appropriate mitigation measures and regulate community consistent with recognized standards.

### Breach

Breach is an act or omission (failure to act) inconsistent with an existing duty. The duty of the fire chief here would be to require mitigation measures or, in the alternative, recommend denial of the land division and/or construction based on the I-Zone high fire hazard safety concerns. The fire chief's passive role in this regard is the failure to act, where action is called for, that satisfies the element.

### Actual Cause

The home was burned by the kind of fire that, planning and regulating with respect to high hazard areas, would have anticipated.

### Proximate Cause

Social policy consideration? Act of God? No obvious basis for community interest in cutting off liability. No reason to negate causal element.

### Injury/Damages

Damages compensatable by dollars? You bet.

All the elements of negligence appear to exist. Wouldn't be a bad time for the chief to shop for some malpractice insurance and look into homesteading his house. But wait! This analysis isn't finished. What about immunities and defenses. First, are immunities available? As we have previously discussed, sovereign immunity has been replaced in California by statutory governmental tort immunity. The general rule is the fire chief may be sued if specific hoops are jumped through with respect to time frames and other procedural limitations. Further the courts will often ignore even these procedural particulars, like deadlines for claims, where substantial injustice would likely result.

Governmental versus proprietary? Not likely to find any protection here. Such review and regulation is traditionally left to state, county and city governmental agencies. It is interesting to note here that the formation of various forms of special districts, homeowner's associations, published conditions, covenants and restrictions, and similar creations could provide additional facets to this issue.

The theory of discretionary versus ministerial could provide some relief if the action (or omission) of the chief could be characterized as a policy setting level. Here the argument will likely include the nationally recognized standards and industry practice. What do most of your peers do?

If no immunity, are there any defenses available? Did the property owner assume the risk by building in a high fire hazard area? Probably not. The fact that the fire chief was not actively involved in the planning and permitting process suggests a scenario inconsistent with "notice" to the builder in these areas. It is interesting to note here, that in California, the law now requires disclosure to buyers of high fire hazard area properties. This "notice" procedure can transfer some or all of the liability to others in the food chain including the seller and broker/agent.

How about "contributory or comparative" negligence? If we assume a typical property owner we can make a good case here but remember it does not take the chief off the hook in California. It only reduces, proportionately, the amount of dollar damages. Here the owner allowing brush on the subject property may satisfy the requirement. The standard of care of the average reasonable person under the same or similar circumstances is key to this discussion. Remember that this standard is less than that of the average reasonable fire chief. Remember also that actual or constructive notice is critical to this analysis.

## Compensation

In the example the fire chief took no action. Run through the analysis again and have the chief do what you in your respective jurisdictions do. What is the outcome? After you have established that result read the following account of the respected Supreme Court Judge Learned Hand's negligence formula.

The exposure of the fire chief is significant. A few years ago the judgement in a lawsuit was rarely over $1,000,000. Today, it is common for such judgement to be multimillion.

The exposure of the fire chief is significant. A few years ago the judgement in a lawsuit was rarely over $1,000,000. Today, it is common for such judgement to be multimillion.

"In a series of opinions written in the 1940's, Judge Learned Hand, famous and respected Supreme Court Jurist, distilled a negligence formula from the common law approach. The formula provides that one is negligent where the burden (B) of avoiding a risk, or package of risks, is less than the probability of that risk occurring (P) times the gravity or severity of the anticipated risk should it arise (L). Put algebraically, as the great jurist himself put it, one is negligent if B P x L. It must be emphasized that B is not merely the direct cost of avoidance, i.e., repairs to a defective car. It also includes the loss society will suffer because an alternative product design makes it harder to use. B also includes the costs to the defendant of discovering the risk, i.e., the cost of finding out the product is defective" [(United States v. Carroll Towing Co., 159 F.2d 169 (2d Cir. 1947); (Conway v. O'Brien, 111 F.2d 611 (2d Cir. 1940) and (Thomas C. Galligan, Jr., Strict Liability in Action: "The Truncated Learned Hand Formula" 52 La. L. Rev. 323 (1991); cf. Kelly, supra note 27, at 103-4)].

What does all this mean for the fire chief? If you do not take all means available to you to effectively regulate your community and impose conditions and restrictions that, while they may be expensive and otherwise burdensome, are a reasonable investment when balanced against the very kind of risk anticipated, you are likely to be found liable. Have a nice day Chief!

## Barriers

Where do we go from here? It may be appropriate to springboard into this question by reviewing where "here" is. Here is the California Fire Chief in the mid 90's. The fire chief must make every effort to produce reasonable fire safety in the community. The barriers are political, economic, physical, legal and social.

The physical barriers are topography, climate and flammable vegetation. We have the technique and technology to easily overcome these barriers (see Section III, Defensible Space & Fuel Modification), if we use law and the legal system effectively.

The economic barriers are both macro and micro. There will always be fierce competition for dollars to fund fire mitigation efforts. The California economy generates intense resistance to both public response program funding and acceptance of the cost to developers and builders of built-in passive and automatic detection and suppression mitigation systems. We have the ability to stay in the game but never completely overcome this barrier. Being successful in the legal arena will be extremely valuable in this on going effort.

The socio-political barriers are those influence centers within the respective jurisdictions which resist the role of the fire chief as increasingly significant to planning, designing legislating and demanding compliance in the expanding I-Zone community. This barrier is, in many ways, the most formidable. Good planning, continuous effort, hard work, common sense, reasonable expectations, and luck are necessary to achieve sustained success. This is, of course, sufficiently complex to be the subject of another chapter. Suffice to say here that failures in the legal arena will doom your possibility of success on the political fronts.

The legal barriers are the threat of civil lawsuits and the various Federal, State, and local statutory mandates and constraints, including those grounded in other interests and disciplines such as environmental protection, crime prevention, water purity, aesthetics, and economy.

Not a pretty picture is it? But notice how the law and legal issues permeate each and every element of the problem. As in the

National attention, including a presidential blue ribbon commission, flowed from the 700 homes lost in 1970 to the "Devil Winds." Since that time the magic of television has placed these fires in every livingroom as they occur in such glamorous settings as Bel Air, Carmel, Santa Barbara, and Malibu. As the public consciousness has been raised a societal preference has also developed. These preferences can be apprehended in regulatory policies by federal, state, and local governmental agencies, as well as rates and underwriting methodologies of insurance companies, and the decision of the courts.

opening example of the fictional Acme ladder case, one of the keys to success will be to understand and manage the subtleties of the intent of statutory law rather than the literal text. Another key will be to understand the laws of negligence which are the basis of the vast majority of civil lawsuits.

### Summary

So now we know where "here" is. Once again, "Where do we go from here?" I am reminded of the tourist who asked, "How do you get to Carnegie Hall?" The measured response was "practice, practice, practice."

That too is our answer. That is, practice by researching and reviewing the Federal, State, and local laws that relate to the I-Zone community within your jurisdiction. Work with these tools and with the interested public and private sector groups and individuals to assure your influence is felt. Actively support change in these laws where needed and fairly and uniformly apply them. Perfect a working relationship with government legal counsel and, if possible, with attorneys in private practice. The ability to discuss issues with attorneys on a relatively informal and non adversarial basis would be extremely valuable. This relationship would be particularly helpful if the attorney had significant experience in land use or real property but it is not essential. Document your activities carefully. Provide forums for educating the various constituencies affected by your decisions and accessible appeal mechanisms. And... practice, practice, practice.

## GLOSSARY OF LEGAL TERMS

### A

**Action** - An ordinary proceeding in a court of law.

**Actionable** - Any conduct the result of which is sufficient grounds for a legal proceeding.

**Adjudicate** - To settle through the use of a judge; to act as a judge.

**Affidavit** - A voluntary, written statement given under oath and sworn to before some person legally authorized to administer it, such as a notary public or on officer of the court.

**Agency** - A relation in which one person acts on behalf of another, with the latter's consent.

**Allegation** - An accusation of charge.

**Allege** - To assert without proof. An alleged criminal is one who is, as yet, unconvicted.

**Appeal** - A complaint to a superior court of an injustice done by an inferior court, in hopes that the original decision will be reversed.

**Appellee** - In an appeal, the party who argues against the reversal of the decision, having originally won the case.

**Assumption of the Risk** - In tort law, a defense used by the defendant in a negligence suit in which it is claimed that the plaintiff had prior knowledge of a dangerous condition and thus is respon sible for voluntarily exposing himself or herself to that danger.

### B

**Breach** - To break or violate a law, duty, or right, either by commission or omission.

**Brief** - A written argument, concentrating upon legal points and authorities, used by a party's lawyer to convey to the court the essential facts of the case.

**Burden** of Proof - The duty of a party in a lawsuit to prove disputed facts of allegations, either to avoid dismissal of the suit or to prevail in the suit.

### C

**Cause of Action** - A claim in law and fact sufficient to demand judicial attention. Tort liability suits must have a basis for a claim. Facts must support the allegation that a duty has been breached and dollar damages resulted.

**Citation** - 1. A reference to a source of legal authority. 2. An official call or notice to appear in court.

**Civil Law** - That branch of law pertaining to noncriminal matters, such as suits between individuals.

**Civil Suit** - An action at law to recover dollar damages as a result of a wrong other than a crime.

**Claim** - The assertion of a right to property or money.

**Common Law** - Principles and rules of law taken from early English law and now the general concept of establishing a body of law derived from case precedent.

**Comparative Negligence** - The proportional sharing of compensation for injuries between plaintiff and defendant. Damages recovered by the plaintiff are reduced in proportion to the plaintiff's fault.

**Compensation** - 1. Remuneration of work done. 2. Recompense for injury received.

**Complaint** - An accusation or charge against a person alleged to have committed an injury or offense.

**Contributory Negligence** - Conduct on the part of the plaintiff that ignores the exercise of due care, and hence cooperates with the negligence of the defendant to bring about the plaintiff's harm.

**Court of Appeals** - A court having jurisdiction to review prior decisions and either uphold or reverse these decisions.

**Culpable** - Deserving of moral blame. Culpability implies fault rather than guilt, or disregard of consequences which may follow an act.

## D

**Damages** - Monetary compensation that the law awards to one who has been injured by another's action.

**Defendant** - The party denying, resisting, opposing, or contesting an action.

**Deposition** - A written declaration of fact, made under oath by a witness in the presence of a judicial officer, and which is taken down in writing before the trial.

**Discovery** - A modern pretrial procedure by which one party disclosed vital information concerning a case to the opposing party.

**Discretion** - The reasonable exercise of a power or right to act in an official capacity and make choices from among several possible courses of action.

**Doctrine** - A principle of law established through past decisions.

**Due Care** - A conception used in tort law to signify the standard of caution or legal duty one person owes to another. It is the degree of care that a person of ordinary prudence and reason would exercise under the same or similar circumstances.

**Due Process of Law** - The phrase introduced in the Constitution when it guaranteed that no person should be "deprived of life, liberty, or property without due process of law." Though open to considerable interpretation, it generally means that the application of the law to an individual case must be fundamentally fair and consistent.

**Duty** - A person's obligation not to violate the rights of another, flowing from statutory or common law.

## E

**Enjoin** - 1. To command or instruct with authority. 2. To forbid or suspend.

**Equity** - The body of law in England that developed in reaction to the common law's inability to handle all situations. Equity qualifies or corrects the law in extreme cases, often with an injunction or other means of relief.

**Estoppel** - An impediment by which someone is not allowed to allege or deny a fact, based on that person's previous allegation or denial to the contrary.

**Ex Parte** - Latin, "after the fact." A term describing laws passed that punish or increase the punishment of crimes committed before the laws were passed. Such laws are expressly forbidden by the Constitution.

## F

**Federal Tort Claims Act** - An act passed in 1946 that confers exclusive jurisdiction on United States' district courts to hear claims against the United States. In effect, it waives the privilege of sovereign immunity of the federal government, allowing individuals to sue the government in federal court.

## G

**Gross Negligence** - The intentional failure to perform a duty in reckless disregard of the consequences as affecting the life or property of another.

## I

**Immunity** - Exemption or freedom from lawsuits and the subsequent legal liability.Injunction - A writ, issued to remedy a situation, that requires a party to refrain from doing some particular act or activity.

**Injury** - Any wrong or damage done to a person, either to that person's body, rights, representation, or property.

**Intent** - The state of mind in which a person knows and wishes to bring about the result of an action.

**Intention** - A determination to act in a particular way so as to bring about certain results.

## L

**Last Clear Chance** - A doctrine holding that a defendant may still be liable for the injuries caused to a plaintiff, even though the plaintiff is guilty of contributory negligence. The doctrine applies if the defendant, having observed the plaintiff in a position of danger, failed to avoid injuring the plaintiff when in a position to do so.

**Legal Duty** - Something that the law specifies must be done by a particular person or group.

**Liable** - To be legally responsible for.

**License** - A right granted to a person that gives that person permission to do something not legally allowed without the permission.

**Lien** - A hold or claim upon the property of another as security for a debt.

## M

**Malfeasance** - The doing of an act that is wrongful and unlawful.

**Malice** - Evil intent; the state of mind accompanying the intentional doing of a wrongful act.

**Malpractice** - Failure to perform a professional duty or exercise professional skill by one rendering a professional service (such as a physician, fire chief or attorney) that results in loss, injury, or damage.

**Misfeasance** - Doing an act in a wrongful manner, the proper performance of which would have been lawful.

**Mitigate** - To make less sever or harsh.

**Motion** - A request to the court asking that the court rule in favor of the requestor.

**Municipality** - A political unit, usually urban (as a city), having corporate status and, usually, the right of self-government.

## N

**Negligence** - Failure to exercise that degree of caution which a person of ordinary prudence would exercise in the same or similar circumstances.

**Nonfeasance** - The complete failure to perform a required duty.

**Nuisance** - Anything that renders the enjoyment of life and property uncomfortable.

## O

**Opinion** - The reasoning behind a court's decision of a case.

**Ordinary Negligence** - Failure to use normal care that an ordinary person would use in similar circumstances.

## P

**Plaintiff** - The one who initially brings a lawsuit; the complainant.

**Pleadings** - Statements in logical and legal form made by the parties of a civil or criminal suit that constitute the reasons for supporting or defeating the suit.

**Precedent** - A previously decided case recognized as an authority for the decision of future cases.

**Private Nuisance** - Interference with a person's interest in the private use and enjoyment of the individual's land.

**Privilege** - An advantage not enjoyed by all; an exemption from some burden or necessity that a certain group, class, or person has.

**Promulgate** - 1. To put into action or force, as in a law. 2. To make known or public.

**Proximate Cause** - That which in natural and unbroken sequence produces an event.

**Public Duty Doctrine** - Government owes a duty to the general public at large, not to an individual. This can be overcome by a showing that promises of assurances were given and relied upon to the plaintiff's detriment.

## Q

**Qualified Immunity** - Immunity under limited and specific facts and circumstances, e.g., discretionary acts by public officials.

## R

**Reasonable Person Standard** - A phrase used to denote a hypothetical person who has "those qualities of attention, knowledge, intelligence, and judgment which a society requires of its members for the protection of their own interest and the interests of others."

**Remand** - To send back, as for further deliberation.

**Respondent Superior** - Latin, "let the superior reply." The doctrine governing the relationships between masters and servants that holds employers (masters) responsible for the wrongful actions of their employees (servants). It applies to civil cases.

## S

**Sovereign Immunity** - A doctrine that precludes bringing a suit against the government (sovereign) without the government's consent when it is engaged in a governmental function.

**Standing** - The legal right of a person to challenge in a court the conduct of another, especially the conduct of the government.

**Stare Decisis** - Latin, "to stand by that which was decided." The principle that common law courts seldom abandon principles established in former decisions.

**Statute** - A law enacted by the legislature.

**Statute of Limitations** - An act specifying the time within which parties must take judicial action to prosecute a case.

**Subpoena** - A writ issued on court authority that compels a witness to appear in court at a judicial proceeding, the disobedience of which is punishable as contempt of court.

**Summons** - An order requiring the defendant in a case to appear in court for the trial.

## T

**Tort** - A private or civil wrong resulting from a breach of a legal duty, as distinguished from a crime, which is a public wrong.

**Tort-feasor** - One who commits a tort.

## UVW

**V.** - Versus, Latin for "against." A word used in the title of a case between the parties who oppose each other in the case, as in Marbury v. Madison.

**Vicarious Liability** - Responsibility of one person for the actions of another. It is present in the concept of respondent superior, in which an employer may be held liable for the unlawful actions of an employee.

**Writ** - A mandatory order issued by an authorized court or tribunal in the name of the state that compels a person to do something.

To avoid costly litigation and effect successful mitigation measures, local fire administrator's must become involved in, and part of, the planning process.

By **Bob Irwin & Rodney Slaughter**

The losses of life and property to I-Zone fires seems incredible. Every level of government has spent untold amounts of money, time, and effort in an attempt to reduce the impact of these emergencies. Yet they seem to be reoccurring at an alarming frequency and cost.

What we know about planning law, defensible space, and building technology should be applied in an all-out effort to protect lives and property. A glut of information exists in the form of public education, after action reports, recommendations, and model codes. Local enforcement agencies must ask themselves- what are the optimum safety standards, what are the minimum state regulations, how are they accessed, and finally, what is enforceable?

Collectively, there are a number of state laws, model codes, and regulations that could effectively mitigate future losses of I-Zone fires in California. The selection of any one or combination of model code would of course be dependent on local conditions. Weather, topography, geography, structural and vegetal fuels are all important, as are population, building density, infrastructure, and the ability of the local fire services to handle I-Zone disasters.

Not surprisingly, the brunt of adoption and enforcement falls on the shoulders of local government and fire officials. This chapter will outline the requirements of the County General Plan and what is available in terms of model code to support fire safe requirements. We must recognize that if it isn't included in the plan, then it won't get done on the ground.

## The County General Plan

The County General Plan is the master document, or Constitution, that governs land use and development in any jurisdiction. State law gives counties wide latitude in the ways that a General Plan can be put together, but there are fundamental requirements that must be met. These requirements include seven mandatory elements described in the Government Code, and guidelines from the Office of Planning and Research that set forth the required contents of each element.

For well over a hundred years federal and state courts have upheld the authority of local governments to regulate their own internal affairs, subject only to compliance with state and federal laws. Described as "Police Powers" by the courts, these local authorities govern planning and regulations that control the type, size, character, and location of development. In California, the legislature has found that local governments are obliged to use

Police Powers to provide orderly and safe development. The Legislature and courts have further defined the General Planning process is one of many ways to accomplish that obligation.

General Plans have been defined by the courts as the "Constitution for Local Development." This grants great power and prestige to the General Plan, and also means that all development decisions must flow downward from it in a logical manner. All land use designations, zoning, development ordinances, and implementation or mitigation requirements must be consistent within the General Plan. Consistent means that no part of the process can be contradictory to, or uncoordinated with, any other part. For example, a General Plan would be inconsistent if it recognized the need for emergency evacuation as a potential safety measure but did not address adequate transportation routes as a basic goal of the jurisdiction.

California law gives local governments wide latitude in designing or formatting General Plans. There are several different ways to write the Plan, and many ways to place requirements in relation to others. Some elements may be combined. Local differences also add diversity to the content: mountain counties may include avalanche concerns and coastal counties may include tsunami issues. It is rare to find two General Plans that look alike or read in a similar format.

The variety of formats and the legal latitudes granted local government make most General Plans appear confusing or difficult to understand. However, the knowledge of a few key fundamentals will help interpret any General Plan and make them easier to evaluate.

There are two sets of requirements that must be present in all Plans, these are:

guidelines from the Governors Office of Planning and Research (OPR) describing the "required contents" for each element. The OPR requires that each identified issue be addressed in three parts; data and analysis, policies, and implementation measures

the seven mandatory elements required in Section 65000 of the Government Code. As noted, these may not be easy to find in any General Plan because of the latitude allowed in format, but they must be there.

## Office of Planning & Research Guidelines

Office of Planning and Research (OPR) guidelines require that "attention be devoted to issues of concern to the community", and that "cities and counties need to address each issue to the extent it applies to the community." Here again, there is wide discretion allowed in the ways this can be done, but the intent is clear: if wildland fire is a concern, then it must be covered in the Plan.

### Data & Analysis

The data and analysis requirement begins the planning process. It is intended to be a "situation" or "problem" statement that provides details about each issue of concern. It should describe the conditions, constraints, and character of the issue. Fire and resource protection can be enhanced if the data and analysis portion of the Plan describe the wildland fire environment in detail; fire history, topography, fuel loads and types, weather conditions, average/worst fire danger, rates of spread, potential threat to structures, access, and water supplies. Post-fire flood damage potentials could also be described. The data and analysis section may include narrative descriptions, numerical data, maps, charts, and any other means of providing information about the issue of concern.

Many fire jurisdictions already have a jump-start for collecting information required for data and analysis. Two out of three fire departments reported to the California Fire Service Census (1994), as having an urban/wildland intermix problem. Just as many jurisdictions are collecting information to assist the California Department of Forestry and Fire Protection (CDF) in mapping high fire hazard severity zones (FHSZ) throughout the state.

We must realize however that mapping FHSZ's only provides a macro-view of wildland fire potential. Specific data and detailed analysis are still required for site specific planning. Fire administrators need to tell their elected officials that this canyon will give you 50' flame fronts or 150' flame fronts. They need to identify that substandard housing on this ridge will place people and property at risk and why. The information and experience of the fire service is a valuable planning tool. Similarly, the planning process is our greatest asset in effecting fire prevention and mitigation.

The data and analysis section is the starting point for better fire and resource protection. The more complete the analysis, the stronger the justifications for action will be. If data and analysis are weak or incomplete, then everything that follows will also be weak.

### Policy

After an issue or concern is described in the data and analysis, there must be policies that state the jurisdiction's decisions to act, control, or mitigate the defined problem. For example, if fuel loading was identified in the data and analysis section as a problem, there should be some statement to the effect that development will be designed or controlled to reduce the volume. If access was identified as a problem, there should be policies to improve road design.

### Implementation Measures

Implementation is the fundamental steps local government will take to initiate their defined policies. Each policy described must have at least one implementation measure, and may have several. For example, if a policy calls for improved access, then the implementation measure might be to adopt the road and street design recommendations in Public Resource Code (PRC 4290), California Fire Code (CFC), Uniform Fire Code (UFC), International Urban-Wildland Interface Code (IUWIC), NFPA 299, or the model ordinance developed by Assembly Bill 3819 (AB 3819). The key is that any one, or combination of, model code must be adopted by the jurisdiction to become enforceable as a mitigation measure.

### Government Code

Section 65000 of the Government Code is referred to as the Planning and Zoning Law. Section 65302 of the code defines seven mandatory elements that must be included in each General Plan. Each of the elements must contain text that incorporates data and analysis, policies, and implementation measures. The text may be accompanied by descriptive diagrams and maps.

Six of the seven required elements are a perfect opportunity to effect I-Zone prevention and mitigation. The important six elements include; land use, housing, circulation, conservation, open space, and safety.

### Land Use

The land use element dedicates lands to particular purposes. It tells how the jurisdiction will designate and separate various uses such as commercial, industrial, and residential. Natural resource, agriculture, timber production, and flood plain areas must also be included. A major intent of the element is to design areas for development that are compatible with one another. That is, heavy industrial areas should be separated from, and not adjacent to, residential areas. On the other hand, light commercial or shopping center designations may be compatible with residential uses. Sometimes commercial areas are designated as buffers or gradual change uses between residential and industrial areas.

Land use presents a number of opportunities. Greenbelts, fuel-breaks, fuel reduction, buffer zones, and water supply requirements could all be addressed in this element. All of which, are detailed in the CFC, UFC, IUWIC, PRC 4290, and NFPA 299.

Examination of the land use element may show current or future conflicts with fire and resource protection. All too frequently, the compatibility of uses is violated where development encroaches into wildlands. All types of uses designated in, or adjacent to, hazardous fire areas without a buffer zone or other mitigating activity should be addressed. Since zoning districts are derived from land use designations, it is important to assure that those designations, policies, and ordinances are compatible with I-Zone protection.

### Housing

This element is required to designate how the government will regulate density and the intensity of residential development. It includes provisions for low income and handicapped needs. In some cases, it may actually allow lower standards of design and construction to encourage affordable housing.

In hazardous areas, this element could be in conflict with fire safe development. Access, construction standards, and design requirements might be reduced by the jurisdiction in an effort to comply with the needs of affordable housing. Alternative areas for this type of development should be designated.

In other cases it could also allow for more restrictive construction and protection standards. Siting of buildings could be linked to topography. Minimum protection for exterior walls, glazing, eaves, balconies, roofs, chimneys, and sprinkler protection are all required in the model ordinance developed as a result of AB 3819 and the minimum state building standards in the California Building Code.

### Circulation

This element consists of the general location of existing and planned transportation routes and public utilities. Data and analysis, policies, and implementation measures in this element must be correlated with the land use element. The information is usually shown on maps or diagrams to show how the transportation system serves the various land use designations.

The circulation element offers an opportunity for planners and fire prevention officers to designate strategic access, road design, turn-arounds, road widths, helibases, helispots, and evacuation routes. Each of which is detailed in the model codes.

Important is the designation of access routes and road design requirements. The Government Code Section 1400 requires that the circulation element provide transportation facilities that reduce hazards to human life and minimize damage to natural resources, and thus should also include air attack facilities.

### Conservation

This element describes how the jurisdiction intends to protect and conserve its natural resources. The element should cover water, soils, forest, wildlife, and fisheries. Potential fire and flood impacts on all resources should be included.

Conservation has often been maligned in terms of fire prevention. But, what seems unlikely in terms of I-Zone protection and mitigation, becomes another opportunity. Fuel breaks, fuel reduction zones, watershed protection, erosion control, ecosystem management, and species specific protection reinforce data and analysis. Each of which coalesce into developing a sound and methodological approach to effective I-Zone suppression, prevention, and mitigation.

## Open Space

This element designates areas for preservation and managed production of natural resources, outdoor recreation, and public health and safety. The Open Space element is related to the conservation element in some ways, and designated lands in either element could be actually or nearly the same. The important differences between the two elements is the very specific inclusion of public health and safety in open space zoning. Section 65560-4 of the Government Code dictates that the element should include designations of "areas that require special management because of fire risks." The Code authorizes the connecting or linking of these areas into complete networks in the interest of public safety, and that justifies fuel breaks, fuel reduction zones, and specific road locations.

The open space element offers an opportunity to analyze conflagration potential and to design fuelbreaks, fuel reduction zones, helispots, and water systems into strategic fire defense improvement systems. Developers can be required to construct and maintain the improvements. Inclusion of strategic defense improvements in the open space and safety elements will lead to zoning for such improvements and eliminate the owner-by owner agreements and public agency financing now necessary for construction and maintenance.

## Safety

The safety element defines community protection measures in relation to fires, seismic, and geological hazards. It must include provisions for evacuation routes, water supply, minimum road widths, and clearances around structures. It should include mapping of fire hazard severity zones, and could include analyses of minimum suppression resources required.

## Legal Adequacy

California Courts have upheld the provisions of Government Code Section 65860 which requires that General Plans be internally consistent. From a practical standpoint, the requirement for internal consistency has two important meanings. First, it means that elements of the Plan cannot contradict each other- there must be a clear indication that all parts of the Plan are integrated, that all parts offer mutual support to others, and that there has been a coordination of Governments intentions in each and every part of the Plan. Second, it means that the actions which follow general planning, such as zoning and development ordinances, must meet the intent of the Plan's policies and mitigation measures.

The courts have ruled that a lack of consistency invalidates a General Plan and that an invalid Plan means that no development can be approved by the jurisdiction as long as the weaknesses exists. There are many legal rulings in this regard, and two of those make the point very well. In the case of "Resource Defense Fund v. Santa

Cruz" (1982) the court said,"...absence of a valid General Plan or elements thereof, precludes any enactment of zoning ordinances and the like." In "Camp v. Mendocino" (1981) the court ruled that "The county may not approve subdivisions since some of the General Plan elements are inadequate in that they do not meet criteria in state law."

The significance of these decisions is critical. If any General Plan element is judged inadequate, development in the jurisdiction may be shut down until the courts find that the deficiencies have been corrected. This is a powerful incentive for any jurisdiction to improve its Plan before someone brings suit.

## Model Code

An important function of the General Plan is designating model code(s) that can be adapted as an implementation measure to effect fire prevention and mitigation. What's enforceable is predicated on minimum state standards. However, the implementation of the General Plan should incorporate the most appropriate regulation- the regulation that provides the optimum in fire safety. The authority for local fire jurisdictions to modify, adapt, and enforce fire safe regulations begins with the Health and Safety Code.

## Health & Safety Code

The Health and Safety Code (H&SC) mandates that the California State Fire Marshal (SFM) adopt both building and roofing standards relative to fire, panic, and safety (H&SC 13208, 13108.5, 13145). The H&SC also ties the mission of the SFM to the fire service by establishing authority for local fire officials to enforce minimum state standards (H&SC 13146). The SFM regulates building standards through the California Building Code. This code is the minimum standard which can be enforced by all local fire authorities.

This provision, however, does not mean that local fire authorities have to accept the minimum state standard. The H&SC also allows local fire officials to change or modify the minimum state standard when their findings are reasonably necessary because of local climate, geological, or topographical conditions (H&SC 13143.5). Any changes however, can not be less restrictive than the minimum state standard (H&SC 13143.5).

This section of the H&SC is an important first step towards identifying the need for strategic fire planning within your community. The findings referred to in the H&SC are analogous to the finding of facts or data and analysis, required as a component of either a site specific plan or a County General Plan.

## California Building Codes

The California Building Code (CBC) is an adaptation of the Uniform Building Code. Admittedly, the CBC was not specifically written to address the I-Zone. The primary focus of the CBC is fire and life safety for people in any variety of occupancies. We can however, glean useful code information relative to our I-Zone problem.

The CBC reiterates the authority of local fire officials established by the H&S to enforce the minimum state requirements and the local fire authorities to develop more restrictive requirements.

The minimum state building and roofing standards adopted by the SFM are accessed through the CBC. Roofing requirements, in terms of material type, installation, and standards are detailed in the CBC. Class A, B, and C roofing materials are categorized according to their performance under a number of test conditions adopted by the CBC. Roofing standards are a central concern for structures built in the I-Zone. As will be discussed later, a buildings vulnerability begins with flying brands and flame impingement on roof assemblies.

Minimum standards for the construction of chimneys, fireplaces, and barbecues are also detailed in the CBC. Features such as these, that burn solid fuels, can potentially ignite roofs and overhanging vegetation. Provisions for spark arresters chimney height, and construction are an essential consideration for structures built in the I-Zone.

The details for sprinkler standards and installation requirements are also found in the CBC. The provisions for fire extinguishing systems are integrated with occupancy, building construction, and building size. However, a number of fire jurisdictions have successfully implemented residential sprinkler ordinances. In the context of the I-Zone, the effectiveness of exterior sprinkler systems remains questionable. But indoor residential sprinkler systems have been effective in reducing building losses when a wildland fire penetrates the interior.

Fire resistive standards for structural frame and interior walls can be found in the CBC. Technically, these standards are intended to protect critical areas of egress like corridors and stairways. They also protect the structural framework of a building long enough to either effect evacuation or protect people "in place" as in hospitals, high rises, and jails.

Fire resistive standards for exterior wall construction has not been detailed in the CBC. The lack of empirical information on how long, and at what temperature, or radiant heat flux exterior walls must be protected against has not been completed. Therefore, fire resistive standards, for exterior construction, has been extrapolated from interior assemblies. Until further scientific studies are completed, current building assemblies and technology will have to be applied towards exterior applications.

### Title 19 of the California Code of Regulations

The CBC references "nonbuilding regulations" to Title 19 of the California Code of Regulations. As such, Title 19 becomes enforceable by local fire jurisdictions. Title 19 covers information such as housekeeping, maintenance, operation, use, limitations, or prohibitions within any occupancies regulated by the SFM.

Title 19 also adopts by reference the Uniform Fire Code to establish minimum state requirements relative to "control conditions hazardous to life or property in the use or occupancy of buildings (T-19 CCR 1.09)". Additionally, Title 19 recognizes fire prevention engineering practices as detailed in the National Fire Codes and the Fire Protection Handbook as authoritive guides (T-19 CCR 1.09). While no single code can address all the conditions and concerns of the fire service, the inclusion of these nationally recognized standards is an important consideration when searching for a model code applicable to the I-Zone.

### California Fire Code

The California Fire Code (CFC) is of course an adaptation of the Uniform Fire Code. The SFM however, only adopts certain sections of this code, that is only the sections adopted by the SFM are enforceable by local fire officials as a minimum state standard. The exception however, is local jurisdictions who have adopted the entire CFC by local ordinance. The CFC is pivotal to vegetation management and infrastructure requirements, each of which directly relate to many of our I-Zone concerns.

A good example of utilizing the Fire Code is provided by Ventura County. Their Fire Hazard Reduction Program is predicated on specific provisions of the Fire Code and compiled as a stand alone easily referenced document (Wildland Fire Unit: In Pursuit of Consistency, Ventura County Fire Protection District).

Cognizant of the I-Zone problem, the International Fire Code Institute (IFCI) is compiling their own document entitled the "International Urban-Wildland Interface Code" (IUWIC). This is another stand-alone document which will address both fuel management and structural protection. This new document will also have to be adopted by local ordinance to be enforceable.

Both the CFC and the IUWIC contain requirements that would mitigate the issues in land use, circulation, conservation, open space, and safety elements of the General Plan. Water supply, minimum road widths, fire modeling, fuel reduction, building siting, and minimum construction standards, are all examples of what could be garnered from these model codes.

### National Fire Protection Association 299

Similarly, the National Fire Protection Association (NFPA) has developed their own I-Zone model code. The NFPA 299 document is entitled "Protection of Life and Property from Wildfire (1991 Edition). NFPA 299 details vegetation management and infrastructure requirements. To be enforceable, NFPA 299 would have to be adopted by local ordinance. Here again, NFPA 299 relates to a number of elements in the General Plan.

### Public Resource Code

One of the source documents used in the development of NFPA 299 is the "Fire Safe Guidelines for Residential Development in California". The Fire Safe Guidelines is predicated on Title 14 of the Public Resource Code (PRC 4290). PRC 4290 regulations again specify vegetation controls, clearances, and infrastructure requirements such as equipment access, street signs, water supplies, fuel breaks, and green belts. Obviously, these all are considerations for the General Plan.

There are two ways to access PRC 4290 in California. The first is to enter into a contract with the California Department of Forestry and Fire Protection (CDF). CDF enforces the PRC similar to the SFM enforcing CBC. By entering into a contractual agreement with CDF it is understood that the PRC and any other locally adopted ordinance would be enforced.

Secondly, local jurisdictions can adopt the PRC itself as a local ordinance. The decision to adopt the PRC over the CFC, NFPA 299, or the IUWIC would be dependent on local needs and conditions identified in the data and analysis of the General Plan.

### Assembly Bill 3819

Building standards and high fire hazard severity zone mapping are linked together in AB 3819. Just as the Bates Bill (AB 337) became the result of the Oakland/Berkeley Hills fire, AB 3819 came into being after the Southern California firestorm of 1993.

Essentially, AB 3819 requires the SFM to establish building standards in areas designated by CDF as high fire hazard severity zones. Together the SFM and CDF will model defensible space and building standards. Explicit in this bill are additional roofing requirements other than those specified in AB 337. Once again when the model ordinance is developed, it's enforcement will become dependent on local adoption and enforcement.

### Summary

Local fire managers need to become involved in, and a part of, the local planning process. Characteristically, planning has long been dominated by urban interest in zoning, growth, and development. This "urban bias" tends to focus more attention on city-type concerns at the expense of critical I-Zone issues.

Greenbelt dedications in many communities provide an example of this bias in operation. A developer who graciously dedicates lands as open space, greenbelt, or fuel breaks often times donate land too steep to build on. The dedicated area turns out to be the worst possible fire hazard. The planners, in the spirit of saving the environment, often require that this dedicated area is to remain untouched, undeveloped, and left in its pristine state. But these areas must be managed. Working through the General Plan, local fire managers can require fuel reduction and removal by the developers and future lot owners on a continuing basis.

To effectively mitigate this type of concern requires data collection from Federal, State, and other local agencies. Weather, fire behavior modeling, environmental and ecosystem management, building construction and protection are all areas in which information is readily available from one source or another. Working collaboratively with other agencies and professions is tantamount to collecting relevant information and data.

The path of fire prevention and mitigation for many jurisdictions is fairly clear and direct. Many mitigation measures can be identified and required in elements of the County General Plan. Both the General Plan and the adaption of model code allow local governments to address a wide range of options specific to their local needs and long range objectives.

Considerations for the data and analysis of the general plan include a number of components that are identified through fire hazard severity zones.

By **Bob Irby**

Wildfire is a hazard wherever people and residential developments intermix with the wildlands. However, the degree of hazard and the required amount of fire safety measures, vary from area to area. The ability to identify areas of differing severity allows the application of reasonable firesafe standards based on the threat present. It must be remembered, however, that there is a baseline of fire prevention or firesafe activities that must be applied to obtain a basic level of protection.

Assisting local government, private industry has identified and classified areas of varying fire hazard severity. Land use planners for private industry have cooperatively design mitigation measures under which development and use of these areas may occur. This activity was recognized in the late 1960's and early 1970's as a necessary first step in protecting life and property from the devastation of wildfires in California. Fire agencies need to assess their protection responsibilities for applying appropriate fire prevention programs and targeting critical areas for special programs. Insurance companies have shown a significant interest in wildland fire hazard assessment following the Painted Cave (Santa Barbara) and Tunnel fires (Oakland/Berkeley).

To take effective action, involved personnel must understand the elements, components and factors that contribute to the problem. Each of the assessment models and processes described below provides a different level of insight into the wildland fire problem. The expertise of the agency and the complexity of the problem need to be considered when selecting an assessment process.

### History Of CDF Hazard Zoning

In 1973, the California Department of Forestry (CDF) developed a fire hazard severity classification system to provide land-use planners a practical and logical system for classifying the severity of fire hazards on California's wildlands. Fuel loading (the quantity of flammable vegetation and other fuel per unit of land area), fire weather, and slope were the primary criteria for identifying and classifying the severity of the fire hazard in a given area. In order for planners, developers, and fire authorities to have a uniform understanding of the area of reference, these fire hazardous areas were, delineated on U.S. Geological Survey (USGS) topographic maps. These maps served as the basic tools in defining fire hazard severity and administering fire safety measures until new fire hazard severity zones were defined in the early 1980's.

Legislation implemented in 1981 and amended in 1982 required CDF to develop wildland fire hazard severity zones within the State responsibility areas (SRA) for the purpose of "identifying measures to be taken to retard the rate of spreading and to reduce the potential intensity of uncontrolled fires that threaten to destroy resources, life or property. The zoning identifies where the potential of large, destructive wildfires exists (PRC 4201)." Each fire hazard zone "shall embrace relatively homogeneous lands and shall be based on fuel loading, slope, fire weather, and other relevant factors present (PRC 4202)." The zones were intentionally developed without including the elements of value and risk. Additional requirements specified public and county review of the zones and periodic review and update by CDF (PRC 4203 and 4204).

The Bates Bill (AB 337) required CDF to identify fire hazardous areas in Local Responsibility Areas (LRA). Unlike previous hazard zoning, it required CDF to identify very high fire hazardous areas which were not in the SRA, but all areas within counties where fuels, weather, topography combined to present a potential wildfire problem pursuant to a prescribed schedule. CDF was required to identify very high fire hazardous areas based not only on the wildland fire environment, fuels, topography, fire weather, and other relevant factors, but also consider the values at risk- in this case, the inclusion of structures.

## Values At Risk

Clear distinctions between urban, rural and wildland fire protection responsibilities have been confused in recent years by California's rapid population growth and accompanying residential, commercial, and industrial development in rural and wildland settings. As the numbers of people and structures has grown and as they have spread to areas of flammable vegetation with steeper topography, a fire protection problem of unprecedented magnitude developed. California, from 1984 to 1993, lost 75 people to wildfires, over 7000 residences were destroyed resulting in over 3 billion dollars in damage. These figures represent only two percent of the 73,499 wildfires reported to CDF which burned over 1.3 million acres of the more than 33 million acres of SRA lands during the same period.

Where people and their property are coupled with fire prone vegetation, lives, property, and natural resources will be lost to wildfire. The values at risk represented by people and property sharing their physical environment with fire prone vegetation, on steep slopes in California's I-Zone, illustrate the most difficult, dynamic wildfire protection challenge in the world. The CDF meets this challenge by relying on time proven strategy and tactics. For example, the multi-jurisdictional Incident Command System (ICS) allowed fire fighters to attack not only the destruction of natural resources from wildfires, but also focus on its impact on important values at risk: life and property. In the decade of the 1960's, tactical options for controlling wildfire began to become much more complex because of people and structures in the proximity of SRA lands.

## Components Of Traditonal Fire Hazard Zoning

Fundamental to understanding previous fire hazard zoning is the interrelationship of hazards and risk. When the hazards of structures, fire prone fuels, steep topography, and fire weather are intermixed with the risk associated with people, often with no clearly defined boundary or interface, the possibility of mutual destruction by wildfire greatly increases. The threat of exposure to destruction by wildfire to the more than 2,500,000 people and more than 1,000,000 permanent dwellings in the SRA continues to increase due to rising population, heavier fuel loading, recurrent drought, extensive development, and changing land uses. Structures and people represent fire hazards and risks which when coupled with California's wildland fire environment mean loss to human life, tremendous damage to property, and reduced viability environment that actually burn or that cause the fire to burn faster or hotter than normal. This would include structures, vegetation, topography, and weather. Fire risks are those factors that cause fires to be ignited, people. Defining the I-Zone in terms of hazards first will point out the explosive situation that occurs when the risks, represented by people, are coupled with these the hazards defined below.

## Vegetation Hazards

Composed of cellulose materials, all vegetation is flammable to some degree. Some types like chaparral, are much more flammable than others like irrigated landscaping. All vegetation is more flammable at certain times than at others. Vegetation in its wild state consists of both living and dead materials. The dead materials and the fine living materials (leaves or needles and twigs) represent the bulk of the available wildland fuel. In timber stands and heavy brush fields, this available fuel may reach 50 tons per acre. In areas of logging slash, fuel loading may run up to 200 tons per acre. When hundreds or thousands of acres of such volumes of fuel are burned in short periods of time, as often happens under conflagration conditions, the amount of heat and energy released approaches that of an atomic bomb. Flame lengths can exceed 100 feet, radiated heat can ignite exposed flammable materials at distances of 100 feet or more.

Convection columns carrying flaming or glowing fire brands often extend many thousands of feet into the atmosphere and can drop firebrands several miles downwind. Thousands of homes can be exposed to these conditions. Of particular concern is the wildland fuel known as chaparral, because so much of it is in or near metropolitan areas. Chaparral also represents an unusually dangerous fire hazard because of its inherent qualities. As a fire climax plant community, chaparral has for thousands of years not only survived repeated fires but has adapted itself to depend on fire for regeneration and survival. Wherever chaparral exists large-scale fires can be predicted with certainty to occur sooner or later, and the longer between fires the larger the fire. In southern California, the average time between fires in any given area (cycle time) is about 30 years.

### Fire Weather Hazards

Weather, or more specifically fire weather, can properly be termed a fire hazard because it aids ignition and accelerates combustion. Weather is at least as important as fuels in the I-Zone. The weather elements responsible for very high or extreme fire danger are strong winds, high temperatures, low humidifies, and low fuel moisture contents. This combination can happen, and has, at almost any time of the year, including the middle of winter. In areas with Mediterranean climates such as most of California, extreme fire weather is common during late summer and fall. By far the most critical factor in fire weather is wind.

The most dangerous wind is the foehn (subsidence) wind, the most notorious being the Santa Ana's of Southern California. The foehn wind produces the usual effects of winds: fanning and supplying oxygen, preheating fuels by bending flames from the vertical, and carrying burning firebrands ahead of the fire front. But it also brings dry air from continental high pressure areas, then heats and dries it further by compression as it flows to lower elevations at a velocity of 75+ mph.

High temperatures bring the fuels, both vegetative and structural, closer to their ignition temperatures. This occurs with low humidity drying the moisture from these fuels. While, low fuel moisture reduce the total amount of heat needed to raise the fuel to ignition temperature. Even green fuels, particularly chaparral, can have remarkably low moisture contents after long dry summers or under adverse fire weather conditions.

### Topographical Hazards

The third major hazard contributing to wildland and structural fire danger is mountainous topography. Although it increases the costs of construction and development, such topography attracts thousands of homeowners with its feeling of openness, an attractive view, and the possibility of getting above or away from the smog.

Side hill construction often makes structures more ignitable through the use of stilts, cantilevers, balconies, and decks.

Topography affects fires in some of the same ways that wind does by modifying, and often intensifying, the effects of the wind. Generally fires run faster uphill than down. Higher elevation fuels, like houses on ridge tops, are preheated by flames and convection columns even in the absence of wind. Canyons act as chimneys trapping heat and intensifying combustion. Canyons, saddles, and ridge lines, become raging infernos during a Santa Ana wind. Road building is difficult and expensive in mountainous terrain, often making ingress for fire fighting and egress for residents slow and difficult.

### Structural Hazards

The natural fuel accumulation is aggravated by the presence of structures because of the exclusion of wildfire. Vegetation in which fire has always been a natural ecological event gradually continues to accumulate and can go unnoticed until reaching conflagration potential. Fire Control is an absolute necessity because of the risk fire poses to lives and property. Fire hazards of unprecedented scale and severity result from the interaction between unnaturally abundant accumulations of flammable vegetation and the spread of residential development. Catastrophic fire, with high risks to property and life, is an increasingly common event when hazardous situations coincide with a source of ignition. The fundamental problem of I-Zone fire management is to prevent wildfire from spreading and entering structures, as well as to prevent structural fire from spreading and entering flammable wildland vegetation destroying natural resources and adjacent structures.

Any discussion of the problems caused by structural development must include land use policies developed and implemented by the State and local County Boards of Supervisors over the past 25 years. Currently there are approximately 1,000,000 dwellings located in the SRA lands of California. Many of these dwellings are located on lots or parcels "created" during the 1960's, 70's or 80's. Just as many of the lots or parcels were created without the benefit of wildland fire planning.

In California, land is divided for sale in three ways: (1) under the provisions of the State Subdivision Map Act; (2) under the provisions of the State Subdivided Lands Act; or (3) by lot splitting. The Subdivided Lands Act, is administered by the Department of Real Estate. The Subdivision Map Act, is administered by local government which usually requires that a developer submit a plan for subdividing a parcel of land into five or more lots. Through lot splitting, land can be divided into four or less parcels outside the purview of the Subdivision Map Act and the Subdivided Lands Act. This process is regulated by local government and facilitates minor divisions of land.

Lot splitting makes it possible to create a "subdivision" without filing a subdivision map. A parcel is divided into four lots, then each new parcel is divided into four more lots. The process continues until the smallest parcel is achieved and a subdivision is formed. Over the past quarter century, thousands of individual parcels or clusters of lots were created in California by lot splitting and developed with little consideration for roads, water, utilities, or other infrastructure requirements. Once land divisions have occurred, structures are built upon them exacerbating the hazard.

One important problem with these structural hazards is that many are mostly wood frame construction, often with wood siding, and wood shingle or shake roofs. Attic and floor vents can sometimes be left uncovered. Picture windows and stilt or cantilever balconies facing directly into or over heavy wildland fuels are common. Many roofs and rain gutters hold large quantities of dry leaves or needles. Any or all of these qualities contribute to make these structures one of the most hazardous "synthetic" fuels in the I-Zone.

The risk of structural ignition during wildland fires comes from any of three sources: direct exposure to flame, radiated heat, or firebrands carried by winds or convection columns or both. The first two of these sources can be fairly easily guarded against by proper clearance of native vegetation, landscaping, and maintenance. The last is much more complex and requires a combination of defenses. Flying firebrands, which are often carried from one-quarter mile to 2 miles ahead of the fire front, are deposited on the roof. Therefore, roofing materials and cleanliness are important protective measures.

The structures that individually cause the greatest fire protection problems are ones built by or for their occupants on individual parcels of land, each usually with its own water system. The most dangerous of these problems result from so-called lot splitting. Lot splits tend to create densities approaching those of subdivisions without any of the inherent advantages of subdivisions. Most individually developed residences, whether on large farms or small parcels of land, can be difficult to protect from fire if their water supply is inadequate and access is by long, narrow, sometimes steep roads.

The structures themselves are highly vulnerable to wildfire, historically being built with little concern for ignition resistance. Survivability and self-protection were not considered; reliance on fire department response was their protection. It is important to keep in mind, in the populated portions of California, 90 percent or more of the fires involving vegetation are caused either by people directly or by their activities such as, arson, recreational pursuits, machine uses, powerlines, and/or railroads. The mere act of developing, constructing, and occupying structures in wildland areas exposes both the natural resources and urban development to increased risk of destruction by wildfire

## People

Why do people choose to buy and perhaps divide land then construct their homes in this wildland fire environment? The population has grown in fire-prone vegetation zones throughout

California for the last quarter-century. By 1975 the long-established trend of population migration from rural communities to cities had been superseded in magnitude by the migration of city-dwellers to the urban fringe, rural communities, and isolated wildland settings. Such "reverse migration" was an unanticipated consequence of several convergent socioeconomic trends. Reverse migration was stimulated by 1) increasing access to metropolitan economies because of advances in transportation systems, where distance became a function of minutes or hours not miles, 2) increasing decentralization in manufacturing, 3) revival of energy extraction and energy-related industrial development resulting in relatively cheap fuels, and 4) changing American life-styles that include a trend toward early retirement. Migration from cities to aesthetically pleasing rural and wildland settings was viewed as a means of securing a safer environment with more privacy and less competition for limited services.

During the 1960's the effects of reverse migration were just beginning to become evident. Orange County's population grew 102 percent while during the same period San Francisco lost population. Following the baby boom, the State's median age dropped to 28.1 years in age. During the 1970's population growth in California declined to an annual average of 1.9 percent. However, during this same decade the levels of undocumented migration began to pick-up. San Francisco continued to lose population while growth accelerated in the Sierra Nevada foothill counties, and the median age reached 30 years by 1980.

The 1980's recorded another population boom when California gained an average of nearly 620,000 residents per year. Both domestic and foreign migration increased. Suburban counties like Riverside and San Bernardino experienced phenomenal population growth as the acceptable length of a commute, in time or miles, increased. By the year 2040 the Department Finance projects California's total population will reach 63,343,000- more than double the 1992 estimated population of 31,300,000. This represents an annual average growth rate of 2.2 percent over the 50 year period between 1990 and the year 2040. Six counties, Contra Costa, Fresno, Kern, San Joaquin, Stanislaus, and Ventura will accrue a million people during the coming 50 years.

### Individual Hazards & Overall Risk

Over 2.5 million people and 1 million structures risk destruction from wildland fires. Structures and people represent fire hazards and risks which when coupled with California's wildland fire environment equates to the loss of life, tremendous damage to property, and reduced viability of natural resources. Aside from the obvious reasons already stated, what motivates people to choose to live in rural settings amid fire-prone vegetation which often burns with devastating results? Previous analysis of California's rural population points out a number of reasons. Five of the most important reasons are:

First, people are generally reluctant to fear the worst, with the result that they dismiss evidence of hazardous conditions or fail to notice warning signs of accumulating danger. Fear that an entire subdivision or community could be destroyed by fire is so overwhelming that people will avoid noticing danger signs such as the accumulation of vegetation next to structures.

Second, violation of fire prevention laws and rules may be accepted as normal when people obtain misinformation or fail to learn appropriate firesafe behavior. There is surprisingly low compliance with state and local laws pertaining to clearance around structures.

Third, "information overload" in complex situations may be so much of a problem that people fail to attend to signs of danger or observe precautionary actions. Such complexity is far more likely in I-Zone situations where residents have moved there from the suburbs or the cities, commute to work, and do-not attend to local signs of danger because of broader lifestyle interests which command their attention.

Fourth, peoples attention may be directed from potential conflagration warning signs by lesser more immediate danger signals. For example, public attention directed to fire prevention activities such as "Only you can prevent forest fires", may tend to obscure underlying events which give rise to the hazardous conditions in which accidental or malicious ignition will indeed produce a conflagration. The underlying event might be the natural accumulation of hazardous fuel buildup.

Finally, destructive wildfires which reoccur at frequent intervals tend to cause the development of institutions suited to routine accidents rather than disasters. California's I-Zone tend to be treated like other accidental losses; insurance companies, construction companies, disaster relief agencies, flood control agencies, and even fire control agencies routinely handle devastating periodic wildfires.

An understanding of the changing population in California's I-Zone is critical in identifying the risks they present which accompany the hazards they construct and allow to come into contact with fire prone vegetation with devastating results.

**Summary**

The above discussion of fire hazards, risk and associated values at risk attempts to demonstrates the "on the ground" relationship between these complex factors and fire hazard zoning. Each year wildland fires in California cause major damages to natural resources, life, and property. Most of this damage is caused by a small number of conflagrations which burn with high intensity during a few number of days of critical fire weather. While these conflagrations can and do burn anywhere in the state, history shows that their frequency varies from place to place depending on the severity of the fire hazard. Local government land use planning agencies need to identify and classify areas of varying severity of fire hazard and to specify the conditions under which development and use of these areas may occur so that damages can be kept to an acceptable level. The study of past conflagrations indicates that fuel loading (the quantity of flammable vegetation and other fuel per unit of land area), fire weather, and slope are the primary criteria for identifying and classifying fire hazard in varying degrees of severity.

Successful I-Zone mitigation includes the development and maintenance of the communities infrastructure.

By **Jim Hunt**

Implementing state-of-the-art safeguards, for individual structures and surrounding plant fuels, may not sufficiently protect a community during a raging wildland fire. Occupants may need to quickly and safely evacuate from an effected fire area, while at the same time fire and law enforcement units need access to the emergency. Road width and bridge strength is important for these comings and goings. To provide a timely initial attack, fire stations should be in close proximity to the emergency. Water of adequate pressure, flow, and duration is essential. Each of these- roads, bridges, fire stations, and water supply are a part of the community infrastructure. The community infrastructure must be well planned and maintained to provide optimum protection in the I-Zone.

Infrastructure is the foundation, or the basic framework, for a community fire protection system. This system would include resources such as; roads, signs, bridges, helispots, water supply, safety zones, fire stations, utility services, homeowner associations, and special districts. All of which can be identified and required in the Fire Protection Plan and Covenants, Conditions, and Restrictions (CC&R's) of the community or subdivision.

The practice of piecemeal development consisting of individual lots, lot splits, and unregulated or under regulated subdivisions has resulted in many indefensible fire risks. Fire protection for existing fire risks falls upon the local fire agency. These existing risks can only be addressed in the General Plan, or as suggested in the next chapter, as a model ordinance for post disaster planning. However, new development and specific projects can be mitigated through the use and adoption of the Fire Protection Plan. This plan includes construction standards and building siting, defensible space and fuel modification zones, a long with the community infrastructure.

### Roads & Access

Time and time again, inadequate roads have resulted in delays to emergency response and evacuation. During the Oakland Hills conflagration of 1991, inadequate road widths and circulation were attributed to a number of deaths. During a wildland fire, vehicles evacuating an area can be involved in accidents, run out of gas, or even catch fire. Vehicles parked on roadsides and culdesacs can obstruct the operations of fire apparatus. Bridges may be too narrow or could collapse under the weight of fire apparatus, and wooden bridges may ignite. Driveways serving one or more homes may be too long, narrow, steep, or curvy. Street signs and addresses may be inadequate and/or unreadable. Even the most well designed road system can be unusable if vegetation grows alongside or overhangs the road. The lack of multiple entrances and exits in a major subdivision can obviously impede evacuation and response. Alternate evacuation routes, traffic circulation, and well designed roads must be a primary planning consideration.

Fire apparatus should be a primary consideration when designing roads, turn-arounds, and hydrant locations. (Photo Credit L.Flagg CDF, San Luis Obispo)

Most fire apparatus are approximately 10 feet wide from mirror to mirror. A fire engine connected to a fire hydrant, and pumping to hose lines, may require a total of 14 feet of road width. For one fire engine to pass another fire engine, already set-up at the hydrant, the unencumbered road width would need to be at least 24 feet wide. A parked vehicle can easily exhaust another 6 to 8 feet of road width. Collectively, a total of 32 feet in road width would be required if parking is allowed on only one side of the street, and 40 feet if parking is allowed on both sides. Fire agencies should take photos and measurements of their apparatus to substantiate their requirements. Photos should show two engines side by side with one hooked up to a hydrant. Exceptions to wider roads might include situations in which widths cannot be obtained due to physical or geographical constraints, or where the structures are on large parcels (1 acre or more) and are properly protected. In these cases, the unencumbered road width could be reduced to 20 feet in width, as long as 26 feet of road width is provided for a distance of 25 feet on each side of a fire hydrant. Road grades should not exceed 15% (15 foot rise for every 100 foot length) and should be less than 10% where possible.

### Culdesacs and Dead-End Roads

Fire apparatus require large areas to turn around in. Culdesacs should have a bulb which is at least 80 to 100 feet in diameter. Certain culdesacs should be designated as Helipads and be at least 100 feet in diameter with no obstructions. Helipad culdesacs should be red curbed and posted "Fire Lane: No Parking." A low profile Hydrant should be installed at the bulbs entrance and a large "H" should be painted in the center of the culdesac. Local fire agencies should conduct actual tests with fire apparatus to determine the required culdesac diameters, road grades, and turning radius. Photos once again would substantiate the needs of the fire apparatus.

Dead-end roads should be limited in length based upon the fire risk. The determination of fire risks comes from data and analysis of the vegetation type and density, the exposure to unmodified open space, steep slopes, structure density, type of construction, provision of fire sprinklers, and the width of the street. In general, roads on the outside perimeter of a subdivision, facing the open space, should be limited to 800 feet in length. Roads on the interior of properly protected subdivisions may be increased based upon the distance from unmodified flammable vegetation. Where possible, emergency secondary access should be provided, in case the primary road is blocked. Turnouts and turnarounds should be provided every 1/4 mile. As a general rule, access roads should reach within 150' of all structures to allow the use of preconnected hose lines.

Private roads and driveways need to allow clearance for fire apparatus. (Photo credit D.Darrow, Novato F.D.)

### Private Roads and Gates

Public roads are not allowed to be gated per the California Fire Code. Private roads should not be gated. If they are, such gates should be of a sliding type or have the ability to swing in both directions. Gates should have emergency power for motors, knox locks, optical actuation devices, and a manual means to open the gate. Response time can be delayed at least a minute or two, while fire fighters attempt to open a gate. Gates should be inset at least 30 feet from intersecting roadways. Private road systems, and the vegetation surrounding them, should be controlled and maintained by strict and enforceable CC&R'S, homeowners association, special districts, and/or jurisdictional laws.

On site roads at multi-family developments, and at commercial or institutional developments, should meet the same or even more stringent requirements as those imposed in non wildland areas. Such roads should encircle the structures and must allow unencumbered vehicle access to within 150 feet of all portions of all structures. Driveways leading to one or two residences should have at least 12 feet of paved width, with a turnout/turnaround at 150 feet and then every 1/4 mile. Grades should not exceed 15%. Driveways serving more than two residences should be 20 feet wide.

### Bridges

Bridges should be designed to support at least 20 tons for fire apparatus, water tenders, and bulldozers. Bridges on main access roads should be designed to support 40 tons or at least two pieces of equipment simultaneously. Bridges must be seismically designed, non combustible, and should provide for 2 lanes of travel. The weight limitations should be posted on each end of the bridge. Vertical clearance must be at least 13 feet 6 inches with no vegetative canopies.

## Signs and Addresses

Roads upon which parking is prohibited should be properly signed and curbs should be painted red. In addition, the local law enforcement agency must have the authority to cite and remove vehicles. If parking is allowed, then the road must provide an adequate unencumbered width for fire apparatus.

Street signs, and their standards, should be noncombustible. Signs should be mounted at least 7 foot above grade. The letters or numbers should be at least 4 inches size and reflective. Numbers on structures should be 4 inches in size and should also be reflective. If a structure is more than 100 feet from the main access road the numbers on the structure should be 6 inches in size and visible from the road. A sign should also be posted at the road where it intersects the entrance drive to the structure.

## Sasfety Zones & Helipads

In major developments having long roads, or in areas of extreme fire threat, safety zones should be provided at regular intervals (perhaps every 1/4 mile). Such zones may be a landscaped park, golf course, school yard, parking lot or simply an area devoid of vegetation. The area should be at least 200 feet by 200 feet. The purpose is to provide an area of refuge for evacuees unable to escape and to provide a staging area for fire agencies. A fire hydrant should be located at the site. If possible, a highway call box, or pay phone should be provided, as well as rest rooms and water faucets. The safety zone can also be designated as a helipad if properly located. Such helipads must be properly located and designed to fire agency standards.

## Water Supply

Water in proper quantity, pressure, and duration is paramount to fire control and structure protection. Fire apparatus carry about 400 to 500 gallons of water which will only last a couple of minutes in a fire attack. Water is needed in large quantities to protect structures from encroaching fires. The increased use of class "A" foams to pre-treat structures and vegetation also require adequate water supplies. In addition, property owners, and well meaning volunteers tend to use water needlessly to wet down structures well ahead of the fire front. When structures are equipped with interior fire sprinklers, the increased water demand must be taken into consideration. In rural areas, approved pressure tanks may be utilized as the source of supply to a residential system.

At the peak of an encroaching fire it is possible that each engine in a five engine "strike team" could be flowing one handline or heavy stream appliance. Thus, the needed fire flow could be up to 2000 GPM. In addition, sprinkler systems may be flowing in several exposed structures. Therefore, required fire flows should be at least 1500 to 2000 GPM at 30 psi, for 3 hours. In order to determine needed fire flows refer to the California Fire Code, the American Water Works Association Standard M-31 "Distribution

System Requirements for Fire Protection", or NFPA Standard 1231 "Standard on Water Supplies for Suburban and Rural Fire Fighting".

Water supplies can be elevated reservoirs supplying the needed fire flow without reliance on pumps and should provide a residual pressure of at least 30 psi, for 3 hours of anticipated fire flow, in addition to the estimated peak domestic demands upon the system. Such reservoirs must be non combustible and located within a defensible space. Any pumps utilized to refill tanks, or supply pressure zones, must be UL listed or FM approved diesel fire pumps meeting the requirements of National Fire Protection Association Standard 20. Such pumps should be in fire resistive pump houses located within a defensible space. Many disastrous fire losses have occurred in wildland fires when the power supplying water pumps failed and fire hydrants were left dry.

All water systems should be designed to American Water Works Association Standard M-31 and National Fire Protection Association (NFPA) Standards. All systems should be looped with 2 separate sources of supply. Dead-end mains should be avoided. Minimum main sizes should be 8 inches in diameter. Isolation valves should be located at least every 800 feet to meet the needed fire flow if a critical main goes out of service.

### Hydrants and Auxiliary Water Supplies

Fire hydrants should be located at 300 to 500 foot intervals, at every street corner, and on every culdesac, on the entrance to the bulb. No residence should be more than 500 feet driving distance from a hydrant. The blue dot hydrant locator system should be utilized to identify the location of all hydrants. The Red Dot locator system should be used to indicate fire department connections for sprinkler systems. Hydrants and pumper connections should have a concrete pad below them which extends 1 foot in every direction for weed control.

Where two water company systems adjoin, fire hydrants or other approved connections, should be provided to allow interconnection of the two systems. Fire hydrant location and distribution is discussed in Appendix 111-b of the California Fire Code.

In areas where there is no public water system, stored water systems may be allowed if it meets the National Fire Protection Association Standards 20, 22, and 24. Such systems should be designed and located as if they were a public water system with elevated storage, proper fire pumps, looped mains, and hydrants. Storage tanks may be considered for rural developments of four or less residences, if such residences are properly separated and protected. Again, such systems must be properly designed and located to provide adequate supply to fire engines. The amount of stored water may be calculated using NFPA standard 1231. The minimum amount of stored water should be 5000 gallons per residence. Water systems should be designed with seismic safety in mind. An earthquake may be the causative fire factor and may also interrupt the water supply systems.

New projects having community pools, lakes, ponds, and streams, should be required to provide fire department access for drafting water. In order to perform drafting operations fire apparatus must be equipped with hard suction hoses. Interestingly, such equipment has disappeared from most fire apparatus in recent years. Swimming pool drain lines should be equipped with a gated fire department connection installed at an approved location. In addition, homeowners should be encouraged to provide portable pumps with fire hoses. To be effective all water sources must be accessible to fire apparatus and clearly identified with signs.

### Fire Stations

Fire station location should be within 1.5 miles of the area being protected. (Photo credit L.Flagg CDF, San Luis Obispo)

In addition to properly designed and installed roads and water systems the fire department must be able to arrive at the scene of an emergency in a timely manner. Hopefully, before flaming wildland fuels ignite neighboring structures- and definitely before an ignited structure reaches its flashover point. Flashover can occur in 5 minutes or less from the point of ignition. Structural ignition can be the result of flying brands penetrating broken windows or other openings. Once flashover or ignition of a combustible roof occurs, the structure may be lost to the fire. The fire department can protect structures using external handlines within a defensible space around the structure if they arrive and deploy in time. In order to meet these objectives, the first fire engine should arrive within 5 minutes of the alarm. Assuming a one minute reaction time within the fire station, the engine has about 4 minutes to respond to the emergency. With an average response speed of 22 mph (based upon actual tests on flat terrain), the fire station would need to be within 1.5 miles of the Fire. This is also the optimum response time for emergency medical responses. Locating a fire station within 1.5 miles of the service area is similar to recommendation offered by the Insurance Services Office (ISO) for engine company locations.

In addition to properly located fire stations the local fire agency should be involved in automatic aid agreements with neighboring departments, area mutual aid agreements, and the state mutual aid agreement. This will help assure much needed support during a major fire. Agencies must have the capability to immediately request ten or more strike teams (50 engine companies), and other support on a serious I-Zone fire.

Developers of major projects in the I-Zone, should be required to fund the necessary fire stations and engine companies that serve their project. Such funding should continue until the project is generating sufficient tax revenue to fund the ongoing station, apparatus, and staffing costs.

### Utilities

During a fire utilities can exacerbate the fire situation. Powerlines drop from burning poles, block roads, create an electrical hazard, ignite vegetation, and cause electric water pumps to fail. Liquid propane gas tanks can overheat and BLEVE during a fire situation. Natural gas lines can be broken and release flammable gases. Telephone lines can fail and cut off vital communications. Cellular sites can be overrun by fire, and result in a failure of cellular phones. Radio base stations and microwaves can be destroyed and render emergency radio frequencies useless. Communications is vital to emergency command and control.

The protection of vital communication links and utilities can be accomplished by putting all new utility lines (electrical, phone, and gas) underground and by locating permanent equipment at least 30 feet from structures and cliffs. In addition, such equipment should also have a defensible space of at least 30 feet. Utility companies are required to maintain 10 feet or more of horizontal vegetation clearance from all electrical conductors.

Aboveground fuel tanks should be located within a defensible space and be 30 feet from structures. These tanks should comply to the California Fire Code for aboveground tanks with approved fireproofing and pressure relief venting. Aboveground tanks should not be elevated but securely fastened to a grade level foundation. Emergency generators, fire pumps, and fire department connections could be protected from exposure with the installation of noncombustible (block) walls and/or located within a defensible space.

### Covenants, Conditions, & Restrictions

To assure that the fire safety requirements are implemented and enforced- properly drafted Covenants, Conditions, and Restrictions (CC&R's) should be adopted. These CC&R's are to be read and signed by all perspective property owners at time of sale. The CC&R's become a part of the deeded restrictions (a legal instrument) which will follow the property even through subsequent deed transfers. A homeowners association, or a special district should be formulated to enforce the CC&R's well into the future. Another function of the CC&R's, is that they notify potential homeowners that they are purchasing property in a high fire hazard severity zone. The CC&R's become a form of disclosure- prospective owners need to realize that their property and lives may be at risk should a wildland fire occur.

Some examples of fire safety requirements which may be included in the CC&R's are:

Installation of only fire resistive vegetation, in compliance with an approved list.

Ongoing maintenance of defensible space and fuel modification zones.

Maintenance of the required building construction features (fire resistive roofs, fire resistive siding and decks, sprinkler systems, etc).

Location of wood piles, LPG tanks, hay bales, and other combustible storage.

Maintenance of driveways, addresses, and gate system.

The most problematic fire safety feature, as well as the most difficult and time consuming to enforce, is vegetation maintenance. Many fire agencies will conduct annual surveys of high fire hazard areas, and cite property owners for inadequate vegetation clearances. If the owner does not comply, the agency will have the property cleared and forward the cost to the owners tax bill. To assure compliance with the CC&R's, fire agencies have also required the developer to fund the annual inspection of their project.

An effective and efficient way to accomplish compliance, is to require new developments to form a "landscaping district", or "open space and parks district" to maintain the vegetation in the open areas, and alongside roads. This district has the authority to impose taxes and enforce the regulations. This district could be the same authoritive body responsible for the maintenance of private roads and water systems.

### Fire Protection Plans

But how do these requirements become enforceable if they exceed model code and local ordinances? The California Fire Code, Section 103, authorizes the fire chief to require technical opinion and report (fire protection plan). It also addresses allowance for alternate materials and methods. These code sections can serve as tremendous aides to the local fire agency in determining reasonable requirements for unique developments and risks.

Proactive fire agencies require a Fire Plan as a part of the Specific Plan for new development. This plan then becomes a project requirement when agreed upon by the fire agency and the developer. The fire agency imposes the requirement at the time a project is submitted for review. The developer may retain a wildland fire safety expert, who typically has wildland and fire service background, to compose and negotiate the plan. The plan is then submitted to the fire agency for review and approval. Upon approval, it becomes a condition of the project.

There is no reason for a fire agency to approve a project which does not have reasonable fire protection commensurate with the risk presented by the property. In fact, an agency may incur a liability for approving substandard development. No community should have to accept a new development which increases the communities fire threat, poses a threat to existing portions of the community, impacts the community fire protection delivery system, or results in an extreme impact on the local economy and budget due to suppression and enforcement costs.

The fire chief and fire prevention officer are the local experts in community fire protection. The constituency expects their local experts to maintain fire protection based upon the potential risks. If, fire department requirements are overruled by local governing bodies or court challenges, at least the fire department is on record as to the need for certain fire protection components.

The Fire Protection Plan sets forth all the fire protection concepts and standards for a particular project. Such standards and concepts are based upon a valid risk assessment. The assessment, in turn, is developed based upon site inspections and fire spread modeling. This procedure is far superior to reviewing piecemeal submittals for hydrant locations or road systems without a complete picture of the risk, and proposed mitigations. The Fire Protection Plan can be compared, in concept, to the Risk Management Prevention Plan (RMPP) required by California law for occupancies handling acutely hazardous materials.

A complete Fire Protection Plan should include all of the following elements:

Risk Assessment, Data Collection, & Fuel Modeling

Open Space & Fuel Management Zones

Fuel Management Plan & Maintenance of Infrastructure

Building Construction

Roads, Driveways, Parking, Bridges, Signage, Gates, & Fencing

Water Supply, Hydrants, & Sprinkler Systems

Utilities

Fire Alarms

Safety Zones, Helipads, and Helispots

Combustible Storage

Fire Stations & Fire Department Access

A properly designed Fire protection plan can be a valuable component of a Specific Plan or Environmental Impact Report. The fire agency can require that such a plan be included in the overall document. The plan evaluates the risk and identifies mitigations. Unmitigatable risks, such as the risk of constructing in a narrow box canyon, should also be identified and detailed in the plan.

### Summary

Fire agencies must stop bemoaning the inadequacy of model fire and building codes. Model Codes are minimum standards in many states. But your jurisdiction may need more than just minimum standards- you may in fact, realize optimum fire protection standards. If the local regulators have sufficient findings and justifications, they may exceed the minimum standards based upon their expertise and a proper risk assessment. The conflagrations of tomorrow can be mitigated today while projects are still on the drawing boards. Infrastructure requirements in turn, form the basic foundation for saving lives and property.

Pre-planning for post-disaster recovery allows local jurisdictions to identify upgrades in buiding code and infrastrucutre requirements in areas of risk.

By **Kenneth C. Topping**

Natural hazard mitigation should help shape development as an integral part of urban planning and design. But in cities throughout our nation a variety of natural hazards co-exist with the built environment, and safety policy issues are often postponed until a disaster occurs. At that point, however, hazard mitigation options often are restricted by the existing pattern of development, and it may be too costly or too late to appreciably modify hazardous conditions which have accrued over decades.

After disasters, critical policy choices emerge almost immediately which may force an unwelcome choice between rebuilding quickly vs. more safety. Policy choices theoretically range from public acquisition of hazardous sites at one extreme to implementation of relatively minor construction code changes at the other. Viewed practically, real choices may be severely limited by economics and extreme pressures to restore normalcy.

The City Oakland California, is a classic example of a community struggling with risk reduction and community improvement issues after major disasters. The Oakland Hills firestorm occurred in October 1991 just two years after the Loma Prieta earthquake. The community had not recovered from the Loma Prieta earthquake when it was hit by a much more devastating fire disaster raising recovery issues for which the community was not prepared.

Oakland's experience highlights a variety of post-disaster planning issues, and reflects a fundamental nationwide dilemma: how can communities reduce existing risks from large-scale urban/wildland interface or intermix fires in built-out urban and suburban environments? It offers potentially valuable insights into recovery and reconstruction policy pressures and pitfalls which can help planners anticipate and prepare to mitigate such problems before disaster strikes.

While planners are often limited by political or economic factors in attempting to promote and implement wise development in urban/wildland fire interface or intermix areas, if armed with accurate information, they can influence policy and work cooperatively with others to help educate their communities toward better hazard mitigation and reconstruction practices.

## Extensive Fire History

The Oakland Hills fire area is part of the East Bay Hills, an extensive urban/wildland fire interface area which runs approximately 60 miles along the east side of San Francisco Bay from the Carquinez

Strait to San Jose. It was initially developed for residential living during the early 1900s, partly as a refuge for victims of the 1906 San Francisco earthquake.

As a result of early 20th century land development, a variety of non-indigenous species of shrubs and trees, such as French broom, eucalyptus and Monterey pine, were introduced and proliferated over the years to form an artificially forested environment contrasting markedly with the original natural environment of redwood (Sequoia Sempervirens) forests.

As development accelerated before and after World War II, dense new urban forests combined with private landscaping and development features such as steep view lots, narrow streets, wood siding and shake shingles, extensive decks and roof overhangs to create a "woodsy" residential setting having extraordinary charm, prestige and economic value to the community. However, with the presence of the annual dry fall winds, it also represented a deadly mix of hazardous wildland/urban interface conditions.

Over the previous seventy years, destructive fires had recurred in the East Bay Hills during the fall season, when dry offshore winds predominate. In 1923 a major fire destroyed 584 structures in Berkeley. Since the 1930s, fourteen large-scale fires occurred in the Oakland Hills, including seven which originated essentially within the same canyon area where the 1991 firestorm began. In 1970, for example, a 204-acre fire destroyed 37 homes in the Buckingham Road area. Subsequently rebuilt, these homes were again destroyed in the 1991 firestorm.

Although some East Bay communities acknowledged the presence of fire risks, public sentiment and building industry opposition appeared to work against fire hazard mitigation. Water systems installed early in the area's development had not been upgraded to meet modern fire flow standards. Little emphasis was placed on upgrading lot size, paved street width, dual access and building setback standards, except in certain new subdivisions on vacant land.

A notable exception was the *Report of the Blue Ribbon Fire Prevention Committee for the East Bay Hills Area, Urban-Wildland Interface Zone*, published in 1982 by the East Bay Regional Park District. Representing the best thinking of a variety of prominent fire, planning, parks and forestry professionals, including then California Resources Agency Director William Penn Mott, the report recommended a series of specific hazard mitigation measures such as the clearing of fire breaks. However, relatively few of the report's recommendations were implemented, and development continued to favor intensification of quaint, woodsy but dangerous neighborhood settings in the Oakland Hills

## The Fire & Its Aftermath

The fire started on October 19, 1991 on a hillside in an Oakland residential neighborhood near the juncture of the State Route 24 and 13 freeways in the vicinity of the Oakland Tunnel. Initially contained and controlled, fire crews left the scene thinking it was fully extinguished.

The fire erupted the next day from remaining embers whipped by strong, dry northeasterly winds which quickly drove rapidly spreading flames across both freeways and through a series of residential neighborhoods, largely within the City of Oakland. Densely built houses, readily combustible roofing and building materials and heavy, flammable vegetation added to the intensity of a firestorm which destroyed virtually everything in its path. Narrow, winding streets in steep terrain hampered evacuation and fire truck access. Water pressure was insufficient for firefighting. Oakland hydrant connections were larger than the hose couplings of fire trucks from neighboring communities. The fire moved so quickly and intensely that firefighters were virtually helpless to contain it until the winds began to die down.

In all, the Oakland Hills firestorm of October 19-20, 1991 burned over 1,600 acres, destroying or badly damaging 2,021 homes and 756 apartment and condominium units, killing 25 people and injuring 150 others. Approximately 10,000 fire victims were displaced by this event.

The impact of the fire on the community was staggering. Almost overnight, a huge hole had been torn in the fabric of one of its most prestigious areas which represented an important source of income and leadership. There was widespread concern that fire victims would simply sell or abandon their property and choose to move elsewhere, thus threatening the future economic well-being of the community. This event drew an immediate response from elected officials, with Mayor Elihu Harris declaring the day after the disaster that "Oakland will rebuild!"

## Immediate Post-Disaster Phase

The 1991 Oakland Hills firestorm challenged the City of Oakland to address many problems of the urban/wildland interface environment which had previously received insufficient policy attention. In the context of post-disaster evaluations conducted by the media and by federal, state and other groups, the City of Oakland acknowledged an urgent need to develop effective near-term actions on hazard mitigation and emergency management tied to the recovery and reconstruction process. A report titled *Hazard Mitigation Report for the East Bay Fire in the Oakland-Berkeley Hills* and issued by FEMA's Interagency Hazard Mitigation Survey Team identified numerous emergency management and hazard mitigation improvements needed.

As in other disasters, victims needed a rapid return to normalcy. Multiple frustrations were experienced by disaster victims seeking to obtain information regarding rebuilding policy during the time it was still being formulated by staff committees. Over 50 separate neighborhood groups became involved with rebuilding issues. Many identifying themselves as "Phoenix" associations were comprised primarily of fire victims.

During this immediate post-disaster phase, a high level of public sympathy was expressed for fire victims who had lost everything and knew little about the extent to which insurance might cover their losses. Intense anger was directed toward City staff by citizens who blamed the fire department for the disaster. Many longstanding safety problems came into public view for the first time—e.g., highly flammable roofs and vegetation, substandard streets and outdated water systems. Fire victims were annoyed by the seeming slowness with which City reconstruction policies emerged. As such rebuilding policies gradually began to take shape, anger was then redirected at City staff members promoting safety measures seen by fire victims and builders as unnecessarily restrictive or obstructive.

Within this tense situation, strong pressures were exerted by various interest groups urging the City to expedite rebuilding. The most prominent advocates were the fire victims themselves. Other groups sharing a similar interest were members of the building industry, some of whom came from outside the City looking for opportunity, others representing well established local builders, contractors and architects. Particularly influential was an industry organization known as the Oakland Development Council. Interest groups with a different orientation included professional firefighting, planning, scientific and forestry organizations advocating adoption of stricter hazard mitigation measures related to rebuilding. For example, concerns were expressed by representatives of the East Bay Regional Park District and Regional Water Quality Control Board, along with geologists from U.C. Berkeley, regarding potential erosion, siltation and pollution resulting from the fire aftermath and post-fire rebuilding activities.

## Theoretical Vs. Pragmatic Policy Options

After major wildland fires and similar disasters, critical policy issues emerge regarding whether to relocate or replan the community or neighborhood to gain greater safety. In such situations, theoretical reconstruction policy options may cover a wide spectrum, ranging from land acquisition and relocation of the neighborhood or community at one end to imposition of relatively minor construction changes at the other. Choices made tend to honor victims needs to rebuild quickly without sufficient thought to options which may be available. Yet decisions made during the early days following a disaster such as the Oakland fire may have significant long-term consequences for future public safety. Often, in the rush to restore normalcy, development is permitted under some of the same unsafe conditions which contributed to the intensity of the disaster.

The Oakland experience highlighted post-disaster pressures which work against serious consideration of relocation or redesign of a neighborhood or community on a large scale. The immediate post-disaster phase in Oakland represented theoretical as well as pragmatic policy options which inherently exist following any catastrophic disaster, whether or not acknowledged by the affected community.

Should the neighborhood or community be rebuilt or relocated?

If rebuilt, should it first be replanned?

To what extent should new restrictions be imposed to achieve greater safety as the area is rebuilt?

What retrofit requirements should be placed on damaged buildings as they are repaired?

What new restrictions should be placed on new development on vacant land in similar nearby areas?

Most planning issues, however, were shaped by a prevailing policy context which overwhelmingly emphasized the goal of rebuilding as quickly as possible in order to maintain the Oakland Hills as a source of revenue and community leadership. Moreover, there was no political support for imposing additional financial burdens or delays on a population who had lost all their homes and belongings.

One of the important theoretical post-disaster policy issues which might otherwise have been addressed was the question of whether to relocate rebuilding out of harm's way. This issue of whether or not to relocate communities or neighborhoods has emerged nationally in recent years due to excessive past costs of providing disaster assistance to areas struck repeatedly by disaster. Following the Midwestern floods of 1993, FEMA initiated a buy-out program which permanently removes development from certain areas subject to recurring flooding. This solution seldom has been used in the past except in rare cases such as relocation of the town of Valdez following the 1964 Anchorage, Alaska earthquake, public acquisition of the waterfront area of Hilo on the island of Hawaii after their second devastating tidal wave, and relocation of a portion of Rapid City after the 1972 flood.

In Oakland, however, relocation was not a viable option because the decision had already been made politically, in response to victims' suffering, to rebuild as quickly as possible. Moreover, at the time there was no identifiable source of funding for acquisition of property in the fire area or for rebuilding elsewhere, nor was there readily identifiable a place to relocate nearly 3,000 homes and apartments. Even had there been such financing and a place for relocation practically available, the time necessary to acquire land and rebuild elsewhere would have delayed restoration of victims' homes for too many years.

A second policy question would have been whether to replan and redesign the fire ravaged neighborhoods for maximum safety prior to rebuilding. In Oakland, this would have meant substantial transformation of the area through extensive widening and opening of streets, clustering development densities, transferring development rights, and reorganizing open spaces in order to minimize historic fire hazards. This was not considered a viable option, however, since the funding needed to accomplish this was not available and more importantly, it would have taken too long to meet victims' needs. Therefore, few voices were raised in the public discussions on behalf of major redesign to achieve greater safety. Ideal safety-based solutions such as resubdividing were suggested by a few design professionals, but such recommendations were ignored due to perceived costs and practical difficulties.

The local design community, under the leadership of the Bay Area Chapter and California Council of the American Institute of Architects (AIA) gave no support to replanning. In a series of charettes conducted in different neighborhoods in early December 1991 to assist residents with suggestions regarding the rebuilding process, a great deal of attention was given to reestablishment of the architectural diversity which previously characterized various burned out neighborhoods. Very little emphasis was placed on street widening or other safety issues. Moreover, according to some planning staff members, aside from *Community Voices: A Resource Guide for Rebuilding*, a booklet published as a product of the charettes, there was little continuing organized involvement of AIA during the rebuilding process, although a few members stayed involved personally through adoption of the new Design Review Ordinance.

A third policy option might have been to more aggressively address the street width issue, delaying the rebuilding process long enough to identify major emergency access and evacuation routes, determine means to fund required improvements along such routes, and conduct the preliminary engineering to establish pavement widths and grades by which to determine retaining wall setbacks and driveway connection elevations. This would have taken additional time but would not have slowed the reconstruction process nearly as long as if the community were to have been relocated or replanned. Many other time-consuming processes needed to be undertaken, such as restoration of personal records, filing of insurance claims, and determination of home rebuilding plan details. In actuality, many months went by before the largest flow of permit requests began. This might have allowed time to find additional funding (e.g., FEMA or the Measure I bond issue) and conduct preliminary engineering to enable selective widening. As it turned out later, the only widening funded by FEMA was for Charing Cross Road.

Highly visible in the public discussion of policy options was an inter-jurisdictional Mayors' Task Force on Emergency Preparedness and Community Restoration, established jointly by the cities of Oakland and Berkeley. Co-chaired by the mayors of the two cities, this ad hoc task force included residents, professionals, professors, officials and private sector representatives. The *Final Report, Task Force on Emergency Preparedness and Community Restoration* contained dozens of recommendations relating to post-disaster safety improvements and community betterment, many of which were later implemented.

In providing a framework for determining planning issues to be considered in its deliberations, however, the Planning, Zoning and

Design Committee of the Mayors' Task Force focused on more limited and potentially conflicting goals:

> "Through the rebuilding process, encourage diversity in architectural design and site planning;
>
> "Allow rebuilding to occur quickly by developing an expedited process for permit review;
>
> "Encourage innovative parking solutions to help limit the number of cars along narrow roadways which need to be used as evacuation routes and primary access routes for emergency vehicles;
>
> "Seek methods for incorporating some level of neighborhood input into the design review process;
>
> "Develop mechanisms to limit the size and bulk of structures on small lots;
>
> "Underground utilities."

The latter recommendation to place utilities underground was based on a safety as well as aesthetic concern. A fire department battalion chief had been killed by a falling power line during the firestorm. Also, loss of power during the firestorm had significantly interfered with operation of East Bay Municipal Utilities District (East Bay MUD) water pumping stations, seriously interrupting water flows for firefighting.

### Staff Team

During this immediate post-disaster period, planners found themselves in a support function as members of a citywide staff team coordinated by the City Manager's Office on behalf of the Mayor and City Council. Serving as advisers to various citizen and staff committees, Oakland's planners were part of a citywide effort to fashion workable policies and procedures which would expedite rebuilding of the burned area while establishing certain community safety and improvement measures. In this manner, planners were drawn into a variety of recovery policy proposals, many having to do with building, fire safety, street access and permitting issues.

A deputy city manager was assigned to establish the Community Restoration and Development Center (CRDC), a multi-agency one-stop assistance and permitting operation. Another was assigned to work directly and continuously with citizens group representatives through weekly meetings held at the CRDC. Successful establishment and operation of the FEMA-funded Community Restoration and Development Center (CRDC) geared toward meeting victims' needs was a notable accomplishment during this immediate post-disaster period. Funded by FEMA through June 1994 the Center has provided "one-stop" federal and state disaster assistance, city permitting assistance and other victim support services in a converted grocery store near the fire area. This move toward humanizing the bureaucracy and speeding post-disaster permitting and disaster assistance services has been emulated in subsequent recovery situations, most recently after the Northridge earthquake.

## The Emergency Order

One of the first staff products was an *Emergency Order for Fire Reconstruction and Information Regarding Emergency Preparedness,* adopted by the City Council on November 26, 1991. Among other things, it required Class A or essentially non-wood roofs within an identified "fire hazard area" comprising all of the Oakland Hills northeast of the State Route 13 freeway. While this was an extension of prior policy for certain hillside areas, it represented a significant step from a safety planning and policy perspective. Wood shingle roofs had been demonstrated in recent decades to add significantly to fire hazards in urban/wildland interface areas. This action was even more significant in the face of intense opposition to this requirement generated by the wood shingle industry in various cities.

The emergency order also placed certain restrictions on siding, projections, eaves, decks, and balconies within that area. Some of these provisions were later softened or eliminated in response to industry and community backlash. Significantly, the emergency order did not include a staff proposal which would have required internal sprinklering systems within the high fire hazard area. This proposal was opposed by fire victims and the building industry even though average costs for such a safety measure were estimated within a relatively modest range of $3,000 to $5,000 per dwelling unit.

The emergency order also included standards for increasing street widths for evacuation and emergency vehicle response access for selected routes. For other local streets, as a substitute for widening, it recommended parking restrictions on one or both sides, depending on pavement width, to be implemented by subsequent ordinances.

## Street Widening Issues

In many ways, street widening was more difficult to deal with than other issues. Many hillside streets throughout the fire area and the rest of the Oakland Hills could be seen to have insufficient paved width for normal two-way traffic, much less for firefighting response and mass evacuations. Paved widths on even arterials such as Broadway Terrace northeast of the State Route 13 freeway were barely adequate to accommodate one moving lane in each direction. Additionally there were many dead-end cul de sacs with less than two lanes of pavement and insufficient turnarounds for firefighting apparatus.

The problem generally did not involve the need for additional dedications because in most cases rights-of-way were sufficient. The real problem was in the cost of cutting and filling on the upslope and downslope sides, respectively, to provide additional space for pavement widening and shoulders, as well as to build retaining walls on both sides. Also involved was the practical question of how long it would take to prepare widening plans from which elevations and gradients for driveway connections could be identified. Initial estimates for construction of retaining walls for upslope properties was $6,000 and for downslope properties was $10,000. Not calculated were the considerable additional costs for rebuilding on sites with houses which survived the fire to meet new locations of pavements or grades.

In addition to these costs and expected delays, proposals for street widening at the expense of fire victims were also seen as inequitable since the problem of inadequate street pavement widths was prevalent throughout the Oakland Hills. Street widening projects had long been inherently unpopular throughout the Oakland Hills, as evidenced by the many parcels owned by the City from a widening project along Grizzly Peak Boulevard effectively halted by citizen opposition many years before.

Thus costs and practical difficulties associated with street widening, along with its essential unpopularity, persuaded the City Council to minimize street widening as a solution. Instead, it chose to limit proposed widenings to very few routes and opted to honor expressed citizen preferences for on-street parking restrictions as a substitute measure to facilitate future movement. Parking restrictions are now being implemented; however, in light of recent citizen resistance, the jury is still out on how well this particular solution will actually work.

## The Design Review Ordinance

One important outgrowth from the Mayor's Task Force process was the "S-14 Community Restoration Development Combining Zone" initially proposed by staff and prepared at the City's request by a consulting firm in mid 1992 as filing of rebuilding permits was accelerating. According to ordinance language, it was intended to promote the following goals:

> "reconstruction that will replicate, to the extent possible, the pre-fire conditions that contributed to the distinctive character and desirability of the fire area neighborhoods;
>
> "design and construction that is responsive to the substantial variations in topography, access, and parcelization both within and among the respective neighborhoods;

"facilitation and expediting of reconstruction to minimize economic and emotional hardships for fire victims; and

"prevention of conditions that pose threats to life and property."

The purpose of the ordinance was to place greater restrictions on new home development than were reflected in existing zoning. First established in 1935, then comprehensively revised in 1965, zoning generally allowed minimum lot sizes of 5,000 square feet on very steep terrain, with very limited setbacks, and essentially no floor area ratio (FAR) or design review requirements.

Exceptions to these generally permissive zoning provisions were found in areas of the fire area which were covered by the existing S-10 and S-11 "combining zones." The S-10 zone had been mapped along ridgeline streets and protected public views from these corridors. The S-11 zone required architectural review and certain safety provisions.

The proposed ordinance dealt with site development and design review requirements, floor area ratios, height, yard setbacks, projections, parking and loading, landscaping, secondary units, and minimum lot area. The principal concern of its advocates was to reconcile three key goals, i.e., recreate an atmosphere of charm through architectural diversity, expedite the permit process and improve public safety.

Public discussion had reflected an aversion to an immediately evident trend toward building boxy, bulky homes which maximized use of the small lots using stock designs put forward by local builders. The concern was that the area would lose its essential architectural charm and magnificent views of San Francisco Bay which had initially drawn residents and created value.

Meanwhile, fire victims were finding it possible through generous fire insurance payments to substantially increase the floor space of rebuilt homes. While initially there had been a fear that insurance payments would not be adequate to cover the rebuilding costs for replacement of relatively modest but architecturally interesting homes built in the 1920s through 1950s, it was soon found that by careful photographic and other detailed documentation of previous homes and their contents, higher payments than expected could be obtained.

Taking advantage of the relatively unrestrictive zoning which was still in place, property owners found it possible to replace homes previously valued in the $300,000 to $500,000 range with much larger homes in the $600,000 to $800,000 range. Fire victims were caught between their preferences for replacing the previously delightful architectural character of their neighborhoods and the economic opportunity to significantly gain added value and floor space. Consequently, the proposed ordinance ran into substantial opposition from homeowners seeking to better their position as well as the building industry seeking to avoid restrictions. As the months of public review wore on, support for the ordinance waned.

According to one of the key staff members involved, the initial work done on the S-14 zone by the consulting firm of Sedway Cooke Associates was later adjusted by city staff as consensus developed over time between neighborhood representatives, the local construction industry and design professionals. Ultimately, an ordinance was passed. However, to the frustration of many homeowners who had not yet rebuilt, it contained fewer restrictions than previously proposed. Homeowners who had waited to see what would happen with the new ordinance were dismayed because precious San Francisco Bay views which might have been protected under the more stringent proposal were no longer protected under the adopted ordinance. They were already unhappy because of the length of time it had taken to adopt the modified ordinance, during which period many homes were built to the maximum allowable height, bulk, and setback envelopes permitted under existing zoning. Also escaping the modified ordinance restrictions, under grandfather provisions, were many similar homes which had previously received permits but which were as yet unbuilt.

The net result was achievement of one of the key goals, i.e., rapid rebuilding, at the expense of another key goal of recreating a sense of architectural diversity. A staff member close to the situation recently estimated that perhaps 50-60% of the rebuilt homes were "boxy" standard design/build homes, rather than reflecting site-sensitive, diverse architectural design.

Considering the fact that permits have been issued on approximately 80% of the single family home sites affected by the fire, the net effect has been to create greater intensity of development with far less architectural diversity and protection of far fewer Bay views than had been envisioned. While architectural diversity and view protection may have seemed frivolous to some victims who simply wished to reestablish their lives, such elements were also known to have given this area its original value. For some staff members involved in seeing the ordinance through to adoption, there is a feeling that the ordinance may have longer term value as the effects of its provisions are seen in areas remaining to be rebuilt and elsewhere in the Oakland Hills should the ordinance be applied there in the future.

Perhaps most critical, however, is the ultimate effect of creating greater building intensity in an area which remains seriously deficient in street widths and access. The long-term safety ramifications of this reality are yet to become clear.

### Planner Roles & Perceptions

Due to the relatively fresh experience of the Loma Prieta earthquake, Oakland's planners were able to address the initial post-disaster fire recovery situation with a certain amount of background on disaster management issues. However, the Oakland Hills experience was far more intense. Although some new thinking had been given to emergency preparedness prior to the fire, it wasn't enough.

Moreover, under immediate post-disaster circumstances, many normal planning procedures applicable to planning new development didn't apply. As in many other planning situations, multiple and potentially conflicting objectives were being simultaneously sought. However, decisions were greatly sped up, and extraordinary teamwork was required. Planners were seen by administrators as having a hard time shifting gears from a rule-oriented procedural perspective to one which was more flexible, free-wheeling and team-oriented. In this politically charged atmosphere, planners were faced with a serious dilemma regarding how strongly to promote consideration of relevant but unpopular safety measures at the risk of inviting administrative or political opprobrium.

Consequently, planners appear to have emerged with a different perception of their role as team players, heightened awareness of the complexities of the applications of various safety measures, and greater acceptance of team-oriented permit processing. Recent statements by various professional staff members reflect a feeling that, in retrospect, the City as a whole was essentially unprepared for the scope and severity of issues faced following the 1991 firestorm. Their feeling was that a pre-disaster plan might have helped City staff to anticipate and be better prepared for the types of pressures and policy issues encountered. In particular, it is felt that it might have reduced the time needed to sort through the various policy issues and options which had to be addressed essentially from scratch.

### New Opportunities

Many new safety and community improvement opportunities emerged from the crisis. In addition to the flow of professional and community group advocacy influencing outcomes, another critical factor determinant of success in capturing such opportunities was simple proximity in time to the event.

Freshness of memories during the immediate post-disaster period was a critical determinant of which fire safety actions were ultimately successfully implemented. The window of opportunity for implementing substantial changes lasted roughly from eight to twelve months. In retrospect, the window of opportunity for significant safety and community improvements began closing rapidly after successful passage of Measure I, a general obligation bond for selected safety improvements. Subsequently, other major measures, such as formation of the Fire Prevention and Protection District were much harder to accomplish.

Measure I was passed by a substantial majority of Oakland voters in June 1992, raising approximately $50 million at an average annual cost to property owners of $15 per $100,000 assessed valuation over thirty years. Proceeds have subsequently funded additional safety-related capital improvements and equipment for water supply, seismic reinforcement of fire stations, access for emergency vehicles, construction of an adequate Emergency Operations Center, development of an emergency response oriented citywide GIS, and communications upgrades.

### Vegetation Management

During the immediate post-disaster period, the groundwork was laid for later formation of a fire prevention and suppression benefit assessment district. Formed in March 1993, its overall goal is to reduce the number and intensity of large, destructive wildland/urban interface fires in the Oakland Hills and avoid future losses of life and property. At an annual rate of $75 per single-family unit, the district is raising nearly $2 million each year to provide a variety of fire safety services on both public and private property including vegetation management, code compliance, training and education, additional fire suppression personnel, and public information.

Oakland's vegetation management effort has since led to formation of an intergovernmental, public-private Vegetation Management Consortium, including the cities of Oakland and Berkeley, the East Bay Regional Park District, the East Bay Municipal Utilities District, the Pacific Gas and Electric Company (PG and E) and the University of California at Berkeley, all of which have considerable holdings in the East Bay Hills. The consortium is developing a pioneering Interagency Vegetation Management Plan having potentially far-reaching benefits.

**GIS System Development**

Notable among the Measure I initiatives was authorization of a portion of the funds to create a citywide GIS. This initiative was inspired in part by early efforts associated with the emergency response and recovery.

During and immediately after the firestorm, fire and GIS management professionals from the California Department of Forestry, U.C. Berkeley and the California Governor's Office of Emergency Management collaborated in relatively simple GIS applications which mapped fire perimeter boundaries and damage locations in relation to street centerlines. One of the frustrations of field personnel in pursuing damage assessment mapping during this early period was the absence of visible addresses, since all such evidence had been destroyed by fire.

This effort was supplemented during recovery and reconstruction with a more ambitious, definitive GIS database development for the fire area, funded by FEMA. The fire area GIS included mapped features and tabular attributes, such as street right of way lines, parcel boundaries, addresses, and status of permits and reconstruction. It was a valuable tool in clarifying the status of permits and monitoring reconstruction progress.

Recognizing the potential benefits of such early GIS applications to future emergency management planning, response and recovery, city staff included within Measure I an approximate $3 million amount dedicated to the development of a citywide GIS which would support a variety of emergency management and other general government functions. Formally authorized by the City Council in 1994, the initial phase of this system development is under way. Parallel to this has been work undertaken by U.C. Berkeley for the Vegetation Management Consortium to map vegetation and other wildland fire factors throughout the portions of the East Bay Hills covered by the participating jurisdictions and institutions.

### Infrastructure Improvements

A more recently completed safety initiative from the early post-disaster period was the successful formation of the Rockridge Water Assessment District, covering an area of 750 homes in the area adjacent to the south of the State Route 24 Freeway and to the west of Temescal Park. Initiated by fire victims concerned about the possibility of recurrence of fire spread in the future due to inadequate water storage and line capacity, the district has been formed with the cooperation of the City and the East Bay Municipal Utilities District (East Bay MUD), the area's water provider. Residents will pay $134.40 per year for the upgraded water system, with additional contributions to be made by the City and East Bay MUD. This accomplishment was largely due to the Citizen Water Committee, comprised of neighborhood residents whose images of helpless firemen with waterless hoses still remain fresh.

Additional opportunities successfully used following the Oakland Hills fire have included selected street improvements, such as the FEMA-funded widening of Charing Cross Road where people died trying to evacuate during the fire, formation of a sewer assessment district for 36 homes, and implementation of a major utility undergrounding effort led by the PG and E

### 20:20 Hindsight

Oakland is an excellent representation of a built-out community struggling with hazard reduction and community improvement issues following a major disaster. As with many other built-out communities across the nation facing realities of hazard mitigation after a disaster, known hazards issues had essentially not been addressed during early development. Consequently, the community was confronted with a range of safety issues following the fire at a stage when hazard mitigation options were far more limited.

During the Oakland Hills fire reconstruction, many urban planning and design issues related to hazard mitigation and community improvement arose within a typical post-disaster reconstruction scenario reflecting commonly found tensions between humane victim response and potentially conflicting public safety responsibilities. Because the disaster affected older neighborhoods in a largely built-out environment having substandard streets, lots, and infrastructure, public controversy centered on street widening, onstreet and offstreet parking regulations, building height and bulk, setbacks, vegetation management and water supply.

To restore normalcy as soon as possible, critical decisions were driven by practical constraints such as perceived short-term costs and inconveniences of mitigation and the extreme urgency to act expeditiously on victims' behalf. Intense pressures were faced by staff officials responsible for reconstruction in the fire area. Safety and community improvements sought by planning and building staff through the emergency order and design review ordinance were modified during City Council action, resulting in less safety value and amenities for reconstructed neighborhoods.

Nevertheless, a number of positive public safety related outcomes were evident. Oakland staff succeeded in using opportunities arising during the immediate post-disaster period to lay the groundwork for certain key safety and community improvements. Extension of the Class A roof requirement and similar standard construction safety measures to most of the Oakland Hills was a substantial achievement. Working with other entities, the City was able to initiate a variety of other safety improvements such as retrofitting fire stations for earthquake safety, modifying the fire hose couplings to accomodate use by other jurisdictions in future fire emergencies, improving water systems, undergrounding utility lines, developing plans for a new Emergency Operations Center, initiating the emergency management geographic information system (GIS), and forming the Fire Prevention and Protection Benefit Assessment District.

### Seismicity Factor

While this case study concentrates on the aftermath of a fire disaster, equally relevant is the risk of a catastrophic earthquake within this area. California is a seismically active state, and the San Francisco Bay region has a repeated history of disastrous earthquakes.

Although the Loma Prieta Earthquake did substantial damage in the Bay Area, it has been portrayed by scientists as a relatively mild forerunner of a much more devastating event expected on the Hayward Fault which cuts across many East Bay communities from San Pablo on the north to Warm Springs south of Fremont. Scientists have determined a substantial probability of a magnitude 7.0 or greater earthquake occurring on the Hayward Fault within the next several decades. Ironically, some early Oakland Hills subdivisions which were promoted as a refuge for 1906 San Francisco earthquake victims sit directly astride the Hayward Fault.

Recent studies coordinated through the Earthquake Engineering Research Institute have demonstrated that a magnitude 7.0+ event on the Hayward Fault could produce substantially greater destruction than either the Loma Prieta earthquake or the Oakland Hills fire. In such an event, landslides and fault rupture could sever gas and oil lines which cross the East Bay Hills, causing multiple fire outbreaks. Impassable streets and broken water lines could make firefighting difficult. Depending upon weather conditions, conflagration conditions could occur on a large scale.

### Significance Of Narrow Streets

Thus the issue of insufficient street widths could emerge again as a significant piece of unfinished business. As the effects of the City Council decision to rely on parking restrictions instead of street widening plays out, inadequate pavement widths for firefighting and evacuation purposes could again emerge as a major problem, especially in view of the area's seismicity. In a magnitude 7.0+ earthquake scenario, street pavement widths may become a critical factor in moving fire and emergency equipment into and people out of hilly areas.

Among Oakland staff, there remains serious concern that lack of funds to finance long-term major capital improvements to widen streets and upgrade major water delivery systems may aggravate a major hazard in the event of a catastrophic earthquake on the Hayward Fault. Current insufficiencies of water lines and storage capacities for wildland firefighting, together with possible severing of primary water lines might leave the City without water for days or weeks. Depending upon wind conditions, or without water for fire-fighting, large areas might be devastated by earthquake-induced fires.

### Unanswered Questions

From this experience, a critically important question is to what extent did post-disaster actions result in a net gain in public safety in which remaining hazards and risks were reduced overall? It remains to be seen whether the safety measures introduced following the most recent Oakland fire will combine effectively to lower the overall risk in the fire area as time goes on. Complete answers to this question may not be known until a more thorough assessment of recovery and reconstruction experience is conducted, or alternatively, the next wildland/urban fire situation is encountered

An unanswered strategic and tactical question important to many other communities is what might it have taken to achieve a more ambitious street widening effort while meeting other immediate post-disaster social, economic and political needs? It is perhaps both inappropriate as well as unnecessary to pass judgment on the Oakland Hills situation from the outside without real knowledge of the full range of circumstances affecting actual decisions. Yet systematic, objective inquiry into this question is needed because of the potential importance of its answer to creation of greater safety in other communities affected by the threat of repetitive urban/wildland fire disasters.

Given the area's inherent seismicity, the Oakland Hills fire may be a prelude to a much larger catastrophic event. But together with Loma Prieta, the fire will also serve as a cumulative information resource regarding the value and effectiveness of various post-disaster strategies, actions and outcomes. If nurtured through an ongoing preparedness and pre-event planning process, this could build up the institutional memory from which to launch the next round of advances when the next major disaster strikes.

From the Oakland experience, several key lessons have been learned regarding hazard mitigation and disaster recovery. These basically revolve around 1) closer communications and exchange of knowledge between fire and urban planning professionals; 2) better community education in advance of such fire events with collaboration of fire and planning professionals; 3) the need for more pre-event planning for post-disaster recovery.

One valuable tool for structuring fire disaster mitigation and recovery is pre-event preparation and adoption of an ordinance which sets up the recovery organization, procedures, and mitigation strategies. A model pre-event ordinance is provided on the following pages for tailoring to local needs. For more detailed explanations of the reasons and options associated with each provision, the reader may contact the Research Division of the American Planning Association.

## A Model Recovery & Reconstruction Ordinance

This model recovery and reconstruction ordinance provides basic elements of a comprehensive ordinance establishing a recovery organization and authorizing a variety of pre- and post-event planning and regulatory powers and procedures related to disaster recovery and reconstruction. Designed to be adopted in advance of a major disaster, it can also be quickly adapted to post-disaster conditions if it has not been adopted before the disaster.

Unlike ordinary planning ordinances, this ordinance requires involvement by many other departments within the city or county government organization under the guidance and leadership of the city manager, county administrative officer, or equivalent position. Some of the actions called for by this ordinance require direct involvement of the planning department, although frequently acting in concert with other departments. Having an inherently inter-departmental focus, this ordinance structures a model process which has generic value. Due to widely ranging circumstances, however, the content may vary widely.

The essential concepts of this ordinance include: the establishment of a recovery organization before a major disaster to prepare a pre-event plan; the adoption of that plan and this ordinance by the governing body before a major disaster occurs; and the use of the recovery plan and organization to efficiently and wisely guide post-disaster recovery and reconstruction activity. The recovery organization may be constructed differently from place to place, but the idea is to create an ongoing organization integrated with, but extending beyond any existing emergency operations organization.

Although an existing emergency operations organization may serve as a useful base from which to fashion a recovery organization, there are certain fundamental differences in function which make it preferable to establish a recovery organization which operates parallel to the emergency response organization. Continuity of the recovery organization and expediting of the rebuilding processes for which it is responsible become very important.

With some exceptions, local government emergency response organizations tend to focus on emergency preparedness and response operations. Strongly oriented toward police and fire functions, during "peace-time" they characteristically handle routine local emergencies and undertake training and preparedness for disaster response operations. Typically, recovery and reconstruction functions do not fall within their purview, although this is beginning to change in some jurisdictions.

Some powers reflected by this ordinance are activated by the declaration of a local emergency. However, they are characteristically broader than emergency response powers because the latter do not include property, building, land use and development regulations, or the public hearing process.

Certain regulatory powers authorized by this ordinance are identified for initial implementation during the time in which a declaration of local emergency is in effect. However, such powers tend to be extended for much longer periods of time. Although a declared emergency may not be terminated for months after the end of emergency response operations, complete implementation of rebuilding processes often takes years.

In short, this is an emerging area of disaster management practice which crosses over into city planning, redevelopment and building. Much of the thinking and implementation for the processes identified in this ordinance have only emerged within professional literature or practice within the past decade. Although some form of ad hoc recovery organization is created with every major disaster, such arrangements tend to exist for the peak rebuilding period and then are disbanded. As yet, very few local jurisdictions have formally created recovery organizations in advance of a disaster or maintained them continuously afterwards.

This ordinance structures many processes which tend to take place anyway after a major disaster without forethought or knowledge of available options. It provides organizational and procedural dimensions which can accelerate fundamental thinking and planning needed in advance of a disaster to recover and rebuild more wisely and efficiently than would happen were such preparation not to occur. It captures the broadest possible range of pre-event and post-disaster activities which interact with urban planning and development, recognizing that not all provisions may be germaine to circumstances within individual communities.

There is little established practice of record to use as a point of departure. Few ordinances in use by local jurisdictions deal with such a broad scope of recovery functions. Those which have been adopted tend to cover a more limited range of elements, such as rebuilding permitting and nonconforming use procedures. With the upswing in major disasters in the last several years, however, substantial experimentation is taking place, and more communication is occurring regarding outcomes of various recovery strategies attempted.

These processes will inevitably lead to revisions of the ideas reflected here. Therefore, this ordinance should be considered a framework for flexible application of pre-event and post-event procedures which can be modified to fit emerging ideas as well as local conditions. Although a separate ordinance is not essential to performance of many functions represented, the value of adopting a recovery ordinance is in providing clear policy guidance in advance for dealing with contingencies as well as an overall rationale in case of legal challenge.

## Disaster Recovery and Reconstruction

WHEREAS, the city is vulnerable to various natural hazards such as earthquakes, flooding, wildfires, and wind, resulting in major disasters causing substantial loss of life and property;

WHEREAS, the city is authorized under state law to declare a local state of local emergency and take actions necessary to ensure the public safety and well-being of its residents, visitors, business community and property during and after such major disasters;

WHEREAS, it is essential to the well being of the city to expedite recovery and reconstruction, mitigate hazardous conditions, and improve the community after such major disasters;

WHEREAS, disaster recovery and reconstruction can be facilitated by establishment of a Recovery Organization within the city government to plan, coordinate and expedite recovery activities;

WHEREAS, preparation of a pre-event plan for disaster recovery and reconstruction can help the city organize to expedite recovery in advance of a major disaster and to identify and mitigate hazardous conditions, both before and after such a disaster;

WHEREAS, recovery can be expedited by pre-event adoption of an ordinance authorizing certain extraordinary city actions to be taken during the declared local emergency to expedite implementation of recovery and reconstruction measures identified in a pre-event plan;

WHEREAS, it is mutually beneficial to cooperatively plan relationships needed between the city and other governmental authorities such as the Federal Emergency Management Agency, Small Business Administration, Department of Housing and Urban Development, State Emergency Management Agency (or equivalent);

WHEREAS, it is informative and productive to consult with representatives of business, industry and citizens' organizations regarding the most suitable and helpful approaches to disaster recovery and reconstruction;

The City Council (or county or town equivalent) does hereby ordain:

**Section 1. Authority.** This ordinance is adopted by the City Council (or county or town equivalent) acting under authority of the City Municipal Code (or county or town equivalent), State Emergency Management Act (or equivalent), and all applicable federal laws and regulations.

**Section 2. Purposes.** It is the intent of the City Council under this chapter to: authorize creation of an organization to plan and prepare in advance of a major disaster for orderly and expeditious post-disaster recovery and to direct and coordinate recovery and reconstruction activities; direct the preparation of a pre-event plan for post-disaster recovery and reconstruction, to be updated on a continuing basis; authorize in advance of a major disaster the exercise of certain planning and regulatory powers related to disaster recovery and reconstruction to be implemented upon declaration of a local emergency; identify means by which the city will take cooperative action with other governmental entities in expediting recovery; and implement means by which the city will consult with and assist citizens, businesses and community organizations during the planning and implementation of recovery and reconstruction procedures.

**Section 3. Definitions.** As used in this ordinance, the following definitions shall apply:

3.1 **"Director"** shall mean the Director of the Recovery Organization or an authorized representative;

3.2 **"Disaster Survey Report or DSR"** shall mean a request by a local jurisdiction for financial reimbursement for a public facility damaged in a major disaster, as authorized under the Stafford Act and related federal regulations, plans and policies;

3.3 **"Event"** shall mean any natural occurrence which results in the declaration of a state of emergency and shall include earthquakes, fires, floods, wind storms, tsunamis, etc.

3.4 **"Emergency"** shall mean a local emergency, as defined by the Municipal Code, which has been declared by the City Council for a specific disaster and has not been terminated;

3.5 **"In-kind"** shall mean the same as the prior building or structure in size, height and shape, type of construction, number of units, general location and appearance;

3.6 **"Historic Building or Structure"** shall mean any building or structure included on the national register of historic places, the state register of historic places or points of interest, or a local register of historic places, and any buildings and structures having historic significance within a recognized historic district.

3.7 **"Major Disaster"** shall mean a locally declared emergency also proclaimed as a state of emergency by the Governor of the State and by the President of the United States;

3.8 **"Recovery"** shall mean the process by which most of the immediate repair and restoration of buildings and structures damaged in the major disaster, including public facilities, is accomplished and most public and commercial services are restored to normal;

3.9 **"Reconstruction"** shall mean the rebuilding of permanent replacement housing, construction of large-scale public or private facilities badly damaged or destroyed in a major disaster, addition of major community improvements, and full restoration of a healthy economy;

**3.10 "Stafford Act"** shall mean the Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 93-288, as amended).

**Section 4. Recovery Organization.** There is hereby created the Recovery Organization, for the purpose of coordinating city actions in planning and implementing disaster recovery and reconstruction activities.

**4.1 Powers and Duties.** The Recovery Organization shall have such powers as enable it to carry out the purposes, provisions and procedures of this Chapter, as identified in this chapter.

**4.2 Recovery Task Force.** The Recovery Organization shall include a Recovery Task Force comprised of the following officers and members:
**a.** The Mayor (or county or town equivalent) who shall be Chair;
**b.** The City Manager (or county or town equivalent) who shall be Director and Vice-Chair;
c. The Assistant City Manager who shall be Deputy Director, and who shall act as Vice-Chair in the absence of the City Manager;
**d.** The City Attorney (or county or town equivalent) who shall be Legal Adviser;
e. Other members, including the Building Official, City Engineer, Community Development/Planning Director, Fire Chief, Emergency Management Coordinator, General Services Director, Police Chief, Public Works Director, Utilities Director, together with representatives from such other departments and offices as may be deemed necessary by the Chair or Director for effective operation;

**4.3 Operations and Meetings.** The Director shall have responsibility for Recovery Organization operations. When an emergency declaration is not in force, the Recovery Task Force shall meet monthly or more frequently, upon call of the Chair or Director. After a declaration of an emergency, and for the duration of that declared emergency period, the Recovery Task Force shall meet daily or as frequently as determined by the Director.

**4.4 Succession.** In the absence of the Director, the Assistant Director shall serve as Acting Director and shall be empowered to carry out the duties and responsibilities of the Director. The Director shall name a succession of department managers to carry on the duties of the Director and Assistant Director, and to serve as Acting Director in the event of the unavailability of the Director and Assistant Director.

**4.5 Organization.** The Recovery Task Force may create such standing or ad hoc committees as determined necessary by the Director.

**4.6 Relation to Emergency Management Organization.** The Recovery Organization shall work in concert with the city Emergency Management Organization (or equivalent) which has inter-related functions and similar membership.

**Section 5. Recovery Plan.** Before a major disaster, the Recovery Task Force shall prepare a pre-event plan for post-disaster recovery and reconstruction, referred to as the Recovery Plan, which shall be comprised of pre-event and post-disaster policies, plans, implementation actions, and designated responsibilities related to expeditious and orderly post-disaster recovery and rebuilding.

**5.1 Recovery Plan Content.** The Recovery Plan shall address policies, implementation actions and designated responsibilities for such subjects as business resumption, damage assessment, demolitions, debris removal and storage, expedited repair permitting, fiscal reserves, hazards evaluation, hazard mitigation, historical buildings, illegal buildings and uses, moratorium procedures, nonconforming buildings and uses, rebuilding plans, redevelopment procedures, relation to emergency response plan and comprehensive general plan, restoration of infrastructure, restoration of standard operating procedures, temporary and replacement housing, and such other subjects as may be appropriate to expeditious and wise recovery.

**5.2 Coordination of Recovery Plan with FEMA and Other Agencies.** The Recovery Plan shall identify relationships of planned recovery actions with those of state, federal or mutual aid agencies involved in disaster recovery, including but not limited to the Federal Emergency Management Agency (FEMA), the American Red Cross, the Department of Housing and Urban Development (HUD), the Small Business Administration (SBA), the Environmental Protection Administration (EPA), the Department of Transportation (DOT), the State Emergency Management Agency (or equivalent) and other entities which may provide assistance in the event of a major disaster. The Director shall distribute a draft copy of the plan to such agencies in sufficient time for comment prior to action on the Recovery Plan by the City Council.

**5.3 Recovery Plan Adoption.** Following formulation, the Recovery Plan shall be transmitted to the City Council for review and approval. The City Council shall hold one or more public hearings to receive comments from the public on the Recovery Plan. Following one or more public hearings, the City Council may adopt the Recovery Plan by resolution, including any modifications deemed appropriate, or transmit the plan back to the Recovery Task Force for further modification prior to final action.

**5.4 Recovery Plan Implementation.** The Director and Recovery Task Force shall be responsible for implementation of the plan both before and after a major disaster, as applicable. Before a declaration of emergency, the Director shall prepare and submit reports annually, or more frequently as necessary, to fully advise the City Council on the progress of preparation or implementation of the Recovery Plan. After a declaration of emergency in a major disaster, the Director shall report to the City Council as often as necessary on implementation actions taken in the post-disaster setting, identify policy and procedural issues, and receive direction and authorization to proceed with plan modifications necessitated by specific circumstances.

**5.5 Recovery Plan Training and Exercises.** The Recovery Task Force shall organize and conduct periodic training and exercises annually, or more often as necessary, in order to develop, convey and update the contents of the Recovery Plan. Such training and exercises will be conducted in coordination with similar training and exercises related to the Emergency Operations Plan.

**5.6 Recovery Plan Consultation with Citizens.** The Recovery Task Force shall schedule and conduct community meetings, periodically convene advisory committees comprised of representatives of homeowner, business and community organizations, or implement such other means as to provide information and receive input from members of the public regarding preparation, adoption or amendment of the Recovery Plan.

**5.7 Recovery Plan Amendments.** During implementation of the Recovery Plan, the Director and the Recovery Task Force shall address key issues, strategies and information bearing on the orderly maintenance and periodic revision of the plan. In preparing modifications to the plan, the Recovery Task Force shall consult with City departments, business and community organizations and other government entities to obtain information pertinent to possible Recovery Plan amendments.

**5.8 Recovery Plan Coordination with Related City Plans.** The Recovery Plan shall be prepared in coordination with related elements of the Comprehensive General Plan and Emergency Master Plan, or such other plans as may be pertinent. Such related plan elements shall be periodically amended by the City Council to be consistent with key provisions of the Recovery Plan, and vice versa.

**Section 6. General Provisions.** The following general provisions shall be applicable to implementation of this chapter following a major disaster:

**6.1 Powers and Procedures.** Following a declaration of local emergency in a major disaster and while such declaration is in force, the Director and the Recovery Task Force shall have authority to exercise powers and procedures authorized by this chapter, subject to extension, modification or replacement of all or portions of these provisions by separate ordinances adopted by the City Council.

**6.2 Post-Disaster Operations.** The Director shall direct and control post-disaster recovery and reconstruction operations, including but not limited to the following:

**a.** Activate and deploy damage assessment teams to identify damaged structures and to determine further actions which should be taken regarding such structures;

**b.** Activate and deploy hazards evaluation teams to locate, and determine the severity of natural or technological hazards which may influence the location, timing and procedures for repair and rebuilding processes;

**c.** Maintain liaison with the City emergency operations organization and other public and private entities, such as FEMA, the American Red Cross, and the State Emergency Management Agency (or equivalent) in providing necessary information on damaged and destroyed buildings or infrastructure, natural and technological hazards, street and utility restoration priorities, temporary housing needs and similar recovery concerns;

**d.** Establish "one-stop" field offices located in or near impacted areas, staffed by trained personnel from appropriate departments, to provide information about repair and rebuilding procedures, issue repair and reconstruction permits, and provide information and support services on such matters as business resumption, industrial recovery, and temporary and permanent housing;

**e.** Activate streamlined procedures to expedite repair and rebuilding of properties damaged or destroyed in the disaster;

**f.** Recommend to the City Council and other appropriate entities, necessary actions for reconstruction of damaged infrastructure;

**g.** Prepare plans and proposals for action by the City Council for redevelopment projects, redesign of previously established projects or other appropriate special measures addressing reconstruction of heavily damaged areas;

**h.** Formulate proposals for action by the City Council to amend the Comprehensive General Plan, Emergency Master Plan and other relevant pre-disaster plans, programs and regulations in response to new needs generated by the disaster;

**i.** Such other recovery and reconstruction activities identified in the Recovery Plan or by this chapter, or as deemed by the Director as necessary to public health, safety and well-being.

**6.3 Coordination with FEMA and Other Agencies.** The Director and Recovery Task Force shall coordinate recovery and reconstruction actions with those of state, federal or mutual aid agencies involved in disaster response and recovery, including but not limited to the Federal Emergency Management Agency (FEMA), the American Red Cross, the Department of Housing and Urban Development (HUD), the Small Business Administration (SBA), the State Emergency Management Agency (or equivalent) and other entities which provide assistance in the event of a major disaster. Intergovernmental coordination tasks including but not limited to the following:

**a.** Assign trained personnel to provide information and logistical support to the FEMA Disaster Field Office;

**b.** Provide personnel to provide information support for FEMA Disaster Assistance Centers (DACs);
c. Participate in damage assessment surveys conducted in cooperation with FEMA and other entities;
**d.** Participate in the Multi-Agency Hazard Mitigation Team with FEMA and other entities;
e. Cooperate in the joint establishment with other agencies of one-stop service centers for issuance of repair and reconstruction permits, business resumption support, counseling regarding temporary and permanent housing, and other information regarding support services available from various governmental and private entities;
f. Coordinate within city government the preparation and submittal of Disaster Survey Reports (DSRs) to FEMA;
g. Determine whether damaged structures and units are within floodplains identified on Flood Insurance Rate Map (FIRM) maps and whether substantial damage has occurred;
h. Implement such other coordination tasks as may be required under the specific circumstances of the disaster.

**6.4 Consultation with Citizens.** The Director and the Recovery Task Force shall schedule and conduct community meetings, convene ad hoc advisory committees comprised of representatives of business and community organizations, or implement such other means as to provide information and receive input from members of the public regarding measures undertaken under the authority of this chapter.

**Section 7. Temporary Regulations.** The Director shall have the authority to administer the provisions of this section temporarily modifying provisions of the Municipal Code (or equivalent) dealing with building and occupancy permits, demolition permits, and restrictions on the use, development or occupancy of private property, provided that such action, in the opinion of the director, is reasonably justifiable for protection of life and property, mitigation of hazardous conditions, avoidance of undue displacement of households or businesses, or prompt restoration of public infrastructure.

**7.1 Duration.** The provisions of this section shall be in effect for a period of six months from the date of a local emergency declaration following a major disaster or until termination of a state of local emergency, whichever occurs later, or until these provisions are extended, modified, replaced by new provisions, or terminated, in whole or in part, by action of the City Council through separate ordinances.
**7.2 Damage Assessment.** The Director shall direct damage assessment teams having authority to conduct field surveys of damaged structures and post placards designating the condition of such structures as follows:
**a.** Inspected—Lawful Occupancy Permitted is to be posted on any building in which no apparent structural hazard has been found. This does not mean there are not other forms of damage which may temporarily limit occupancy.
**b.** Restricted Use is to be posted on any building in which damage

has resulted in some form of restriction to continued occupancy. The individual posting this placard shall note in general terms the type of damage encountered and shall clearly and concisely note the restrictions on continued occupancy.
**c.** Unsafe - Do Not Enter or Occupy is to be posted on any building that has been damaged to the extent that continued occupancy poses a threat to life safety. Buildings posted with this placard shall not be entered under any circumstances except as authorized in writing by the department that posted the building or by authorized members of damage assessment teams. The individual posting this placard shall note in general terms the type of damage encountered. This placard is not to be considered a demolition order.
**d.** This chapter and section number, the name of the department, its address, and phone number shall be permanently affixed to each placard.
**e.** Once a placard has been attached to a building, it shall not be removed, altered or covered until done so by an authorized representative of the department or upon written notification from the department. Failure to comply with this prohibition will be considered a misdemeanor punishable by a $300 fine.

**7.3 Development Moratorium.** The Director shall have the authority to establish a moratorium on the issuance of building permits, approval of land use applications or other permits and entitlements related to the use, development and occupancy of private property authorized under other chapters and sections of the Municipal Code and related ordinances, provided that in the opinion of the Director such action is reasonably justifiable for protection of life and property, and subject to the following:
**a.** Posting—Notice of the moratorium shall be posted in a public place and shall clearly identify the boundaries of the area in which a moratorium is in effect as well as the exact nature of the development permits or entitlements which are temporarily held in abeyance;
**b.** Duration—The moratorium shall be in effect subject to review by the City Council at the earliest possible time, but no later than 90 days, at which time the Council shall take action to extend, modify or terminate such moratorium by separate ordinance.

**7.4 Debris Clearance.** The Director shall have the authority to remove from public rights-of-way debris and rubble, trees, damaged or destroyed cars, trailers, equipment, and other private property, without notice to owners, provided that in the opinion of the Director such action is reasonably justifiable for protection of life and property, provision of emergency evacuation, assurance of fire-fighting or ambulance access, mitigation of otherwise hazardous conditions, or restoration of public infrastructure.

**7.5 One-Stop Center for Permit Expediting.** The Director shall establish a one-stop center, staffed by representatives of pertinent departments, for the purpose of establishing and implementing streamlined permit processing to expedite repair and reconstruction of buildings, and to provide information support for provision of temporary housing and encouragement of business resumption and industrial recovery. The Director shall establish such center and procedures in coordination with other governmental entities which may provide services and support, such as FEMA, SBA, HUD, or the State Emergency Management Agency (or equivalent).

**7.6 Temporary Use Permits.** The Director shall have the authority to issue permits in any zone for the temporary use of property which will aid in the immediate restoration of an area adversely impacted by a major disaster, subject to the following provisions:
**a.** Critical Response Facilities—Any police, fire, emergency medical or emergency communications facility which will aid in the immediate restoration of the area may be permitted in any zone for the duration of the declared emergency;
**b.** Other Temporary Uses—Temporary use permits may be issued in any zone, with conditions, as necessary, provided written findings are made establishing a factual basis that the proposed temporary use: 1) will not be detrimental to the immediate neighborhood; 2) will not adversely affect the Comprehensive General Plan or any applicable specific plan; and 3) will contribute in a positive fashion to the reconstruction and recovery of areas adversely impacted by the disaster. Temporary use permits may be issued for a period of one year following the declaration of local emergency and may be extended for an additional year, to a maximum of two years from the declaration of emergency, provided such findings are determined to be still applicable by the end of the first year. If, during the first or the second year, substantial evidence contradicting one or more of the required findings comes to the attention of the Director, then the temporary use permit shall be revoked.

**7.7 Temporary Repair Permits.** Following a disaster, temporary emergency repairs to secure structures and property damaged in the disaster against further damage or to protect adjoining structures or property may be made without fee or permit, where such repairs are not already exempt under other chapters of the Municipal Code. The building official must be notified of such repairs within ten working days and regular permits with fees may then be required.

**7.8 Deferral of Fees for Reconstruction Permits.** Except for temporary repairs issued under provisions of this chapter, all other repairs, restoration and reconstruction of buildings damaged or destroyed in the disaster shall be approved through permit under the provisions of other chapters of this Code. Fees for such repair and reconstruction permits may be deferred until issuance of certificates of occupancy.

**7.9 Nonconforming Buildings and Uses.** Buildings damaged or destroyed in the disaster which are legally nonconforming as to use, yards, height, number of stories, lot area, floor area, residential density, parking or other provisions of the Municipal Code may be repaired and reconstructed in-kind, provided that:
a) the building is damaged in such a manner that the structural strength or stability of the building is appreciably lessened by the

disaster and is less than the minimum requirements of the Municipal Code for a new building;
**b)** the cost of repair would exceed 50 percent of the replacement cost of the building;
**c)** all structural, plumbing, electrical and related requirements of the Municipal Code are met at current standards;
**d)** all natural hazard mitigation requirements of the Municipal Code are met;
**e)** reestablishment of the use or building is in conformance with the National Flood Insurance Rate Map requirements and procedures;
**f)** the building is reconstructed to the same configuration, floor area, height, and occupancy as the original building or structure;
**g)** no portion of the building or structure encroaches into an area planned for widening or extension of existing or future streets as determined by the comprehensive general plan or applicable specific plan;
**h)** repair or reconstruction shall commence within two years of the date of the declaration of local emergency in a major disaster and shall be completed within two years of the date on which permits are issued. Nothing herein shall be interpreted as authorizing the continuation of a nonconforming use beyond the time limits set forth under other sections of the Municipal Code that were applicable to the site prior to the disaster.

**Section 8. Demolition of Damaged Historic Buildings.** The Director shall have authority to order the condemnation and demolition of buildings and structures damaged in the disaster under the standard provisions of the Municipal Code, except as otherwise indicated below:

**8.1 Condemnation and Demolition.** Within days after the disaster, the building official shall notify the State Historic Preservation Officer that one of the following actions will be taken with respect to any building or structure determined by the building official to represent an imminent hazard to public health and safety, or to pose an imminent threat to the public right of way:
**a.** Where possible, within reasonable limits as determined by the building official, the building or structure shall be braced or shored in such a manner as to mitigate the hazard to public health and safety of the hazard to the public right of way;
**b.** Whenever bracing or shoring is determined not to be reasonable, the building official shall cause the building or structure to be condemned and immediately demolished. Such condemnation and demolition shall be performed in the interest of public health and safety without a condemnation hearing as otherwise required by the Municipal Code. Prior to commencing demolition, the building official shall photographically record the entire building or structure.

**8.2 Notice of Condemnation.** If, after the specified time frame noted in Subsection 8.1 of this chapter and less than 30 days after the disaster, a historic building or structure is determined by the building official to represent a hazard to the health and safety of the public or to pose a threat to the public right of way, the building official shall duly notify the building owner of the intent to proceed with a condemnation hearing within business days of the notice in accordance with Municipal Code Section, building official shall also notify FEMA, in accordance with the National Historic Preservation Act of 1966, as amended, of its intent to hold a condemnation hearing.

**8.3 Request to FEMA to Demolish.** Within 30 days after the disaster, for any historic building or structure which the building official and the owner have agreed to demolish, the building official shall submit to FEMA, in accordance with the National Historic Preservation Act of 1966, as amended, a request to demolish. Such request shall include all substantiating data.

**8.4 Historic Building Demolition Review.** If after 30 days from the event, the building official and the owner of a historic building or structure agree that the building or structure should be demolished, such action will be subject to the review process established by the National Historic Preservation Act of 1966, as amended.

**Section 9. Temporary and Permanent Housing.** The Director shall assign staff to work with FEMA, SBA, HUD, the State Emergency Management Agency (or equivalent) and other appropriate governmental and private entities to identify special programs by which provisions can be made for temporary or permanent replacement housing which will help avoid undue displacement of people and businesses. Such programs may include deployment of mobile homes and mobile home parks under the temporary use permit procedures provided in Section 7 of this chapter, use of SBA loans and available Section 8 and Community Development Block Grant funds to offset repair and replacement housing costs, and other initiatives appropriate to the conditions found after a major disaster.

**Section 10. Hazard Mitigation Program.** Prior to a major disaster, the Director shall establish a comprehensive hazard mitigation program, which includes both long-term and short-term components:

**10.1 Safety Element.** The long-term component shall be prepared and adopted by resolution of the City Council as the safety element of the City Comprehensive General Plan, for the purpose of enhancing long-term safety against future disasters. The safety element shall identify and map the presence, location, extent and severity of natural hazards, such as:
**a.** severe flooding;
**b.** wildland and urban fires;
c. seismic hazards such as ground shaking and deformation, fault rupture, liquefaction, tsunami and dam failure;
**d.** slope instability, mudslides, landslides and subsidence;
e. technological hazards, such as oil spills, natural gas leakage and fires, hazardous and toxic materials contamination, nuclear power plant and radiological accidents.
The safety element shall determine and assess the community's vulnerability to such known hazards, and shall propose measures to be

taken both before and after a major disaster to mitigate such hazards.

**10.2 Short-term Action Program.** A short-term hazard mitigation program shall be included in the Recovery Plan. It shall be comprised of hazard mitigation program elements of highest priority for action, including preparation and adoption of separate ordinances dealing with specific hazard mitigation and abatement measures, as necessary. Such ordinances may require special site planning, land use and development restrictions or structural measures in areas affected by flooding, urban/wildland fire, wind, seismic or other natural hazards, or remediation of known technological hazards such as toxic contamination.

**10.3 Post-Disaster Actions.** Following a major disaster, the Director shall participate in the Multi-Agency Hazard Mitigation Team with FEMA and other entities, as called for in Section 409 of the Stafford Act and related federal regulations. As appropriate, the Director may recommend to the City Council that the City participate in the Hazard Mitigation Grant program, authorized in Section 404 of the Stafford Act in order to partially offset costs of recommended hazard mitigation measures.

**10.4 New Information.** As new information is obtained regarding the presence, location, extent, location, and severity of natural or technological hazards, or regarding new mitigation techniques, such information shall be made available to the public, and shall be incorporated as soon as practicably possible within the Comprehensive General Plan safety element and the Recovery Plan through amendment.

**Section 11. Recovery and Reconstruction Strategy.** At the earliest practicable time following the declaration of local emergency in a major disaster, the Director and the Recovery Task Force shall prepare a strategic program for recovery and reconstruction.

**11.1 Functions.** To be known as the Recovery Strategy, the proposed strategic program shall identify and prioritize major actions contemplated or under way regarding such essential functions as business resumption, economic reinvestment, industrial recovery, housing replacement, infrastructure restoration, and potential sources of financing to support these functions.

**11.2 Review.** The Recovery Strategy shall be forwarded to the City Council for review and approval following consultation with FEMA, other governmental agencies, and business and citizen representatives. The Recovery Strategy shall provide detailed information regarding proposed and ongoing implementation of initiatives necessary to the expeditious fulfillment of critical priorities and will identify amendment of any other plans, codes or ordinances which might otherwise contradict or otherwise block strategic action. The Director shall periodically report to the City Council regarding progress toward implementation of the Recovery Strategy, together with any adjustments which may be called for by changing circumstances and conditions.

**Section 12. Severability.** If any provision of this chapter is found to be unconstitutional or otherwise invalid by any court of competent jurisdiction, such invalidity shall not affect the remaining provisions which can be implemented without the invalid provision, and, to this end, the provisions of this ordinance are declared to be severable.

# II. BUILDING STANDARDS AND TECHNOLOGY

Survival mechanisms developed over time, allowed the original inhabitants of California's I-Zone to secure their homes and resources from the threat of wildland fires just as we do today.

By **Rodney Slaughter**

Ethnographic research has been used repeatedly to defend the reintroduction of fire into the environment. The ethnographic record includes written accounts by early California explorers and settlers, interviews with Native California Indians, suppported with research in dendrochornology (the study of tree rings and fire scars), and interpretations of archival photographs. All of which, supports what we now know of the environment and the role of fire in it.

Absent in any ethnographic research of fire management, is an interpretation of Native California phenomenology, beliefs, and customs. For example, gathering firewood for Karok men had important religious implications. Limbs were supposed to be cut from the uphill and downhill sides of tall fir trees. Did Karok men believe that by cutting only these limbs they would retard the spread of wildland crown fires? For the Asumawi, sagebrush, dried juniper branches, and wind toppled trees provided most of their firewood. The Indians wasted nothing. How much of the forest litter was collected? Wouldn't collecting deadfalls and snags in the immediate vicinity of the village reduce the fuels and therefore reduce the chances of a major conflagration? What rules, beliefs, or values were used in determining what to take and what to leave behind? An ethnography of Indian beliefs and customs may give us an insight on how they dealt with fire management on a broader scale. In terms of fire awareness, the research and analysis of Indian villages and building technology is also missing. The Indians were the original inhabitants of the I-Zone, they too should have had mechanisms for dealing with the threat of wildland fires.

The study of Native California phenonmenology will require intensive research beyond the scope of what is offered for this chapter. However there exists within the literature enough information on settlement patterns and building technology for a cursory review. This chapter will combine, patterns of Indian burning with Indian building technology, up to and including the Spanish occupation of California.

**Naked In The Wilderness**

Considering that the state has been continuously inhabited for an estimated 15,000 years. We should probably ask ourselves- Haven't California wildland fires always threatened human habitation? The answer of course is- yes! Perceptual differences do exist between our cultures, but the lifestyles between modern society and ancient California cultures illustrate similar responses to a very real threat.

Contemporary society has insulated itself from the natural environment. Few of us could name a handful of wild plants let alone their uses as food, medicine, or even whether they are poisonous. How many more of us could survive a month let alone a year naked in the wilderness? Our lack of understanding for the environment is evident in settlement patterns across the state. But, what we do appreciate is our "natural views". High value homes are built in canyons, ravines, forests, and on top of mountains and ridges to celebrate these California views. This reverence for nature is appreciated from the boundaries of our balconies, porches, and picture windows.

In contrast, California Indians were an integral part of their natural environment. Every plant and animal had a name, and every name told a story of their use and importance in Native California cultures. Young children were taught by their mothers the boundaries of their environment. Major landmarks, rock formations, trees, and trails were named and passed on to the children in song and stories. Many California Indians also believed in a parallel existence between the spirit world and the real world. Central to this belief is that plants, animals, waterways, and geologic formations all possessed spirits which must be regarded, revered, and respected.

It is within this, spiritual context, that Indian social and cultural development became dependent on fire as an effective and universal technology. Indian people used prescribed fires to suit their needs for food, shelter, protection, and to minimize the threat of large, frequent, and catastrophic wildland fires. Similarly, there is some evidence that the native people were conscious of the devastating effects fires could have on their villages.

"We did not think of the great open plains, the beautiful rolling hills and the winding streams with tangled growth as 'wild.' Only to the white man was nature a wilderness and...the land 'infested' with 'wild' animals and 'savage' people"

–Standing Bear, Ogalala Sioux

## Biotic Zones & Lifestyles

California can be broken into six general biotic zones. These would include; boreal (mountain/alpine), transition (coniferous pine/fir forest), upper sonoran (oak/chaparral), lower sonoran (desert/grasslands), as well as inland and coastal waters.

In most cases the indigenous culture of any region took advantage of two or more biotic zones for sustenance. Seasonal changes marked migrations from one biotic zone to another. Each biotic zone had its advantages for hunting, fishing, and gathering. And,

(Photo Credit Special Collections, Meriam Library C.S.U., Chico)

eventhough the coastal and inland waters were important in terms of survival and sustenance, they are not an I-Zone consideration. Nor is the boreal or alpine zone which exist above the tree-line. Our I-Zone concern focuses on habitation and survival techniques in the transition, upper sonoran, and lower sonoran biotic zones.

The biotic zones described here are largely over generalizations. It would be difficult to find the line of demarcation as plant indicators of one zone slowly merge, one into the other. Additionally, it is at the edges, between these generalized zones, were the greatest diversity of plant and animal life exists. The Indians exploited these edge areas or ecotones and maintained or enhanced them with prescribed fires.

Modern society has taken a liking to a number of plant communities. So, coastal redwoods can be found planted in the central valley. Likewise, non-native and exotic species have been introduced into natural areas like scotch pine in the ponderosa forest of Nevada County, or pampas grass in the coastal communities of Mendocino County. As such, the definition for biotic zones is limited to indigenous reference. Which for our purposes, should provide a common and shared understanding of a precontact environment.

## Transition Zone

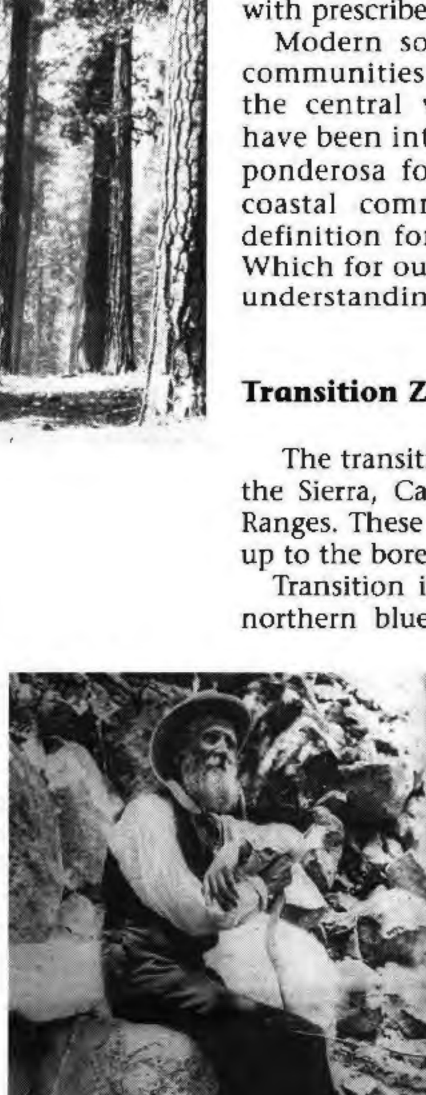
The transition zone is demarcated by the conifer/pine forests of the Sierra, Cascade, Klamath, Coastal, and Transverse Mountain Ranges. These forest begin at the 3,000 to 5,000 foot elevations on up to the boreal zone.

Transition indicators would include; southern ponderosa pine, northern blue oak and digger pines. Plant types for the Sierra include, western yellow and sugar pine, incense cedar, white fir, sierra redwood, ponderosa pine, lodgepole pine, tanbark and blue oak. In the coastal mountains plant types include, coastal redwood, douglas fir, and madrone.

"The inviting openness of the Sierra woods is one of their most distinguishing characteristics. The trees of all species stand more or less apart in groves, or small irregular groupings, enabling one to find a way nearly everywhere, along sunny colonnades and through openings that have a smooth park like surface"

—John Muir

(Photo Credit: USDI Nastional Park Service, John Muir National Historic Site)



The Tolowa, Yurok, Karok, Hupa, Shastan and Achumawi Indians, of Northern California's Cascade and Klamath Mountains typify a lifestyle found in the transition zone. They used prescribed fires periodically to open tree canopies and create grassy meadows. The grassy meadows were burned annually from the late summer to late fall. This practice improved seed production and promoted tobacco growth. Open meadows in coniferous forests allowed for herbaceous growth and grasslands attracting deer for forage. Ladder fuels were reduced by burning away the understory. With the reduced understory, travel was easier, while at the same time the chance for large and damaging wildland fires was reduced.

Among the northern coast Indians, the redwood forest provided little in the way of plant or animal diversity. The homogenous forest was easy to get lost in. Downed redwood trees made traveling through the forest difficult if not impossihle. A group of early explorers discovered that the Indians had created little oases of cleared forest by regular and localized burning. But, not before they lost one man and several mules to starvation. Within the oases, grass, and other herbaceous growth attracted deer and elk. A variety of edible plant foods grew within these open areas. The explorers learned that the Indians had foot trails between the oases and their villages.

Transition cultures certainly did not burn all of the forest or grasslands. But rather, each group had selected sites and opportunities to use fire to suit specific goals and objectives. Diaries of early settlers support the idea that the Indian people did not burn everywhere as they report mountain forest thick and choked with underbrush.

Semi-subterranean plank sweatlodge photo taken in 1893 (photo credit Special Collections, Meriam Library C.S.U., Chico)

## Transition Zone Building Technology

Relying on the building materials at hand, the transition zone cultures built their structures from the slabs of redwood and bark. The north coast people built substantial houses redwood planks. These houses were 16 by 20 feet with the outer upright walls extending 15 feet. These walls were built over a rectangular interior pit about two to three feet deep, ten feet of which extended alongside the exterior walls to form a storage shelf at ground level. Additional planks were used as a retainer to keep the excavation from caving-in. A simple pitched roof of redwood planks was supported by ridge poles. An adjustable smoke hole extended through the roof. The exterior opening was protected with a sliding door plank. Cohblestone paving covered the ground outside at the entrance and was also used around the fire pit excavated deeper in the center of the floor.

This building technology was borrowed from similar structures in the Pacific Northwest. Like our own building technology, the weather and moisture of the north coast made wooden structures practical from a fire safety perspective. The thick redwood planks also provided a degree of ignition resistance.

South, on the coast, the Pomo would construct single family

Strips of bark built over a pit and held together with grapevine in southwestern Tehama County (Photo credit Special Collections, Meriam Library C.S.U., Chico)

dwellings of redwood bark slabs, around which they would construct brush fences to enclose the acorn drying area. Farther south and inland, other transition zone housing technology would also included the use of redwood or fir bark over a circular pit. These were either leaned against a wooden frame or the slabs of bark supported one another.

Among some transition zone cultures assembly houses were also constructed in the larger villages. The assembly house built by the Shastan Indians was similar to their homes only on a grander scale. The assemhly house would measure 20 by 27 feet and was excavated to a depth of 6 feet. Its sides almost flat were covered with earth. Handsplit boards covered the interior sidewalls and functioned as a retaining wall. One ridge pole and center post were used in construction. The assembly house of the Pomo measured 70 feet in diameter and was used as a single mans living quarters as well as dancing and ceremony for the entire village.

Smaller structures in a village would include a sweatlodge and menstrual hut. Each was built as a smaller version of the wood slab homes. Domed shaped structures built from willow poles and covered with bark slabs, animal skins, or covered with earth were also constructed for sweatlodges and menstrual huts. The sweatlodges were usually heated directly by fire. In the case of the Shastan water was thrown on hot rocks to produce steam.

Most villages were located within a days travel of many hunting and gathering areas. All were located by some body of fresh water. Archival photographs indicate that the villages were located in a cleared area with little vegetation surrounding the structures.

"the old squaws began to look for the little dry spots of headland or sunny valley, and as fast as dry spots appeared they would be burned. In this way the fire was always the servant and never the master... By this means, the indians always kept their forest open, pure and fruitful, and conflagrations were unknown." Joaquin Miller wrote in 1887 of the Yosemite Valley (Photo credit courtesy of the Oakland Museum of California)

## Upper Sonoran

The upper sonoran zone exists between the lower sonoran and the transition zones. This zone is typified hy foothill plant communities. In the north state this zone is between the 500-3000 foot elevation, and in the south state at the 1000-5000 foot elevation. Plant types of the upper sonoran would include; blue oak, live oak, digger pine, willow, sycamore, buck brush, manzanita, chamise, wedgeleaf ceanthous, yerba santa, poison oak, live oak, scrub oak, eastwood manzanita, california laurel, toyon, birch leaf mahogany, and deer brush.

The Wintu, Maidu, Eastern Miwok, and Northern Valley Yokuts Indians, who occupied the watershed areas of the central Sierra and Coast Range foothills, typify the upper sonoran lifestyles. These groups burned grasslands annually after August to improve seed bearing crops and increase forage for deer, elk, and antelope. Many grasses would resprout with the first rains, and the young shoots or "little hairs" would also be collected and eaten.

Annual fires in the grass and other flashy fuels occurred in late fall and early winter, usually after the seed harvest. Prescribed fires around oak trees insured a productive crop of acorns. The fires would kill insect larvae that would infest the acorns. The use of prescribed fires also reduces competing plants for plants with more value. This is especially true for promoting plant material suited to basket making and other manufactured materials. Baskets were used to collect, store, process, and cook the acorns- an early Californian staple.

Michopda Indians of the Chico Rancheria built a traditional semi-subterranean earth covered assembly house. This photo taken in 1898 shows evidence of burned grass in the foreground. (Photo credit Special Collections, Meriam Library, C.S.U., Chico)

Prescribed fires also increased the number of game animals. Partridge and quail, for example, once ran in coveys of 300 to 400 birds! The burned over grasslands quickly resprouted and increased forage for deer, elk, and antelope. Father Serra reported in June of forage for deer, elk, and antelope. Father Serra reported in June of 1796 "entering a valley more than a league in width and parts of which so green that, if I did not know in what country I was, I would have taken it, without hesitation, for land under cultivation" (Balckbourn and Anderson:1993). Insects provided variety in many diets. Grasshoppers were collected by burning the grass in a circular pattern and the roasted hoppers were collected and eaten. Another technique, was to place hot coals in the center of a circle, while the people beat the brush and drove the hoppers into the hot coals.

The California Indians also used prescribed fires in the chaparral. The Coastanoan and Chumash, of California's coast, used control burns on the chaparral to retard growth, reduce dead plant material, increase grazing, and increase seed bearing crops. Chaparral burning of five to ten acres provided evenly scattered patterns of growth. The chaparral was burned every two to three years. A mosaic pattern of new and old chaparral growth developed from this practice- breaking-up the fuel load and allowing for the Indians to hunt deer attracted to the open grassy areas. An experiment by foresters found that prior to prescribed fires, in dense unburned chaparral, the deer count was 30 per square mile. After the first prescribed burn deer count rose to 98 deer per square mile and up to 131 deer by the second year. The deer count dropped to 84 the fifth and sixth years after the prescribed fire.

## Upper Sonoran Building Technology

Conifer trees supplied the center poles and cross beams for the Achumawi Indians semi-subterranean winter houses. These were approximately 15 feet square. The frame was covered with bark slabs, grass, and tule reeds then covered with earth. The entrance was provided through the smoke hole with a ladder, although children would come and go through a tunneled draft hole. Similarly, interior valley cultures would have either a combination of conical bark slab structures or semi-subterranean houses about 15 to 20 feet in diameter. The smoke hole again served as the exit via a notched center post or a ladder of sticks lashed to the post with grapevines. The Lake Miwok used a similar design for permanent multi-family dwellings. Poles were erected over an excavated pit with a center pole for support. Over the framework brush, leaves, and tule were fastened. The whole thing was then covered with a layer of earth.

Assembly houses were built in the same design only much larger. The larger assembly houses were also wooden framed and covered with earth leaving only a smoke hole exit at the peak and a tunnel side entrance. Sweatlodges and menstrual huts were constructed similarly on a smaller scale or were domed shaped brushed covered structures. Shade structures were also built in the foothills of willow sticks covered with brush and held together with grapevines.

A large village must have certainly looked like an ant colony with people emerging and disappearing from the holes of their earthen mounds. But imagine the fire resistive qualities such a community might enjoy. Once again archival photographs of these structures suggest that the villages were created in open areas with little vegetation surrounding the structures. One photograph, of an earth covered Miwok roundhouse near Ione, even suggests that the grass growing on and around the mound was systematically burned away.

### Lower Sonoran

The lower sonoran biotic zone is distinguished by grassy valley floors, as well as the arid upper and lower deserts of California. Plant types for the valleys include; grasses, oaks, sycamores, redbud, and marsh grasses. The desert plant communities would also include; yucca, agave, cactus, brittle bush, desert lilies, creosote bush, sage brush, cottonwood, palms, mesquite, and saltbushes.

Don Antonio Codero describes in his detailed 1796 report of Apache burning as; "a large scale circular fire and noisy game drive that burned an area five or six leagues, about 12 to 15 miles round, as a technique used when grass and shrubs were dry (Dobyns:1981)." This is the same technique used in the deserts of Southern California by the Diegueno, Cahuilla, and Mojave. In 1602, Vizcaino reported from Coronado Islands that the Indians "made so many columns of smoke on the mainland that at night it looked like a procession and in the day time the sky was overcast (Blackbourn and Anderson:1993). The Cabrillo expedition reports "many smokes were seen in early October along the San Diego Coast northward. These fires were so extensive that the Spaniards gave the name 'Bahia de los Fumos' to Santa Monica Bay" (Blackbourn and Anderson:1993). According to the local newspapers and settlers of San Diego, Indians were still burning as late as 1870.

Prescribed fires in the lower sonoran occurred in late summer and fall. Sagebrush was kept at minimal levels, allowing for the growth of grasses, which in turn attracted rabbits and antelope. Without prescribed fires in the desert, sagebrush quickly reclaimed the habitat.

The benefit of these fires was of course multiple. The fires would destroy mistletoe in mesquite groves, kill date scale and spider mites in date palms oases, and expose mineral soil favoring new palm growth.

Open range fires were also a concern for the first settlers crossing the Great Basin into California. But the frontier people quickly learned of the Native technique to escape uncontrolled grass fires. The method used, to avoid the fire danger, was to start a fire in the immediate vicinity. This fire usually small and harmless would burn over a wide enough area to form a safe asylum. Within this freshly burned asylum the range fire would burn safely around the frontiersman and Indians alike.

This technique was successfully employed in August 1949 in Montana's infamous Mann Gulch Fire. A smokejumper by the name of Wag Dodge, attempted to save the lives of his crew by starting another fire ahead of him. Unfortunately, Dodge could not communicate what he was doing to the rest of his crew. Thirteen of the smokejumpers perished in the fire that raced over them.

### Lower Sonoran Building Technology

The Yokuts, Coastanoan, Chumash, Gabreilino, Luiseno, Tipai and Ipai all represent the lower sonoran lifestyles. Like their northern neighbors, they used what building material was available to them. In lower sonoran zones building material was limited to lighter weight thatch. The Coastanoan built domed structures with thatched tule, grass, wild alfalfa, or ferns over a light wooden frame. These houses were so spacious that they could hold up to 50 people. Although some of these houses were semi-subterranean, many in the lower valley were not to avoid flooding and water seepage. Housing for the Luiseno, Cahuilla, and Tipai, and Ipai, were conical partially semi-subterranean thatched structures of reeds and brush.

Sweatlodges were employed by the Coastanoan, Yokuts, and Chumash, but not by the groups farther south. The sweatlodges were small, round, subterranean, and earth covered. Other structures included ramadas. These were brush covered wall-less rectangles supported by four or more willow poles in the ground. The Tipai and Ipai constructed assembly houses with thatched walls and roof supported by a stone foundation. The combustibility of thatched structures is unquestionable. Archival photographs once again illustrate an absence of other vegetal fuels in and around these villages and the ground appears well packed.

### Settlement Patterns

As a general rule, Indian settlements occurred around fresh water sources and close to, or within a days travel, of available food supply. As such, villages were typically found in close proximity to lakes, rivers, arroyos, year round streams, and fresh water springs. These villages were fairly permanent. Although many people traveled seasonally to exploit the resources, of other biotic zones, within their respective areas. Simple structures were built in these seasonal hunting and collecting areas.

Depending on the cultural group, a large village might include an assembly house and several single family and/or multi-family dwellings, sweatlodges, granaries, and toward the perimeter menstrual huts. Reasons to abandon or divide a permanent settlement might include, interpersonal conflicts, depletion of natural resources, sickness, religious or spiritual reasons, or to rid the village of fleas, lice, and other vermin. The assembly house of the Shastan, for example would pass on to the male heirs of the village headman. If there were no heirs it was abandoned. If there were only female heirs it was burnt down. When the dwellings of the Coastanoan and Chumash became flea infested they were burned. Religious taboos would also preclude inhabitating a dwelling in which someone had died.

Additional ethnographic research may reveal that California Indian Cultures had respect and a deep regard for fire and its potential. Settlement patterns and archival photography suggests that wildland vegetation was kept at a respectable distance from their combustible buildings. The fact that every structure had an open flame hearth in the center of it would also suggest that special care and handling of fire was of utmost importance. Earth covered lodging may have become an ignition resistant adaptation to frequent grass fires. Fuel reduction of both living and dead biomass may have been practiced. All of which may become discernable through an analysis of Indian beliefs, customs, and phenonmenology.

**Indian Fires**

It has been suggested that many prehistoric wildland conflagrations may have been started accidentally by the Indians themselves. This idea seems unlikely for a population whose very being and existence is dependent on their natural environment. Evidence shows Indians to be keen observers of the environment and very attentive to it. Research scientist have postulated that regular and localized burning by native cultures may have increased the time between large conflagrations.

Scientist have calculated that the number of lightning strikes in California average between 200 and 1,700 annually. Most of which occur in the higher elevations of the Sierras. It is more than likely that many of the large prehistoric fires recorded in tree scars and rings, as well as ash sediments in the ocean and lakes were natural in origin.

Foresters believe that less than 20% of California was purposely burned by the Indians. It maybe that the California Indian's burned no more than 20% on an annual basis. But more than likely, a greater portion of the state was burned rotationally to meet the needs of the Indians living in it. The truth may never be known with any amount of accuracy. But unlike the early miners, cattlemen, and sheepherders who allowed their camp fires to burn out of control, the Native California Indian use of fire was both purposeful and utilitarian.

Regrettably, it has taken us over 200 years, since the first European set foot on California soil, to begin to recognize the knowledge and value of Native California practices. The cultural conflict between the Indians and European settlers began with the arrival of the Spanish soldiers and missionaries. The early Spanish explorers and missionaries were the first to record the native practice of prescribed fires. A practice which, to them, wasted winter fodder for the horses and cattle that they introduced into the California landscape.

### The First Fire Exclusion Policy

The first fire regulation in California, was written May 31, 1793 by Governor Jose Joaquin de Arrillaga while visiting the Mission Santa Barbara. Officials and Mission Fathers complained that both Christian and Gentile Indians damaged valuable rangelands by setting fires annually. The Governor responded to this complaint by issuing his proclamation. Within the Governors proclamation he notes "the widespread damage which results to the public from the burning of fields". He summarily prohibits "all kinds of burning, not only in the vicinity of the towns but even at the most remote distances (Blackbourn and Anderson: 1993)."

### Insert Fire Exclusion Policy

The California Indian community understood the relationship between fire, the eco-system, and their own general welfare. So much so, that they were able to use fire to their own best advantage. The number of laws and regulations proposed since Governor Arillaga's first proclamation is incalculable. Two hundred years later, the threat of wildland fires is as great as it ever was. We can blame this greater threat, in part, on our lack of understanding of the role fire plays in the ecosystem. Today, the pendulum of public policy has swung away from fire exclusion policies towards recognizing the role of fire.

As newcomers to California, the Spanish had to come to terms with their adopted environment. Regulating the Indians use of fire was one step. The other step was to create permanent structures that would withstand the elements including fire.

### Ignition Resistant Construction

The missionaries were assigned to California to bring Christianity and make the native inhabitants loyal citizens of Spain. By the time of their secularization, 21 missions had been established along the California coast. The Friars, had to adapt new world materials into some resemblance of their old world architecture style. The sanctuary was typically the first major construction project. The missions had to not only withstand weathering elements but also insurrection by the Indians themselves. The experiences at Mission San Luis Obispo demonstrates how California Missions came to define ignition resistant construction.

The Mission of San Luis Obispo was dedicated by Father Serra in 1772. Three fires ravaged the Mission in the ten years that followed. In 1774 a permanent church was erected, measuring 24 by 60 feet. The superstructure was made from shaved limbs and tule built on top of an adobe foundation. Two years later a fire nearly destroyed the entire mission including all the furniture, farm implements, and granary. Upon investigation, a group of Indians 25 miles from the mission was held responsible. The arson was accomplished by shooting burning brands affixed to arrows into the missions tule roofs. A second fire occurred Christmas Day in 1781, when a carelessly discharged firearm in the midst of Midnight Mass again lit the mission roof on fire. The third fire occurred in November, 1782.

It became obvious that the tule roofs had to be replaced with less combustible tile roofs. This was not employed initially because of the amount of skill and patience it took to manufacture the tiles. The Mission San Antonio was attributed to the first application of clay tile roofs in a letter from Father Serra dated December 8, 1781. The first roofing tiles were manufactured using local clay. The wet clay was formed into semi-cylindrical shapes and set in the sun to dry. The green tile was then fired in wood burning ovens. The fire-hardened tiles were applied in overlapping layers on the roofs wooden frame. This experiment proved successful- and became the roofing standard throughout the California Mission system during the 1780's.

To support their own weight, the adobe walls of the missions had to be thick and the arches squat. The long eaves and overhangs served to protect the adobe walls from the sun and rain. Exposed rafters and beams, of the low sloping roofs, were formed from heavy timbers. Doors were made of solid wood and windows were small, recessed, and narrow.

Built out of necessity the Mission Fathers affected the first modern "ignition resistant structures." The architectural style of the early Missions, has been reinterpreted for homes, shopping centers, and office buildings throughout California. Fortunately, "Mission Style" infers ignition resistance. Complete with stuccoed walls, protected openings, and real or imitation clay roofs.

## Summary

The I-Zone is a new term applied to an age old problem. Living in California's combustible wildlands was just as much of a concern for the Indians and Missionaries long ago as it is today. This ethnohistory should remind us that the I-Zone is a building technology problem, a fuel management problem, and a regulatory problem. It also hints that it is a perceptual problem for people who insist on living in the I-Zone. It is they who must ultimately come to terms with the wilderness in their own backyards.

Our hindsight view of early California demonstrates that this is not a new or unique problem. But, the application of our ethnographic knowledge should help us come up with new and unique methods for living in the I-Zone.

## The Proclamation

*With attention to the widespread damage which results to the public from the burning of the fields, customary up to now among both Christians and Gentile Indians in this country, whose childishness has been unduly tolerated and as a consequence of various complaints that I have had of such abuse, I see myself required to have the foresight to prohibit for the future (availing myself, if it be necessary, of the rigors of the law) all kinds of burning not only in the vicinity of the towns, but even at the most remote distances, which might cause some detriment, whether if be by Christian Indians or by Gentiles who have some relationship or communication with our establishments and missions. Therefore I order and command all commandantes of the presidios in my charge to do their duty and watch with the greatest earnestness to take whatever measures they may consider requisite and necessary to uproot this very harmful practice of setting fire to pasture lands, not omitting any means that may lead to the achievement of the purpose which I propose in this order, to which effect they will publish it in their respective jurisdictions with particular charge to the corporals of the guard, commissioners, and magistrates of the towns that they exercise equal vigilance in trying to advise the Christian Indians and the Gentiles of the neighboring rancherías about this proclamation and impressing upon them that those who commit such an offense will be punished, and in case some burning occurs, they are to try immediately to take the most appropriate means to stop the fire, of failing that, to direct it into another direction which may result in less damage, apprehending the violators, of whatever class or sex, who would be punished in accordance with the degree of malice there may be on the part of the offenders; and in order that there may be no obstacle to the observance of this order, I beg and charge the Reverend Fathers, priests of the missions, that they do their part in instructing the Christian Indians not to commit such transgression. And in order that it come to the attention of all and that nobody may allege ignorance, I order that this decision of mine be published by proclamation in the presidios as well as the missions and towns of this province which is in my charge, making it be known to all classes of Indians, Christians as well as Gentiles, and repeating its publication annually, with the full understanding that whatever lack of observance may be noticed in this matter (which is) of such great interest will be worthy of the most severe punishment.*

**Don José Joaquin de Arrillaga,**

*Captain of Cavalry, Interim Governor and Inspector Comandante of Upper and Lower California*
*Given in Santa Barbara, May 31, 1793*

## Tribal Areas of California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Quantitative analysis of past fires provides the empirical information necessary to design and implement future building requirements.

By **Ethan I.D Foote & J. Keith Gilless**

There is no shortage of recommendations on hazard mitigation strategies for buildings at risk to damage from wildfire. Most are based upon the professional judgment and experience of members of the fire service and reflect intuitive comparisons of the homes saved or lost in thousands of cases. It is notable that few fundamentally new concepts for protecting buildings exposed to wildfire have been proposed in the past decade. We know, and have known for a long time, what needs to be done to reduce such losses, but change has come slowly. Finding more effective methods to implement recommended hazard mitigation strategies remains a major challenge.

This chapter outlines the potential of quantitative analysis as a means to improving implementation of hazard mitigation strategies. After reviewing hazard mitigation implementation in general, two methods of quantitative analysis will be introduced, experimental and observational. It should not come as a surprise to anyone in the field that the strongest findings of this study is the need for non-flammable roof covering and clearance of flammable vegetation from around buildings. Both of these have been professional recommendations for over thirty years, but implementation has been slow, weak, or absent. However, quantitative analysis can validate existing professional recommendations of this sort, lead to new recommendations, and/or establish cause and effect relationships, all of which will result in better implementation of hazard mitigation measures and reduced fire losses.

### Implementation Of Hazard Mitigation Strategies

There are basically two approaches to implementation: voluntary or mandatory. The voluntary approach can include measures ranging from public information and education to monetary incentives. A mandatory approach, in contrast, focuses on building codes, land-use planning, and fire safety regulations. With either approach, decision makers outside the fire service need to be convinced to take action. A quantitative understanding of building loss in wildfires may improve reception of a hazard mitigation program. Quantifying the impact of hazard mitigation strategies may be essential to implementing monetary incentive programs, and it opens the door to cost-benefit analysis of alternate strategies, such as non-flammable wall covering versus additional brush clearance.

Historic (non)regulation of wood roofing provides an apt illustration of how knowing what needs to be done (from the fire loss perspective) does not necessarily lead to doing it, and the difficulty in trying to quantify fire loss arguments. An insurance industry report following the Berkeley Hills Fire of 1923 cited wood roofing as a major cause for the large loss. "Of all the factors entering into the rapid [three hour] spread of the conflagration, not excluding the high winds and the weak water system, this [wood roofing] was of the greatest weight." Quantitative evidence was provided to back up this conclusion, "Of the 584 buildings totally destroyed, 540, or 92.5 percent, had roof covering of wooden shingles (National Board of Fire Underwriters: 1923)." Within a month of the fire The Berkeley City Council banned wood roofing and ordered all existing wooden shingle roofs to be replaced within 10 years. In a brief to the city council the wood products industry countered with the observation that 85% of the undamaged houses on the immediate perimeter of the fire had wood shingle roofs and contended that class C roofing was no better than wood.

The Berkeley wood roofing ban was repealed in a city referendum six months after its passage, and as recently as 1991 Californians were subjected to wood shake industry advertisements stating that "Over the years, cedar shake and shingles have been the scapegoat in residential fires throughout the state (California Journal:1990)." In 1995, 72 years after the Berkeley Hills Fire, untreated wood roofs were effectively banned in new construction in the State of California by the O'Connell bill (AB 2131).

Numbers, statistics, percentages, and numerical comparisons are often employed in public debates to advance a proposition or its implementation. This quantitative approach can be very effective. However, without sound and comprehensive methodology, it can also be inconclusive or misleading, as was the case with the quantitative evidence provided after the Berkeley Hills Fire. Neither side compared roof type in both damaged and undamaged buildings exposed to the fire and the true role of roof type in this fire was lost. A few quantitative studies have been published on mitigation factors for building loss in wildfires, but this is an under utilized approach and could be a valuable tool in the challenge to increase implementation of hazard mitigation strategies.

## Experimental Vs. Observational Analysis

There are two broad avenues to obtaining a quantitative understanding of building loss in wildfire- experimental studies and observational studies. Experimental studies follow the classic scientific methods of control and replication to allow one to draw cause and effect conclusions from the results. Observational studies on the other hand exhibit no control over the forces producing the outcome of interest. The scientific inferences that can be drawn from observational studies are accordingly quite limited and there is no way to assess cause and effect relationships. Observational studies, however, can provide valuable insight into complex phenomena, and the real-world events on which they are based can be an asset in communicating with the lay decision makers.

To put the I-Zone fire loss problem into a similar analytic framework, think of a subject (house), exposed to a hazardous event (wildfire), the outcome of which is either loss or survival of the subject, with hazard mitigation factors that are either present or absent (non-flammable roof, and defensive actions), and a hazard mitigation factor that can take on a range of values (brush clearance distance).

In practice there is a full range of approaches covering a spectrum from full scale experiments to observational studies. True classical experimentation is often not possible because of limitations on manipulating exposure of subjects to hazardous events and controlling large scale environmental phenomena. Examples of other approaches in the middle of this spectrum include, semi-empirical modeling, quasi-experiments, less than full scale experiments, and experiments on parts of a system such as building components.

In the absence of any experimental understanding of the this fire loss problem and wishing to establish some quantitative basis for fire safety recommendations, the California Department of Forestry and Fire Protection (CDF) initiated a data collection effort in 1989. Known as the Defensible Space Factor Study, this post-fire structure loss data collection program was the basis for the observational study of the Paint Fire discussed in this chapter.

### An Observational Approach to Building Survival

In preparation for the Paint Fire research, previous observational studies of building survival in wildfires were reviewed. Three investigations were found which reported survival and loss data in percentages and three additional studies were found that went further in their analysis and applied statistical methods. The findings on hazard mitigation factors in these previous statistical studies will be discussed later in relation to the Paint Fire results. It is of interest to note that for the studies where information was available the average proportion of buildings that were damaged but survived wildfire exposure was 12%, as a percentage of buildings burned. The Paint Fire followed this pattern with 12% of burned buildings surviving as damaged. (Table 1 shows 66 buildings damaged, which is 7% of all exposed buildings: destroyed, damaged, and undamaged. The 66 buildings damaged is also 12% of all burned buildings: destroyed or damaged. The latter figure needed to be used for comparison among studies. The five studies where damage figures were reported spanned a fifty year period. In all these fires there was almost a nine out of ten chance that buildings would either survive unscathed or be destroyed. In other words once ignited, buildings were overwhelmingly lost, an observation that should be carefully evaluated in selecting hazard mitigation strategies.

The Paint (or Painted Cave) Fire was started by an arsonist at approximately 6 pm on June 27th 1990. The weather was extreme with 105 degree temperature, 25 mph winds (gusting to 60 mph), and relative humidity below 9%. Two days of such conditions leading up to the fire compounded by a prolonged drought, resulted in 10-hour fuel moisture at 2% and live fuel moisture at 60%. The fire initially spread downslope with 40-70 foot flame lengths at 2-3 mph. Spot fires ignited 1/2 to 3/4 of a mile in front of the main fire. During the first hour of the fire, scattered rural homes and ranches were exposed as the fire spread down through brush-covered mountain slopes. In the following hour, 800 buildings, primarily homes, were exposed as the fire spread through grass oak woodland, riparian vegetation, suburban neighborhoods, and small commercial districts.

| | Post-fire Building Condition | | | Total Exposed |
|---|---|---|---|---|
| **Survey Categories**<br>Number of Buildings<br>% of Total Exposed | **Destroyed**<br>479<br>53% | **Damaged**<br>66<br>7% | **Undamaged**<br>357<br>40% | <br>902<br>100% |
| **Analysis Categories**<br>Number of Buildings<br>% of Total Exposed | **Destroyed**<br>479<br>53% | **Survived (not destroyed)**<br>423<br>47% | | <br>902<br>100% |

Table 1. Paint fire building damage summary. Number and percent of buildings exposed by the fire shown by post–fire building condition for the three survey categories used during data collection and the two analysis categories used for statistical analysis.

Immediately following the fire, an interagency group of data collectors was assembled to survey the buildings subjected to wildland fire exposure. The survey was sponsored by the CDF. The data collection group consisted of 19 representatives from the: CDF, Santa Barbara County Fire Department, Santa Barbara County Building Department, USDI National Park Service, Office of the California State Fire Marshal, and USDA Forest Service.

Paint Fire data collection was initiated on each of 902 buildings threatened by the fire. The post-fire building condition was recorded in the survey as undamaged, damaged, or destroyed. To more easily evaluate the effectiveness of hazard mitigation factors, post-fire building condition was evaluated in the analysis with two categories: building survived, yes or no. The distribution of Paint Fire buildings in these categories is shown in Table 1.

| Non-flammable Roof Type | Post-fire Building Condition | | TOTAL BuildingsSurvived |
|---|---|---|---|
| **Present**<br>Number of Buildings<br>% of Total Surveyed | **Destroyed**<br>125<br>30% | **Survived**<br>290<br>70% | <br>415<br>100% |
| **Absent**<br>Number of Buildings<br>% of Total Surveyed | <br>233<br>81% | <br>53<br>19% | <br>286<br>100% |
| **Total**<br>Number of Buildings<br>% of Total Surveyed | <br>358<br>51% | <br>343<br>49% | <br>701<br>100% |

Table 2. Single factor analysis contingency table. Hazard mitigation factor "Roof Covering Non–flammable Yes/No" cross tabulated with post–fire building condition categories "destroyed" and "survived" showing proportion and number of surveyed buildings.

Individual hazard mitigation factors were evaluated with 64 separate variables derived from the survey data.The majority of the Paint Fire data analysis was in the form of single-factor comparisons where buildings with and without a hazard mitigation factor present were tabulated in the two post-fire building condition categories. The result is a contingency table, like the one in Table 2 for roof type, where all the buildings for which there was survey data available on roof type are sorted into the four cells of the table. If there is a pattern in the distribution of buildings surviving fire exposure, with respect to the absence or presence of a factor, statistical analysis can be used to determine whether the factor is associated with post-fire building condition. A number of the factors tabulated revealed patterns of building survival but were not statistically associated. This could be due to insufficient data or random chance.

Of the 64 variables used in this single-factor analysis, 43 were found to be associated with building survival. The remainder were either not associated or there was insufficient data to conduct the statistical analysis. All but three of the hazard mitigation factors found to be associated with post-fire building condition exhibited the pattern of building survival expected based on professional recommendation.

The patterns in contingency tables are often easier to see when the results are shown graphically. Figure 1 does this for roof type, taking the 19% (in Table 2) of buildings without non-flammable roofing that survived and depicts it as an open bar, the height of which is the proportion (0.19) of surviving buildings with the hazard mitigation factor absent. The shaded bar depicts the proportion of surviving buildings with the hazard mitigation factor present, in this case 0.70 for buildings with non-flammable roofing present. The extent to which the bars are substantially above or below the average proportion of building survival (0.49 for buildings with roof type data collected shown as a line across the bars) is a measure of effectiveness for the hazard mitigation factor.

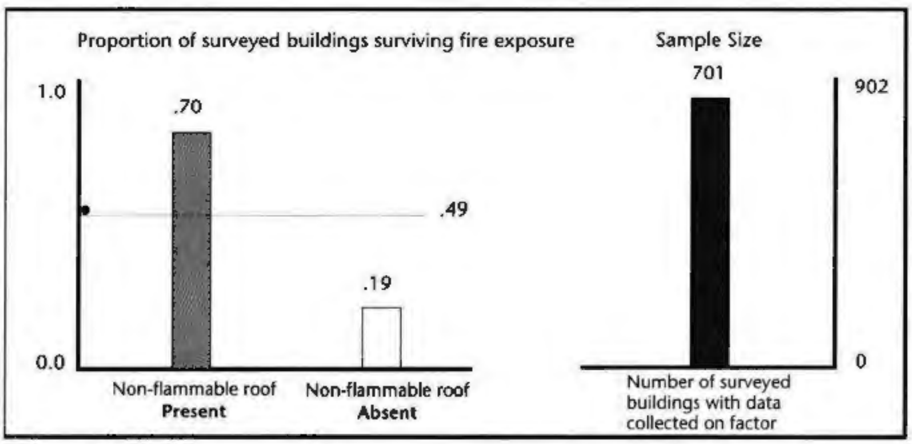



Figure 1. Single factor analysis bar graph for hazard mitigation factor "Roof Covering Non-flammable Yes/No." Proportion of surveyed buildingswith hazard mitigation factor "present" and "absent" shown only for post-fire building condition "survived." Number of buildings surveyed with data collected on roof top shown as sample size. Average building survival proportion for the sample shown (0.49) with average building survival proportion for the fire indicated (0.47).

The black bar (the graph on the right) in Figure 1 shows the number of buildings surveyed where data was available on roof type. The height of the bar also represents the factor sample size as a proportion of the total number of buildings (902) with wildfire exposure. The average proportion of surviving buildings for this total number of buildings exposed (47% from Table 1) is also shown on the left graph as a bullet point with a short horizontal line.

The total number of buildings with wildfire exposure and the proportion of surviving buildings in the Paint Fire as a whole are important points of reference. In order for the building survival data for a hazard mitigation factor to be representative of the fire as a whole, it must be collected using a systematic and statistically valid survey method or, as was the goal in the Paint Fire research, it must be collected from all buildings with fire exposure. Because none of the factors had complete data collection, there is the possibility that results are biased. This possibility increases as the factor sample size drops away from the total of 902 and the average proportion of surviving buildings for the factor is substantially different from the total of 47% (shown with the bullet point on the left graph).

The results shown in Figure 1 for roof type were the strongest single factor findings in the study. With the hazard mitigation factor non-flammable roofing present, building survival was found to be well above the average for the sample. When the factor was absent, building survival fell to among the lowest in the study. The large sample size combined with very similar average building survival proportions between the factor sample and the total for the fire (49% vs. 47%), make it likely that these sample findings are representative of the fire as a whole.

The data used in the roof-type contingency table was collected using California Fire Incident Reporting System roof-type categories. The non-flammable roofing absent category was composed entirely of untreated wood shake/shingle roofing (or fire retardant treatment status unknown), and comprised 41% of the sample size. The majority (51%) of the sample consisted of various types of tile and composition shingle roofing.

While roof type was the only building construction factor to be included in the final results and presented in detail in this chapter, ten of the fifteen data collection survey questions on building construction factors in the study produced variables associated with building survival. The three areas of building characteristics investigated on the Paint Fire were exterior building covering flammability, openings in the building exterior, and firebrand or convective heat concentration features.

The other horizontal building surface flammability factor, in addition to roof type was, "Deck surface nonflammable," and it too was associated with structure survival. "Exterior wall covering type," displayed a strong association with structure survival, but was one of the three such variables in the study for which the direction of association was opposite from that which was expected. In other words, the survey category "Walls burn readily" had higher structure survival than category "Walls won't burn". A full discussion of such anomalous findings can be found in the study. Suffice to say here that this is a complex phenomena and that there are many pitfalls in attempting to elucidate structure ignition working only after the fact from a data collection survey.

Several of the factors in the "openings in the building exterior" group were associated with building survival ("Attic peak vent screened", "Overhanging boxed-in-eaves vents absent", "Subfloor (ground level) vent screened", and "Window/door open absent during fire front passage"). Here again, there are a few apparent contradictions and less than straight forward interpretations when the results are viewed as a whole, which the reader is urged to do if these findings are of interest.

Lastly, among the building characteristics, are the construction features which may act to concentrate convective heat flow or windblown firebrands. The results were mixed. "Deck, overhanging

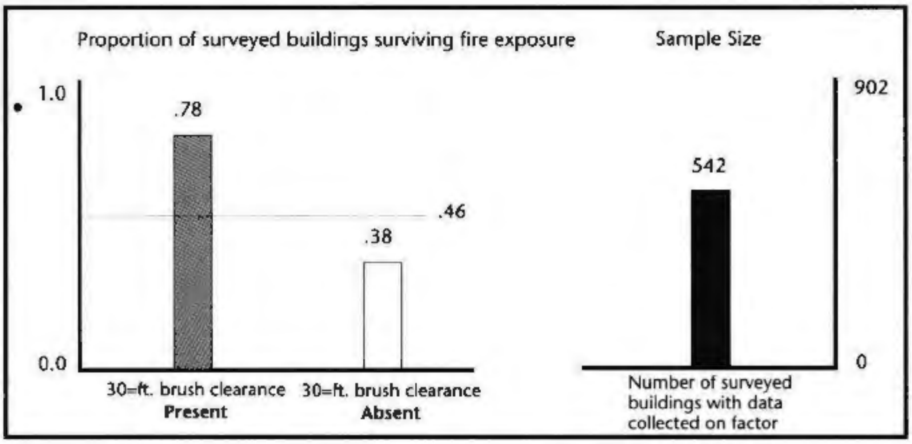



Figure 2. Single factor analysis bar graph for hazard mitigation factor "30+ ft. Clearance of 3–10 ft. Flammable Vegetation Yes/No." Proportion of surveyed buildings with hazard mitigation factor "present" and "absent" shown only for post-fire building condition "survived." Number of buildings surveyed with data collected on brush clearance shown as sample sample size. Average building survival proportion for the sample shown (0.46) with average building survival proportion for the fire indicated (0.47).

substructure enclosed" was associated with building survival. Interpretation of the remaining results should be in context of the findings as a whole, space for which is not available here.

In Figure 2 the results for brush clearance around buildings are presented in the same graphical format as was done with roof type. The hazard mitigation factor here is: 30 feet or more clearance distance of flammable vegetation, 3 to 10 feet in height, present or absent. Buildings exposed to wildfire with this mitigation factor present had a survival proportion (0.78) well above average and when the factor was absent, building survival (0.38) was below average. The data collection effort was able to obtain brush clearance information on over half (60%) of the buildings exposed in the fire and the average building survival proportion for this sample was 46% compared to 47% for the total.

Brush clearance had the strongest results of the four flammable vegetation clearance factors assessed on the Paint Fire. The vegetation clearance information was collected in four vegetation height classes (grass, shrub, brush, and trees) and all were grouped into ten foot increments of clearance distance. With limited exception, building survival increased with every additional ten feet of clearance around an exposed building for all classes of vegetation height.

Defensive action taken by fire fighters or civilians to protect exposed buildings also produced strong findings (see Figure 3). The variahle "defensive actions by fire fighters and/or civilians" consolidates the data of a number of survey questions concerning specific details of actions taken to defend buildings from wildfire exposure. For the buildings surveyed with this factor present, there was a 0.83 proportion of building survival.

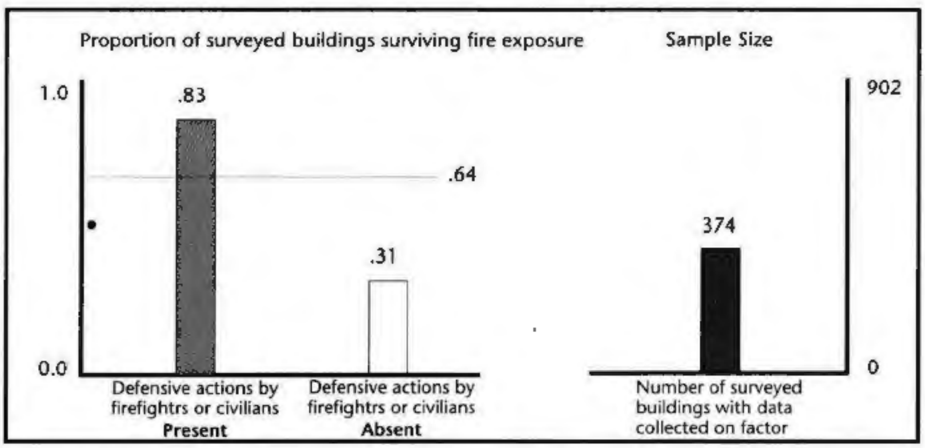



**Figure 3.** Single factor analysis bar graph for hazard mitigation factor "Defensive Actions by Firefighters and/or Civilians Yes/No." Proportion of surveyed buildings with hazard mitigation factor "present" and "absent" shown only for post-fire building condition "survived." Number of buildings surveyed with data collected on defensive actions shown as sample size. Average building survival proportion for the sample shown (0.64) with average building survival proportion for the fire indicated

There are, however, two elements in Figure 3 of concern: the relatively high (64%) average survival in buildings surveyed and the relatively low (374) number of buildings surveyed where data on defensive actions was available. One of the assumptions underlying the statistical analysis here and throughout the study is that the sample of buildings used to derive the structure survival proportions is representative of all 902 buildings in the fire. This assumption is questionable when the average building survival is nearly 20% higher in the sample of buildings where data was available on defensive actions as compared to the average building survival for all buildings exposed in the fire.

One explanation for this difference in average building survival is that the data collection was biased. The term bias is not used here to imply prejudice in analysis or data collection, but rather that "systematic bias" in the data collection methodology produced a sample that was not representative of the whole group under investigation. The goal of the Paint Fire data collection was to collect data at every building site subject to wildfire exposure. Full data collection was not achieved but every building site was at least visited for data collection. However, no similar effort was made to contact all persons who may have taken defensive actions at buildings. As data collectors became aware of information on defensive actions, it was recorded, and as a result the sampling was neither random, nor systematic, nor did it encompass the entire population of exposed buildings. It is possible, if not likely, that data collection on defensive actions was biased toward buildings that were more likely to survive.

This does not invalidate the defensive action results of the study. The substantial difference in building survival shown in Figure 3 is statistically significant and applicable to the sample of 374 buildings from which the data is drawn. Caution needs to be exercised, however, in applying these results beyond the sample, especially with regard to the magnitude of proportions for building survival.

A weakness with the type of analysis described thus far is that one can only look at a single factor at a time. There is no way to ascertain potential synergistic effects for combinations of factors. Nor is it possible to reveal any potential confounding effects of other factors on the results for the factor of interest. There is no way of knowing, for example, how much the building survival observed in Figure 2 is due to brush clearance, or is due instead to roof type or some other factor that happens to occur in concert with vegetation clearance.

This problem can be partially addressed by multivariate analysis techniques, such as logistic regression which was used in the Paint Fire study. Through this analysis, the factors discussed so far (roof type, brush clearance, and defensive actions) were selected for inclusion in a three-factor logistic regression model representing the most meaningful combination of factors within the aim of the study to validate fire safety recommendations. The outcome of a logistic regression model is the estimated conditional probability of building survival given the presence or absence of explanatory factors in the model. With non-flammable roof type, 30+ feet brush clearance, and defensive actions all present, the model predicted a probability of building survival over 99%. There are a number of observations, in addition to the potential of biased data collection, that raise concerns about including defensive actions in the final model. The presence of defensive actions appears to overly inflate the probability of building survival with and without the presence of the other two factors. The most robust interpretation of the results is to include the defensive actions factor, but focus on the findings where defensive actions were absent (see Figure 4). This approach gives much greater explanatory power to the remaining factors, brush clearance and roof type, by accounting for the potentially confounding effect of defensive actions.

The potential value of multivariate statistical analysis is illustrated by the results of this study. The statistically significant inclusion of roof type, brush clearance, and defensive actions into a logistic regression model says that these factors are both independently and mutually associated with building survival in wildfires. In other words, roof type is statistically associated with building survival both with and without the presence of brush clearance and defensive actions. This is true regardless of the magnitude of the conditional probabilities for building survival generated by the model, two of which are presented in Figure 4, and which reveal additional insights.

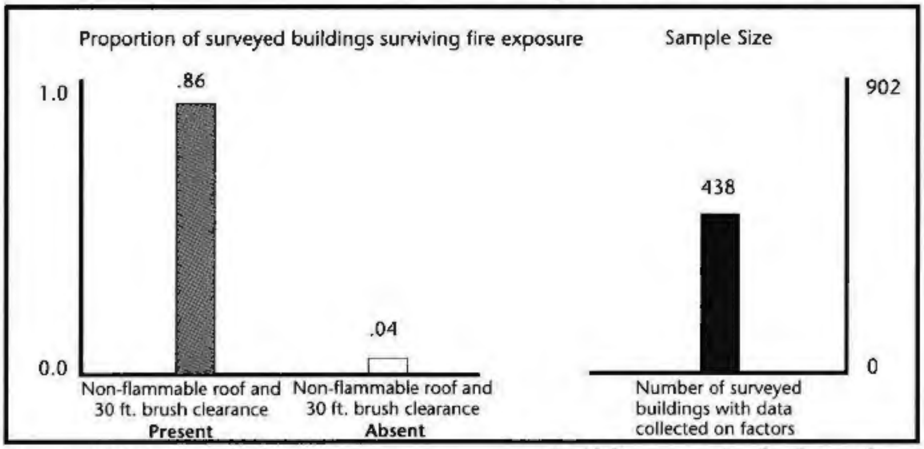



**Figure 4.** Multi-factor analysis bar graph for hazard mitigation factors " Roof Covering Non-flammable Yes/No", "30+ ft. Clearance of 3–10 ft. Flammable Vegetation Yes/No" and "Defensive Actions by Firefighters and/or Civilians Yes/No." Probability of building survival in the absence of defensive actions with other hazard mitigation factors "present" and "absent" shown only for post-fire building condition "survived." Number of buildings surveyed with data collected on all factors shown as sample size.

The 0.86 probability of building survival in Figure 4, for non-flammable roof type present and 30+ ft. brush clearance present (in theabsence of defensive actions), lends support to the contention that there is a synergistic effect with these factors. In this sample there is a greater positive impact on building survival when these factors are present together in combination as compared to their presence individually. The multivariate analysis reveals an even stronger building survival pattern with respect to the absence of these factors. In the single-factor analysis, each factor had a proportion of building survival from between 0.19 and 0.38 when the factor was absent. The probability of building survival when all factors were absent in the multivariate model plummeted to 0.04. This may be a result of additional synergistic effects and/or reduction in the confounding effects of other variables in a single factor analysis. With such strong results, it is important to reflect back on the limitations of the statistical methodology which produced these findings.

## Application of Observational Research

There is a strong tendency to apply observational results too broadly. Findings from studies such as this can only be expected to give a true representation of building survival for the buildings actually surveyed. Recall that observational studies do not establish a cause and effect relationship. Therefore, one cannot statistically conclude from these results that non-flammable roof covering or flammable vegetation clearance will reduce building loss in future fires. Nor should one expect to see the exact building survival proportions reported here replicated in any future retrospective studies. On the other hand, is it also inappropriate from a public safety perspective to postpone action on hazard mitigation until there is sufficient experimental evidence to scientifically conclude cause and effect relationships.

Well conducted observational studies, in the absence of experimental results, should be enough to guide decision making.

One factor in evaluating "appropriate steps" would certainly be the strength of the studies providing the information. Furthermore, a series of such observational studies, with a continuing pattern of similar associations, should be sufficient for other entities to decide to act, for the present, as if the associations were cause and effect relationships.

Several quantitative observational studies on the building loss problem in wildfires have been published over the past decade with some consistent results emerging. Two of the studies were on the Australian "Ash Wednesday" Fires of 1983 and the other was on the Florida Palm Coast Fire in 1986. Wilson & Ferguson have been the only ones to evaluate wood roofing, prior to the Paint Fire, and roof type was also found to be associated with building survival. Flammable vegetation surrounding the building was directly evaluated by both studies and found to be associated with building survival. Defensive actions by civilians were also found in these studies to be associated with building survival.

Finally, consider one last hypothetical scenario. Had better quantitative analysis been conducted following the 1923 Berkeley Hills Fire, it is certainly possible that the wood roofing ban would have survived the city referendum and by the 1930s, all of the homes in Berkeley would have had non-flammable roofing. It is not inconceivable that the neighboring city of Oakland would have followed suit and mandated replacement of untreated roofs, especially after the 1970 Oakland Hills Fire which destroyed 36 homes. It is not yet possible to model what effect removing untreated wood roofing from the 1991 Oakland Fire scenario would have had. But it is tantalizing to contemplate the fire loss reduction potential of hazard mitigation factors, such as non-flammable roofing, especially in light of repeated studies finding these factors associated with structure survival. One of the keys to unlocking that potential is a commitment of resources to understanding the dynamics of the problem from a systematic and quantitative basis.

The lack of empirical data for ignition resistant construction requires the fire administrator to evaluate building materials and installation on a case by case basis.


By **Fred L. Fisher & Brady Williamson**

An impediment to attaining cost-effective building fire safety within the I-Zone is the lack of knowledge, in a quantitative sense, of the threat represented by wildfires. Without a clear understanding of the threat represented by wildland fire it is unclear how the building codes pertaining to very high fire hazard severity areas should be written and what levels of fire performance should be required. It is also difficult to know if the various trade-offs in fire protection features make sense.

Due to catastrophic fire losses within the I-Zone, and the clear necessity for protecting buildings located within these areas, additional building regulations are, and will be, enacted. The question is, will these regulations make sense from an engineering and cost standpoint? As much as possible, it is important that the regulation of buildings within the I-Zone be based on knowledge of the threat represented by wildland fire and not simply on outdated information or on someone's best guess. An example of the latter is the requirement that combustibles be cleared 30 feet from the perimeter of structures located within the I-Zone. While this requirement sounds reassuring, no one seems to know its technical basis or how much of an impact it has on fire safety. I have been told the purpose of this regulation is to prevent a fire originating within a structure from igniting a wildland fire. Another purpose, is to provide a space between the wildland fuels and structural fuels in which fire fighting operations can be accomplished.

This chapter will examine a few of the many issues which affect building standards within the I-Zone and point out areas where research is needed in order to develop intelligent performance based building code requirements. This chapter is intended to raise questions for people to consider. While few outright answers to these questions are offered, possible paths to their solution will be discussed.

### I-Zone Requirements & Model Building Codes

Model building codes and ordinances prescribe actions that are to be taken in order to attain a certain level of safety from wildland fire. The codes attempt to translate a fire safety objective into prescriptions or performance requirements. The performance based model building codes use test standards to measure the performance of a given building component to verify that it meets the previously stated fire safety objective. If the building component passes the test, then it can be used and there is the expectation that it will provide the required level of fire safety. This scheme works very well as long as the test standard provides a reasonable simulation of the parameter of interest of the expected or design fire. Problems can arise when the test standard does not do a good job of simulating the design fire parameter of interest. If the test standard under predicts the required level of protection, then safety can be compromised. If the test standard over predicts the required protection, then there is a cost penalty.

At the present time California law, pursuant to Chapter 843 of the Statutes of 1994 (AB 3819), requires new construction, and construction in which 50% or more of the roof is replaced, to have a minimum Class C rating. In addition, the law requires a Class B rating in very high fire hazard severity zones. The fire hazard severity zones are established by the California Department of Forestry. Beginning in 1997 there will be a Class A roof requirement for the very high fire hazard severity zones. These class ratings refer to the American Society for Testing and Materials (ASTM) Standard E-108, "Standard Test Methods for Fire Tests of Roof Coverings" (NFPA 256 and UL-790 are similar standards). The ASTM E-108 Standard has three parts which deal with a roofs resistance to fire penetration and flame spread. These sections are the burning brand test, the intermittent spread of flame test and the spread of flame test.

The question is, how well do these parts of the ASTM E-108 test method simulate the important parameters of a wildland fire burning in a very high fire hazard area? The answer is, we don't know.

The following is a short description of the burning brand section of the ASTM E-108 test standard. The burning brand test consists of three different size brands for the three different classes (i.e. A, B or C). The Class A brand weighs 2000 - 150 gm. (4.4 - 0.33 lb.) and measures 305 mm (12 in.) x 305 mm (12 in.) in plan and is 57 mm (2.25 in.) thick. The Class B brand weighs 500 - 50 gm. and measures 152mm (6 in.) x 152mm (6 in.) in plan and is 57 mm thick (2.25 in.). The Class C brand weighs 9.25 - 1.25gm. (0.020 - 0.00275 lb.) and measures 38 mm (1.5 in.) x 38mm (1.5 in.) in plan and is 19.8 mm (0.781 in.) thick. All brands are oven-dried to essentially 0% Equilibrium Moisture Content prior to the test. The test deck is placed at the maximum roof angle appropriate for the roofing material of interest and a 12 1/2 mile per hour wind is directed over the top of the test deck.

The Class A test requires that a total of four decks be tested with one Class A brand per test. The Class B test requires that a total of two decks be tested with two brands per test. The Class C test requires a total of two decks with 20 brands per test. The main test criterion is that no sustained burning occur on the underside of the roof deck. The intent of this test is to prevent exterior fire brands from causing burn-through into, and ignition of, the attic space.

The burning brand portion of ASTM E-108 standard is a perfectly good test method. It is probable that a roof covering material meeting the Class A requirements would resist any fire likely to be encountered in a very high fire hazard area that would not destroy the structure by some other means (e.g. fire entry through windows). The problem is, we do not know if the Class A or B burning brands are representative of the burning brand threat found in very high fire hazard severity areas. This is to say that the fire exposure of the test standard may not adequately model the parameter of interest (i.e. burning brands) of the design basis fire. This is an area in which additional research is needed.

## Designing Fire Safe Structures In The I-Zone

In order to design structures with a given level of fire safety it is necessary to have an understanding of the fire threats or "loads" the structure is likely to encounter. This general line of reasoning is the basis for modern performance based building codes. This type of reasoning needs to be applied to wildland fires in order for fire protection engineers to be able to design fire safe structures. The fire protection engineers need wildland fire scientists to quantify the expected or "design fire" for a given building site or development region.

Fire protection professionals would like to obtain the following basic information from future I-Zone fire research:

The expected time vs. temperature profile, time vs. energy release rate and flame height of the fires in different urban and/or wildland fuel mixtures.

How quickly the fire moves through a given area.

The burning brand impact at any given location within the fire affected area. That is, what the mass deposition rate, the brand size distribution, and total brand mass deposited are at any given location.

The burning characteristics of landscape plants that may be found in close proximity to a structure.

Fortunately, the level of understanding of many of these areas is increasing and computer models such as BEHAVE, and its successor, FARSITE, make possible a description of many aspects of the expected fire. Models such as FARSITE are invaluable tools for quantitatively estimating wildland fire severity. The development, validation and widespread use of such models should be a high priority. The results of wildland fire simulations using FARSITE may indicate areas in which economically viable fire safe designs cannot be built and thus, development should never take place. Pagni has noted that there are areas, some within the Oakland-Berkeley hills, which due to unmitigable factors, such as terrain and weather patterns, should never be built upon. He notes that some lands are so prone to catastrophic fire that they should be held as fire-shed areas in order to help protect adjacent urban areas from the threat of mass wildland fire. Rice notes, "Local community planning entities should recognize that hazard is great enough to preclude development in some areas on the basis of (a) water scarcity, (b) high fire hazard rating, or (c) limited access for fire equipment." Some of this information should be available to urban planning professionals who help make the local zoning policies.

One important aspect of the wildland fire that is not yet fully defined by these models is that of the production and lofting of large burning brands (i.e. brands >25mm (1 in.) in diameter). Another important area that needs to be explored further is that of determining the radiant output of wildland fires based on the fire intensity and flame heights predicted by the FARSITE model.

Apart from the very difficult problems associated with calculating the behavior of large wildland fires, there is a need to understand the fire threat associated with the torching of individual or small groups of trees and shrubs. The need for this information has to do with the safe use of landscape plants. A data base for landscape plants needs to be developed which provides the time history of heat release, thermal radiation output, flame height and burning brand production. These parameters are important when deciding the type and number of a given species of plant that can safely be placed near a building. Some work in this area has been accomplished but a great deal more research is needed.

## Building Design Considerations

In order to provide fire safety, the building design must incorporate features which prevent a wildland fire from spreading on the exterior envelope of the structure and from penetrating to its interior. As noted previously, the design features necessary to accomplish these goals are dependent upon the expected severity of the wildland fire source.

## Roof Design

The roof of a structure is perhaps the most susceptible to ignition from a wildland fire. The primary means of ignition is due to the deposition of burning brands. It should be pointed out that burning brands can be deposited far in advance of the actual fireline itself. The 1991 Oakland Hills fire provides an example of the long range spotting caused by burning brands. Roofs may also be ignited by direct flame impingement from trees and large shrubs.

At the present time some limited predictions of brand production and deposition can be made. FARSITE predicts the lofting and deposition of small brands (i.e. <25mm (1 in.)) but does not yet deal with larger brands. The issue of brand size distribution may be important with respect to the testing procedures that are used to qualify roofing materials for use in very high fire hazard severity areas of the I-Zone. The specifics of the burning brand sections of the ASTM E-108 test method were previously described.

The spread of flame sections of the ASTM E-108 test were originally intended to evaluate the propensity for a roofing material to spread flame when it was exposed to a flame plume issuing from a window of the structure on which the roofing material was installed. In a qualitative sense the two spread of flame sections of the ASTM E-108 test method are applicable to the case in which landscaping trees or large shrubs are very near or in contact with the roof of a house. The slot burner used in the ASTM E-108 spread of flame tests does produce a large diffusion flame which is qualitatively similar to the flame from burning vegetation. In a quantitative sense we do not yet know what the energy release rate or total emissive power of the burner flame used in the ASTM E-108 method equates to with respect to a burning tree or shrub. This is an area in which research is needed.

If the flame exposure during the flame spread portions of the Class A roof test are as severe as most of the tree and shrub fire exposures, then it provides a useful indication of the likely performance of the roofing material during wildland fire exposure. If the severity of tree and shrub fire exposures far exceed the flame exposure of the E-108 standard, then perhaps the standard should be modified to include a third spread of flame test exposure for the purpose of qualifying roofing materials for use in very high fire hazard severity zones.

### Attic Openings

There are two concerns with attic ventilation openings, burning brand intrusion and flame intrusion. Significant amounts of cross ventilation are required in an attic in order to prevent degradation of wood roof rafters and ceiling joists. The 1991 Uniform Building Code, in section 3205(c), requires 1 square foot of opening per 150 square feet attic floor area. It is important that these ventilation openings are properly screened to prevent burning brands from being deposited within the attic and that all other roof joist openings are fire blocked.

Flame intrusion into an attic through ventilation openings can occur from ignition of and vertical flame spread on combustible exterior cladding materials. It can also occur from the torching of landscape trees and large shrubs which are in contact with, or very near, the exterior of a building. It is much more difficult to prevent flame intrusion into an attic than it is to prevent burning brand intrusion. Screened covers over ventilation openings are not effective in preventing flame intrusion into an attic space. Possible active solutions include installation of automatic sprinkler protection in the attic and or at the eaves. These solutions can require complicated installations since many of the structures requiring protection will be in areas where freezing occurs during the winter months. Other active methods of protection involve fire dampers with fusible links which close off the opening upon exposure to flame or hot gas. All of these measures are costly and subject to continuing maintenance in order to be effective.

A passive means of preventing flame intrusion into the attic is to use noncombustible exterior siding materials and to site trees and shrubs far enough away from the walls of the house to prevent flame travel into the attic even if a tree or shrub does torch. Siting of landscape vegetation requires information on the burning rates and flame heights produced by the specific plant species of interest. As previously noted, this is an area where additional research is needed.

The use of thermoplastics, such as PVC, in or near attic ventilation openings can lead to rapid flame intrusion into the attic. Thermoplastic siding will be discussed in the following paragraph, but most manufacturers of thermoplastic siding also produce and sell matching "soffit" closing details which, in general, are just mounted to the underside of the roof rafters. This closing out of the attic with thermoplastic materials has been directly responsible for fire spread into the attic of actual buildings from exterior fires. Aluminum soffit closing materials have also failed under exposure fires to allow flames from entering into the attic.

### Exterior Wall Construction

Ideally, in very high fire hazard severity zones, exterior wall construction should be of noncombustible materials such as stucco or masonry. Combustible wall cladding materials are subject to ignitions from thermal radiation from adjacent structures and large wildland fires, and from the torching of landscape plants near or in contact with the wall. As noted previously, the ignition and burning of combustible wall cladding materials can also cause fire involvement of the attic spaces. One mitigating factor with respect to exterior wall ignitions by wildland fires is their relatively short duration at a given location. That is to say, most of the dangerous active burning (i.e. large open flames) at a given location in a wildland fire occurs over about a 5 - 10 minute period.

At the present time there are no fire test standards specifically aimed at evaluating the fire resistance of exterior wall assemblies from large exposure fires (e.g. adjacent buildings and large wildland fires) or from small exterior contact fires (e.g. landscape vegetation). The ASTM E-119 fire test standard has been used by the model codes to assess the fire resistance of exterior walls to exposure fires. This is not an appropriate use of the test since the ASTM E-119 test is meant to represent a fairly severe interior postflashover fire.

A test procedure was developed for the evaluation of the fire performance for residential exterior wall assemblies exposed to small flaming sources. The gas burner ignition source was modeled after burning eucalyptus duff and grass and is appropriate for evaluating the performance of residential walls subjected to fires from the torching of shrubs and other small to medium sized landscape plants. This test procedure could also be of value in evaluating whether or not the exterior siding material would lead to fire exposure of the attic through eaves vents.

The lack of appropriate standard fire test methods for the evaluation of exterior wall assemblies results in the inappropriate use of existing test standards in performance based building codes. When prescriptive language is used, over or under design generally results.

## Windows

Window openings, if not properly protected, offer a direct path into a structure for flame and burning brands. Glass typically cracks and breaks in a fire due to rapid changes in temperature, restraint to thermal expansions at its perimeters, and bombardment by wind blown projectiles. Therefore the probability of breakage and the resulting area of exposure increase with size of individual pieces of window glass. Large expansive windows would probably fare better if they were broken into individual panes as opposed to large sheets of glass.

It is generally recognized that single pane, annealed glass windows are quite susceptible to breakage from thermal radiation and from direct flame contact. Multiple pane windows fare much better than single pane windows and can endure higher levels of radiant heating without breaking. Tempered glass windows perform much better than annealed glass windows but they also cost more. Double pane, energy efficient windows for residential use cost approximately 2/3 more if the glass is tempered versus annealed.

Due to the energy conservation requirements within the state of California, double pane windows are the norm for new construction. It should be possible to easily develop double pane windows in which the outer pane is tempered glass and the inner pane is annealed glass. Such a design would provide the increased fire resistance of the tempered glass but only have a cost penalty of about one-third that of all annealed glass units. Fire experiments with this type of window unit would be useful.

Experience from Australian brush fires indicates that the use of metal screens will absorb significant amounts of thermal radiation from a wildland fire and thus enhance the survivability of the window glass. The full-time use of metal screens over all the windows in a residence may be objectionable due to the impact on vision through the window. One of the reasons for moving to the I-Zone usually has to do with views from windows. A method of quickly attaching screens to windows in advance of a wildland fire may be a more acceptable solution.

Joshi and Pagni, have conducted research into the mechanisms of glass breakage under fire exposure. The reason glass windows crack during fire exposure is that the glass under the window frame is protected and remains cooler than the glass in the center part of the window pane. The differential thermal expansion induces stresses in the glass which result in tensile forces at the perimeter of the pane causing it to fracture. Fractures start at a flaw site in the perimeter of the glass. The larger the pane of glass, the longer its perimeter and the higher the probability that a flaw site exists.

Cohen has reported on laboratory experiments which investigated the breakage of glass exposed to exterior fire sources. His experiments have investigated two fire exposure conditions: propane burner impingement of 0.61m (2 ft) x 0.61m (2 ft)x 4.8mm (0.19 in.) thick glass windows and radiant heat exposure from a burning wood crib of windows measuring 0.91m (3 ft) x 1.5 m (5 ft)x 6mm (0.24 in.) thick. Specific details of the propane burner exposure were not given, but Cohen states that the exposure was primarily convective. For the radiant condition, Cohen used wood cribs spaced at various distances from the window. This condition is similar to wildland vegetation burning at some distance from a structure or radiant heat exposure from a nearby burning building.

The research investigated single and double pane windows and plate glass and tempered glass. Cohen reported that for the convectively heated windows all of the single pane plate glass windows broke at each of the three heat flux levels used (i.e. 9.3, 13.6 and 17.7 kW/m2). When double pane plate glass windows were tested at the same heat flux levels, all of the front panes broke, none of the second panes broke at the 13.6 kW/m2 level, and three out of four second panes broke at the higher flux levels. When the tempered glass panes were subjected to the same three convective heat flux levels, none of panes broke from either the single pane or double pane windows.

The radiant heat exposure of the larger windows produced the following results: All of the single-pane plate glass windows broke at flux levels of 16.2 kW/m2 and above; for the double-pane plate glass windows, the second pane did not break at the 16.2 kW/m2 flux level but did break at heat fluxes of 21.4 kW/m2 and above; the single pane tempered glass was only exposed to a single flux level. Three experiments indicated that a single-pane tempered glass window was capable of surviving at a flux of 29.2 kW/m2.

Three things are needed in the area of window breakage and wildland fire. These are (1) a description of the radiant source represented by individual landscape plants; (2) a sophisticated computer program with a good user interface to permit the accurate determination of radiation configuration factors from multiple sources; incident heat flux, and the surface temperature history at a user specified target, and (3) use of Joshi and Pagni's algorithm to predict glass breakage.

The second area is currently being pursued by Dr. Fleischmann at the University of Canterbury, New Zealand. He is developing a program which will calculate the incident radiant flux and the temperature history at the face of a building from the burning of discrete items of vegetation or from the burning of large areas using the data generated by the FARSITE model.

These computational tools could also be useful for predicting ignition of exterior walls. The ability to accurately predict the incident heat flux at a target could be combined with the use of the

Cone Calorimeter and or the ICAL apparatus in order to evaluate the ignition potential for various exterior cladding materials proposed for use on construction projects in very high fire hazard severity zones.

## Sub-floor Crawl Spaces

The ventilation requirement for sub-floor crawl spaces when wood sub-floor construction is used is the same as noted previously for attics. Section 2516(c) of the Uniform Building Code requires a ventilation rate of 1 square foot of opening per 150 square feet of crawl space. Sub-floor spaces are not of much concern with respect to burning brands, provided the ground beneath them is clear of debris. Burning brands blown into the sub-floor area will land on bare ground and not have fuel to ignite or spread on. Direct flame exposure of the sub-floor structure through ventilation openings is possible through burning of landscape plants or grasses which are in contact with the foundation. One possible method of protecting wood floor joists in sub-floor crawl spaces is through the use of intumescent paint.

## Summary

Meaningful performance based building codes for the I-Zone cannot be developed without appropriate fire test standards. Meaningful fire test standards cannot be developed without quantitative data concerning the expected or "design" wildland fire.

Much of the work in the area of wildland fire characterization has been aimed at predicting how fire will move through a wildland area. There is a gap between this and quantifying the fire with respect to the types of information that building fire protection engineers need. The introduction and use of computer fire models such as BEHAVE and FARSITE are beginning to provide quantitative descriptions of expected fires which can be used by the building fire protection engineer.

A number of areas have been noted in which research is needed. These areas can be summarized as follows:

Burning brand production from wildland fires.

Additions to the FARSITE model to enable prediction of the generation and lofting of large burning brands.

Development of an exterior wall fire test standard applicable to the threat from exposure fires due to the burning of adjacent structures or large areas of wildlands.

Investigation of the burning characteristics of landscape plants leading to a data base for planning safe landscaping.

Development of an exterior wall fire test standard applicable to the threat from landscape plants burning in contact with, or very near, exterior walls.

Development of a thermal radiation program to determine radiation intensities from large area wildland fires and from single or small groups of landscape plants at a user specified target.

Analysis of window performance under direct flame exposure and when exposed only to thermal radiation in order to determine optimum designs.

A variety of building materials are available for the design and construction of ignition resistant structures. Each must be evaluated against geo-climatic conditions and the threat of a wildland fire.

By **G. Juri Komendant**

# 10

The adoption of performance based building requirements will open the flood gates for alternative building methods, materials, and architectural designs in residential construction in an I-Zone environment. Certainly regulatory restrictions that limit design options and prevent the building of a hom eowner's dream house will not be well received nor are they necessary. Regulatory officials need to recognize that alternative methods and materials exist that will provide the fire resistive construction desired without compromising architectural designs. At the same time, homeowners, architects, and builders must understand the potential fire hazard in their designs and select appropriate materials and detailing to minimize that hazard. Performance based building codes can define the fire protection required and still allow for architectural uniqueness and balance in designs.

Each design must be evaluated against the perceived risk from wildland fires and coordinated with requirements for climatic conditions and earthquake hazard. Keeping in mind that the wildfire risk varies between I-Zones. Vegetation, climate, weather, terrain, density of development, type of construction, and public services available all influence the intensity and spread of fire as well as the ease of its containment. Regulatory restrictions cannot anticipate all the variations present in residential construction in an I-Zone and, thus, cannot provide the fire protection implied or expected by property owners forced to comply with them.

Regulatory restrictions on design typically apply only to new construction and are not applicable to existing construction. However, the fire hazard is typically highest in existing communities where the fuel value of vegetation is high and where construction was completed under older regulatory requirements. Performance based building requirements are less likely to become obsolete and will encourage the use and development of new materials in residential construction. Many fire resistive materials are currently used in commercial construction. They are lightweight, weather resistant, and durable. They are also applicable for providing alternatives to the renovation and maintenance of existing structures consistent with their original architectural design.

Several years ago the newly appointed State Fire Marshal, Ronny J. Coleman, at a symposium on the interface, stated that "our challenge is planning, preparation, and the pursuit of technology..." He went on to say if the fire service continued to rally around current techniques and technology, that we would ultimately be caught in the role of scapegoat instead of heroes (First Annual Urban/Wildfire Seminar, June 1992; Partnerships for the Future, Lake Tahoe).

## Residential Construction

Most of the structures in an I-Zone are residential and wood-framed. People build in wildland areas because of the natural beauty and privacy offered. They build their dream homes on hillsides, in canyons, on ridge tops, on grass and brush land and among trees. Most people may acknowledge the fire risk but either hope "it will not happen here" or that fire protection forces can prevent wildfire. Often they are unaware of how the construction of their homes and the management of their landscape and vegetation relate to their own fire hazard and that of their neighbors and the community as a whole.

Wood is used in residential construction because its material and labor costs are initially low. It provides the required structural strength and flexibility in design and construction that make it easy to use with a minimum amount of tools. It is considered aesthetically pleasing and warm in appearance, and it is a renewable natural resource. Architects, designers, builders, and small contractors are all familiar with its use. It is the expected norm in residential construction.

However, wood does have its limitations. It is organic and, thus, burns and decays. Observations made in conflagrations have defined some of the most vulnerable materials and components of wood design and construction that increase a structure's flammability, contribute to flame spread, and require more fire fighting personnel to defend a structure. Regulatory restrictions attempt to minimize and protect the vulnerable components of wood design. Unfortunately, they also imply to property owners and builders that if these guidelines are followed their structure will be fire safe.

The fire safety of a structure is dependent on many variables in an I-Zone and each variable comes with its own most hazardous or extreme conditions. Fire resistive construction regulations must take into consideration the following:

Type of fire, its potential intensity and rate of spread, based on fuel load of typical vegetation, weather and terrain in the area.

Fire protection response in the community, including available manpower, equipment and mutual aid, condition of roads and proximity of vegetation to roads, availability of water supply, air tankers and helicopters, and importance and susceptibility of power supplies.

Density of development, including spacing between structures, lot density, development of greenbelts and fuel breaks, type of construction, typical materials of construction and management of vegetation and landscape.

Knowing the combination of conditions present, or that are most likely to occur, helps a community assess the fire risk appropriately. Design and materials of construction alone will not reduce the fire hazards or increase the fire safety. They only partially help in reducing the rate of combustion and spread of a fire. Design and Materials may also determine which structures, and how many structures, can be saved in the event of a conflagration.

### Construction Requirements & Fire Hazard

While it may be possible to build concrete boxes with small windows and 100-foot vegetation clear zones around them, this is not the type of construction and interface with nature people desire when they choose to live in an I-Zone. A compromise between construction requirements and fire hazard risk is inevitable. Restrictions on design is one of the compromises some regulatory officials and fire experts think must be made. This, however, forces conformity in architectural appearance and will not guarantee that the vulnerability of a residential structure is not transferred to some other component of design. Rather than placing limits on architectural design features, building regulations should be based upon performance based standards established for the perceived risks and dangers in a given I-Zone. Then homeowners, architects, and builders can respond to the requirements. There are numerous noncombustible and fire resistive materials and treatments available in the construction industry that can be incorporated into any design to meet fire resistive construction requirements and not compromise the appearance or individuality of a design or structure.

Many of the newer materials available in the commercial construction industry have not been utilized in residential construction, partially because of initial cost, availability to local contractors, and lack of familiarity with use, detailing requirements and installation. Wood products have dominate the residential construction market because fire resistive construction has not been required for residential dwellings (Group R, Division 3 Occupancies, Uniform Building Code) unless the structure is more than three feet from property line or adjacent to a higher fire hazard occupancy. If fire resistive performance is desired, these new materials, as well as some of the noncombustible traditional materials, become competitive with wood construction.

Fire resistive performance requirements in I-Zones are not the same as in urban zones. Urban fire resistive standards, such as " one-hour" construction, may not provide the protection implied for residential construction exposed to a wildland fire. Urban standards were developed to protect lives and to control the spread of fire in a defined environment within individual structures or between different fire hazard occupancies. In an I-Zone, life safety is dependent more on evacuation from an area rather than from a structure. Requiring "one-hour" construction for an exterior wall in residential construction may be beneficial for delaying the pen etration of flames through the protected sections of wall, but the residence, as a whole, may still be destroyed by fire in considerably less than an hour if the vulnerability of the structure, as a whole, is not evaluated.

### Fire Vulneribility

Not all structures have the same vulnerability in a wildland fire. Structures are exposed to external ignition either by wind-blown burning brands, radiant heat, or direct exposure to flames. The I-Zone environment, fuel load of vegetation, and density of development determine what fire protection measures are most beneficial.

In wooded and highly flammable brush areas, burning brands can be carried by winds miles from the flame line, jumping greenbelts and fire defense lines. Roofs, open-sided enclosures, and interior corners of walls and decks are the most vulnerable to initial ignition by fire brands. The vulnerability of a structure is dramatically increased if the roof surface can be readily ignited. Untreated wood shake roofs have been shown to be a primary factor contributing to conflagration in an I-Zone.

Roof valleys and dormers with large eaves tend to collect debris and concentrate the deposit of burning brands, thus increasing a roof's vulnerability. Debris-filled gutters, especially for Spanish tile roofs without bird stops, can accelerate the spread of flames and penetration of a roof's assembly.

Open-sided enclosures, including covered entries and porches, exterior stairs, and elevated decks, can entrap and collect fire brands within their confines. They provide protection for embers to simmer and for the collection of hot gases and heat. Flames can climb structural support elements and corners, setting the underside of the enclosures on fire. Undersides of structures are more vulnerable to fire due to preheating of fuels by rising heat currents and flames. Flames below the enclosures will be spread horizontally and wrap around exterior edges, spreading the fire to other parts of the structure.

Radiant heat from fire increases the susceptibility of igniting and damaging combustible materials. Walls, window openings, and large vents on the side facing an approaching fire are most vulnerable to radiant heat. While a fire can approach from any direction, typical paths for high intensity flames and radiant heat are up slopes and canyons. Radiant heat can cause ignition of flammable materials on wall surfaces and on the interior side of glass. Large pieces of glass are more likely to break than smaller panes of glass due to thermal expansion restraints and out-of-plane deformations. Breakage of large areas of glass will expose the interior to more flames and radiant heat faster than sequential breakage of several smaller pieces of glass over the same size opening. Once the fire has entered the interior of a structure with its high fuel load, it typically cannot be defended during a conflagration.

Direct exposure to flames comes from burning vegetation or from adjacent structures that have ignited. If the flames are close to the ground, as opposed to a crown fire in the trees, then most structures can be constructed to be defendable against exposure to direct flames. The most vulnerable parts are the walls and wall openings, the undersides of decks and exterior stairs, and low overhangs and eaves. If the flames are wind blown up a hillside or in the crowns of trees, a structure in the direct path of flames is totally vulnerable and few, if any, structures can escape without burning or sustaining significant structural fire damage.

Flames from an adjacent burning structure can ignite roofs, walls, and eave lines and expose a structure to additional radiant heat. Typically, eave lines and combustible wall finishes are the most vulnerable to ignition, and breakage of glass accelerates the ignition of the interior. Eaves, because they protrude outward, are closest to a burning structure. Heat, hot gases and flames become entrapped under the eaves and can enter the roof structure through vent openings, exposing the underside of roofs and the roof support structure to ignition. Flames and hot gases wrap around eave edges, create exposure and preheating on three sides of the roof (top, side edge, and bottom), and disperse flame and hot gases horizontally along eave lines or up gabled slopes.

## Construction Materials

For structures in an I-Zone, the fire related materials used in construction of the outer shell are very important. The finish materials of the outer shell determine how fast a structure will ignite, where the flames will spread, and thus, where fire fighting resources and defense lines will be needed. The construction of the outer shell, and the assembly of its materials, determines the time it will take fire and radiant heat to penetrate throughout the exterior shell and expose the interior to ignition. Once a fire penetrates the interior, the probability that the structure can be saved in a wildfire diminishes significantly.

The outer shell includes the roof, exterior walls, underside and edges of eaves and unenclosed areas, windows, vents, and openings. A structure's exterior stairs, decks, balconies, and rails are typically not part of the outer shell; however, they can influence the fire performance of a structure. The outer shell may be interrupted at connection points with these elements and the elements can cause a concentration of flames and hot gases adjacent to the walls or eaves above.

Fire resistant requirements for the finishes and construction of the outer shell are dependent upon the intensity and type of fire exposure expected in a given I-Zone. Performance requirements should define the acceptable flame spread, ignition resistance, fuel contribution, and physical and mechanical thermal properties for the outer shell finish materials as well as the time duration the outer shell, or sections of the outer shell, shall be fire resistant for the expected wildland fire exposure. Then a property owner, architect, or builder can design and build for the fire performance required.

Specifying finish materials to be noncombustible and all outer shell construction to be one-hour is not reasonable for all perceived fire exposures. It will definitely increase the cost of construction. For residential construction, one-hour construction is not obtainable unless all window openings, exterior wall openings, vents and penetrations through the outer shell are controlled and maintained and the interior construction satisfies the one-hour assembly requirements. One-hour construction requires fire protection for steel support members and allows heavy timber construction (7-1/2-inch minimum dimension for columns). The requirements are based upon maintaining structural support as opposed to flame spread or ignition. One-hour construction must meet specific code requirements and implies certain expectations. Unless the expectations are the same in residential construction, the term should not be used. Regulatory references made to using the outer assembly of one-hour construction may be well intended but are not based upon known performance and falsely imply a comparable level of protection.

No material is "fire-proof", but there are many new as well as traditional materials available in the construction industry that have acceptable fire resistive properties or can be combined with other materials into an acceptable fire resistant assembly.

Ignition resistant construction is a schedule of additional fire resistive requirements for structures built in the I-Zone.Class 1 is specified for extreme fire hazards, Class 2 for high fire hazards, and Class 3 for moderate firehazards (International Urban-Wildland Interface Code).

### Concrete, Masonry, & Brick

Traditional noncombustible materials such as concrete, masonry, and brick have very good fire performance properties and can obtain maximum fire ratings (four hours). In residential construction, concrete and concrete masonry units are typically used for foundation and retaining wall construction, and brick is used in chimney construction or as a facade material for stud framing. All three materials significantly increase the self-weight of the structure above that obtained with wood or metal stud framing, and thus, foundation support and earthquake resistant requirements are increased. If the materials are not properly reinforced, earthquake performance has been shown to be catastrophic. These materials provide excellent durability and fire ratings and can be selectively incorporated into many styles of architectural design and construction of exterior walls. However, interior finish, insulation, electrical, plumbing, and mechanical elements are more difficult to achieve and modify than in stud frame construction.

The fire vulnerability of these structures is typically through windows, external wall openings, and the roof structure. Exposure to high temperatures results in thermal cracking and loss in compressive strength in concrete and mortars. However, damage is usually limited to surface effects when exposure times are less than one hour.

## Concrete

Concrete can be used for the construction of exterior walls, floors, and roofs. Forming and labor costs are more expensive than with stud framing, and typically only walls are constructed from concrete. Unique construction and architectural detailing are primarily achieved in custom built, modernistic homes. Form work can be used to create different textures, patterns, and reveals on concrete surfaces. Construction requires engineering and specialization and is typically out of the realm of the small construction firm for anything but the foundation and site work.

Concrete forming systems, using stay-in-place expanded polystyrene (EPS) forms, have been recently introduced that make concrete construction more efficient and competitive for residential construction. EPS forming systems are very flexible, easy to handle, provide insulation, and allow unique architectural design options and exterior wall finishes. Reinforcement for earthquake and structural requirements can be added to the forms, as required. Layout of wall, window, door, and floor systems not aligned with prefabricated form joints results in increased cost. EPS must be protected and covered on both the interior and exterior sides. Materials for exterior finishes range from brick to stone veneer, stucco, and most other exterior cladding, including wood. Gypsum wall board is typically bonded to the interior side. EPS is a combustible material and can ignite when exposed to flames and radiant heat. The ignition or burning of EPS does not compromise the fire rating of the concrete wall itself but under extreme fire exposure conditions may influence attachment of cladding and flame spread to other components of construction. Whether or not this concern is significant, in comparison to the protection provided, needs to be evaluated for given fire exposures and construction.

Many newer products have been introduced that include the words "concrete" or "cement" in their descriptions. They are used in the manufacture of wall panels, wall cladding, roofing materials, and architectural molded products. There is glass fiber reinforced concrete (GFRC), polymer concrete (PC), polymer modified concrete, fiber-reinforced cement, fiber-cement board, and concrete tile, to name just a few. Many people, including those in the construction industry, intermix the word "cement" with "concrete" and, thus, a brief description of these terms and products is warranted. Concrete is made from cement, sand, and aggregate. Cement, specifically portland cement (generic name), is the bonding agent in concrete that reacts with water and hardens. Sand and aggregate are just filler materials to reduce the amount of cement used. Cement trucks are actually concrete ready-mix trucks, cement walks are made from concrete, and cement finishers finish concrete. Portland cement is also the bonding agent in stucco (cement, lime, and sand), grouts, and mortars. Products that use portland cement, combined with sand/aggregate, often include the word concrete (or cast stone) in their description. Concrete block, concrete brick, and concrete roof tiles are typical examples. Cement products use portland cement without the addition of aggregate. Concrete and cement products are reinforced to obtain tensile strength, allowing them to bend or flex without breaking in a brittle manner. Glass fiber and fiber refer to the type of reinforcement used. Glass fiber is typically used in chopped form, but some products incorporate woven fiberglass cloth. Polymer concrete is not portland cement based but instead uses polymer resins to bond aggregate (thus the name concrete). Polymer concrete is a combustible material, but resins can be formulated to meet Class A fire requirements. Polymer modified concrete is portland cement concrete to which polymers have been added to enhance certain performance requirements.

Fire rated assemblies and materials for fire resistive and ignition resistant construction can fail if not installed according to the manufacturers specifications. Do not assume that materials which form, for example, a Class A or Class B roof are indeed Class A or B until they have been inspected and/or certified that they have in fact been installed according to prevailing code and / or manufacturers specifications.

### Cement Panels

Fiber-reinforced cement boards and panels are available in a multitude of cladding types. They are noncombustible, durable, and economically competitive. Many of the original panels were developed to be competitive with preformed metal siding and as a substitute for asbestos siding. Newer products have considerably more architectural flair, are lightweight, require minimal maintenance, and are ideal for residential use. Lightweight concrete and cement roofing tiles are already used in residential construction.

### Masonry

Masonry construction is one of the oldest forms of construction. It has been extensively used in residential designs. Inappropriate construction and nonexistent seismic design have resulted in poor earthquake performance and malignment of the materials. However, with proper use and design, masonry materials are a good choice for fire resistant residential construction. Use of masonry is limited to wall construction. Structural masonry materials include natural and cast stone masonry, brick, structural clay tile, and concrete masonry blocks. Many different styles and surface finishes are available in masonry units, and masonry wall construction can be incorporated into many traditional and modern architectural designs.

Masonry veneer is used as a decorative finish material that is either anchored or bonded to some structurally sound surface. Solid stone blocks, slabs, or brick veneer can provide fire rated protection but are relatively expensive and increase foundation and seismic design requirements. Thinner masonry veneers have been developed that provide the architectural appearance of traditional masonry but place no excessive demands on foundation and seismic design. Thin masonry can be field installed or mounted on prefabricated panel systems. The thin materials are noncombustible but do not provide independent fire rated protection. Thin veneers include thin brick (1/2-inch thick), glazed tile, cut stone or limestone veneer, and manufactured stone (cultured stone). Manufactured stone is made from portland cement and lightweight aggregates with mineral oxides added to obtain the desired stone color appearance.

## Glass Block

Glass block is considered a masonry material. It has been traditionally used to fill openings in exterior masonry walls. It has the dual advantage of admitting light but minimizing heat transmission. More recently it has also been used to accent unique architectural designs, including exterior wall construction. In seismically sensitive zones, it must be reinforced; reinforcement has been developed specifically for glass block. Fire rated window assemblies (not less than 45 minutes) can be obtained with fire rated glass blocks and use of fire retardant sealants. Glass block assemblies have also been developed for use with horizontal surfaces and skylight construction. Many different patterns are available, and use of engineered glass block materials (Lexan) makes glass block windows virtually unbreakable and lighter in weight. Lexan has a Class A flame spread rating but, as with any combustible material, its use must be evaluated for a given exposure and structure.

## Metal Stud Framing

The majority of residential construction is wood framed and stud wall construction. Light gauge metal studs and framing are also used, but typically labor costs are higher than for wood framing and detailing. Construction for nonrepetitive architectural features found in residential construction can also be more difficult. The obtainable fire ratings for assemblies using either framing system are equivalent. The advantage of light gauge metal framing is that it is noncombustible, and thus, does not add interior fuel load to a fire (an extremely important consideration for life safety in a commercial building). However, for residential construction, wood framing is one of the last elements to survive, and once the interior has ignited, the fuel load contribution of wood framing is insignificant. Light gauge metals are very susceptible to temperature deformations. Maximum service temperature for steel is approximately 1600oF before it deforms and begins to lose its structural load-carrying capacity. Both framing systems are dependent upon cladding and sheathing for their fire related performance.

## Gypsum Wallboard

Gypsum wall board is typically used to provide fire protection to stud walls. There are basically two types of gypsum board core formulation available, regular and Type X. Type X provides better fire resistance and is typically used in fire rated assemblies. Both types need to be protected from weather. Exterior fiber reinforced gypsum sheathing has also been developed that can withstand considerable in-place moisture or weather exposure (from one side) and has better fire resistive properties than paper mat Type X. Inorganic glass fiber is used for its mat surface. Exterior fiber reinforced gypsum sheathing can be used to provide rated fire protection to soffit areas.

### Plywood

Use of gypsum sheathing for fire protection must be coordinated with seismic design and weather proofing requirements. Gypsum sheathing does offer some structural value for resisting seismic forces, but allowable design values are considerably less than those obtainable with plywood. Fire rated assemblies typically show gypsum sheathing applied directly to studs, but plywood may be installed between the fire protection and the studs. Engineers prefer to have the shear plywood applied directly to the studs. The Uniform Building Code only provides design values for plywood applied over 1/2-inch gypsum board and requires that the nail size be increased. If gypsum is installed over plywood, the length of nails for attachment of gypsum must also be increased by the thickness of plywood penetrated, and attachment must still be made at stud locations. Shear wall fire rated assemblies should be tested to determine actual design requirements.

### Stucco

Stucco, or exterior portland cement plaster, when applied in three coats with a 7/8-inch total thickness provides good fire protection to stud wall framing. It is a versatile facing material that can be applied to flat, vertical, overhead, and curved surfaces and is extensively used in Mediterranean, mission, and modern architectural designs. Weather resistant properties of correctly proportioned, mixed and applied, and cured stucco include freeze-thaw durability and resistance to rain penetration, high temperature, and extreme moisture changes. Cold weather stucco application requires protection against freezing temperatures. In areas where snow, slush, and de-icing chemicals may be splashed against walls or where the water content of hardened stucco may be close to critical saturation levels, air-entrained stucco is recommended. Air-entrainment is obtained with chemical additives that produce small air voids in the plaster that absorb the expansive forces developed by freezing and thawing, thus eliminating deleterious cracking and surface spalling. Air-entrainment is also common for freeze-thaw protection of concrete.

### Exterior Insulation Finish Systems

Exterior Insulation Finish Systems (EIFS) are used in commercial and residential construction. Dryvit is an example of an EIFS system. The system can be used in new construction and in the renovation of existing homes in all climates. Finish textures range from smooth solid coatings to fine grain sand finishes. Architectural styling is similar to stucco construction. A typical system consists of exterior grade sheathing, insulation board, reinforcing mesh bonded to the insulation with specialty products, and the finish coat. The system can be applied on any structurally sound surface. Three dimensional, large or small scale, architectural detailing can be achieved with cutting, shaping, bonding, layering, and sanding insulation board.

Exterior fiber reinforced or Type X gypsum board, when used for the substrate, also provide fire protection for the assembly. Expanded polystyrene (EPS) is used for insulation board. Dryvit states that fire testing of its Outsulation EIFS system has demonstrated that it does not propagate fire. "Even under the conditions involving exposed insulation board, the system demonstrates no tendency to spread fire, produces limited smoke and evidences no delamination of the system. Both full-scale fire testing and 'actual fire' experience confirms that use of the Dryvit Outsulation System on building exteriors does not effect building fire safety nor compromise fire rating of exterior wall assemblies." Many in the masonry industry would like to see more testing to determine how readily and under what conditions EIFS will burn. Direct Exterior Finish Systems (DEFS) are also used but performance is best suited for areas with minimal freeze-thaw cycles. The system consists of applying the same materials as in an EIFS system but without the insulation board.

## Metal Panels & Vinyl Siding

Metal panels and siding, manufactured from galvanized steel, are used for cladding in commercial construction. Metal roofing and tiles are used in both commercial and residential construction. Galvanized metal cladding and roofing provide a noncombustible finish surface and come in many colors and different cross-section profiles. Some metal panels come with insulation backing. Fire rated construction is dependent upon substrate assembly. Metal roofs are common in residential construction; however, the use of metal siding has been limited mainly to prefabricated homes.

Aluminum and vinyl siding are used extensively in residential construction. They are also used as soffit materials. Aluminum is noncombustible, and vinyl siding can obtain a Class A fire rating. However, aluminum melts at about 12000F, and its recommended maximum service temperature is 5500F. Vinyl siding has a self-ignition temperature of around 6800F to 8800F. When vinyl is exposed to significant heat or flame, it will soften, sag, melt, or burn. The fire related performance of these materials, along with proposed substrate construction, needs to be evaluated for perceived I-Zone fire exposure and expected performance requirements.

## Manufactured Wood Products

Wood and manufactured wood products are the most common materials used in residential construction. Manufactured wood siding can duplicate the architectural appearance of painted wood. With appropriate materials and construction, wood assemblies can be made to resist the effects of fire up to two hours. As previously discussed, rated performance may not be the only type of protection warranted for an I-Zone fire. Wood cladding and sheathing will burn and can spread the flames to other parts of the structure. However, all wood cladding does not have the same fire related performance. Untreated shingles provide a rough surface and are readily ignitable. Pressure impregnated cedar shingle panels can obtain a Class B fire rating. Tight skinned boards and panels, with T&G (tongue and groove) joints and no reveals, may not ignite or catch sparks as easily as non-tight V-rustic, board and batten, or shiplap siding. All can be used in one-hour assemblies in residential construction. Some wood cladding, such as batten and board, create vertical air spaces between itself and the surface it is mounted on, allowing for potential vertical flame spread. Others, like shiplap siding, create horizontal air spaces. An exterior surface with 3/4-inch wood drop siding placed tight over normal 1/2-inch gypsum is rated for one-hour (with appropriate stud spacing, attachment, and interior surface assembly).

### Solid Wood Products

Solid wood products, minimum 1-inch in thickness, have a better flame spread rating than plywood or manufactured wood products. Oak has a flame spread rating of 100, by definition. All other materials have their flame spread ratings compared to oak's. Douglas fir has 70-100, Western hemlock has 60-75, red cedar treated shingles have 49. Plywood has ratings ranging from 115 to 190. Some engineered wood products have flame spreads of 200 to 300. Class A, the best rating given to products, implies a flame spread of less than 25. Solid wood siding with tight joints, however, will provide better fire resistant performance than vinyl siding (Class A) in an intense fire.

### Plywood

Plywood and engineering products have higher flame spread ratings because of the glues and resins used in their manufacturing process. Resins can be modified to decrease flame spread and provide fire resistive properties. Wood can be impregnated with fire-retardant chemicals. These treatments do not make these products noncombustible, but they do reduce the surface-burning characteristics, such as flame spread and rate of fuel contribution. Flame spread ratings less than 25 can be achieved.

### Roofing Materials

Materials used for residential roofing include asphalt and composite shingles, clay and concrete tile, stone and slate, ceramic slate, metal roofing, fiber-cement tiles and preformed panels, and portland cement and wood fiber shakes. All can obtain a Class A fire rating. Of structural importance is the self-weight of the roofing. Heavier materials, such as slate and clay tile, require stronger roof framing and increase seismic design and resistance requirements. A structural evaluation should be made if an existing structure is reroofed with heavier materials. Ultra-light and metal roofing weigh less than 180 lbs. per square (100 square feet of surface), typical asphalt/fiberglass shingles weigh 210 to 240 lbs., heavy wood shakes weigh 350 lbs., concrete tiles weigh from 200 to 550 lbs., clay roof tile weighs 850 to 1000 lbs., and slate and stone can weigh up to 1200 lbs.

## Additional Areas of Concern

Specifying one-hour construction for exterior stairs, decks, and balconies requires waterproofing of these elements to protect the fire protective sheathing from moisture and weather. Waterproofing adds additional expense and can be problematic if adequate detailing and attention to flashing and ventilation requirements are not addressed. Alternatively, the ground areas below exterior stairs, decks, and balconies could be made noncombustible and their sides could be closed with screening to prevent embers from entering.

Vent openings, as an element of the outer shell, must also be protected if rated construction is required or if flame and gas intrusion are to be minimized. Eave vents are the most problematic to protect in a fire, but with the possible exception of their use in mild warm climates, should not be eliminated. Lack of ventilation and heat loss cause condensation, which in turn can cause decay of wood framing and sheathing. In colder climates, ice dams can form that present water leakage and maintenance problems. Wire cloth screening can prevent the passage of flames from hot gases if the maximum size of the opening is less than 1/16-inch. With such small openings, however, only about 20% to 30% of the vent area is available for ventilation. Fire activated mechanical louvers or vent closures are used in commercial construction but are currently too expensive for residential use. Vent requirements should be coordinated with siding and eave construction requirements.

## Summary

It is evident from the many conflagrations that have occurred in California that the fire hazard risk can be extreme in an I-Zone environment. One means of attempting to minimize the risk to communities is through restrictive regulations on design and materials allowed in construction. The regulations either attempt to minimize the presence of vulnerable design features or specify noncombustible and fire rated construction. Regulatory restrictions cannot anticipate all the variables in residential architectural designs, differences in I-Zone environments, or the combination of materials and assemblies available now or in the future. Performance related fire regulations are required.

One convenient means of regulating fire resistive construction in an I-Zone might appear to be to specify one-hour construction or the use of any exterior portion of a one-hour assembly. However, the actual fire protection achieved may not be as good as implied and may lead to a false sense of security and complacency in an I-Zone fire hazard environment. In the Oakland-Berkeley Hills fire the construction materials used included combustible, fire-resistive, and noncombustible wall construction. All structures, regardless of materials used, burned to their foundations in the interior area of the fire and even at the periphery of the fire zone; noncombustible exteriors did not guarantee the survival of a structure. The fire vulnerability of the whole structure and the fire hazard from adjacent structures and vegetation must be considered.

Fire-resistive construction regulations must be coordinated with seismic design, waterproofing, and ventilation requirements and must lead to buildable structures appropriate to the community and climatic conditions in the area. Regulations should be descriptive as to perceived fire risk and expected performance and take into consideration that if some elements of a structure are made more fire resistive the fire hazard for other elements may be either reduced or increased. Performance requirements for the finish materials of the outer shell and fire resistance duration requirements should be established for the perceived fire risk and for the structure as a whole in its I-Zone environment.

There becomes a point of diminishing returns- any regulatory activity must consider the cost vs. benefit of proposed regulation.

By **Randy Roxson**


A few decades ago, much of the area surrounding cities consisted of wildland and those few people who chose to live in rural California. Absent in the rural areas were the grand mansions and sprawling neighborhoods. Trees and brush were all that dominated this area now called the I-Zone. But why do Californians now move in droves to the I-Zone? The answer is easy, the I-Zone represents less crime, better schools, and cleaner air. And, because of advanced information and communication technology, the I-Zone has become desirable among young professionals who can now conduct business from their I-Zone homes.

Due to its popularity, the I-Zone is not the tranquil area of yesteryear. In fact, modern development has drastically changed the landscape to an intermix of trees, brush, and rows of housing. What hasn't changed is attitude.

Many who move to the I-Zone do so not only for its schools and clean air, but because they distrust government. At one time, politicians had no interest in the I-Zone because it had few people, translating to few votes. Subsequently, it was an area with few regulations for fire safety. As a result, one could just about do whatever they wished to their land and the structures on it.

**Goverment Intervention**

Government attention to the I-Zone really did not begin until after the 1980 Panorama fire in San Bernardino, California. This fire burned some 23,600 acres, 325 structures, and caused 4 deaths. Since this fire destroyed many dwellings that were not protected by fire resistive roof coverings or fire safe landscaping, the push for regulation began. The Panorama Fire prompted legislators and the Governor to pass a law directing the California Department of

Forestry and Fire Protection (CDF) to designate fire hazard severity zones and the State Fire Marshal (SFM) to adopt roof covering standards for structures within those designated zones. The first draft of proposed regulations paired off the roofing industry, fire service, and those who lived in the I-Zone.

But why does regulating the I-Zone create such a division of the people? Typically, whenever government attempts to regulate anything, political contentions will follow its course. Like everything else, when the government regulates, somebody stands to lose. It seems odd that a government regulation intended for the good of the general public would be opposed by so many. In a newspaper interview, a homeowner who just lost his "I-Zone" home, said that he would still be opposed to any roof covering ordinance in his city. This "attitude" is common of those who have fled urban areas for the I-Zone to escape interference of their lifestyle by the government.

### Big Business

But not only do regulations affect those who dwell in the I-Zone, they affect business, BIG BUSINESS. When the SFM first attempted to adopt roofing standards, roof covering manufacturers "drew a line" daring anyone who crossed it. Both sides of the affected business spectrum were represented; the Red Cedar Shingle and Handsplit Shake Bureau representing wood roof coverings, and the Committee for Fire Safe Roofing, an industry association representing fire resistive roof covering manufacturers.

As would be expected, the wood roof manufacturers argued for less restrictive regulations, and the fire resistive roof manufacturers argued for more restrictive regulations. The wood roof manufacturers feared the State Fire Marshal's regulations would significantly impact sales in their most profitable state, and cause other states to adopt California's logic of regulating the I-Zone. Contrast this with the fire resistive roof covering manufacturers, who visioned significant profits from California's endeavor to regulate roof coverings in the I-Zone.

The Committee for Fire Safe Roofing were very wise in their crusade for selling more roof coverings. The Committee first created a name which would lead one to believe it was representative of the fire service, and then rallied the California fire service to promote its goal to dominate the roof covering market.

Also included as interested parties, are the home builders and the insurance industry. Home builders have their interests represented by home builder associations. Their goal is to keep the price of a home in an affordable range for most people. Requiring enhanced building standards usually increases the cost of a new home. The cost increase determines the amount of pressure cast by the building industry.

The insurance industry is another player involved in regulating the I-Zone. When CDF began designating land within cities as "Very High Fire Hazard Zones", insurance companies saw this as a opportunity to increase the rates for those who lived in these areas. Since adoption of the "Very high Fire Hazard Severity Zone" is discretionary, many cities have opted not to accept the "zone" designation for fear of rate increases to I-Zone homeowners.

### Fire Service Interest

But not only is private industry interested in the regulation of the I-Zone, the fire service is also a stakeholder. After the State Fire Marshal developed the first draft of roof covering standards, the fire service rallied behind the SFM to support this draft for adoption as a statewide standard. As originally proposed, the SFM applied the three different roof covering classifications (Class A,B, & C) to the three different levels of fire hazard severity. Only after extensive discussions with Underwriter's Laboratories, Inc. (U.L.), and other nationally recognized laboratories responsible for testing roof coverings did the SFM find the proposed roof covering standard to be flawed.

The SFM discovered that the classifications of fire resistive roof coverings were not necessarily cohesive to the three levels of fire hazard severity. For example, Class A roof coverings are intended to protect the structure from large flying brands, such as those flying from heavy timber.

Ironically, much of the area designated as a Very High Fire Hazard Severity Zone is located in the high desert, an area consisting of sage brush, a relatively small plant with small branches. But, as proposed, the roof covering standard would have required those structures within the designated area to have a Class A fire resistive roof covering. Since Fire Hazard Severity Zones are determined, among other things, by the slope of the land, prevailing winds, and fuel type, the Class A roof covering would have been much too costly without equal benefit.

Consequently, the SFM decided to rescind the proposed regulation for another which best reflected the actual hazard, resulting in a less stringent, but more effective standard. This action was met with tremendous resistance from the fire service. In fact, the Los Angeles City Fire Department immediately adopted a roof covering standard which excluded wood, regardless of its fire resistive capability.

### Cost vs. Benefit

The California fire service criticized the SFM, claiming the office was not attempting to prevent conflagrations, but was more concerned with fraternizing with industry interests. This, however, was far from the truth. In fact, the SFM only researched the issue in a more scientific manner, including analyzing the cost versus the benefit of fire resistive roof coverings within each of the Fire Hazard Severity Zones.

When regulating the public good, evaluating the benefit against its cost is essential. This practice is not only a recommended practice, but is required by law in California. Because a "cost" can be a subjective measurement, determining the proper regulation may be difficult. Costs are not only the monetary expense associated to the cost of compliance, but the broad affect the regulation may have on the economy and employment.

But, if a cost can be quantified, then a cost/benefit analysis is possible with minimal difficulty. Data must simply be reduced to a numerical value. It is very easy to overregulate to ensure life safety, and conversely cause other ill effects to those the regulation is intended to protect. Cost/benefit simply evaluates the hazard, determines the method to control the hazard, then analyze the cost to control or eliminate the hazard. Many state and federal agencies now collect data which is available for the purpose of analyzing the cost/benefit of a fire regulation.

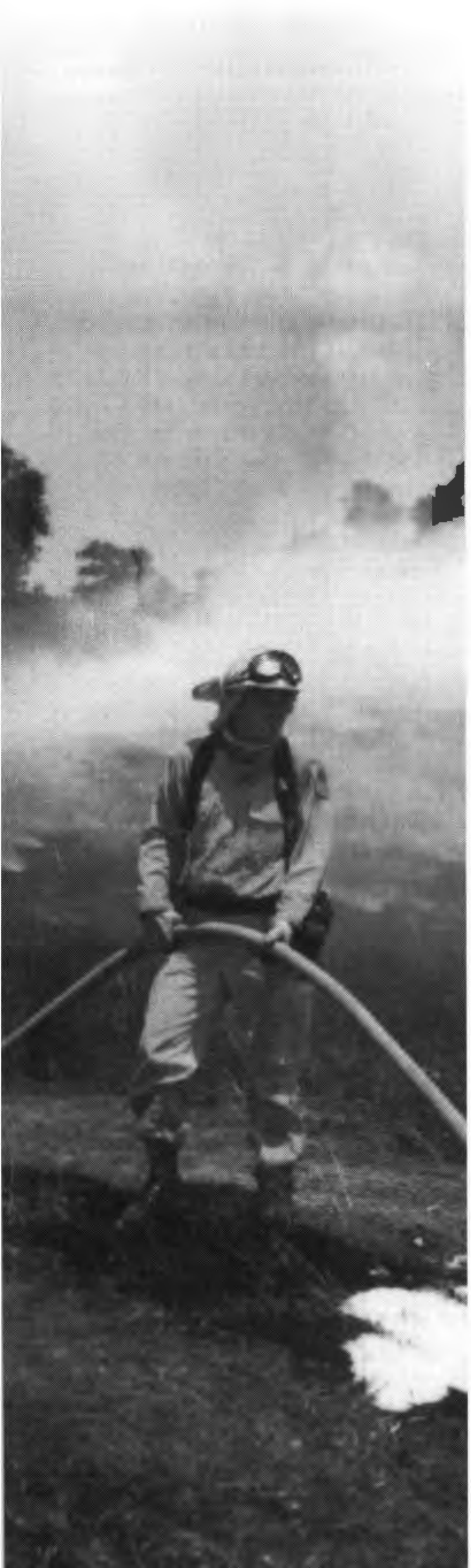
There is a point where the benefit no longer increases at the same rate as the cost. This is known as the "law of diminishing returns". The point where beneficial returns begin to decrease regardless of the cost expended can be found with most any quantified data. This approach can be applied to the roof covering case study previously discussed. Because the purpose of a Class A wood roof covering is to protect the roof structure from being burned by timber-sized flying brands, its use in the high desert presents a question as to its value and associated expense.

The roof covering case study not only impacts the homeowner, but has a indirect impact on those who depend upon the forest products market for their livelihood. Consequently, when regulating the I-Zone regulators must proceed with caution.

## Summary

As I-Zone communities grow and use regulations developed by CDF and SFM, fewer acres will be burned, fewer structures lost, and most important, fewer people will suffer injury or death. But, government must be sensitive to the law of diminishing returns, otherwise there will be no harmony between the fire service, the industry, and those who live in the I-Zone.

# III. DOMESTIC & WILDLAND FUELS



# THE HISTORY OF WILDFIRE

A long and rich history surrounds the development of wildfire control and management in California.

By **Robert Cermak**

# 12

Climate has to be the backdrop of any history of wildfire in California. Our Mediterranean climate produces long, hot, dry summers every year. These mini-droughts are often made worse by heat waves in the summer and north or east (Santa Ana) winds in the fall and winter. Without this climate and weather, wildfire would be a footnote in California history, rather like a major fire every 150 years is in the history of Yellowstone National Park. Despite our wildfire climate other states have had much larger and more damaging wildfires than California. Some historic examples include: the great Idaho Fire of 1910 which burned over 3 million acres, most of it in two days; the Tillamook (Oregon) Fire which burned 330,000 acres of old growth forest, most of it in just 20 hours; and the great fires in the Lake States, the worst of which was the Peshtigo Fire which swept over 1,280,000 acres and killed at least 1,152 people. What was the common denominator, besides human carelessness, in all of these fires? It was drought. Even in California with its wildfire climate, the worst fires and worst fire seasons tend to occur during drought years. However, we have the potential for serious fires every year, and so we have a continuing history of wildfire. To paraphrase Robert Frost, "California is so blessed in climate that it never saw a wildfire that wouldn't burn."

Fire was an important part of the daily life of native Californians, and they used it for many specific purposes. How extensive was native burning in wildlands? This is not certain, but the Spanish tried to prohibit native burning in 1793. The first to report forest conditions were Spanish and Mexican explorers and soldiers, and American and British fur trappers. However, their reports were fragmentary and the location of most of what they saw is unknown because there were no names on the land until the emigrants and miners arrived.

## They Saw the Elephant - and a Few Other Things

The Gold Rush brought hundreds of thousands of people to California and changed it forever. This mass of people required food, shelter and equipment. Vast herds of cattle and sheep were brought to the state, forests were cut down in the foothills and intensive placer mining continued for a decade on streams in the gold regions.

"Seeing the Elephant" was a saying 150 years go which described facing extreme hardships or danger. After the 49er's (not the football team) traveled 2,000 miles across plains, mountains and deserts, they still had to face that elephant - the Sierra Nevada. These people knew that they were in the adventure of a lifetime and many wrote diaries, letters or reports about life on the trail, and in the mines and about their surroundings. In the Sierra Nevada they wrote about all kinds of forest conditions but mostly about dense, dark forests of huge trees with brush underneath. This was a wet period when vegetative growth was rapid and wildfires few and relatively small. If they had arrived during a long term drought they might have seen much different conditions.

## "We Burned Everything that Would Burn."

This was sheepherder P. Y. Lewis' comment about coming out of the Sierra Nevada in the fall of 1877 with his band of sheep. Lewis and hundreds of other sheepherders burned the mountains of California for forty years after the Gold Rush. They weren't alone. Miners, loggers, cattlemen, and hunters burned both carelessly and deliberately. For many of them it was just economic good sense to get rid of trees and brush that were in the way of mining, logging, cattle or sheep. But by the 1880's smoke was becoming such a nuisance that it was said that a farmer near Yreka could smoke his hams by hanging them out of the window of his ranch house. Even mountain people could see that some controls were needed. As early as 1849 the state legislature sought to prevent and suppress wildfires but with little success. In 1885 the state legislature created the first Board of Forestry. Reports to the board from counties throughout the state told of severe damage from uncontrolled fire. It was 40 years after the Gold Rush and the Sierra foothills were thick with brush and young trees that were ripe to burn, just as they are today. Much of the central and southern Sierra was open forest created by decades of burning, but the northern forests were a patchwork with large areas destroyed by fire and logging and other areas as thick as ever. In southern California orange groves and vineyards were destroyed by floods caused by heavy rains on burned watersheds. The Board functioned into 1893 and reported many problems caused by widespread burning in the mountains.

John Muir, born in Dunbar Scotland in 1838, became an advocate for the protection of the Sierra Nevada. His writings influenced past and present perceptions of the great mountain range (Photo credit USDI, National Park Service, John Muir National Historic Site)

These problems added to the concerns of wildlife, forestry and preservation groups and resulted in growing national pressure to

Cattle, sheep and fire were taking a toll of forests and brushlands, many game birds and animals were market-hunted almost out of existence, and soil was being eroded by hydraulic mining. Meanwhile, natural processes were restoring the land. Twenty great floods between 1850 and 1911 washed away evidences of mining and created new riparian areas. Ten years after placer mining was finished in Sierra Nevada streams, brush and small trees were reclaiming the sites. A report to the Board of Forestry stated, "It seems impossible to destroy a pine forest as long as fire is kept out."

reserve forests from the public lands. Over 200 forest reserve laws were introduced in Congress, but all failed to pass. At the end of the session in 1891 another land disposal law was passed by both houses and sent to conference committee. An obscure committee member, William Holman of Indiana, succeeded where the likes of John Muir had failed. He managed to insert a new Section 24 in the bill authorizing the President to set aside forest reserves. Even though this was against the rules of both houses, the members were eager to get home and passed the revised law. It was signed by President Benjamin Harrison on March 3, 1891. He began proclaiming forest reserves later that year.

### Forests and Men

You have locked up our forests! This was the cry throughout the mountains of the West. When Congress passed the 1891 Act, it caused millions of acres of forests to be reserved from the public lands. But it failed to provide for their management. No one could legally use the reserves. Finally after much complaint and debate Congress passed the 1897 Act which provided for the protection and use of the forest reserves, today's national forests. What next? Who would manage these millions of acres of rough forest land? Why political appointees, of course. Ministers, retired businessmen and political hacks were made forest supervisors, some of them effective, most of them not. There was also a sprinkling of local cowboys and woodsmen who did the day to day field work. These men became known as "rangers." Some of them were like "Barefoot Tom" Lucas of the Angeles Reserve who sported a beard to his waist and was noted for killing grizzly bears. Others like clean shaven R. L. P. Bigelow, spent most of their time in the High Sierra driving bands of illegally grazing sheep off the reserves. All of them began the slow process of building ranger stations out of logs, stringing telephone line from trees, constructing and maintaining trails, and building crude lookouts on remote mountain peaks. In 1905 many of these men formed the nucleus of a new professional agency - the Forest Service. Congress could legislate forest reserves, but it took strong men to make the reserves a reality.

The San Gabriel, Trabuco, San Bernardino and Sierra were the first reserves proclaimed in California. Mountain residents in northern California did not want reserves. They felt that the "flatlanders" had taken all the good public lands and now wanted to prevent them from getting their share of the public domain. The reserves were supervised by the General Land Office, Department of Interior, a bureau noted for graft and corruption. The Division, later Bureau of Forestry, in the Department of Agriculture provided technical assistance to the GLO.

### The President's Best Friend

The two men grunted and strained until finally the taller man with the sweeping mustache applied a hold that the shorter, stocky man could not escape. The shorter man, President Theodore "Teddy" Roosevelt, gasped, "Enough." The taller man, his best friend, Gifford Pinchot, let him up and both men laughed. This was the kind of action that often went on between the two men, wrestling, boxing, rowing, sailing and rugged outdoor sports that both men enjoyed. They were both well connected wealthy easterners who loved the outdoor life and both were dedicated to the cause of Conservation. Pinchot was the first American forester, the head of the Bureau of Forestry, a man who believed the answer to American forest problems was professional forestry. In 1905 Teddy Roosevelt managed the transfer of the forest reserves from the graft-ridden General Land Office to the Department of Agriculture. In the same act, the Forest Service was created to administer the reserves, and Roosevelt made Pinchot its first Chief.

But friendship was not the main reason for Pinchot's appointment. He was a highly intelligent, hard driving man, who could charm his supporters and irritate his enemies, of whom there were many. Historians are split on Pinchot, some believing he was a great leader and others that he was a self-serving autocrat, but there is no doubt that he was the inspiration that galvanized the new Forest Service into unusual performance. He was convinced that wildfire had to be controlled. He also knew that a series of wildfire disasters in the Lake States and the Pacific Northwest had captured the public's attention. Therefore, he made control of fire the first priority for the new agency and a reason for expansion of the national forests.

Gifford Pinchot supported California Governor George Pardee when the Governor pushed for forestry legislation. The result was the Forest Protection Act of 1905 which provided for a new Board of Forestry, a State Forester, fire districts, volunteer fire wardens, fire patrols and a requirement that citizens fight fire when asked. The first step toward state-wide fire protection had been taken. (Photo credit; Gifford Pinchot USDA, Forest Service, Grey Towers National Historic Landmark, Millford, PA) (Photo credit Pardee Home Museum, Oakland, CA)

**Fire Fighting in the Good Old Days.**

Round up a few cowboys or loggers and a stray tourist or two, give them axes or shovels and head for the smoke, this was fire suppression in the early days. There were no roads, no aircraft, no dozers, no radios, no tank trucks, no chainsaws, and no set methods to fight fire. A ranger or guard might be on a fire for a month before he finished "cold-trailing" it. Fortunately these early firemen had strong support from their wives and families. Fire control was a man's game and would be for decades to come, but women also made their mark. Wives of rangers and guards often cooked at fire camps, dispatched firemen, answered the telephone while minding the baby and the livestock, even fought fire in a pinch. A 1915 photo shows two Forest Service wives ready for the fireline dressed in white blouses, black bloomers and canvas leggings. In 1912 Hallie Daggett applied to the Klamath Forest for a job as a fire lookout. This was unheard of, but the ranger forwarded her application and reported that she, "was not afraid of anything that walks, creeps, or flies ... and is a perfect lady." With that kind of recommendation she was a cinch to get the job as a Forest Guard at an annual salary of $840. Hallie was on the job in June 1913 and for 14 seasons thereafter. She was followed by many other women lookouts, some of whom became the best in the business. On the Sierra Forest, rangers and users went to Chief Clerk Julia Shinn, the supervisor's wife, because she pretty much ran the outfit. She also created some of the first standard fire rations. According to Julia 40 cent coffee went twice as far as the 25 cent kind.

**The Army Air Patrol**

In the late winter of 1919 a major in the U. S. Army just returned from France, walked into the bar of a hotel in San Francisco. He saw another major sitting at a table, walked over, introduced himself

The 1910 fire season changed the history of wildfire in the West. Over 3 million acres burned in Idaho and 85 lives were lost including 78 fire fighters. In California more than a half million acres burned, and the regional forester was furious at the poor job done by his men. Each supervisor and ranger was assigned a fire topic to investigate. Their reports were put together by the new regional forester, Coert DuBois, in the first fire control manual anywhere titled, "Systematic Fire Control in the California Forests." This was followed by the first fire control handbook called "Fire Suppression" which laid out large fire organization, fire suppression tactics and management. These were the most important documents in early fire control history.

and asked if he could join the major. Thus began a conversation which had a lot to do with the first large scale use of aircraft in fire control. One major was Coert DuBois, regional forester for California, the other was Henry "Hap" Arnold, in charge of the Army Air Service in California. Other talks in Washington, D. C. resulted in agreement that the Army would fly over the national forests of California looking for forest fires. Pilots and planes operated out of March and Rockwell Fields in southern California and Mather Field near Sacramento. It was very tough duty, flying at altitudes up to 11,000 feet without oxygen, in cranky aircraft whose engines needed overhaul after only 100 hours flying time. Crashes were frequent and several pilots and observers were killed or injured during the three year experiment. Careful record keeping showed that fixed lookouts did a better job of fire detection except after lightning storms when detection from aircraft was unmatched. Several firsts were recorded by the Army Air Patrol before it ended in 1921. The patrol was used for reconnaissance on several fires, for transporting overhead from one unit to another, for dropping supplies to fire camps and for making the first water "bomb" runs on a test fire.

**"Stop the Forest Fires!"**

Meanwhile, many other new fire control methods were underway on the forests. The Angeles Forest tried goat grazing to control brush on its fire breaks, and introduced campfire permits; the Sierra Forest equipped a Model T Ford with railroad wheels to carry the fire prevention message; the Tahoe Forest launched the "Ranger," a fire control boat on Lake Tahoe; Ranger Mal McLeod invented the McLeod fire fighting tool; the Sierra and Sequoia Forests built a 110 mile long firebreak along their western boundary; the Lassen and Stanislaus Forests developed horse and plow line building units; and the Weather Bureau began fire weather forecasts.

In 1924 former Chief of the Forest Service, Gifford Pinchot, was leading a drive to put private forest lands under Forest Service regulation. His most prominent opponent was the current Chief William Greeley who believed in cooperation not confrontation. When Senator Charles McNary of Oregon asked Greeley how he could get a cooperative forestry bill through the U. S. Senate, Greeley said, "Stop the forest fires!" "All right," said McNary, "but first we have to build a fire - under Congress." Greeley helped by packing the hearing rooms with fire witnesses. When it was all over Congress had passed the Clarke-McNary Act which established cooperation in forestry and fire control between the federal government and the states and private individuals. It wasn't the first time that the threat of wildfires spurred Congress into action nor would it be the last, but it was probably the most important. Among other things the act provided matching funds for forestry and fire control and soon California was the greatest beneficiary of this funding. In 1927 Governor C. C. Young established the Division of Forestry and took advantage of matching funds to start the Division on its way to the top rank amongst fire fighting agencies. The Clarke McNary Act became the foundation for forestry on private lands and for fire control by the states. The act also silenced a long standing controversy over who would manage private forest lands.

The Ravenna and San Gabriel Fires burned 135,000 acres in the Angeles National Forest during September 1919 and revealed flaws in large fire organization and a lack of cooperation between fire agencies. They were followed by three years of huge fires on the Santa Barbara Forest which burned a total of 250,000 acres. Then the drought of 1923-24 set the stage for the worst fire season in California history. Before the 1924 season was over a million acres had burned, and many mountain communities such as Quincy, Susanville, Ft. Jones and Alleghany had barely escaped the flames. The last fire was another San Gabriel Fire in the Angeles which burned 50,000 acres and had far reaching consequences. A public Board of Review was held which resulted in splitting the Angeles into two forests, the second being the San Bernardino. The Angeles Supervisor was transferred to the wilds of Arkansas, and a long range program of road development in the San Gabriel and San Bernardino Mountains began. Other severe fire seasons followed in 1926 and 1928 making the twenties the worst wildfire decade in California history.

Several important new fire control methods were developed during the twenties included the bull-dozer on the Santa Barbara Forest, the pumper truck by the Forest Service, L. A. County and CDF, and fire crews on the Sierra Forest.Unfortunaty, the twenties were also noted for the first of the large suburban wildfires when the Berkeley Fire in 1923 destroyed 584 homes, and the Mill Valley Fire of June 1929 burned 125 homes.

## Ninety Days in 1933

In 1932 there were more than a million unemployed young men wandering the roads and railroads of the United States. After Franklin D. Roosevelt's election in November 1932, the Forest Service began working on a plan to enroll young men into labor camps. In the previous winter the state of California had successfully run 30 such camps employing 3,000 men on fire hazard reduction and road projects. The planners thought in terms of 25,000 men, but in December Roosevelt said he wanted 250,000. Roosevelt upped the ante at a cabinet meeting on March 9, 1933, when he said, "I want 500,000 men in camp this summer." There was near panic in Forest Service headquarters and Congress. However, by March 29th a labor camp bill was passed by Congress, and it was signed by Roosevelt on March 31st. Roosevelt not only wanted a half-million men, he announced one Friday that he wanted to see maps showing the location of all 1,300 camps by the following Monday. The maps were on his desk bright and early, and the first camp opened on June 1, 1933. The program became known as the Civilian Conservation Corps (CCC), and it employed and brought discipline to 2 1/2 million American young men. They planted millions of trees, fought thousands of fires, and built thousands of miles of roads and trails, thousands of buildings, and hundreds of recreation areas. It was the most successful of Roosevelt's depression measures, and it got underway in just ninety days! Can anyone imagine that happening today?

California had more camps than any other state, averaging 75 during the thirties. The CCC had two major benefits for fire fighting; one, was an unlimited supply of initial attack and follow-up forces. The supply of manpower was so great that despite dry conditions during the thirties there were low annual wildfire losses. The second benefit was the construction of hundreds of lookouts, ranger stations, crew stations, roads and trails for all of the fire agencies. The CCC also built the Ponderosa Way, a road and firebreak planned for a distance of 687 miles from the Kern River to the Pit River. Twenty-four CCC camps and many other labor camps worked on the project which was never finished. Sections of the old road and the facilities built by the CCC are still in use today, sixty years later! The CCC prepared all fire agencies for more difficult times ahead.

Technology improvement continued during the thirties with new and better bulldozers and much improved tank trucks. From this time on tank trucks became the unit around which fire crews were built. The Pacific Northwest Region of the Forest Service also developed portable radios for fire use that were so successful that the Army adopted them. Dropping supplies by parachute was developed in the late thirties, but attempts to bomb test fires with five gallon cans of water failed.

During September 1932, the Matilija Fire, largest in California history, burned 219,254 acres under the influence of Santa Ana winds. Fire camps were burned out, many narrow escapes were recorded and 35,000 acres exploded in one hour on the second day of the fire. In October 1933 the Griffith Park Fire in Los Angeles was attacked by untrained labor camp enrollees and 28 lost their lives. The Pickens Canyon Fire burned only 2,771 acres in November 1932. However, on New Year's Eve 1932, 13 inches of rain fell on the fire area in 12 hours. The canyon spewed a torrent of mud and debris directly into the towns of La Crescenta and Montrose killing 44 people and damaging over 400 homes. As a result, the San Gabriel River was dammed in three places and debris dams were built on most streams entering the Los Angeles Basin. Flood control money became an important part of wildfire control funding in southern California.

### "Flash Warnings," Smokey the Bear and Balloon Bombs.

California during World War II was overcrowded, short of gasoline and tires and of manpower for fire fighting. Boys were hired to replace men, and by the end of the war inmate fire crews were introduced for the first time. The first all-woman fire crew was recruited in Soledad, California. Many fire lookouts became Aircraft Warning Service stations calling in "Flash Warnings" whenever they saw an aircraft. In 1944 Smokey the Bear was introduced to make the public aware of wildfire. The first posters showed the enemy as fire starters. That threat became real that same year when the Japanese began launching 70 foot tall balloons armed with five bombs each designed to start forest fires. Many of the bombs were carried to Western states but no fires were started because fire season was over by the time the westerly winds began to blow. However, a balloon bomb landed near Bly, Oregon and killed a woman and her five children, the only people to die from enemy action within the United States.

The armed forces started numerous fires with artillery practice and crashing aircraft, but also were available to help suppress fires. Unfortunately, 11 marines were killed and 72 injured on the Hauser Creek Fire (Cleveland Forest) in October 1943 when a frontal passage shifted wind 180 degrees. Even more unfortunately a fire review did not recommend training in fire behavior or prohibit sending poorly trained crews to fires.

### Air Attack!

The postwar period saw the first major change in fire fighting since the advent of the bulldozer, tank truck and fire crew. This was the introduction of aerial attack. In 1939 the Forest Service and U. S. Army chose the helicopter over the autogiro for development. When war started the Army took over and by war's end had three helicopter models in use. In late 1945 tests were carried out on the Angeles Forest and by 1947 the Bell G47B helicopter was ready for use in scouting and transporting fire fighters and equipment. By the early 1950's the helicopter had been adapted for hoselays and water drops. Helitack crews followed soon thereafter.

Operation Firestop, a fire research project, brought together several approaches to air attack, but the major breakthrough was in December 1953. Douglas Aircraft Co. was testing a new passenger plane, the DC-7, when the pilot dumped ballast of 1,300 gallons of water at 190 miles per hour. The drop left a strip of water a mile long and 200 feet wide. The company notified Los Angeles County Fire Department and further tests were carried out in cooperation with the Angeles Forest and CDF. Operation Firestop took over and the air tanker was born. But it was Joe Ely, Fire Control Officer of the Mendocino Forest, who first put research into action. He formed a squad of crop dusters into the first operational air tankers in 1956. Within two years, more and larger air tankers were in use.

Major fires continued into the 1970's. In 1977 the Sycamore Fire burned 234 structures in Santa Barbara, and in 1978 the Kannan Fire burned 224 structures in Los Angeles. The 1976-77 drought proved to be one of the worst on record in California. In 1977 lightning fires burned 370,000 acres in five northern California counties.

### A New Age Begins

The modern era of wildland fire fighting can be said have begun in 1961 when the Bel Air Fire burned 484 homes. The intermix of forest or brush with housing had long been a problem in California, and fires had burned homes almost every year. However, before the Bel Air Fire there were few occasions when wildfires burned 100 homes. Afterwards there were many. The entire state was affected. In 1961 Mariposa County lost 106 homes to the Harlow Fire. In 1964 174 homes were destroyed by wildfires in Napa and Sonoma Counties. During the 1960's over 2,000 structures were destroyed by wildfires. Then in 1970 disaster struck throughout California when fires burned nearly 600,000 acres and 722 homes and killed 19 people. Some areas, like Wheeler Springs, had burned repeatedly. Major fires burned there in 1917, 1932, 1948 and 1985 and either threatened or actually burned part of the town of Ojai each time. Wildfire had become a major threat to life and property in California.

The fire agencies responded in 1972 with a state sponsored task force which identified problems and solutions. Suppression capabilities were increased and cooperation between agencies improved. Fire fighter deaths in the Loop Fire of 1966 and the 1970 fires caused Regional Forester Douglas Leisz to institute a Safety First program which eliminated Forest Service fire-related deaths for ten years. The program used a "bottoms-up" approach which resulted in field participation in and support of new fire qualifications and suppression strategies. Techniques of fire safety for wildland residences were developed - and ignored by most wildland residents and developers. Prescribed burning and fuelbreaks were used more and more in fire protection each year, but results were mixed. Despite improvements in the tools and methods of fire fighting, the fire agencies lost ground. The reasons were; increasing development in wildlands, north or east (Santa Ana) winds, heat waves and drought.

The postwar period also resulted in a population and building boom in California. National forest timber was soon being cut to meet the demand and the forest road network expanded rapidly providing more access but creating more risk. Hydropower and other developments also resulted in more risk during construction and afterwards from recreationists. The state began experimental range improvement burns and other prescribed burns were conducted by the Forest Service; some were very successful, others escaped and became major burns. Fuelbreaks were constructed on many national forests and intensive presuppression planning began. Disastrous loss of life in the Mann Gulch Fire (Montana), the Inaja Fire (Cleveland Forest) and Rattlesnake Fire (Mendocino Forest) resulted in widespread fire behavior training and other safety measures. The first hot shot crews were established in 1946 to provide better fireline performance.

### Back to the Future

The years between 1980 and 1995 brought the worst wildfire disasters in California history. Between 1960 and 1990 California's population doubled from 15 to 30 million. Estimates were that one million people lived in the foothills of the Sierra Nevada by 1990. Everywhere people wanted to live with natural surroundings. This was not a new phenomenon, but the scale of the urban/wildland intermix in California was far beyond anything anywhere else in the world. Drought and associated extreme fire weather provided the other ingredients that spelled disaster. Severe fire seasons became the norm rather than the exception. It is tempting to recite the long list of devastating wildfires which occurred during this period, but there is not space to do so. Suffice it to say that very large forest, brush and/or structural wildfires occurred in 1980, 1981, 1985, 1987, 1988, 1990, 1991, 1993 and 1994.

Two wildfire situations deserve special mention The worst structural wildfire disaster in California history occurred under an east wind in the East Bay Hills on October 20, 1991 when wildfire burned 3,354 residences and 456 apartments and killed 25 people. The worst lightning fires in California history occurred in August and September of 1987. Most of the fires started on August 30th and eventually grew into 77 large fires which burned 710,000 acres, mostly national forest land. This was the worst wildfire loss ever suffered in one year by the Forest Service in California.

Important changes in wildfire management occurred in the late 1970's and 1980's, not the least of which was the change in terminology from fire control to fire management. This assumed that the future would be more concerned with managing fires than controlling them, an assumption yet to be confirmed. Notable was the fact that over the last twenty years women have been integrated into fire management at all levels. Hallie Daggett would be proud! The most important wildfire management event since 1914 was the eight-year FIRESCOPE research and development program which was coordinated by the Forest Service and included federal, state, county and city fire agencies. Common organization, wildfire terminology and training for all fire services were developed and standardized. The Incident Command System, Multi-agency Coordination System and Central Operations Coordination Center came from this effort as did new uses for computers and telemetry. These innovations were first tested in southern California and by 1995 were in use throughout the United States and in many other countries.

ICS placed emphasis upon fire teams with highly qualified people as members of each team. This resulted in more efficient use of skills, but every plus has a minus. Unfortunately, fire teams de-emphasized responsibility for large fire suppression at the local level, at least within the Forest Service. Other important changes included improved physical testing of fire fighters and mandatory use of personal protective equipment. These changes led directly to the exclusive use of trained crews since pick-up crews were often not physically qualified, trained,or properly equipped. The need to coordinate crews, aircraft and other services resulted in the establishment of a interagency Fire Center in Boise, Idaho which dispatched aircraft and crews from all over the country during widespread wildfire outbreaks. As a result of these changes and declining funding, a trend toward centralization of wildfire suppression services intensified. It is too early to tell whether or not this trend is good for wildfire suppression.

Another task force looked into the wildfire problems in 1981 and issued much the same kind of report as those that went before. Meanwhile, reams of information on how to make residences in wildlands fire safe were published. Some communities such as

Incline Village prepared comprehensive fire safe plans and began carrying them out. Others that are much more at risk, have yet to move on this issue. Some counties have required fire safe plans of developers, others are far behind. The basics of living fire safe in the wildlands are known. Now they must be applied. Easier said than done. Los Angeles County wanted to ban shake roofs in the early 1900's. After 90 years that small but important step has yet to be accomplished by the state. A call for extensive prescribed burning of forests and chaparral to reduce fuel loads seems sure to fall short unless ways can be found to finance and maintain such a large program. The outlook is for more fire disasters during droughts, heat waves, and winds from the north or east.

The role of fire in the environment is complex and just recently understood, it effects every ecosystem and life form throughoutCalifornia.

By **Carol Rice**

# 13

Fire is considered a fast "oxidizer" in chemical arenas, and the fastest decomposer - compared to fungi and insects - in environmental arenas. Fire converts matter from one form to other: from solid biomass to gas, liquid or changed solids. Another universal quality of fire is that it also releases heat - sometimes in large quantities.

Effects fall into three categories: direct, indirect, and off-site effects. Direct effects include such impacts as plants and animal mortality, or creation of smoke. Indirect effects are the alteration of the habitat or environment, which would create either positive or negative results for the plant or animal after the fire. This encompasses such changes as species composition, structure of the vegetation (height, density, size class distribution), patchiness in areal distribution of vegetation, or range of wildlife. Off-site effects are generally erosion-related impacts, or patchiness and edge effects.

The long-term effect of fire depends not only on fire regime, but on events long after or before any one fire. Weather, human development, and wildlife use all influence the eventual outcome of the landscape long after the fire is extinguished. For example, continual grazing and browsing of deer can maintain a burn which is smaller than two acres in grass which would have otherwise changed into shrubs in less than 15 years (Biswell, personal communication, 1982).

Fires vary in their fire regime, which is defined as the interval between fires, season (or phenological condition of the plant), spatial attributes (size, shape, patchiness, juxtaposition), and fire behavior (such as fireline intensity and fuel consumption). The range of variability of all factors in the fire regime is extremely important. Fire regime and the variation in fire characteristics directly and indirectly affect vegetation. In turn, fires are affected by the responses of existing vegetation (fuels) to previous fire and post-fire conditions.

Fire is also considered a rejuvenator or "cleanser" of plant communities, ridding the forest of unwanted insects, overcrowded trees, dead wood from frost damage, or accumulated duff and forest litter. Fire is also a rejuvenator of plant communities which are dependent on disturbance for germination or establishment of a new generation. This is especially true in chaparral, some pine stands, and many for wildflowers.

Fire plays large role in regulating succession. Fire can (1) set back succession, from brush fields or forests to grass, (2) hold succession in any one seral stage by removing climax species, or (3) even advance succession.

Fire is a powerful force in natural selection, and thus a major influence on the evolution of species. In 1970, Mutch hypothesized that species which are favored by burning have developed adaptations which make them prone to burning, thus giving those species a competitive edge. Eucalyptus, chamise, and ponderosa pine are all examples of species which are favored by frequent fires and which have corresponding adaptations for survival and regeneration with fire. Finally, fire often creates diversity in landscape, with the patterns produced by variations in topography, fuels, and weather all reflected on the slopes and valleys of California.

Robert Green Ingalis stated in the 19th century, "In nature there are neither rewards nor punishments - there are consequences."

## Specific Fire Effects

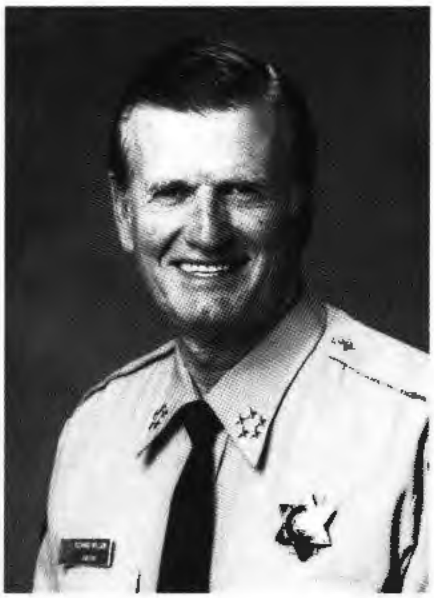
A serious shortcoming of many ecological studies of fire is that fire characteristics (e.g. fireline intensity, fuel consumption, rate of spread etc.) have not been quantitatively measured or have been mis-interpreted as to their relevance to fire effects. Because fireline intensity, foliar moisture, season, fuel consumption, and soil moisture, and all inter-related, linking fire intensity and fire effects can be questionable. For example, low intensity wildfires tend to occur when fuel and soil moistures are both high, and high intensity wildfires tend to occur during extremes of low fuel and soil moisture.

Most relationships between effects or responses and fire intensity are based only on post-fire observance. Many more large, fires with erratic fire behavior have been studied than small fires under more benign conditions.

Despite the gaps in knowledge, the following are generalizations concerning fire regimes and responses of vegetation, wildlife and other component of the ecosystem.

"We need to decide which fires should be allowed to burn, and which fires should be fought, and we must thin the forests, or we will never get a handle on stopping intense wildfires" Terry Gorton, Assistant Resources Secretary for Forestry and Rural Economic Development (CDF Communique' Winter 1994).

"CDF Director Richard Wilson believes that as much as 1 million acres of forest must be treated annually for 10-15 years on publicly and privately owned forest lands" (CDF Communique' Winter 1994).



### Fire Effects on Plants & Individual Pant Adaptations

The numerous indirect effects are based on the sensitivity of plant tissues to high temperatures. How lethal the temperatures are to any one plant depends on the temperature and period of heat exposure.

Heat is transferred to plant tissue, which includes leaves, stems, seeds, bark, roots, and buds. While most of the plant tissue is above the ground, the heat from fire often kills roots, and has both a positive and negative effect on underground (and above ground) seeds. Fire can trigger germination, but can also "steam" or even consume seeds. Several pines and giant sequoia depend on fire to open the seeds while they are on tree branches.

There are several strategies for survival of individuals of the species as a strategy to continuing the species. The individual may have thick bark, buried roots, a high branching habit, or thick, sheltered buds and twigs, or any combination of the above adaptations. In determining whether a fire's heat will be lethal at the cambium layer, bark thickness is of greatest importance. Regardless, all these mechanisms act to buffer the effect of fire's heat and promote survival of the individual plant.

### Population-level Adaptations for Species Survival

In other plant species, the individual may succumb to fire's heat, and instead, adaptations are made to promote species' survival through regeneration of a subsequent population. These adaptations span the germination of seeds, sprouting capability, and other means for perpetuating the species after a disturbance such as fire. Some species (such as chamise) have ability to both store seeds in the soil and sprout.

Seeds stored on the plant that need heat to open are defined as serotinous. In some cases, several years of seed production are held in the branches, where the heat of the fire opens the cones and a rapid release of seeds are dropped onto a newly-bared soil (which is suited for germination and growth). Usually serotinous cones are pine trees, however, the Giant Sequoia can store seeds on branches for several decades while waiting for a fire. Knobcone pines, lodgepole pine, Bishop Pine, Monterey Pine and Giant Sequoia all have at least partially serotinous cones.

Other seeds are stored in the soil or duff, in what is termed a "seed bank", with the number of seeds per area gradually decreasing with depth in the soil. While the length of viability is not known for each species, some types of ceanothus and other species important for wildlife habitat can last decades in the soil. The seeds wait for a trigger of some sort to germinate. The triggers are most often associated with heat transfer into the soil, and include char, heat itself to break or melt a hard or coated seed, or a chemical leachate of some sort which is associated with fire.

Fire can also destroy the seeds in the top layers, and can steam the current year's crop of unripe seeds which are still attached to the above-ground plant. When fire behavior does not generate much heat into the soil such as may occur in cold and/or moist conditions, a lack of seed germination may also be caused by the continued storage of seeds when they did not get hot enough to germinate.

Light and/or short-lived seeds such as those produced by willows are often killed by fires. However, the long-distance dispersal via wind is common and re-establishment of burned areas is often common.

A powerful adaptation of plants is the ability to sprout when the above- ground portion of the plant has been burned. One of the most vigorous sprouters is the alien tree, blue gum eucalyptus, or Eucalyptus globulus. Many common native oaks such as Coast Live oak, also sprout vigorously, but several important oak species do not always sprout after fire. Most common native hardwoods sprout and include bay, tanoak, and interior live oak. Less vigorous sprouters encompass valley oak, madrone, and blue oak. Conifers typically do not sprout, however coast redwood is an exception to that rule. Aspen, poplars, and berry species all sprout from root suckers. Many chaparral species use sprouting rather than seeding as a mean to recover the fire site; few species such as chamise both sprout and set viable seed. A surprising number of common landscape species sprout vigorously, as evidenced by their response to hard pruning.

In addition, several other factors influence vegetation and species survival after a fire. Diseased or plants at the end of their life span have a decreased ability to sprout. Both bitterbrush and aspen are examples of species which often lose with age their ability to regenerate after fire. The frequency of recent fires may dramatically change species composition. If a second fire occurs before seeding plants are able to produce seeds (in some trees and shrubs it can take several years), those species can be dramatically reduced in distribution. In contrast, a long interval since the last fire can result in an intense fire which is more likely to kill more plants.

Obvious to a farmer, drought, oddly spaced timing of rain, and the vagaries of nature of course influence the germination and survival rate of plants after a fire. Soil characteristics also help determine the plant effects after fire— for example, loose soils have more organic matter, and less capillary action.

Seed availability and animal movement which may help distribute seeds also changes the eventual outcome of a fire. In the past, this aspect has been considered in the limitation of plants, however, with increasing presence of exotics, land managers more often are worried about the presence of seed sources (for French broom, yellow star, purple, and artichoke thistle, or other noxious weeds). Similarly, the competition from other plants (such as newly invaded exotics or from native species also influences dramatically the eventual plant species composition after a fire.

## Fire Effects on Wildlife

Generally, mortality or immediate displacement of organisms are the most significant direct effects to wildlife. Most discussion regarding fire suppression and ecology regards habitat management- focusing on vegetation management. Indirect effects of fire have the greatest impact on wildlife and can be both positive or negative for most species, depending on the fire characteristics. Individual animals may be lost due to a fire, but species are usually not lost.

There is generally minimal mortality, with major causes of death being incineration, smoke inhalation, or fright. Mortality is greatest for slow-moving animals such as amphibians and for animals that hide in shallow burrows. The extent of mortality to animals in shallow burrows is most related to the magnitude and duration of the heat transfer into the soil.

The spatial pattern of the fire is an important factor in determining mortality of slow-moving species, because islands or the fire perimeter would be within reach in small or patchy fires. Fire size and patchiness are strongly linked to vegetation type, environmental parameters at the time of the burn, and time since last fire. For example, grass fires are rarely patchy. Whether a chaparral fire is patchy depends on the ignition pattern, fuel moisture, and weather conditions. In general, wildlife mortality will be reduced with small or patchy fires, resulting from mild environmental parameters and high fuel moistures.

Another direct impact of fire would be destruction of nests (usually during the spring). Above-ground nests, any ground-nesting species that use biomass in nest construction, plus nestling not able to flee, are very sensitive to any type of fire. If the nest is constructed without flammable material, fires of low intensity and short residence time would not affect the nests or the individuals. Fires of higher intensity or longer residence time could cause mortality from lethal heat and oxygen deletion.

Fisheries may have a temporary reduced capacity after a fire. This result, in part, from a loss of ground cover and resulting increased sedimentation, and potentially changed water chemistry. A loss of cover also often results in a rise in stream temperature- often to lethal levels, or levels which result in a lower capacity to support fish. Fires often cause a flush of nutrients which may translate into greater or reduced fish habitat.

Mortality from fire is particularly important where a small total animal population exists or when one population is small (since one fire could destroy the entire gene pool of that population). This is the case for all species listed as threatened, endangered or rare with either the Federal of State Government.

While escaping the direct effects of fire, the displacement of individuals may cause pre-mature mortality as they move into territories which are already filled. In addition, fire may cause isolation and dispersal of family units, which could in turn reduce breeding success.

Fire of any type produces a dramatic change that creates opportunities for some species and hindrances for others. The greatest diversity and equilibrium are probably established with variable burning regimes. Those species which are more likely to survive tend to dominate the community after a fire. For example, deep-burrowing animals such as kangaroo rats and pocket mice survive underground, insulated from intense heat and thrive after a fire. Their relative abundance declines as rapid succession tends to decrease habitat for burrowers.

Whether any fire improves or degrades the species' habitat depends on their life requirements in comparison to the nature of the new vegetation. However, the enhancement of growing conditions for aggressive alien species changes the scenario. In one instance, Arundo donax grows readily in what once were willow thickets. The least's Bells vireo population depends on the willow thicket. Willows normally resprout vigorously after fire and would quickly occupy a site (providing suitable and possibly enhanced vireo habitat) but the invasion of Arundo spp. caused a dramatic negative.

Fire can provide diverse habitat types (which encourages species diversity) if it creates mosaics of different aged communities. Small burns create maximum edge (areas with a flush of production created by disturbance) with handy escape cover in surrounding non-burned sites. Unburned islands generally persist and serve as refuge as well as centers for re-entering burned sites. Survivors reproduce quickly as succession occurs. In contrast, large burns do not offer much escape cover. Consequently, fires greater than 1,000 acres may not be recolonized by some animals.

Most game species are adapted to frequent fires and a wide variety of fire regimes. Fire generally brings a flush of nutrients in the new green growth, and protein levels can be increased during the three years following fire. In addition, the height of the vegetation is low enough to be reached by browsers. Nutrient-rich ash can cause grasses to grow up to two weeks earlier, which can be important for deer.

For many other species, the effect of fire may not be benign. In some cases, an immediate loss of forage, and food (such as insects or other invertebrates) occurs after a fire. In addition, a loss of cover often results, which makes some species temporarily more vulnerable as prey. Last, fires often consume important special habitat elements such as downed logs and snags.

### Fire Effects on Soils

While much of the literature regarding fire concerns fire effects on soil movement, fire also affects nutrient cycling (and eventual site productivity), and soil micro-organisms. The majority of effects of fire on soil are negative. For example, soil sterilization by heating constrains nutrient availability, and volatization of nitrogen (and other nutrients) decreases those nutrients available to post-fire vegetation.

Fire affects several processes of soil movement, including surface erosion and mass wasting. Fire usually accelerates surface erosion, and encompasses erosion from wind, sheet flow, rill, and dry ravel. The nature of erosion depends on the amount of heat transmitted to the soil, and amount of surface organic matter left after a fire, since increased speed of runoff created by the lack of cover carries a vastly greater amount of sediment. This cover protects soil from erosion by wind and raindrop impact as well.

### Effects of Soil Heating

The degree of soil heating is highly variable and depends on fuel type, fire intensity, the nature of the litter layer (thickness, density, moisture content) and soil properties (texture, amount of organic matter and soil water). The majority of prescribed fire studies show that temperatures are not high enough to alter soil structure. However, complete removal of litter and exposure of mineral soil to rain can result in a change in structure through puddling and baking of the surface (Wells et al. 1978).

Soil heating curves, created by compiling all the data for prescribed burns over a ten-year period in Southern California chaparral, show maximum surface temperatures at about 1292°F, 797°F, 482°F during an intense, moderate and light burn respectively. At 2.5 cm below the soil the maximum temperatures do not rise above 392°F, even under an intense chaparral blaze. Only about eight percent of the energy released by the burning canopy is absorbed by the soil surface and available to travel downward via conduction, convection and vapor flux (Wells et al. 1978).

Heating the soil can alter the physical and chemical when organic matter is an important portion of the soil. Presence of organic matter improves soil aggregation and structure by binding individual soil particles together, and creating pores large enough to allow good heat penetration and aeration. During a fire, organic matter can be totally removed or translocated down through the soil profile, depending on fire intensity.

Since soil is a poor conductor of heat, there are large temperature gradients from the surface down through the soil profile. Additionally, surface temperatures vary greatly over small distances: temperature differences of up to 421°F have been measured over a distance of only 90 cm (De Bano et al. 1979).

Heating Effects on Soils

| Tempurature | Comments |
|---|---|
| Below 212° | Destroys humic acids, which is 3% of organic matter in soil. |
| 212° – 392° | Non-destructive distillation of volatile organic occurs. |
| 392° – 572° | Destructive volatilization |
| 572° or higher | 572° or higher |
| Above 842° | Above 842° |

Moisture content of the soil is also important in determining the amount of damage due to heating because the temperature of a wet layer does not increase above the boiling temperature of water until all the water evaporates or moves away. Texture is also important in determining heat transfer. For example, quartz has a thermal diffusivity three time greater than clay minerals. Organic matter has a lower thermal diffusivity than soil minerals but it can combust and also add heat (Wells et al. 1978).

Nutrient loss to the ecosystem following fire is a dependent on: (1) the concentration of plant nutrients available; (2) slope; (3) amount and intensity of rainfall; (4) burn intensity; and (5) soil properties (De Bano et al. 1979). Nutrients are lost to the ecosystem via volatilization during fire. Most nutrients are lost via eroded debris while some nutrient leaching in runoff occurs.

Burning the surface organic matter reduces or removes the litter and duff layers, volatilizes nitrogen and other elements (sulfur, phosphorus, chlorine). Nitrogen (sometimes the nutrient most limiting plant growth) and sulfur particularly have a low temperature of volatilization. Less volatile elements are transformed to a soluble mineral form more easily absorbed by plants.

Normal decomposition of plant tissues is very slow and nutrients are re-utilized before they are lost to leaching or erosion. Fire provides an instant release of minerals from organic matter, concentrating nutrients in the soil and soil surface. In a low intensity burn, unburned or partially burned plant parts will comprise organic matter which provides and retains nutrients.

Chemicals such as exchangeable potassium, calcium, and magnesium all increase after a fire. The pH of the soil also generally rises which can be a positive effect. Nitrogen forms are altered with fire. Between 10% - 20% of total Nitrogen is lost in fires for chaparral and Ponderosa Pine vegetation types. Ammonium nitrogen increases after fire, with the amount related to fire intensity. Nitrate nitrogen unchanged with fire, but increased after fire. Nitrogen fixation is more active after fire with rapid growth of nitrogen-fixing plants such as ceanothus and vetch.

Fire suppression itself also impacts soils due to soil disturbance via line building, mop-up and overhaul. Firelines may increase the speed of water transport across the soil surface and reduce infiltration, and may channel water rather than disperse the flow across the soil surface.

Fire can cause water repellency (hydrophobic soils). This occurs in the litter layer, and especially in ash dust layer, and at the top of the mineral soil layer or slightly lower. The depth of the water repellent layer is dependent on fire intensity, soil water content, and physical properties of soil. The persistence of this phenomenon is usually 1 to 5 years, longer under slash piles.

Creation of a water-repellent layer increases the likelihood of erosion through mass wasting. Mass wasting also sometimes occur after fire, due to root decay, "piping" in root cavities, and decreased soil wettability. Removal of organic matter increases raindrop impact, and minimizes insulating properties from radiant heat, and can change the soil chemistry and in ways that reduces site productivity.

Heat from fire may sterilize soils (temporarily). Of the microflora in the soil, fungi are more susceptible than bacteria. This reduction in microflora may actually aid vegetation recovery if undesirable species are killed, or the reduction may limit re-vegetation if all nitrifying bacteria are killed.

Fire changes physical properties of the soil. Aeration is decreased, aggregates are washed away with raindrops, and fire's heat can "fire" clays into hard, impenetrable material. Fire sometimes darkens the soil surface, which results in greater evaporation rates and root morality as well as more frost heaving and seedling death.

## Fire Effects on Air Quality

The most significant impact on air quality is the emission of particulates. These include such material as soot, tar, and volatile organic substances. Current regulations regarding particulates are based on "PM 10" (10 microns in size) standards. Particulates have been shown to be an irritant of lungs, with no lower limit of particulates found before impacts; this health effect has been the justification for increasingly stricter standards regarding emissions. In addition, emissions cause impaired visibility, and regulations are in place to control visibility (in Class I, II or III airshed). Smoke management is based on reduction of emissions, and dispersal of those emissions.

Emission rates are determined by fire type, intensity (emissions are inversely proportional to fire intensity), and burning phase — since the smoldering phase of combustion produces eight times greater higher emissions than the flaming phase.

The chemical content of emissions are categorized into several categories. From 200 to 3500 pounds of carbon dioxide (CO2) are produced per ton of fuel consumed. Carbon monoxide (CO) is produced in volumes of 500-800 lb/ton in smoldering fuels. This chemical is the most abundant pollutant, and a significant health hazard to fire fighters and nearby persons. The amount of sulfur oxide (SO) produced in wildland fires is negligible, because sulfur is less than .2% in fuels. Sulfur dioxide (SO2) affects Class I airsheds, and is a common pollutant from urban sources; it is not produced in significant quantities in wildland fires. Nitrogen oxides (NOX) is formed at extreme temperatures which may be produced in some wildfires, but are rarely found in prescribed fires, however there is scanty information regarding this chemical. Most hydrocarbons found in both wildfires and prescribed fires have shown no harmful effect.

Some indirect effects of fire include those resulting from smoke. While particulates have been shown to cause severe human health issues, smoke itself can result in positive impacts by causing significant mortality in mistletoe, and some insect species such as termites.

### Fire Effects on Water

The effects of fire on water focus on the quantity and quality, and are dependent on several factors. The spatial distribution of the fire is important in determining the sedimentation that results from a fire as a strip of unburned cover above a riparian zone will filter fairly large quantities of sediment. For the same reason, a patchy or small fire will create little impact on sedimentation. The percent of cover left on the ground is the most important factor controlling water quantity and quality. Ground cover helps break up raindrop impact (a significant cause of erosion), and can greatly increase the amount of infiltration which occurs. A reduced infiltration rate often results in an increased flow of greater turbidity and short duration shortly after the rain event. The various sediments which are carried in faster-moving surface flow may cause a change in water chemistry.

Fire behavior is a significant factor to consider since water-repellant layers can be formed by fires which penetrate heat into the soil. An indirect effect of fire is the possible addition of water to aquifers, reservoirs and waterways resulting by a reduction of plants transpiring and thus depleting the underground stored water.

### Fire Effects on Cultural Values

Fire of every intensity damages and destroys carbon-based artifacts such as wood structures or wood in the soil surface. Fire has routinely destroyed buildings constructed by miners, and settlers. While low intensity fires generally do not damage other artifacts (and most areas have been experienced fire previously), high temperatures can alter obsidian and flake ceramic. The greater impact of fires noted by archaeologists have been the effects of fire suppression through the efforts of line building (either by mechanical or hand means) and mop-up or overhaul.

### Fire Intervals in Varying Eras of Human Use

Fire history is recorded not only in written records of agencies, but also through old field survey notes, tree analysis of fire-scarred trees, and in pollen deposits of bogs and undisturbed lakes. Through these analyses, we can classify fire history into four eras: (1) pre-Native American, (2) Native American, (3) European settlement, and (4) modern suppression era.

The pre-Native American extends to 10,000 years ago, when lightning was the only ignition source (with few exceptions that may include volcanoes). During that time, the distribution of water, and character of vegetation and weather were dramatically different. While information regarding the fire regimes during this era is much more vague and limited, fires were probably larger, of longer duration, and possibly of an interval similar to or slightly less than during the Native American era.

The Native American era spanned approximately 10,000 years ago to the 1840 or 1860's. This era produced the largest number of fires, because most tribes tended the ecosystem with fire for berry production, hunting purposes, acorn production, safety, recreation, and even warfare. There were possibly larger fires- smaller in chaparral, larger in pine or grass. Fire was a common occurrence in the California landscape: Sapsis and Martin (1991) estimate 5.6 % to 13% (5.6 million to 13 million acres) of California burned each year, based on fire frequencies for forest, shrub and grass ecosystems.

One of the most profound changes European settlement brought was the cessation of Native American burning. The preservation of buildings, timber and feed for cattle justified fire prevention. Sheep herders commonly would burn the pastures at higher elevations when returning to lower land. Occasionally, a fire was set for recreational purposes. But these occurrences were exceptions to the rule of fire exclusion.

Settlement also dramatically altered fuels as a result of their resource management. Timber harvesting, mining (including the timber harvesting required for the mine development), and grazing of sheep for cattle all changed the fuel complex which both promoted fire's occurrence and spread or limited ignitions.

The modern fire management era is associated with fire suppression, where forest fires were seen as an enemy, and Smokey The Bear was created. The amount of annual wildland areas burned- decreased as more equipment and people were allocated to suppression. The advent of aerial attack lengthened the span for the amount of wildland areas burned on an annually basis. However, this trend has not continued. Instead, the acreage burned has increased during the last several years, even though the costs and resources allocated for suppression have risen during the same time period. The numbers of ignitions have stayed relatively the same, however, fire intensity has almost uniformly increased.

## Fire Suppression & Ecosystem Health

The effectiveness of fire suppression during the most recent several decades has, in part, compromised the health of several ecosystems. In forests, fuels on the forest floor have accumulated to possibly unprecedented levels. Stand density has often increased a quantum level from 50 to 500 trees per acre. The vertical continuity of fuels has vastly increased, with a dramatic change in species composition (generally from a pine-dominated forest to a fir-pine mix).

These changes result in a questionable sustainable ecosystem for three reasons. First, species which have become more common during the suppression era (such as fir) are more vulnerable to fire. Second, the accumulated fuels are likely to create a more intense fire over a greater portion of the state. Third, the fuels are more continuous, with previous breaks in vegetation such as meadows, balds or recent burns now grown in; this makes the fires more difficult to suppress.

In many chaparral stands, the viability of fire-dependent seeds is increasingly questionable as time since the last fire lengthens. In many oak woodlands, an understory has developed which often jeopardizes the survival of the overstory oaks should a fire occur. In other oak forests, the stand is similarly becoming more dense, with Douglas fir competing successfully for needed light and dominance.

The chances are uncertain that the existing forest, chaparral or oak woodlands can be sustained indefinitely. In addition, the changes in fuel amount and continuity combine to increase costs for suppression and management. Last, the increased fire intensity, resulting erratic fire behavior, and increased difficulty to suppress all combine to form an increased risk to fire fighter safety.

The current efficiency of fire suppression is changing the fuel complex and fire regime. Not only is the density of trees greatly increased, the duff layer is often 4 to 8 inches deep in forest stands, and up to 4 inches deep in some chaparral stands. Vegetation density has increased in historic grass stands which are now covered with scrub, chaparral, hardwoods or coniferous forests. The volume of down, dead material has also dramatically increased from the era of Native American management.

Obviously longer intervals between fires are the rule, while Native Indians probably shortened the interval. In some cases, such as Ponderosa pine stands the fire interval has changed from one fire every 10 to 15 years, to an interval of one fire every 100 years- an interval which has basically missed five fires.

Currently a large proportion of fires burn under the driest parts of the year- usually in the fall. In contrast, a much larger proportion of acreage would have burned at other times of the year- from spring through winter with the Native Americans extending the season of burning.

Recent fires are evidence that almost all the wildland areas are burned with severe fire behavior. In the Native American era, the proportion of area burned with severe fire behavior was likely less. It is likely fires were quite variable in their behavior, as exhibited in some of the present prescribed natural fires in National Parks. Large acreage probably were burned with low-intensity fire behavior.

As noted earlier, the areal distribution of fires creates varying effects. Now a small number of fires burn the vast majority of acres in single large fire. In contrast, the size of fires were much more diverse in the period from approximately 10,000 years ago to the time when fire suppression became effective.

In turn, the change in vegetation has effects on the wildlife it supports. Nutrients are stored in older vegetation and larger proportion of woody material rather than foliage useable to wildlife. The plants themselves are often decadent, of reduced palatability and nutrition, and often beyond reach to browsers. Wildlife which are supported by early seral communities are hampered by limited acreage in this vegetation category.

### Fire Suppression & Ecosystem Diversity

The long intervals between fires create a less diverse pattern of vegetation in California, with more uniform expanses of older vegetation. Plants vary in their life span and time to maturity. More grasses and herbaceous species are short-lived, shrubs are short to moderately lived, and trees are long-lived. The lack of diversity in the types, seasons and sizes of fires reduces the diversity of species, both overall and in smaller distributions, by excluding young stands of early-successional species, as well as those short-lived herbaceous species which require fire for germination. The large size of the fires tends to perpetuate the uniformity of age classes, and vegetation types into the future generation of plants.

Fire managers may ponder the many effects of fire and agree with the Scotsman Robert Burns when he said, "Gie me ae spark o Nature's fire, that's a' the learning I desire".

Realizing the important role fire plays in the environment, we can now begin to use fire to successfully mange a variety of ecosystems.

By **Sherry Teresa & Brenda Pace**

# 14

Fire management is an intrinsic part of management for endangered species and habitats. The methodology and purpose of the fire management process may vary substantially. The Center uses controlled burns, grading, and mowing to control invasive exotic grasses and shrubs, to reduce the potential for catastrophic wildfire and to improve wildlife habitat.

The Center for Natural Lands Management (CNLM) was formed to protect and preserve native species in their natural environments and to promote the continued functioning of natural ecosystems. The Center is accomplishing this purpose by providing management in perpetuity for lands set aside for their biological resources. Lands are managed by the Center on a contract basis for governmental agencies or land trusts. Additionally the Center accepts the donation of fee title for these properties with their accompanying responsibilities, stewardship, and liabilities, and with appropriate financial backing.

### Management Analysis

Prior to accepting the responsibility of a conservation property, the Center routinely conducts a detailed analysis to outline the management activities and expenses of maintaining and enhancing these lands. This analysis includes identifying monitoring and reporting responsibilities (including the required agency documentation), the maintenance of the physical and biological resources, control of invasive exotic species, educational and visitor service efforts, water and fire management, and administrative expenses such as personnel, accounting, legal, and insurance items. An important assumption of these analyses is stewardship in perpetuity and, therefore, provisions are included for sporadic natural and induced events that are destructive to the habitat area.

With mitigation projects, the funding source is often a one-time endowment. Alternatively, the funding source may be one element in the annual fee structure of a special district. Once the Center has received title to the property, it is responsible for performing stewardship including fire management without further monetary support from the community or project proponent.

In a study of 22 existing and proposed conservation projects prepared by the Center in 1994, most of these projects incorporate fire management techniques. Seven specifically use burning, others either mow fire breaks and trails, or generally control invasive exotic species to reduce fuel loading. These projects are located throughout California, vary in size from 8.5 acres to 17,000 acres, and are managed by a broad sample of public agencies and private organizations.

Most small projects work closely with local fire departments and California Department of Forestry and Fire Protection to plan and conduct fire control programs. Larger projects, operated by governmental agencies have the equipment and personnel to conduct these operations independently.

For many mitigation projects, the project managers are responsible for fire control. The implementation program for the Fort Ord Reuse Habitat Conservation Program recommends that the habitat managers have the responsibility to check for compliance with fire control ordinances among neighboring developed projects. Compliance may be achieved with setbacks for buildings, equipment, and vehicles, and/or by using mowed firebreaks and various trespass deterrent measures. The latter is important since uncontrolled trespass by vehicle or on foot are the source of many accidental fires. The Fort Ord HCP recommendation that project managers monitor fire control compliance is practical since an important task of the land managers is to patrol the perimeter of the conservation property for uncontrolled trespass or damage to fences and gates. The habitat manager then often works with the land owner and reports compliance problems to the relevant fire agency. The purpose of Fire Management for Environmental Land Stewards is dependent on the specific goal of the project.

## Invasive Exotic Plant Species

Many invasive exotic species are less fire adapted than native species and fire has proved to be an effective means of reducing competition. Prescriptive burning at the appropriate time of year may allow native species to gain a foothold over invasive exotic species such is the case with yellow star thistle and french broom. On occasion, combinations of prescriptive burning, hand removal, mowing, and spraying are used in succession to slow the spread of invasive exotic species or to clear them completely from a test area. On one preserve in Monterey County, controlled burning was used to reduce the spread of young eucalyptus trees. The older trees were hand cut and burned in waste piles, and finally, the new sprouts were sprayed. The operation successfully eliminated a vast store of fuel and an aggressive exotic species. Exotic grasses have invaded but due to fire management, fire tolerant coyote bush is expanding rapidly along with oak seedlings which were planted as acorns.

### Encourage New Generation

The Nature Conservancy's Santa Rosa Plateau Ecological Reserve in Riverside County is studying the effects of fire on restoring areas to a natural condition. Prescriptive burning is conducted in various habitats at intervals of five to twenty years. Transects within the project measure the impact of prescriptive burning in many natural communities such as: vernal pools, riparian, tenaja, oak woodland, chaparral, sage scrub, and native perennial grassland. Most of these habitats are fire adapted and require controlled burns on a regular basis to maintain productivity and prevent the establishment of exotic species. Some native plants seeds in this area require fire in order to germinate.

### Protect Adjoining Uses

Many mitigation projects are located in urban or rural areas adjacent to development. Often these projects are the backdrop to residential homes. As a marketing tool, designers purposely construct boundaries between the developed and conserved environments that are difficult to identify or protect. In such cases, the Center insists in formal agreements that fire control measures are the exclusive responsibility of the homeowners. Regardless of the formal agreements, the property and preserve managers are mutually very concerned about the potential for wildfire.

The management program for all such projects incorporate fire breaks and controlled burns. Burns are programmed and planned in conjunction with CDF or other local fire protection entities. Variables such as the dominant species of the area, the climate of the location and the habitat enhancement goals will affect the timing and the acreage of prescriptive burn.

### Reduce Fire Incidence

In western Kern County, two preserves of valley sink scrub and saltbush scrub contain sixteen state and federally-listed species including: the San Joaquin kit fox, blunt-nosed leopard lizard, Tipton kangaroo rat, San Joaquin antelope squirrel and numerous listed plant species. The dry desert condition in this area is not a fire climax community. Before the invasion of exotic species, spacing between plants provided significant protection against wildfires. Since exotic annual grasses have infilled between native plants, there is a significant fuel load to spread fire over large acreage.

Numerous accidental wildfires in the preserves have become the basis of several study plots which chart the regeneration of native and non-native species in the area. At present, it is known that the signature shrub in the area, saltbush (Atriplex species ) is very slow to recover from fire incidences. Due to this discovery it is clear that the high fuel load provided by the non native exotic grasses must be reduced without compromising the native species. The method currently used to reduce the likelihood of fire in the preserves is sheep grazing. Under a program beginning this year, sheepherders will be paid a small amount to tend their sheep in a manner to reduce exotic grasses but protect native plants. Once a large percentage of the fuel load has been removed via grazing, very localized and closely monitored prescriptive burns may be a possible second stage management technique to help reestablish the native populations.

Prescriptive burning is also used to reduce wildfire potential in fire climax communities such as senescent chaparral. Large mosaics are burned on 10-20 year rotational cycles. This methodology tends to increase habitat for wildlife while reducing the potential for catastrophic wildfire.

### Prescribed Burning

Several studies utilizing prescribed burning to restore and maintain native San Joaquin Valley grassland have been conducted in the past 35 years (Fossum 1990, Hansen 1986, Langstroth 1986, Menke 1993, TNC 1994, Zaninovich 1987) and concluded that most native plant species benefitted and responded favorably, while non-native species decreased significantly by the utilization of prescribed burning.

### Restoring San Joaquin Valley Wildflower Habitat

In an attempt to restore native plants to a 2-acre preserve of formerly cultivated wheat, Zaninovich (1987) first allowed the parcel to lay fallow for five years between 1962 to 1967. During the 5-year period of rest, alien grasses increased rapidly and it did not appear that natives were going to be successful at reestablishing themselves. Zaninovich reintroduced native plants to the property using several different methods of transplanting bulbs, plants, and seeds from other local sites. Between 1962 to 1970, several accidental burns occurred on the preserve resulting in noticeable wildflower displays the following spring after each burn. Due to the favorable results observed after the accidental burns, Zaninovich then decided to start prescribed burning treatments on the preserve every 2-3 years for a 17-year period. Zaninovich reported that out of 71 species monitored during the 17-year period, 40 species increased, 7 species decreased, and 24 species did not show a change in response to the prescribed fire treatments.

Zaninovich (1987) reports a reduction of alien grass species populations by as much as 95%, and an increase in the natives Festuca reflexa and f. pacifica as a result of the prescribed burning program on the 2 acre preserve. A shift in alien grass dominance also occurred, Bromus rubens, B. diandrus and Hordeum glaucum were replaced by Vulpia myuros. Non-native Erodium spp. also increased due to fire. The following table contains non-native plant species for which Zaninovich reported prescribed burn responses during his 17 year restoration study on the 2-acre preserve.

**Non-native plant species response to Rx burning every 2-3 years between 1970 - 1987.**

NON-NATIVE SPECIES FIRE
RESPONSE
D N/C I ABUNDANCE
IN 1967 ABUNDANCE
IN 1986 PRESENT
IN 1962

| | | | | | | |
|---|---|---|---|---|---|---|
| Bromus diandrus | X | | | C | O | X |
| Bromus mollis | X | | | O | O | |
| Bromus rubens | X | | | VC | C | X |
| Vulpia Myuros | | | X | O | VC | X |
| Hordeum glaucum | X | | | O | C | X |
| Hordeum leporinum | X | | | O | C | |
| Avena barbata | X | | O | C | X | |
| Avena fatua | X | | - | O | | |
| Schismus arabicus | - | - | - | R | O | |
| Polygonium sp. | - | - | - | - | - | |
| Amaranthus albus | - | - | - | O | O | X |
| Capsella bursa-pastoris | - | - | - | O | O | X |
| Sisymbrium irio | | | X | R | O | |
| S. altissimum | | X | O | N | | |
| Medicago hispida | | | X | R | O | X |
| Erodium cicutarium | | | X | O | VC | X |
| E. moschatum | | | X | O | C | |
| E. obtusiplicatum | | | X | - | O | |
| Malva parviflora | - | - | - | R | O | |
| Senecio vulgaris | - | - | - | O | O | X |
| Matricaria matricarioides | | - | - | - | O | O |

**FIRE RESPONSE: D=Decreased, N/C=No Change, I=Increased, -= Not Recorded**
**PRESENT IN 1962:X=Present, Blank=Not present**
**ABUNDANCE: VC = Very Common - 5,000+ total plants**
**C = Common - 2,000 to 5,000 total plants**
**O = Occasional - 100 to 2,000 total plants**
**R = Rare - 1 to 100 total plant s-=Not Recorded**

From studies and personal observations from his 25 year project on the 2-acre preserve, Zaninovich (1987) concluded that;

Alien grass reduction and control was necessary for establishing or improving native species and native perennial grassland.

Prescribed fire reduced non-native grasses such as Bromus sp. and Avena sp., and increased non-native Erodeum spp. and Vulpia spp.

The native grasses Festuca reflexa and F. pacifica benefitted from the prescribed burning program.

Native plants increased in frequency and cover in response to fire, non-native annual grasses increased when fire was not present.

A burning frequency of every 2-3 years increased target native plant species and did not disfavor most fire-sensitive plant species.

Annual burning may eliminate fire-sensitive plant species.

Prescribed fire can only restore native plants and grasslands when the seedbanks are still intact; if they are not intact a deliberate introduction of target species greatly increases the restoration success.

Some native plants are very unpredictable and are hard to monitor in response to a management program (even within a 25 year period). Restoration of these species may not be possible (i.e. Caulanthus californicus).

Not all native plant species benefitted from prescribed fire and extirpation may result from implementing a burn program (i.e. M. lancedata, Layia pentachaeta var. albida and Microseris spp.).

Prescribed fire in areas of fire-sensitive Atriplex spp. must be given special concern since these shrubs do not stump sprout and are easily killed by fire. Reduction of litter must be done prior to burning in these areas, i.e. through controlled use of grazing, prior to burning.

Burning Atriplex spp. dominated shrubland areas probably would not be in the best interest of rare and endangered animal species living there.

Certain grassland and alkaline shrub grasslands, already consisting of large percentages of natives, might actually be harmed by prescribed fire.

### Effects of Fire on Grassland Species

Hansen (1986) studied the effects of prescribed fire on native and alien forb and grass species composition and density on The Nature Conservancy's Pixley Vernal Pools (PVPP) and Creighton Ranch Preserve (CRP) in the Tulare Basin. The dominant alien grass species at both sites included Hordeum spp. and Bromus spp. Both of these grass types comprised greater than 65% of the total species composition in the control plots at both preserves.

Prescribed burns were conducted on PVPP during the fall in 1980, 1981, and 1983 and at CRP during the fall in 1982, 1983, and 1984. The burns were timed to coincide with the period of maximum dryness of the mulch layer during cooler, more humid weather for burning safety. Step-point sampling continued at CRP for 4 years and at PVPP for 5 years.

Hansen (1986) reported that in the six year study, the generalized trends in response to fire was a reduction of the dominant non-native grass group, and an increase in forbs. Specific responses and changes in response to fire was evident for each species, therefore Hansen warns that they should not be generalized. The five most dominant grass species present at each preserve; Hordeum depressum, H. geniculatum, H. leporinum, Bromus mollis, B. rubens, and Vulpia myurios all exhibited different responses as a result to prescribed burning. H. leporinum and B. rubens displayed the least tolerance to fire. B. mollis may benefit from fire when it is released of competitive pressures from other less fire tolerant grasses. H. depressum and V. myuros are better adapted to fire and benefit from it. V. myuros and B. mollis will outcompete Stipa spp. seedlings by shading and soil moisture utilization. These two species may become accidently selected for in a prescribed burning program. The native Stipa cernua and Poa scabrella, both rare Tulare basin perennials, grow with the only abundant native annual, H. depressum. Since H. depressum is intolerant to fire, S. cernua and P. scabrella may have been more abundant under natural fire conditions in the Tulare basin (Hansen, 1986).

Hansen (1986) also points out the effects of mulch as a requirement for seedling establishment and maintenance of non-native annuals. Prescribed burns designed to control mulch buildup can be an effective tool to reduce and control dominant alien annuals. Too much mulch or dead material creating high levels of RDM will negate the beneficial effects of a prescribed burn. When older, decadent stands of Sporobolus airoides were accidently burned at PVPP after an eight year growth period without fire, most were killed because dead material had accumulated within each bunch and kindled the green living parts of the plants.

The surviving bunches appear to have become more vigorous and adapted to more frequent fires of 1-2 year periods. Overall, natives respond unfavorably to unnatural fire conditions such as prolonged periods of lack of fire, high levels of fuel loading (RDM), low humidity, and no winds during fire occurrences (winds decrease burning time and temperatures in burning bunchgrasses) Hansen (1986).

### Fire Effects on Cryptogamic Crusts and Soils

St. Clair et al. (1984) studied fire recovery patterns of cryptogamic crusts in Utah. One year after fire, St. Clair found that algal percent cover in burned areas was less than half of that in unburned areas. By the second year, most of the algal types in the burned areas showed significant recovery and closely matched densities and composition of the algal community in the unburned areas. One group of algae, the chrysophyte crusts, had more than 4 times the cover frequency in unburned areas than that in burned areas after the first year. In the second year after fire, chrysophyte crusts were still less than half frequent in burned areas compared to the unburned areas.

Jeffries and Klopatek (1987) found very little evidence of cryptogamic recovery 10 years after fire, even after 6 years of substantial rainfall. Callison et al. (1985) found no recovery of cryptogamic crusts in 19 years after being removed by fire.

Lichens and mosses seem to be impacted by fire more than algae (St. Clair et al. 1984). The lichen Collema tenax, shown to be most sensitive to grazing and fire impacts and the quickest to restore in other studies (Anderson et al. 1982, Brotherson et al. 1983, Belknapp, pers. comm. 1993), was more than 52 times less frequent in burned areas than in unburned areas during the first year after fire. In the second year, C. tenax increased to less than twice as frequent in burned areas than in unburned areas.

St. Clair et al. (1984) also found that mosses were the slowest to establish after fire. No difference was noted in cover frequency of mosses two years after fire, and five years later no significant reestablishment was noted for moss except with the species Pterygoneurum ovatum, considered by St. Clair to be a highly invasive species that becomes easily established in disturbed areas. Five years after fire, St. Clair found that most lichens and mosses still did not significantly recover inside the burned areas.

Johansen et al. (1982) studied the effects of wildfire on algal composition in Utah. Burned and unburned soil samples were cultured and compared for algal composition. Johansen reported that significant decreases in algal relative frequency was noted in the soil samples taken from the area burned by wildfire. Plots were also sampled in the field in and adjacent to burned areas. Algal biomass was lower in burned areas, yet composition remained similar to unburned areas. Diatom flora remained similar, but a decrease of absolute density was noted in the burned areas.

Johansen et al. (1982) concluded in discussion that the reasons for the observed frequency differences of algae and diatoms in burned and unburned areas was undetermined by his study. Johansen postulates that the frequency differences may have been caused by;

> Damage by fire and that they did not have adequate time to recover.

Fire could have altered soil nutrients, which may have created differential algal growth in burned and unburned areas.

Soil fire-crusting may have changed runoff patterns and caused differences in water permeability.

Fire may induce differences in composition of vegetation and may effect algal communities (shrubs dominated the unburned areas and grasses were dominating the burned areas).

Allelopathic reactions may have occurred after burning which inhibited algal growth.

Livestock grazing preferences may have been different in the burned and unburned areas resulting in increased cryptogamic crust damage due to trampling.

### Summary

In general, conservation managers should be eager to work with fire managers in a community because of a substantial confluence of interests. Whether a natural area is fire adapted or not, fire can play an significant part in the success or destruction of a natural community. Fire management can be used as a preventive measure for both the developed and the natural lands and can promote the recolonization by native species which tend to be more fire resistant and/or tolerant.

Prescribed fires are but one of many methods used to reduce wildland fuels in I-Zone areas.

By **Scott E. Franklin**

# 15

Vegetation reduction is the practice of reducing and / or rearranging both green and dead biomass to improve environmental habitat and to reduce the damage of destructive wild fires. Vegetation reduction or vegetation management may be accomplished through a variety of approaches. The term "vegetation management" in this text is synonymous with "vegetation reduction" because vegetation management includes both reduction and rearrangement of fuels. Another term in vogue is "fuel modification" or "fuel mod".

To better understand the principles of vegetation management we must recognize that all vegetation is in fact a "fuel". The United States standard for measuring energy of burning fuel is the British thermal unit or "Btu". A Btu is the amount of energy it takes to raise one pound of water one degree fahrenheit.

A single candle flame or a kitchen match equals about 1 Btu. A cup of gasoline contains 8,500 Btu's. Comparably, one pound of chaparral also contains about 8,500 Btu's. Ignite gasoline in a cup and it will burn evenly. Ignite gasoline spread across the floor and it will burn extremely rapidly- if not explosively. Similarly, "aerate" the chaparral by suspending it in air, pass a thirty-plus mile per hour wind through it at 80°F, provide a source of ignition, and the chaparral will react almost as explosively as the cup of gasoline. This demonstration suggests that fuel arrangement and fuel loads play an equally important role in combustion.

By increasing the surface to volume ratio, that is the amount of surface exposed to air, also increases the rate of energy release. Consider small twigs less than 1/4 inch in diameter suspended in air. The twigs, when ignited will burn rapidly. Place the same twigs on the ground, as a "mulch" and they will only smolder. Managing the rate of energy release is key to fuel reduction. The BEHAVE Fire

Behavior Prediction and Fuel Modeling System developed by the United States Forest Service is based upon the energy release concept.

Wildland vegetation is not the only consideration however. A close analysis of wildfires impacting the communities of Goleta/Santa Barbara 1990 (Paint fire), Oakland/Berkeley Hills 1991 (East Bay fire), Laguna Hills, Altadena, Malibu, and Topanga Canyon ("Firestorm" '93) will show ornamental vegetation or cultivated biomass as the fuse for structural ignition.

First characterized in 1990, the cumulative effects of a prolonged drought cause ornamental vegetation to display the same characteristics as drought stressed wildland vegetation. Because ornamental or "exotic" (non-native) shrubs and trees are generally shallow rooted and water dependent, they tend to react less favorably than native shrubs or trees when stressed. A valid vegetation management approach must therefore consider ornamental as well as native wildland fuels and the cumulative effects of drought induced stress, including dead fuel buildup.

Irrigated wet zones adjacent to structures failed miserably during the extended drought of the late 1980's and early 1990's. This occurred at a time when people had to choose between bathing and irrigating the yard— bathing of course took a priority! Unfortunately, irrigated wet zones are still being advocated. High-altitude infra-red photography and satellite data of Southern California between 1988 and 1991 clearly displays the lack of reflectance (moisture) in chaparral and ornamental biomass surrounding homes.

The purpose of fuel reduction/management is to provide a "break" between fuels. All management or fuel reduction methods involving soil are perturbations. That is, they create a disturbance in the top layer of the soil. This disturbance, followed by rain and sunlight will result in plant regeneration. Unless mitigated, this creates an additional fire hazard through the introduction of undesirable and highly flashy fuels such as grass, mustard, and thistle.

## Fuel Management Practices

Range scientist Lisle Green, defines the following fuel reduction practices:

Fireline- a narrow line, 2' to 10' feet wide, from which all vegetation is removed.

Firebreak- specifically, a fireline wider than 10' feet, prepared each year.

Firelane- an access line, prepared either ahead of the fire or in advance of the fire season, forming the basis for a fire break.

Fire control line- the mineral soil line used for firing out an area.

Fuelbreak- a strategically located wide block, or strip, on which a cover of heavy dense vegetation has been changed to lower fuel volume.

Fuelbreak system- a system of relatively large open areas, interconnected by fuel breaks.
Fuel modification practice- the broad approach to fuel Management on a large are of wildland.

Fuel modification treatment- an individual treatment or technique used to modify fuels.

In heavy chaparral fuels having 20 plus tons/acre, 70% or greater slope, and high winds would require a minimum fuel break width of 200 feet between vegetation fuels and structures according to Mr. Green. The 200 foot figure is based upon radiated energy release from the burning fuel that would cause burns on humans. This of course, does not take into consideration flying brands or "spotting" from the head of the fire. Continued research conducted by Mr. Jack Cohen of USDA-Forest Service will assess and update our knowledge of "radiated heat zones".

## Fuel Reduction Methods

There are several methods or options available to change, remove, or manipulate vegetation to modify or curtail the rate of energy release. Each of these methods have both a positive and negative environmental impact according to their use or misuse.

## Chemical Applications

Herbicides were used extensively from the late 1950's through the early 1980's. Because of their danger to personnel, water supplies, impacts upon riparian zones and overall regulation, their use as of late is extremely limited. Several environmental groups are using phosphate based herbicides to remove thistle and mustard from public lands. But even this is on a very limited basis. On the other hand, the application of clear phoscheck, used as a fire retardant, inadvertently fertilizes and promotes new growth of flashy fuels with nitrates inherent in the product.

## Prescribed Fire

Prescribed burning is the application of fire to wildland fuels when conditions such as; weather, fuels, and topography permit the specific objective to be accomplished safely. The use of prescribed fire escalated in the early 1980's through the efforts of the California Department of Forestry and Fire Protection (CDF), the United States Forest Service, and the California Department of Fish and Game. Importantly, CDF encouraged legislation (SB 1704) that addressed liability concerns for the parties involved in prescribed burning.

An environmental impact report was conducted for the use of prescribed fire on state lands. Trailer legislation also allowed for burning on non-state lands- only if the lands posed a threat to state interests. Specifically, all federal lands in California were exempted from this act. There does exist, however, a cooperative method to jointly burn on state and federal lands through a Memorandum of Understanding (MOU).

Prescribed fire is the most economical and environmentally sound approach to managing large blocks of fuel. Burned areas cost less than $5.00 per acre in low population areas to as high as $1,100.00 per acre in upscale communities such as Bel Air. Fire rotation varies from chaparral to timber species. Generally, areas within coastal scrub communities can be burned on an 8 to 10 year rotation. Hard chaparral is generally treated on a 15 to 20 year rotation.

Prescribed fire is used for:

Limiting impacts of catastrophic wildfire through age-class management of chaparral.

Reducing fuel load adjacent to structures.

Wildlife enhancement.

Protecting oak and conifer woodlands through understory burning.

Provide increased forage for cattle and wildlife.

Removal of unwanted or exotic species.

Prescribed fire is also a perturbation. Consideration in sensitive watershed areas should be provided for high intensity fires and the potential for hydrophobic soils and resulting erosion. A word of caution, prescribed burning requires experience and mastery. Even though all aspects and procedures are well defined for prescribed fires, only the experienced should attempt to conduct a burn.

## Heavy Equipment

Clearing by machines, primarily bull dozers, has been widely used due to low costs per acre. However, with the advent of landfill limiting legislation (AB 939) and tight air quality laws, this practice is losing favor. Until recently, there existed a significant market for green biomass for use in co-generation power plants. This use was most prevalent in the central and northern areas of California. However, with the advent of deregulation in the power industry, the chipped or ground biomass market has cut back. In addition, costs have escalated on providing cover for bull dozed hillsides. Bull dozer activity, with the blade down can create irreparable environmental damage. Appropriate mitigation measures dramatically increase the costs per acre.

In some areas, an anchor chain is strung between 2 dozers, or with a large ball if a single dozer is used, to clear large acreage. Unless type conversion is the objective, the use of the anchor chain is not recommended, because the heavy weight of the chain will pull out the burls of shrubs, causing significant environmental degradation.

Disking appears to be the most widely used mechanical method. Disking allows for high acreage per hour production at a reasonable rate. However, there is mounting evidence that long term impacts and costs may be catching up with the disking method. Disking once started creates a flash fuel situation. As was mentioned earlier, the disturbance of the top soil invites undesirable fire prone grasses, mustard, and thistle to occupy the area.

Mowing grass on an existing break is an option, if the area is flat. Steep slopes tend to make mowing risky. This method, as does bull dozing and disking, requires annual upkeep. The negative impact for heavy equipment use, is that it reduces the ambiance of surrounding wildland areas for homeowners. Also in use are various track laying vehicles using articulating arms with cutters, saws or flails to reduce the standing fuel. These treated areas are then burned.

A new method employs a bull dozer to crush chaparral with the blade up and then burn the material after 30 days. The result is a low (less than 3 foot flame length) manageable fire. An important consideration for crushing, is that there appears to be no hydrophobic soil impact and the regeneration of hard chaparral was enhanced. An additional benefit of this method is that smoke particles emitted from crushed chaparral is significantly lower than that emitted from standing fuels.

A device developed in New Zealand by Mr. Lex Norton termed the "gravity roller" shows great promise. The Gravity roller weighs about 9 tons, is 12 feet long and 4 feet in diameter. It is worked from a dozer with 2 high speed winches, with a fetch of about 300 feet. The device is allowed to roll down slope, on cables, then retrieved at a rate of over 100 feet a minute. This crushes the brush and after 30 days of desiccation it is burned. Los Angeles County Fire Department in cooperation with Caterpillar is developing a prototype of this device.

## Grazing

Several areas within the state use goats to establish and maintain fuel breaks. Most notable are the herds found in Laguna and the Berkeley Hills. Based upon the recent catastrophic wildfires impacting these areas, the quadruped approach appears only cosmetic, and may in fact, increase the fuse effect that most ill-managed fuel breaks create. California Department of Parks has ceased to use goats in Topanga State Park due to significant damage to hard chaparral species.

### Hand Clearing and Burning

Clearing by hand, placing the cut material in piles and burning has proven to be an alternative. However, tests have shown pile burn sites creates a hydrophobic condition of soils, precluding water penetration for several years. This condition can be mitigated to some extent by burning in small windrows instead of large piles.

### Strategic Recycling

New concepts and applications have been tested, adopted, and are gaining favor state wide in their application. The term "strategic recycling" was coined by Battalion Chief Don Pierpont of L.A. County Fire to lump together the multicutting, chipping, and tub-grinding concepts that proliferated after the passage of AB 939.

AB 939 mandates a reduction of biomass to land fills by 25% in 1995 and 50% by the year 2000. As with mechanical clearing, there was competing demands from co-generation plants for the biomass, but that condition no longer exists. Cost of application vary depending on methodology from less than 5 cents per square foot to over 60 cents per square foot depending upon access, type of material, and topography. First year costs are significant, but the following 3 to 4 year cost is significantly reduced. Managed areas can be treated by one person with a weed whip at costs below $5.00 per acre.

Applications for strategic recycling have a variety of uses and benefits, these include:

Development projects as well as existing communities, from San Diego to Santa Cruz are adopting the "Strategic recycling" concept for enhanced wildfire protection.

Landscape architects realize that strategic recycling will reduce the need to irrigate entire landscapes, while the use of native shrubs and trees provide a drought resistant and aesthetically pleasing firescape.

In heavy chaparral or timber communities, strategic recycling is the answer for "defensible space", without creating unsightly staging areas for fire fighting resources.

Existing long narrow roads can also be made tenable by using chipped biomass along the roadside for a distance of 10' feet or more on each side.

Multicutting is a recycling method defined by the cutting of chaparral into lengths no longer than 6 inches, preferably 3 to 4 inches, much like chipped biomass. The cutting is done by hand, using clippers or chain saws on the larger material. This approach was introduced by Battalion Chief Jim Haworth of L.A. City Fire in the mid-1980's to minimize the standing fuel impact in Bel-Air. The effect of the multicutting creates what is termed as "Fuel Model 8" or "forest litter". The concept requires cutting-up all dead and down material as well as limbing-up green material five feet or more in standing chaparral. If the chaparral is only 3 feet tall then it is simply cut back. All material is left on-site to emulate the forest litter. Ideally, the cut material should be at least 3 inches deep. This will act as a mulch, absorb rain drop energy and preclude the impact of sunlight from regenerating highly flashy and undesirable fuels.

This concept is particularly effective in steep, highly erosive hillside situations. But will it burn? The answer is yes, however in modeling and research this type of fire demonstrates that flame lengths were less than 2 feet as opposed to 60 plus feet for standing chaparral. Even the scorch height is less than 3 feet. Scorch height is determined by the height that the burning fuel hits 140°F. Under high intensity fire conditions, with Rh below 10% and winds in excess of 30 MPH, Fuel Model 8 will only be a creeping smoldering fire moving at less 100 feet/hour. In contrast, standing grass (Fuel Model 1) will have flame lengths in excess of 6 feet and a forward rate of spread in excess of 1000 feet/hr. Recall that the arrangement of the fuel is key. Strategic recycling lowers the surface to volume ratio of the fuel. The "edge" effect of multi-cutting reduces the harsh lines associated with required fire clearance, resulting in an aesthetically pleasing appearance and provides improved wildlife habitat.

Chipping is another recycling method gaining wide acceptance as a means of handling dead and green biomass and using the material as a cover to control undesirable flashy fuels. There are various size chippers, from light weight portable units to heavy industrial models. Several jurisdictions, including Cal-trans, Santa Barbara City, L.A. City and L.A. County are employing chipped biomass for management reasons. All federal agencies are required as of last year to utilize chipped, cut, or ground biomass on all applicable projects.

Another recycling method includes tub-grinding. The tub grinder is over 12' feet in diameter and typically powered by a diesel engine. This method consists of hauling cut biomass to the large tub and grinding the material to a particular size. Care must be exercised in both chipping and grinding green or dead biomass to be sure that it is free of animal waste. Animal waste acts as a nitrate and can cause unplanned ignitions under specific weather conditions.

The size of the cut for ground or chipped material is also important. Finely ground material is an excellent soil amendment, but can also create spontaneous ignition under specific weather conditions. Material should be at least 1/2 inch in diameter if it is spread over 3" inches deep.

The overall benefits of Strategic Recycling include:

Providing a sustainable fuel break.

Soil stabilization, even on 1 to 1 slopes.

A means for local communities to meet the mandates of AB 939.
A long term means to prevent proliferation of undesirable flashy fuels, thistle or mustard.

Improve aesthetics through the edge effect.

A savings for local communities by reducing annual weed/brush clearance costs.

## Defensable Space

A goal in landscaping terms is to develop an appropriate "palette" for the eco-system being mitigated. As such, fuel management begins at the structure requiring fire protection and radiates out into the wildland area. An example of a Southern California Coastal Palette would include the following recommendations:

Within the first 30' feet, none of the high ether extractive (oil) bearing shrubs or trees allowed. This includes all species of sage (Salvia and Artemisia), manzanita (Arctostaphylos), chamise (Adenostoma), as well as eucalyptus, acacia, cypress, conifers, or juniper. If large single specimen conifers are present, they must be well maintained of all dead material and limbed up above the roof line of the structure.

Acceptable low fuel volume trees would include; coastal live oak (Quercus agrifolia), sycamore (Platanus racemosa), and walnut (Juglans California). The trees, when pruned of dead material actually act as an energy diffuser/absorber. All are drought resistant. Various shrubs such as lemonade berry (Rhus integrofolia), catalina cherry (Prunus lyonii), for example provide the same effect.

Within the next 70' feet selective clearing of shrubs is adequate, if the slope is moderate (Less than 20%). Steeper slopes require more thinning. Chipped or multi-cut biomass is used in this zone to reduce erosion, provide moisture and hold down flashy fuels.

If the slopes are steep, fuel modification may be required 100 feet or even at 200 feet. The BEHAVE System can be used as a planning tool to predict the required modification. Several projects in the Santa Monica Mountains require 400 feet of fuel modification based upon BEHAVE calculations and personal experience.

## Summary

The variety of California eco-systems requires an extensive evaluation to determine a site specific and appropriate landscaping palette. Certainly the degree of slope, weather conditions, vegetation types, fuel load, and fuel configuration are all factored into the modification requirements.

There are a variety of ways to provide for management and fuel reduction. The use of any particular methodology or combination of methodologies should be validated by using BEHAVE and balanced with the desired impact on the environment, property aesthetics, and of course the necessary fire protection.

Wildland fuels have received the most attention in I-Zone fires, but ornamental & exotic plants have also played a role.

By **Maureen Gilmer**

The term landscape is not well defined, and here in California it may refer to native vegetation or ornamental plants, a basic lawn or high intensity gardens. In recent years there has been a dramatic increase in the popularity of gardening, calling for a more broad approach than the standard maintenance tasks of mowing the lawn and raking up autumn leaves. A 1995 survey by Rodal Press published in the May 22, 1995 issue of Forbes magazine showed that over 78 million Americans now claim gardening as their favorite pastime, which is due to a number of different socio-economic issues. Americans watch nightly news, and as crime, gangs and drugs invade every level of our society, they have become understandably afraid. As a result they choose the safety of their backyards over the vulnerability of exposed parks, recreation areas and gathering places. And naturally, they enhance the quality of these yards by gardening.

The baby-boomer, post World War II generation is reaching its forties, the age when most people become interested in gardening. In addition, their children are reaching adulthood, freeing the backyard from a battering of bicycles, toys and Slip-n-slides. Combined with virtually no rise in property values and a flat sales market, Californians have ceased trading up to larger homes as occurred in the 1980's, and in many cases they are trading down for financial relief.

A third issue which impacts the landscape is increased environmental awareness which spills into all aspects of our lives from recycling paper to protection of vernal pools. The emphasis on conservation has led residents to view their home in the context of a larger ecological perspective, and in general we have become reasonably well educated on the nuances of wildlife and wildlands. Though not all this information is correct, nor is it always beneficial, this consciousness encourages today's public to listen a bit more intently to our messages than did previous generations.

These factors: crime, gardening and the environment combine to provide us a perfect climate for reaching residents of the I–Zone. If you add the most elemental motivation of any human being, fear of fire, the stage is set for a successful program of promoting defensible space. Just as advertising agencies research their markets and identify critical points, so should fire prevention officers cultivate the public's needs and fears to gain support.

Gardens of spring bulbs are perfectly adapted to the California Fire regime. They grow and flower in spring, then die back entirely by fire season ( Photo credit Maureen Gilmer)

### California Climate, Plants, and Fire Season

Fire season in California begins in mid–summer and extends well into November, leaving from half to three–quarters of the year when there is little or no threat. It is important to know that the active growing periods for California native plants are in winter and spring, then most species become dormant for the long summer drought. Some such as the California buckeye (Aesculus californica) completely defoliates by midsummer, while herbaceous species like monkeyflower (Mimulus spp.) die off entirely with living roots protected underground. We can gain a better understanding of defensible space landscaping from the life cycle of these natives which is conveniently adapted to the season of fire in California.

Mild winters allow us to grow a great diversity of herbaceous plants unlike other states which experience frozen ground. With the rising interest in gardening, homeowners are substituting low maintenance plants with bold and colorful annuals, perennials, herbs, and bulbs. Most of these will grow and bloom throughout the spring in our climate, then die back, or may be cut back with the onset of late summer heat.

This cycle allows annuals to be removed entirely, spring bulbs lifted or allowed to remain dormant in the soil, and perennials pruned down to minimal sizes before fire season. It matters not what their original fuel volumes may be, any plant that can be made small by fire season is suitable for defensible space in California.

### Myths and Truths of Fire Resistive Plants

The term fire resistant when defining plants is often misunderstood. Most lists of fire resistant landscape plants in use today were prepared from testing done thirty years ago by the Los Angeles City and County Aboretum. The resulting data was published in the September, 1970 issue of the Arboretum journal, Lasca Leaves, in the article: The Study of Fire-Retardance in Plants by P.C. Cheo and Kenneth R. Montgomery.

In laboratory conditions samples were exposed to muffle furnace temperatures of 1200 degrees F., and the times to ignition were recorded. Closer study of the statistics show that plants recognized as fire resistant simply ignited moments later than did plants not considered fire resistant. In firestorm conditions so typical of California, this minor difference proves the resistance factor is negligible, and thus relative.

It is interesting to note that the same qualities that make a plant drought resistant also make if somewhat fire resistant. This is because these plants close the stomata in their leaves when temperatures rise and humidity decreases in order to check moisture loss through the foliage. When the same plants were exposed to the heat of fire, this mechanism kept them from losing vital moisture through the stomata as did species not considered drought tolerant. Thus there is indeed a relationship between drought tolerance and moisture loss, but whether or not this is relevant in field conditions is certainly debatable.

The fundamental concept behind defensible space landscaping is the separation of planting masses with pavement, and in this case brick. Here the herb garden at the Huntington Library in San Marino, California shows that even when there is no wildfire threat, this garden style is still very popular. (photo credit Maureen Gilmer)

Iceplants and other succulents ignited a bit more slowly because they contain high amounts of water. Saltbush, (Atriplex spp.) on the other hand resisted ignition due to a high salt content. But unless the iceplant is fully hydrated, and the saltbush meticulously relieved of its tendency to develop an abundance of dead twigs, neither exhibit any fire resistance at all. Thus arises the another difficulty in using fire resistance as a criteria.

It is much more reliable, and easily understood by the public to concentrate on low fuel volume as a qualifier. A low growth habit less than eighteen inches in height is the single quality which links all plants on existing fire resistant plant lists, and if neglected, this accumulated fuel ultimately overrides fire resistance. It is also dangerous to allow the public to take fire resistance in plants too seriously as this provides them with a false sense of security. A secure homeowner may suspend attention to fuel buildup in what they believe to be a naturally fire "resistant" landscape.

## Erosion Control Plantings: Yesterday – Today – Tomorrow

As California's population continues to rise, the need for more housing forces developers into less desirable terrain where cut-and-fill building pads, extensive large scale grading or small ridge top sites become widespread. As a result the subdivision is crisscrossed with many newly graded slopes, some nearly 2:1 ratio,

Low concrete barrier curbs surround the colorful annual and perennial garden at the California State University at Fullerton Arboretum. The field is paved with packed and rolled decomposed granite, and the separation of fuel masses is clearly seen. Certainly a beautiful scheme in its own right, the garden also qualifies as defensible space landscaping. (Photo credit Maureen Gilmer)

plus the remaining natural slopes too steep to work with. This presents one of the most challenging I–Zone fire protection areas.

The first criteria of landscape design under these conditions is to hold the soil against both surface runoff which generates silt, and deeper destabilization– the cause of liquefaction and slope failure. Both may be mitigated by erosion control plants with the ability to survive fire and resprout quickly afterwards. Newly burned slopes are vulnerable to splash erosion from raindrops and the resulting surface scouring by runoff. Though this type of erosion causes problems with sediment in downstream drainage structures, it can be mitigated somewhat by strawbale dikes, jute mesh and annual ryegrass. Resprouting plants, if irrigated, can also help reduce this potential.

The most serious threat is slope destabilization as saturated soil suffers liquefaction and literally disintegrates into a mudslide. This not only threatens the site but can cause serious damage to property down–slope from inundation. Inspection of homesites where the house has burned to the ground after the Oakland Hills and Laguna Beach fires emphasizes how small these pads truly are, and points out the threat of losing not only buildings but the ground they sat upon as well.

This scenario shows how vital it is that landscaping on steeply sloping subdivisions be planted with species adapted to fire. Even though there may be little left of the plant above ground, the network of roots remains alive and retains its ability to bind soils together. Because there is little that can be done to mechanically stop liquefaction of soils on fire damaged slopes, these fire adapted plants prove the only viable means of protection, and should figure largely in the planting scheme.

This beautiful garden comprised of annuals, perennials, herbs and roses is one of the finest examples in California of just how attractive a defensible landscape can be. There is clear separation of the planting islands in broken circular bands separated by a field of pea gravel. (Photo credit Maureen Gilmer)

Plant species which have evolved to resprout vigorously after fire originate in fire dependant ecosystems of California, the western US and Australia. Many herbaceous groundcovers in fire resistant plant lists resprout quickly after a mild fire if irrigated immediately. But as is often the case, the fire may be severe and irrigation systems destroyed, making this a less viable option. Shrubs are better able to resprout without irrigation, which include most of the chaparral species such as California lilac (Ceanothus spp.), saltbush (Atriplex spp.) and coyotebush (Baccharis spp.).

Trees offer the greatest ability to stabilize burned slopes as their root systems are far larger than that of shrubs and herbaceous plants. These reach deep into hillsides to bind weaker strata far below the surface. Trees also offer the greatest diversity of resprouting species. Some, such as alder, can be cut to a stump and will sucker heavily, making it more shrub–like in fuel volume while retaining the larger root system.

Maintenance is critical to the effectiveness of defensible space landscapes. Mowing down seasonal grasses while still green, limbing up ladder fuels in trees and removal of dead or unnecessary branches from the canopy are all ongoing maintenance efforts. (Photo credit Maureen Gilmer)

**Fire Resistive Plant Lists**

**Group 1 Greatest Fire Retardance**
**Low-growing succulent plants with thick fleshy leaves or stems.**

Aeonium decorum
Aeonium simsii
Agave victoriae-reginae
Aloe aristata
Aloe brevifolia
Carpobrotus edulis – Hottentot Fig
Crassula lactea
Crassula multicava
Crassula tetragona
Delosperma 'Alba' – White Trailing Ice Plant
Drosanthemum hispidum – Rosea Ice Plant
Drosanthemum speciosum
Lampranthus aurantiacus – Bush Iceplant
Lampranthus filicaulis – Redondo Creeper
Lampranthus spectabilis – Trailing Ice Plant
Malephora crocea – Croceum Ice Plant
Malephora crocea var. purpureo-crocea
Malephora luteola – Yellow Trailing Ice Plant
Portulacaria afra 'Variegata' – Elephant's Food
Sedum acre – Goldmoss Sedum
Sedum album – Green Stonecrop
Sedum confusum
Sedum lineare
Sedum rubrotinctum – Brown Bean
Senecio serpens

Though trees retain a high fuel volume, if properly spaced they offer many more resprouting species which include oaks (Quercus spp), western redbud (Cercis occidentalis), alder (Alnus spp.), California pepper (Shinus molle), Brazilian pepper (Shinus terebinthifolius), California laurel (Umbellularia californica), California sycamore (Platanus racemosa) and black locust (Robinia pseudoacacia).

## Breaking FuelContinuity: Planting Arrangement

The concept most critical to a defensible space landscape is how fuels are arranged on the site. Fire requires fuel, and will only travel where there is sufficient amounts of fuel. Thin fuels reduce fire intensity, clean breaks in fuels stop fires. Though wind can push embers beyond the break to continue its travel, the pause created by the lack of fuel continuity provides an opportunity to stop its movement altogether.

Defensible space landscapes are composed of trees and low fuel volume plants. The goals of tree placement is to separate individuals to interrupt the continuity of aerial fuels. This spacing from canopy edge to canopy edge must increase with the severity of slope, and the wider it is, the more effective the fuel break. The roofs of homes and outbuildings should be considered equal to a tree canopy because in suburban fires they have combined with landscape trees to create an unbroken mass of aerial fuels.

Low fuel volume plants don't present nearly the mass of fuel as do trees, but they too can combine to create a fast moving surface fire if not interrupted. Low growing shrubs and groundcovers should be broken into islands with as much open space between each as possible.

The areas in between islands may be planted with annuals and bulbs to be enjoyed during winter, spring and early summer, then removed by fire season to reveal the framework of a permanent landscape. The separations should be kept barren of fuels until winter. These areas can also be designed so that walkways, driveways, paved patios, dry stream beds, and other nonflammable surfacing is used to break up planting areas.

## Defensable Space: Size and Layout

The ideal defensible space homesite is on level ground, but unfortunately wildfires do not discriminate according to topography. In fact, fires are much more active, unpredictable and intense on the most difficult terrain, which is why the size of defensible space increases with the severity of slope. This is in part due to fire behavior, but also because steep sites present access problems for fire fighters.

The most vulnerable side of a home is that which faces downhill as fires gain momentum as they burn uphill and preheat fuels. As a result this part of the defensible space must be larger than the sides and above the house. A frequent problem in California is that lots may not be large enough to accommodate defensible space of sufficient size, or the downhill slope is part of a common area planted and maintained by association or municipal agencies. Therefore, the only real means of creating defensible space for high density hillside subdivisions is to treat the entire community as a single entity rather than as individual homes.

Within the defensible space limits lies three zones, each treated differently. Zone I immediately adjacent to the building walls extends only ten feet outward and should contain planting with minimum fuel volumes. Lawn, iceplant or herbaceous groundcovers are ideal here as all contain high moisture content. Only an occasional small tree is allowed.

Zone 2 extends another thirty feet out and should be limited to low fuel volume plants, but these must be broken into islands. If the water supply is inadequate to support much planting, then it may be combined with landscape boulders, paving and rock mulches. Trees should be present if erosion is an issue, but only if sufficiently spaced.

Zone 3 extends to the limit of the defensible space area and may contain a greater amount of fuels, but these should be open enough to supply easy access for fire fighters and their equipment. It also serves as a transition between the cultivated landscape and uncontrolled vegetation comprised of grassland, brush and chaparral, or forest depending on location.

## Irrigation

In most of California, irrigation is essential for the survival of a landscape. It is provided in many forms depending on the availability of water. Because the state's population is growing so rapidly, even if we experienced no more droughts, the water supply and its delivery system will not meet future needs. This assures the inevitability of water rationing and landscape professionals all agree the traditional water dependant planting will be forced to yield to a drought resistant garden.

As discussed above, the moisture content in landscape plants is critical to their limited ability to resist ignition. Landscapes planted today with more water demanding species may be forced to wither under rationing, and this renders them dry and vulnerable. It is well known that succulents, although able to withstand drought die back to survive. These dead parts become just as volatile as any other plant and thus a landscape designed around such species which depends on municipal water supply is doomed to failure. It is better to have no plants than dead, desiccated volatile plants.

It is essential to promote defensible space landscapes for longevity and resistance to drought. This restricts plant selection to California natives and plants from other arid regions of the globe well adapted to a long dry summer. But keep in mind that these plants only develop their ability to resist drought after the root system has grown beyond the size of the container it was started in,

**Group 2 Moderate Fire Retardance**
**Low-growing herbaceous perennials and sub-shrubs not distinctly succulent.**

Erosion control:
Achillea tomentosa – Woolly Yarrow
Ajuga reptans – Carpet Bugle
Arctotheca calendula – Cape Weed
Artemisia caucasica – Caucasian Sagebrush
Atriplex cuneata
Atriplex gardneri – Gardner's Saltbush
Atriplex semibaccata – Creeping Australian Saltbush
Cerastium tomentosum – Snow In Summer
Euonymus fortunei var. radicans – Wintercreeper
Fragaria chiloensis – Wild Strawberry
Gazania uniflora – Trailing Gazania
Lippia canescens repens
Lonicera japonica 'Halliana' – Hall's Honeysuckle
Myoporum parvivolium prostrata
Osteospermum fruticosum – Trailing South African Daisy
Pelargonium peltatum – Ivy Geranium
Potentilla verna – Spring Cinquefoil
Salvia sonomensis – Creeping Sage
Santolina chamaecyparissus – Lavender Cotton
Santolina virens – Green Lavender Cotton
Thymus serphyllum – Mother Of Thyme
Thymus serphyllum lanuginosus – Wooly Thyme
Verbena peruviana – Peruvian Verbena
Vinca major – Periwinkle
Vinca minor – Dwarf Periwinkle

and extend deep into native soil to trap lingering moisture. A landscape designed for true drought resistance must be irrigated for two years or more after planting, and then occasionally depending on weather conditions. Low pressure drip irrigation systems are best as these deliver water to a limited area saturating deep into the soil to promote adventurous rooting. Surface water delivery may actually discourage drought resistance in plants by luring rooting to the top few inches of soil.

## Maintanance - Maintainance - Maintainance

Landscape architects all agree that even the most perfectly designed landscape can be ruined by careless maintenance. Unlike buildings which are static, landscapes are living and continually growing with gradual increases in overall biomass. Unless a landscape is properly managed it will soon lose part or all its defensible space qualities.

The greatest challenge is promoting the need for maintenance of defensible space landscaping, not only to single family homeowners, but to municipal and corporate entities which are responsible for large common areas and public open space. Fires can move swiftly through some cut–and–fill subdivisions consuming fuels in common areas, typically vegetation used for erosion control. Where homeowner's associations are concerned, prompt attention to fuel management is often complicated by cost, group meeting dates and decision by consensus.

Defensible space landscape maintenance is basically the control of fuels. These correspond to the types of fire such as aerial fuels, surface fuels and ladder fuels. Whenever you consider the needs of such a landscape, fall back on your knowledge of fuels and fire types, and there you will find the clear answers. In general, these are the critical areas:

Pruning  The reduction of plant size both height and width, plus cutting out dead or dying parts.

Litter  The gathering and removal of any dead flammable materials from the soil surface.

Weed control  Typically done with string trimmer (remove clippings), manually or with carefully timed herbicide applications.

Mowing  Unirrigated grassland must be mowed while still green. Groundcovers are renewed by mowing. Bag clippings if possible.

Removal  Prompt removal of dead plants or those to be removed before onset of fire season. Replant if necessary.

**Group 3  Low Fire Retardance**
**Low growing shrubs and sub–shrubs with rather dry, leathery or rigid leaves and branches.**

Arctostaphylos hookeri 'Monterey Carpet' – Monterey Manzanita
Arctostaphylos uva–ursi – Bearberry
Arctostaphylos uva–ursi 'Point Reyes' – Point Reyes Manzanita
Baccharis pilularis prostrata – Dwarf Coyote Bush
Baccharis pilularis 'Twin Peaks'
Carissa grandiflora 'Green Carpet' – Natal Plum
Ceanothus gloriosus – Point Reyes Ceanothus
Ceanothus griseus horizontalis 'Carmel Creeper' – Carmel Creeper
Ceanothus prostratus – Squaw Carpet
Cistus crispus
Cistus salviifolius – Sageleaf Rockrose
Hedera canariensis – Algerian Ivy
Hedera helix – English Ivy
Helianthemum nummularium – Sunrose
Hypericum calycinum – Aaron's Beard]
Lantana montevidensis – Trailing Lantana
Rosmarinus officinalis prostratus – Dwarf Rosemary
Teucrium chamaedrys – Germande
Verbena peruviana

## The Homeowner Paradox

The homeowner is often caught in a paradox of conflicting information between the fire service and other well meaning agencies. Law enforcement agencies for example, recommend that homeowners should plant defensive vegetation under windows and around fences to ward off intruders. Typically, these are the same plants that appear on list of least desirable plants. Junipers, pyrocanthus, and berberis, often recommended to ward of burglars, are the least fire resistive. These plants grown under windows and the eaves of the house could only intensify the potential for structural ignition.

To reduce energy use, utility companies recommend planting deciduous trees around the house to cool it in the summer and allow sunshine to warm the house in the winter. But leaves fall at the height of California's fire season, filling roofs and gutters with combustible vegetation. Trees planted close to the house eventually grow above and over the roof adding to the danger of burning embers falling on the roof. The sparing use of water during droughts also stresses ornamental vegetation making them more vulnerable to ignition.

## Problem Areas

Difficulty will inevitably arise because there are many decisions and problems to solve when designing a landscape. From structures to fencing, plant type to pools, and dozens of other factors are involved. Before you face the homeowner, become aware of the issues he or she may be concerned with so the answers are close at hand.

Next to erosion control, the second reason for an abundance of high fuel volume plants is privacy. This is of particular importance in the city where high density areas combine with fear of intruders to make plant material an essential barrier. Defensible space landscapes are not good for privacy due to their open nature. The only solution is to suggest the construction of masonry walls as visual barriers as these are nonflammable and also serve as a barrier to surface fires.

There can be great difficulty with homes designed for passive solar heating and cooling because to maximize these qualities there must be "solar friendly" trees on the south side of the house. A sufficient number of them to have a noticeable impact on the home may present an unusually large fuel mass. Homes also rely on foundation planting to insulate building walls with dead air spaces and protection from direct solar exposure. Traditional foundation planting places too much fuel in direct contact with buildings and thus cannot be suitable for defensible space.

Frequently local ordinances and CC&Rs stipulate how vegetation can be managed within the community. At Lake Wildwood, the site of the 49er fire, homeowners were required to petition the association to remove any tree with a trunk more than about an inch in diameter. Sometimes the petitions were denied and the homeowner was forced to leave the tree no matter how dangerous it was in terms of fire. In situations such as this it is

**High Hazard Plants**

**Natives**

Adenostoma fasciculatum – Chamise
Adenostoma sparsifolium – Red Shanks
Artemisia californica – California Sagebrush
Erigonum fasciculatium – Common Buckwheat
Salvia species – Sage

**Ornamentals**

Acacia
Bougainvillea
Cedrus
Cortaderia selloana – Pampas Grass
Cupressus
Dodonaea viscosa
Eucalyptus
Gelsemium sempervirens – Carolina Jessamine
Hakea suavolens
Juniperus
Pennisetum
Phormium tenax – New Zealand Flax
Pinus

important to take a close look at such ordinances and adapt them to defensible space goals.

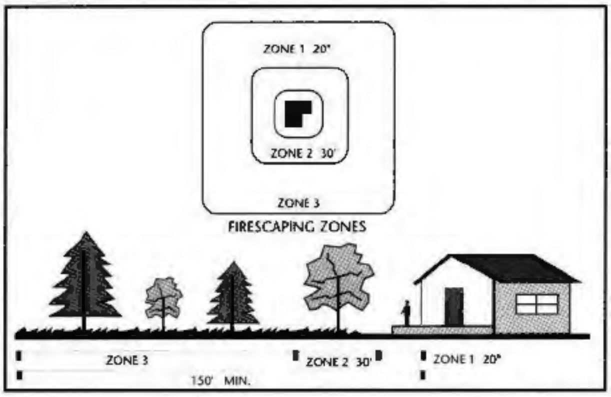
In suburban and rural areas of California there is a mind set which leads newcomers to the country to cherish every native plant on the site. This is aggravated by threats of global warming and the notion that more trees are better no matter how overcrowded they are. A rather odd analogy can be found in Africa where people base their wealth on the number of cows they own. In that frame of mind, the owner believes it is better to have twenty starving cows than ten healthy ones. Sort of a quantity over quality approach.

Therefore it is important to educate the public on the state of our native ecosystems since exclusion of fire. The homeowner must do the work of a fire by culling trees and control of brush. The more the public knows about our current forest health problems, distortion of plant communities by suppression of fire and invasion of vigorous exotics such as Scotch broom, the more open they will be to implement vegetation management practices. The motivations which made them cherish their native plants in the first place can be repackaged into a more proactive management approach.

### Government and the Landscape Industry

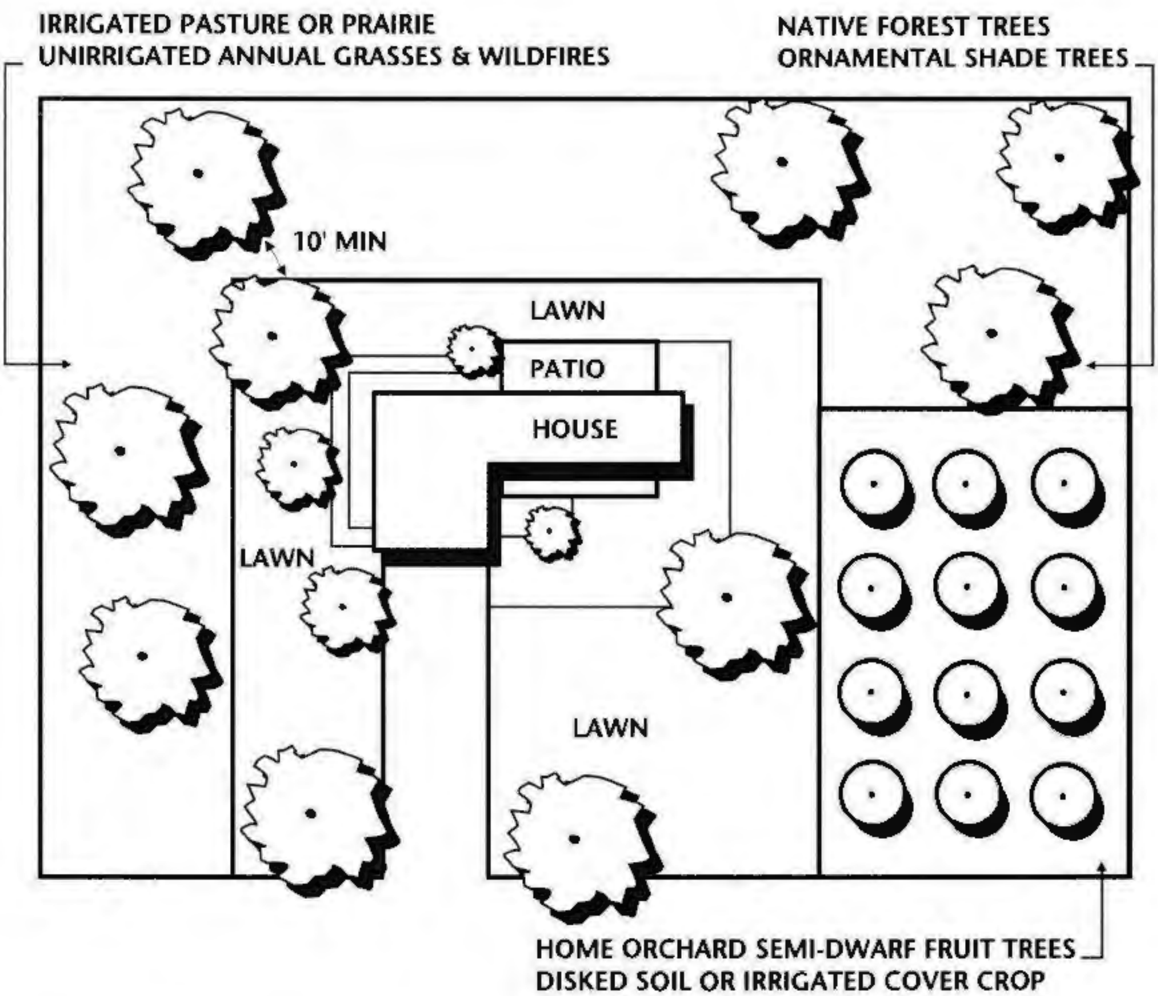
The landscape industry is growing rapidly and involves many disciplines both on the drawing boards and in the field. There is a great diversity of businesses that need to hear your defensible space landscaping message so they can take these concepts to their customers. This is particularly critical where defensible space ordinances are going into effect mandating this type of landscape and its periodic maintenance requirements.

**Firescaping Zones**




The industry presents an ideal conduit for information and welcomes your suggestions for promoting defensible space design concepts, irrigating firescapes, implementing long term vegetation control and landscape maintenance services. In addition the products of the agricultural chemical industry, power equipment manufacturers, seed suppliers, wholesale growers and retail plant sellers plus dozens of other related product sources will also be interested in using your program to promote sales.

Where government agencies sometimes lack the ability and/or funding to effectively advertise these issues, the private sector may provide solutions. This is made even more critical as budgets shrink and the fears of consumers reach new heights each fire season. But where the free market economy benefits from the goods and services involved with creation of defensible space, they will ultimately take up the torch that we light with our life's work of protecting the public from the devastating effects of I-Zone wildfire in California.




LAYOUT OF A DEFENSIBLE SPACE HOMESITE

Research has focused on predicting the spread of fires in wildland fuels, the application of this information is just as valid for fire prevention officers mitigating the I-Zone, as it is for on-scene commanders.

By **David Sapsis**

Fire is a natural process on virtually all terrestrial ecosystems in California. The juxtaposition of human development within these natural systems has led to the need to better understand how fire occurs, what kinds of impacts can be expected from what types of fires, and how the fire environment can be managed to better meet the needs and expectations of society. Fundamental to this process is the development of tools that enable us to predict the physical nature of a fire given information about the fire environment. This physical description of a subject fire—its forward rate-of-spread, flame length, rate of energy release (intensity), etc. is referred to as fire behavior. Fire behavior forms the parameters of a fire that drive impacts on the resources that we as a society value. Hence, if we are concerned under what kinds of conditions might lead to a crown fire completely killing a stand of forest trees, or what types of fire environments lead to devastating I-Zone fires, we must be able to understand potential fire behavior in these systems. By using models to predict fire behavior under a variety of circumstances, the fire manager can gain not only a better understanding of the complex interactions driving fire behavior, and consequently its capacity to do damage, but more importantly significant insight into the means necessary for mitigating that damage. That is, fire fighters and land managers need a consistent method to predict fire behavior, both strategically to mitigate loss from the potential fire, as well as tactically to limit loss of an ongoing fire.

**Wildland Fire Behavior**

Fire behavior is the result of the interaction of three sets of variables that describe the burning conditions or fire environment: fuels, topography, and weather. Once sufficient external energy is provided to a system (ie, ignition), the manner in which a fire propagates will be determined by these variables. The following table outlines the various measures that are important in defining this fire environment:

Fuels:

- amount or load measured in Milligrams/hectare (Mg/ha), or tons/acre (t/a)
- size distribution (load by fuel particle size-class)
- arrangement (horizontal and vertical continuity, fuel bed depth, compactness)
- chemistry measured in kilojoules/kilogram (kJ/kg) or BTU/lb moisture content (% of oven dry weight)
- fuel temperature

Topography:

- slope (% or degrees)
- aspect (degrees from north)

Weather:

- air temperature
- relative humidity
- wind speed and direction
- cloud cover
- time since precipitation

Fuel modeling forms much of the preparatory work in modeling fire behavior. Detailed descriptions of the fuel complex not only allow the user the capacity to understand fuel effects on predictions, but also where fuel treatment programs might be most effective. Fuel loads range from lows in grass fuels of less than 1 t/a, to greater than 100 t/a in heavy logging slash. But the total mass of fuel is not sufficient to describe the fuel complex; masses of individual size classes need to accounted for in the size-class distribution. Some fuels are entire one size class, such as grass, others are made up of a variety of sizes. Fire behavior modeling requires detailed descriptions of each size class (see Brown 1974).

The weather variables are an important agent of uncertainty in fire behavior modeling. Despite their strong influence on fire behavior, we are often required to dramatically simplify weather variables. The fire behavior analyst should make every effort to understand fire weather influences, and model uses of these inputs. An excellent summary of fire weather can be found in Schroeder and Buck (1970).

As is evident, many of these variables have a direct influence on others; for example, cloud cover and slope aspect have a significant impact on solar radiation flux to the fuelbed, and consequently influence fuel temperature. It is important to note that although fire behavior is driven by first principles of physics and chemistry, the interactions amongst all these variables are generally not linear, and are not always straightforward. Thus, we are forced by the limits of our understanding of these dynamic relationships, as well as the constraints associated with free-burning fires, to use a modeling approach to understand and predict fire behavior. The following sections will introduce the reader to a number of current fire behavior models that are used in North America, what they do and do not do in regard to prediction, what their assumptions are, and what types of applications are best suited to these models.

### Wildland Fire Models

Early work on forest fire behavior was conducted to develop simple relationships between burning conditions and obvious variables that would enable forest managers to cope with fire problems. Some key variables— fuel load, fuel moisture, windspeed, etc. were isolated and empirically assessed for their effect on fire. Much of the current fire danger and fuel classification is based on this early work. However, not until the 1970's did comprehensive models aimed at integrating all elements in the fire environment begin to take shape.

Although a variety of modeling approaches have been utilized to predict occurrence and potential fire behavior, including empirical (Forestry Canada 1992) and probabilistic/ observational (Campbell 1991), the most widely used prediction system is that developed by the U.S. Forest Service using a mathematical approach (Rothermel 1972). Early work on fire spread indicated energy dynamics at the head of a fire— the interface between the burning front and the adjacent unburned fuel— were fundamental to a fire's capacity to sustain its spread (Fons 1946). Later, using this understanding in connection with the theoretical basis pinned on the conservation of energy principle, Fransden (1971) isolated a fundamental mathematical description of energy dynamics at the fire front. The basic form of this mathematical relationship is a ratio of energy released to the adjacent fuels from the burning front (ie, the propagating flux or heat source), to that energy required for that adjacent unburned fuel to ignite (heat sink of potential fuel). However, this ratio contained terms that involved heat flux mechanisms that were not known, and could not be solved analytically. Rothermel (1972) redefined the ratio in new terms that allowed for a mathematical approximation, and then tested the model using known variables in a wind tunnel/combustion chamber. The resultant mathematical model for fire spread has been incorporated into both the National Fire Danger Rating System (NFDRS) and the BEHAVE group of fire prediction programs. Although the NFDRS and BEHAVE use the same mathematical model, the uses of the two programs differ significantly due to different target applications and different weightings of parameters within the model.

### Assumptions & Limitations

All systems employing the Rothermel model are subject to the same constraints and limitations. Like any model, it is a simplification of a complex phenomena, and solid understanding of what assumptions are made are critical in proper inference of model outputs. First and foremost, the type of fire that is being modeled is a surface fire only, spreading along a fuelbed that is continuous, uniform, homogenous, and contiguous to the surface. That is, fire behavior outputs only reflect a surface burning front, burning in an entirely (both horizontal and vertical) uniform fuel complex. The more fire behavior actually deviates from being a surface fire, and the more an actual fuelbed deviates from the ideal, the more unreliable the predictions. Further, both site conditions (slope or aspect) and weather variables, are simplified into uniform constants as model inputs. If one wants to assess fire spread across a number of slope conditions, individual model runs are necessary for each set of environmental circumstances under examination. This limitation on spatially explicit information will be addressed in the discussion of the FARSITE model.

The outputs from any model used in a predictive capacity permits the user to generate estimates of fire behavior that may disagree with observed data. There are three principal reasons that a model may result in unreliable results;

Model not applicable to situation,

Model's inherent accuracy at fault, and

The data used in the model may be inaccurate. All three may come into play when using these fire behavior systems.

### National Fire Danger Rating System

Fire-danger rating is a management tool designed to establish the degree of fire hazard and risk of fire outbreak. It is consequently directed at land unit level planning and preparedness, basing its ratings on a number of indices of fire behavior useful for determining fire control activities (Deeming et al. 1978). It is not designed as a site-specific prediction system. Rather, it bases its outputs on a worst-case scenario, using mid-day weather inputs and idealized fuel characterizations over large planning units, typically on the order of 10,000 acres and larger. Not only does the NFDRS assess fire behavior potential, it also includes components relating to fire occurrence. It is not advisable to use NFDRS outputs for site-specific predictions. Although both NFDRS and BEHAVE use the same core model, they are weighted differently according to the divergent applications that each is designed for.

Both models develop characteristic parameters of the fuel complex that are simplified rendering of actual fuel bed variables. For example, although a fuel model may have a number of different fuel size classes in the fuel array, the model develops a singular characteristic size class, which are a product of weightings and averages of the size distribution. In general, the NFDRS tends to weight the fuel array based on loading while BEHAVE weights on surface-area-to-volume ratios. The resultant systems have consequently different outputs under different degrees of large fuel moisture content. This difference underscores the fundamentally different applications of the two systems. When large fuels are relatively wet, but fine fuels are dry enough to actually support fire spread, the NFDRS will predict no spread due to the load weighting. Conversely, BEHAVE tends to under predict fire behavior when it is significantly influenced by large downed fuels. As the NFDRS is designed for low resolution, medium-to-large applications, and the BEHAVE system designed for high resolution, small scale application, it is incumbent upon the user to employ the system best matched to the need. For institutional planning and staff preparedness, the danger-rating scheme is effective; however, strategic and tactical needs for highly resolved questions require the greater specificity and surface area weighting afforded in the BEHAVE system.

**Figure 1**—BEHAVE system design. RXWINDOW is a program in the BURN subsystem. It reverses the DIRECT-SCORCH-MORTALITY modules of the FIRE1 program. (Andrews & Bradshaw, 1990)

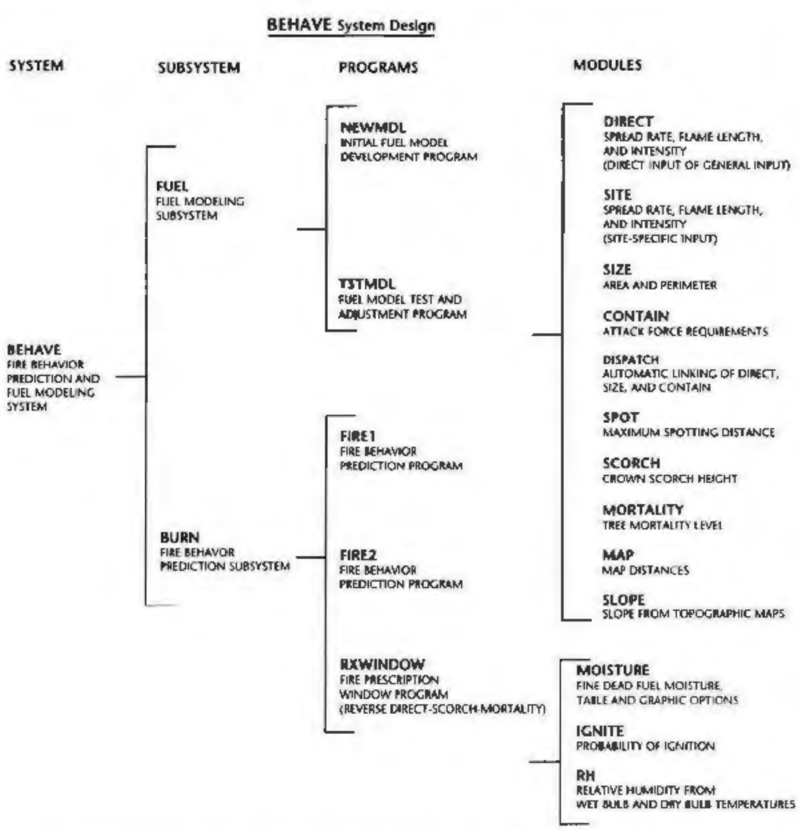



Figure 1—BEHAVE system design. RXWINDOW is a program in the BURN subsystem. It reverses the DIRECT-SCORCH-MORTALITY modules of the FIRE 1 program.(from Andrews & Bradshwa, 1990)

## BEHAVE

The BEHAVE system of fire behavior programs are designed for site-specific predictions of fire behavior based on fine scale data inputs describing the fire environment. It is a pc-DOS based computer program that can run on most IBM compatible machines. Although there is no direct treatment of fire occurrence (ie, a fire is assumed to have started under the conditions established) there is a module to establish the probability of ignition relating to spot fire growth. Figure 1 shows the system structure contained in the BEHAVE family of programs.

The computer-based BEHAVE programs allow the user to systematically describe the variables of the fire environment, and using the mathematical model described above, output parameters of a fires behavior: rate-of spread, intensity, etc. Additionally, some modules have been developed to predict fire effects based on the predicted fire behavior. For instance, the SCORCH and MORTALITY modules allow the user to determine effects on trees from modeled fires. However, the basis of the system involves modeling fuel, weather, and topographic features, then allowing them to be integrated into an estimate of what kind of fire behavior would result.

As fuel characteristics form the basis for the energy source for fire propagation, and have a number of important variables associated with them, it is not surprising that there is an entire subsystem devoted to fuel modeling. A fundamental component in any fire behavior prediction system is that of the fuel model. This model forms gives the system information regarding fuel characteristics that affect fire behavior. As such, loading, size class distributions, depth, etc, are all components of a fuel model. Although there are 13 established standard fuel models for use in BEHAVE (see Anderson 1982 for a description of these, as well as comparisons to the 20 standard NFDRS models), there are instances where fuel arrays are not well represented by these standard models. To aid in the development of custom fuel models, BEHAVE has two programs designed to translate fuel survey information into custom models — NEWMDL and TSTMDL (Figure 1). NEWMDL is used to develop fuel characteristics, while TSTMDL is used to investigate how these characteristics alter fire behavior outputs (Burgan and Rothermel, 1984). An example of a custom fuel model is given in Figure 2. This custom model, number 26, is meant to represent sierran chaparral fuels. Note how fuel size classes are based on their time-lag constant. This relates to the time it takes for a fuel of this size to change its moisture content. It is important to note that fuel models are really only a characterization of fuels information that the model uses to predict outputs. As BEHAVE predicts only spread of a surface fire, you will notice that there is no allocation of aerial fuels within the model. Users wishing more background on fundamentals of fuel sampling are encourages to see Brown (1974) while those interested in advanced fuel modeling should see Burgan (1987).

```
                 CURRENT VALUES OF FUEL MODEL PERAMETERS
DYNAMIC 26.      BY:SAPIS

   LOAD (T/AC)            S/V RATIOS                     OTHER
-----------------   ------------------   -----------------------------
1  HR        3.60   1 HR          2000.  DEPTH (FEET)               4.00
10 HR        3.60   LIVE HERB        0.  HEAT CONTENT (BTU/LB)     8600.
100 HR       1.60   LIVE WOODY    1500.  EXT MOISTURE (%)            30.
LIVE HERB    0.00   S/V = (SQFT/CUFT)
LIVE WOODY   2.40
```

**FIGURE 2**—Current values of fuel model parameters.

The engine of BEHAVE— the algorithms that calculate fire behavior outputs— reside in the BURN subsystem of the BEHAVE program (Figure 1). BURN is composed of two programs FIRE1, where most basic calculations can be found, while FIRE2 contains some newer features. Each of these subsystems has an accompanying users guide (Andrews 1986 and Andrews and Chase 1989, respectively). The basic outputs of fire behavior— rate of spread, flame length, fireline intensity, reaction intensity, heat per unit area— can be modeled in either the DIRECT or SITE modules of FIRE1. In these routines, the user defines environmental and site information to round out the modeling of the fire environment, and the mathematical model is put to work predicting fire behavior. Again, these outputs are meant only to reflect active surface fire spreading in quasi-steady state along its perimeter of front Since BEHAVE was designed to predict the spread of a fire, the model describes only what is happening in the active flaming zone. As wind and slope act to increase frontal spread rate, the program does offer the ability to estimate fire behavior along flanking and backing portions of the perimeter by designating the degree offset from the wind/slope (heading) vector. An example listing both environmental and site information, as well as predicted fire behavior outputs from the DIRECT module are shown in Figure 3. SITE offers the user the added capacity of finer resolution of environmental factors associated with fuel moisture, wind, and slope, where direct requires the user to specify these parameters. Again, I caution the user to read the detailed discussion of the model's assumptions and limitations found in Andrews (1986) pp. 8-11.

```
DIRECT module fuel, site, and weather inputs:

1--FUEL MODEL                       10 -- TIMBER (LITTER AND UNDERSTOR
2--1-HR FUEL MOISTURE, %           3.0
3--10-HR FUEL MOISTURE, %          5.0
4--100-HR FUEL MOISTURE, %         6.0
6--LIVE WOODY MOISTURE, %         80.0
7--MIDFLAME WINDSPEED, MI/H        8.0
8--PERCENT SLOPE                  40.0
9--DIRECTION OF WIND VECTOR        0.0
    DEGREES CLOCKWISE
    FROM UPHILL
10--DIRECTON OF SPREAD             0.0   (DIRECTION OF MAX SPEED)
    CALCULATIONS
     DEGREES CLOCKWISE
      FROM UPHILL


DIRECT fire behavior outputs:

      RATE OF SPREAD, CH/H-----------   25.
      HEAT PER UNIT AREA, BTU/SQ.FT--  1486.
      FIRELINE INTENSITY, BTU/FT/S---   673.
      FLAME LENGTH, FT---------------     9.0
      REACTION INTENSITY, BTU/SQ.FT/M  6827.
      EFFECTIVE WINDSPEED, MI/H------     8.8

note: the units of rate of spread are chains per hour, which are
equivelent to 1:1 times the ROS in ft/min.
```

**FIGURE 3**—DIRECT module fuel, site, and weather inputs.

Other modules within the BEHAVE system allow the user to predict fire area and perimeter size (SIZE), attack forces required for containment (CONTAIN), and other means of modeling fire suppression activities and mapping requirements. SPOT allows for the prediction on maximal spotting distance based on fire behavior, stand characteristics, and topography, Additionally, some basic fire effects, such a crown scorch (SCORCH) and tree death (MORTALITY) are included. For most users investigating fire behavior, SITE and DIRECT will generate the desired information.

The FIRE2 subsystem allows further refinement and modeling of fine fuel moisture content (MOISTURE), the probability that a fuel complex will ignite from a burning brand (IGNITE) as well as a module allowing the calculation of relative humidity bases on wet bulb, dry bulb, and elevation data (RH). These features further refine both the inputs regarding the fire environment used to predict fire behavior, as well as the inferences that can be drawn from the modeling procedure. An additional program, Rx Windows, rearranges the models used in DIRECT, SCORCH, and MORTALITY to determine prescribed fire prescriptions based on desired fire behavior and effects (Andrews and Bradshaw 1990).

The BEHAVE set of models form the core curricula for wildland fire behavior analysis training. By using the models in an exploratory fashion, the user can gain insight into the complex interactions between fire environment variables, as well as a general understanding of what types of modeling procedures are required for what types of wildland fire management tasks. Fire behavior is as much an art as it is a science, and only by working with the models can the user become adept at understanding their utility. One final caution regarding this models structure in regard to accuracy and precision: BEHAVE is a deterministic model— it only gives a singular predictive output. There are no confidence intervals explicitly applied to any of its predictions. Although a general level of precision has been established as a factor of 2, it is again incumbent upon the user to determine where and how the model may diverge from reality, and make inferences to take these into account in any tactical or planning use of BEHAVE.

### Farsite

A recent adaptation of the Rothermel model allows the ability to overcome some of the simplifications inherent in the BEHAVE system. This new program, FARSITE, uses the Rothermel model for calculation of spread, but does it on an explicitly spatial and temporal landscape where fuels, topography, and weather variables are actually spatially referenced, and things that change (e.g., weather) are changing in the time domain (Finney 1994). Utilizing the spatial database capabilities of Geographic Information Systems (GIS), FARSITE allows the user to simulate the spatial and temporal spread and behavior of a fire over heterogenous terrain, fuels, and weather. It thus allows more realistic modeling of actual fire growth, as well as the capacity for investigating effectiveness of fuel treatments designed to mitigate hazard (Van Wagtendonk 1995). Additionally, since spotting and crowning are included within the model, it provides an ideal tool for investigating extreme fire behavior.

FARSITE is a WINDOWS based computer program that was originally intended for use as a management support tool for prescribed natural fires (lightening ignited prescribed fires) in wilderness areas under management by the National Park Service. However, the model can be useful in both planning and operational phases of fire management. That is, it may serve as a tactical model for interpreting future fire position and behavior, for which the model has been verified (Finney and Ryan 1995), or it may serve as an alternative to field tests for analyzing proposed changes in the fire environment.

The modeling approach used by FARSITE employs an implementation of Huygen's principle of wave propagation for simulating the growth of a fire front. It is very similar to the widely used methods for manually doing the same modeling (Rothermel 1983), but it is automated, faster, and more detailed than is practical when doing it by hand. Furthermore, the outputs of fire perimeters and behavior variables are portable both numerically and graphically to other pc and GIS applications. However, as these advantages come with the additional costs of more, and more organized (e.g., spatially explicit) information on fuels, weather and topography.

The following data themes are required from a GIS to build a FARSITE landscape:

fuel model
canopy cover
elevation
slope
aspect

Additional themes are required if site specific determination of crown fuels are to be utilized, they include; tree height, height-to-live-crown base, and canopy bulk density. As these three variables are often difficult to resolve, FARSITE can make global default assumptions in the absence of these layers, and still generate crown and spot fire behavior.

Weather inputs into FARSITE resolve at two different scales. General weather inputs of maximum and minimum temperature and relative humidity, as well as any recorded precipitation, are logged on a daily basis. The program then fits the temperature and humidity data to a sine curve form for interpolation of these parameters throughout the day cycle. Using these data, as well as initial starting points for fuel moisture, the model provides dynamic inputs of weather and fuel moistures over time. Wind speed and direction are logged at sub-daily intervals, usually hourly, because of their fine temporal variation, and their profound impact on fire behavior. Although these wind vectors are assumed constant between periods, the landscape can be broken into a mixture of cells each applied to a different weather/wind stream. That is, if some spatial information is known about variation in the weather/wind stream, it can be spatially applied to the landscape.

The user applies ignitions, start times, end times, and some model parameterization (e.g., time steps for calculating fire perimeters) when initiating a simulation. The user also has a variety of behavior outputs that can be saved from a model run. Table 1 shows a fire simulation of time vs. fire size, while table 2

Table 1. FARSITE fire size output.

Fire Areas (Hectares)

| Elapsed | Current | Horzontal | Slope |
|---|---|---|---|
| 00 00:00 | 07/20 11:00 | 0.000000 | 0.000000 |
| 00 00:30 | 07/20 11:30 | 0.007360 | 0.007579 |
| 00 01:00 | 07/20 12:00 | 1.752715 | 1.800379 |
| 00 01:30 | 07/20 12:30 | 4.588718 | 4.707301 |
| 00 02:00 | 07/20 13:00 | 11.874128 | 12.150685 |
| 00 02:30 | 07/20 13:30 | 24.067808 | 24.645135 |
| 00 03:00 | 07/20 14:00 | 38.777656 | 39.692659 |
| 00 03:30 | 07/20 14:30 | 53.355994 | 54.599478 |
| 00 04:00 | 07/20 15:00 | 74.507583 | 76.216399 |

**TABLE 1**—FARSITE fire size output. (above).

shows an output of time vs. numbers of fires. These output tables can be saved as simple ASCII files within the pc platform. Alternatively, more complex, spatial outputs of the fires position over time, as well as faster information (cell by cell) about various fire behavior descriptors (e.g., flame length, rate-of-spread, etc.) can be saved for importing back into the GIS for plotting or further analysis.

Although FARSITE v 2.0 is currently under revision and beta testing (Finney 1995), it offers state of the art wildland fire modeling capacity. It is currently being used to explore a variety of fire management problems both in wildlands and in the I-Zone. Interested fire service professionals are encouraged to contact the author of FARSITE computer modeling about its current status.

Table 2. FARSIT outputs of numbers of fires.

Fire Statistics

| Elapsed | Current | | Fires | Spots | Enclaves |
|---|---|---|---|---|---|
| 00 00:00 | 07/20 | 11:00 | 1 | 0 | 0 |
| 00 00:30 | 07/20 | 11:30 | 3 | 2 | 0 |
| 00 01:00 | 07/20 | 12:00 | 4 | 1 | 0 |
| 00 01:30 | 07/20 | 12:30 | 11 | 8 | 0 |
| 00 02:00 | 07/20 | 13:00 | 18 | 8 | 0 |
| 00 02:30 | 07/20 | 13:30 | 16 | 5 | 3 |
| 00 03:00 | 07/20 | 14:00 | 16 | 9 | 0 |
| 00 03:30 | 07/20 | 14:30 | 26 | 10 | 2 |
| 00 04:00 | 07/20 | 15:00 | 23 | 6 | 2 |

**TABLE 2**—FARSITE outputs of number of fires. (below)

## Summary

Fire management requires sound understanding of the principles of fire behavior. Fire behavior modeling provides the means by which both understanding and wise management decisions can be made. A variety of models are currently in use in the wildland fire community, each with its own particular niche of use. Exploratory uses of these models will enable the student to learn much about what drives fire behavior. Model outputs, tempered with actual observed fire behavior will form a knowledge base providing a background from which to base fire management decisions in the future.

# IV. RISK, RESPONSIBILITY, & PROGRAMS

Managing the risk of I-Zone fires is the responsibility of the individual homeowner, the fire service, local government, local developers and builders, as well as the insurance industry.

By **James A. Snyder**

18

"The view is spectacular, you ought to see it. The location is unbelievable, right on top of the hill, we love the view." How many times have you heard that from a friend or relative describing a new home or second residence? Or, perhaps someone you know has moved into a home rebuilt in a wooded area which had been previously destroyed by fire. You ask your friend why he or she would build there again, knowing it is in an area that is extremely prone to fires. More than likely you may hear, "Well that's why we have insurance!"

The point is well taken—insurance does pay when disaster strikes. The insurance product is a promise to restore a policy holder as closely as possible to the position he or she enjoyed before a loss.

As property owners, everyone agrees that insurance should be affordable. In fact, many of us go out of our way to shop each year for the best insurance coverage available at the lowest price. The demand for affordable insurance today may be reaching a point that exceeds the capacity of insurers to pay for even more costly natural and man-made disasters that strike each year in California and around the world.

### Adding-up the Disasters

In 1993, the National Fire Protection Association estimated that \$8.546 billion in direct property damage resulted from fire, up 3 percent from 1992. This figure includes an estimated \$1.7 billion in insurance damages caused by the wildfires in Southern California. Broken down, it means that the property loss rate in the West averaged \$37.20 per person. Naturally, insurance plays an important part in loss payments. When tabulations are complete, important part in loss payments. When tabulations are complete, the 1994 figures are expected to top the 1993 estimate.

Hurricanes, a major concern to insurers nationwide, averaged four to 10 per year up until 1992 when Hurricane Andrew hit Florida. Andrew set an all-time insured loss record of over $16.3 billion, and some complex claims are still being settled today.

Insurers were faced with legitimate and illegitimate claims from this destructive hurricane that left tens of thousands homeless and in financial ruin. The questions of insurance coverage and insurer responsibility to pay claims reached the front pages of every newspaper in America; played out as the top story on every television and radio network news program; and was a daily item in the local press for months following the storm.

Insurers were quick to respond. Thousands of claims adjusters and agents were on the scene immediately following the storm. Billions of dollars began pouring into the local economy as shelter and food were secured for the victims along with insurance claim payments. As the reports on the extent of the destruction and the number of victims involved became known, it became an almost overwhelming task in some cases just to locate the victims.

Many homeowners unknowingly wrote their insurance policy numbers and company on the sides of their destroyed homes. Some unscrupulous people copied the numbers and company names down, then boldly sought out adjusters from those companies and asked for payments based on the policy numbers. In some instances, it worked.

All eyes were on the insurance industry for months as claims were being paid. Insurers were working in a political as well as human interest arena — with one main goal — to pay legitimate claims as fast and efficiently as possible.

It is over three years since Hurricane Andrew struck. Insurers learned quite a bit about what to do following a major disaster. But, when you have to work in a highly politicized climate, where intense pressure is asserted to suppress premiums and expand payouts, it's easy to understand how some companies might appear to have become risk averse.

After Andrew, Hurricane Iniki struck in Hawaii the same year causing an estimated $2 billion in damage, and the seemingly limitless resources of the industry appeared suddenly paltry in the face of a growing string of events with multi-billion dollar consequences.

In 1993, the trend continued and accelerated in what proved to be another bad year for claims. Insured catastrophe losses reached $5.7 billion following four hurricanes, numerous tornadoes, and massive flooding throughout the midwest. In addition, fire losses for the year reached over $8.5 billion.

But in California, the wake up call of all wake up calls occurred on January 17, 1994, when the City of Northridge awakened to a major earthquake that killed 61 people, and destroyed or damaged more than 200,000 homes, apartments and buildings.

Had it not occurred during the early morning hours of a legal holiday, the numbers of dead and injured almost certainly would have been astronomic. In just 30-seconds, it registered 6.7 magnitude — and became the most costly earthquake in United States history.

During the 25 years prior to Northridge, all insurers in the State of California had collected a total of $3.5 billion in earthquake insurance premiums, and with the exception of the Loma Prieta quake of 1989, it had proved to be a profitable line of coverage. To date, more than $12.5 billion has been paid out in insured damages for the Northridge quake alone, and claims are still being settled. However, Northridge has turned out to be the second most costly natural disaster in U.S. history from an insurance perspective. Northridge, and the certainty of bigger more deadly future tremblers, has radically changed the future of earthquake coverage in the state.

Northridge alone produced claims that exceeded 1994 premiums by 2,300%. One of the state's largest domestic insurers teetered on the edge of bankruptcy from its losses (which resulted from coverage that generated only 2% of their premiums), and several major insurers financial ratings were lowered because of huge loss payouts. That meant then as a group, insurers had less capacity to accept risk because they had fewer assets from which they could pay claims. They had to "put on the brakes."

Following Northridge, many insurers came to the realization that they were overexposed on earthquake insurance and simply could not take on any additional earthquake risk without endangering their existing policyholders.

Under current law, insurers who stop offering earthquake insurance also must stop selling homeowners insurance. As a result, in California today, 93% of insurers who write homeowners insurance have either stopped writing completely, or have placed severe restrictions on writing any new homeowners business. Because of a law that requires insurers to offer earthquake insurance with each homeowners policy sold or renewed, this action was taken to protect existing policyholders.

**10 WORST U.S. CATASTROPHES**

Following is a list of the 10 worst U.S. Catastrophes, in terms of insured losses, since the insurance industry began keeping official records in 1949. The totals are not inflation-adjusted. The industry counts the Laguna ($435 million) and Calabasas/Malibu ($375 million) fires as separate catastrophes and has not given the Altadena and other 1993 fires ($140 million total) catastrophe status. The listing below considers all those blazes in total.

| | |
|---|---|
| 1. Hurricane Andrew (1992) | Insured Loss $15.5 billion |
| 2. Northridge, CA. earthquake | Insured Loss $12.5 billion |
| 3. Hurricane Hugo (1989) | Insured Loss $ 4.2 billion |
| 4. East Coast spring storms (1993) | Insured Loss $1.75 billion |
| 5. Oakland/Berkeley firestorm (1991) | Insured Loss $1.70 billion |
| 6. Hurricane Iniki (1992) | Insured Loss $1.60 billion |
| 7. Loma Prieta earthquake (1989) | Insured Loss $960 million |
| 8. California wildfires (1993) | Insured Loss $950 million |
| 9. Alabama to Oregon freeze (1983) | Insured Loss $880 million |
| 10. Los Angeles Riots (1992) | Insured Loss $775 million |

Source: Property Claims Services, American Insurance Services Group

## Shared Responsibility

The first obligation of an insurer is to protect its policyholders by paying claims fairly and in a timely manner. Should another earthquake the size of Northridge strike in the near future, the financial solvency of many insurers could be threatened, and policyholders may find themselves in a position of not being able to collect for their losses following a major disaster.

Another growing problem within the insurance claims process is the fact that many policyholders are no longer content with merely being restored to the financial position they enjoyed before a disaster. Many expect and feel entitled to "betterment" — something insurance was never meant to cover because it can create an incentive to initiate or cause losses. Their attitude is that if insurance companies have collected premiums for many years without paying a loss, it is perfectly acceptable to overstate claims. Current trends within our society hardly suggest that this line of thinking is unique to the insurance process, but it certainly has added to the multi-billions of dollars paid out in major disasters, adds significantly to the price consumers must pay for insurance products, and poses a serious threat to an industry devoted to providing protection and peace of mind to its customers.

Thus today, we have a two-fold problem that is continuing to grow. First, the insurance industry does not have the financial capability to accept the risk for all forms of misfortune from which people seek affordable protection. Secondly, since 1989, billion dollar plus losses have become commonplace, and insurance claims following natural disasters have risen to the point of threatening the financial stability of insurers.

The challenge now is to find a balance between the risks inherent in living in today's world, and how those risks are shared by policyholders, their insurance companies, and other stakeholders. We must agree on what is fair and unfair when it comes to disasters, and who pays. For instance, should insurers be held responsible to pay for losses above and beyond what was promised in the insurance policy? Should the insured expect to pay low premiums for insurance coverage on properties that clearly stand in harms way year-after-year? Should insurers be forced to accept virtually unlimited risk of loss from wind, fire, earthquake and other perils with regulated prices that often do not come close to reflecting the risk?

Let's look at each issue carefully and shed some light on what must be done in order for insurers to survive and grow while providing vital protection to millions of property owners who choose to live in fire-prone areas, on hilltops, on barrier islands, in dense forests, on earthquake faults, or in flood plains.

## Lessons Learned

The obligation to protect existing policyholders is the highest duty of any insurer. In spite of all of the complexities of the insurance business, there is one very simple exercise insurers can perform in order to decide whether they can "afford" to sell more coverage. First, the insurer lists all assets of the company that could be called upon to pay claims. Below that, it calculates the probable maximum cost of a likely disaster scenario which would obligate the insurer to pay claims. When the second line is subtracted from the first, and the remainder is zero or less, the insurer must take immediate steps to reduce its exposure to loss, or run the risk of not being able to make good on its commitment to policyholders. That is precisely why so many insurers have had to cease writing new homeowners insurance policies in California.

Northridge was not the so-called "Big One." If a truly catastrophic earthquake struck Los Angeles or San Francisco today, the insurance claims costs could easily reach as high as $80 to $100 billion — in 30 seconds. A category 5 hurricane could produce $60 to $80 billion in insurance claims — within 24 hours. What if a major quake and hurricane struck in the same year?

So what does all this have to do with fire? The principles are the same. There is a limited amount of "product" available (dollars to pay claims). So insurers and all of their existing customers are best served when the price charged accurately reflects the risk of loss, and when the carrier does not accept large volumes of new exposure with much higher than average probability of loss. And, the way insurers analyze the probability of future loss is by looking at past experience — and projecting it into the future. Often they assume that society has learned lessons from past mistakes that allowed losses to happen or exacerbated them. But that's not always the case.

Ten months after the Oakland Hills fire destroyed more than 3,000 homes in 1991, more than 12 new homes were totally rebuilt and 400 others were in or near construction. The financial consequences of the fire are mind boggling. Insurers have paid over $1.7 billion in insurance claims. The City of Oakland spent $8.3 million to fight the blaze and suffered a $10 million property tax loss, and millions of dollars more in financial disruptions which were felt throughout the Bay Area economy.

### History Repeats Itself

What have we learned? A report on fire conditions in Berkeley was issued in 1920 warning of hazards that could contribute to serious losses from fire if certain safety measures were not taken to mitigate loss. In 1923, a fire struck the area causing serious loss, and another report was filed reiterating that under the same conditions, a fire could happen again. It did happened again in 1970 and in 1991, in spite of the fact that warnings had been given, the loss was enormous.

The area was in the midst of a five year drought when the 1991 fire struck. The structures in the fire area were built between 1921 and 1991. Most appeared to be wood frame with stucco, wood panel, wood shingles, or brick veneer siding. Roofs varied from asphalt shingles and ceramic tile, to wood shake. The vegetation in the area was extremely thick and dry, and many trees bore dead leaves, twigs, and limbs. Add to the scene the problems of narrow streets, limited water supply, and one can readily understand how a small trash fire could suddenly be rekindled into a deadly $1.7 billion inferno.

During the Oakland Hills fire, fire apparatus could not pass fleeing vehicles on narrow roads leading to and from homes, resulting in traffic jams. Eleven of the fire victims died as flames caught up with them while they were trapped in a traffic jam. Eight others died on narrow streets in the same area. The Oakland Hills fire was the equivalent of several years worth of insured losses occurring in a single day.

What lessons were learned from the 1991 fire? There are greater property values and more lives at risk than before the fire. Yet, we can see dense dry foliage building up and the same narrow streets are knowingly being exposed to the same risk — which the property owners want insurers, tax payers, and the fire services to assume. Much to the credit of officials in the City of Oakland, there have been some signs of addressing the problems, but there still is a lot more work that remains to be done. Old problems are compounded by putting more and more people and property at risk in the I-Zone.

According to the California Department of Forestry and Fire Protection, more than 60 percent of all homes in California lost to wildfire since 1923 have been lost in the past six years. In fact, more than 8 million people in California — one in four residents —now live in the I-Zone. People who live in these areas are almost twice as likely to die from fire as city residents, according to a National Association of State Foresters report presented to Congress in 1994.

### Individual Responsibility

Probably the most important cost factor next to insuring homes in wildland areas of California is the cost involved in fire suppression and fire fighting. It is a planning issue that many communities are beginning to address since the fires in Southern California. How much are taxpayers willing to pay for people who build in wildland interface areas?

Today, large stands of timber burn while fire fighters rally to protect a few dozen homes. Fire fighters are having to fight home fires along with forest fires — a feat which has challenged the way wildfires traditionally have been fought. Living in canyons, hills, forests, and on grasslands is a gamble with Nature. So, homeowners who choose to live in these areas should be willing to accept special responsibility — by doing all they can to mitigate the fire risk by building safely and clearing the landscape.

In an era of finite resources, and when the ability and willingness of consumers to pay for the transfer of risk is limited, all parties must work towards more reasonable and equitable procedures for coping with risk. Nevertheless, the Oakland Hills conflagration has been a learning experience for insurers.

Many companies have already instituted improvements. A study conducted by the Research Committee of the Society of Chartered Property and Casualty Underwriters (CPCU) evaluated the insurance industry's response to the insured following the Oakland Hills fire. The study found that most of the insured clients do not read their insurance policies until after a loss occurs. In addition, there was great confusion between stated value policies and replacement cost coverage. Insurers learned that they perhaps didn't ask enough questions at the time insurance policies were sold, or discuss soon enough exactly what coverage was provided in the policy. The conclusion was that early communication, which includes educating policyholders even before an event like the Oakland Hills fire happens, is imperative. Legislation was also passed by the state Legislature mandating disclosures of policy coverages and defining terms such as replacement cost coverage.

Barely ten months after the Oakland Hills fire, as insurance claims adjusters were still paying claims following the Oakland/Berkeley conflagration, brush fires swept through Shasta County in Northern California. More than 64,000 acres of forest land was scorched and 636 buildings were destroyed. The insured losses from the fires reached $19 million. Further tests of resilience for homeowners and insurance personnel took place two years after the Oakland Hills/Berkeley fire in what has become known today as the Southern California conflagration in 1993.

Twenty-one fires, some deliberately set, destroyed or badly damaged at least 537 homes and forced some 30,000 people to flee danger areas. The fires were among the worst in this century, as insured losses reached an estimated $950 million — more than the 1992 Los Angeles riots at $775 million — and rank as the second costliest series of fires since the insurance industry began keeping official fire insurance loss records in 1949.

The fires first struck in Los Angeles and Orange Counties, devouring 40,000 acres and over 150 structures. The next fire struck Riverside County and burned 57,500 acres along with 150 homes, buildings, and one trailer. In San Bernardino, San Diego, and Ventura Counties fires destroyed almost 100,000 acres of land and 118 homes. The fires required more than 15,000 fire fighters and 905 fire engines. Four people died and 160 were injured in the 21 fires, 10 of which were confirmed as arson.

With the frequency and severity of catastrophes growing exponentially, the issue is not whether the insurance industry should assume more and more of the risk in California. It is an issue of capacity. The financial wherewithal of insurers must be strong to pay for untoward events when they happen. Otherwise, the promise of protection becomes an empty one.

## The Fire Service Model

The importance of insurer "capacity" can best be illustrated by looking at it in a way similar to that used by the fire service to analyze the resources needed and required to protect a community.

Obviously, the more developed an area becomes, the more people are attracted to live there, and the more fire protection is needed. But, if financing fire service is hindered in any way, and there are not enough fire trucks, hoses, and water to safely fight a fire, it could result in some very hefty lawsuits against local officials as well as fire service personnel. After all, it is their duty to serve and protect. Hopefully, this scenario will never happen, but it serves to illustrate a very important point regarding insurers. Insurers face the same dilemma in providing protection. The more risks insurers assume, the more resources must be available to respond to claims producing events.

At the same time, a compelling argument can be made that insurance protection should be made available even to those individuals with the greatest risk to loss. Since no individual company wants to knowingly select bad risks, a mechanism known as the California FAIR Plan was established in 1968 as an insurer of last resort for fire risks. Following the Northridge quake in 1994, earthquake insurance was added to the plan and offered throughout the state.

However, the FAIR Plan does not solve the capacity problem of insurers in California. In fact, it makes it worse. The Plan, which charges break-even-rates to homeowners and business owners, is intended to be self-supporting. However, when fires such as those in Southern California, or earthquakes such as Northridge occur, losses from the FAIR Plan exceed the Plan's ability to pay. The shortfall however, is made up through a special assessment against all insurers who sell homeowners insurance policies in the state.

It's a back door Catch-22 for insurers who also must pay their policyholders claims following a disaster. Policies continue to be written in the Plan imposing "risks" upon insurers through the back door that they would have or already have declined through the front door.

## Cooperative Solutions

In the 1995 Legislative Session, the California State Legislature considered several measures aimed at re-opening the homeowners insurance market in the state and resolving the earthquake insurance dilemma. Both houses in the final days of the session passed two measures, one known as the earthquake mini-policy and the other as the California Earthquake Authority (CEA).

The mini-earthquake policy is just what it sounds like — a basic, no frills policy that includes coverage solely for the structure of homes and no appurtenant structures. It also provides $5,000 in contents coverage, and $1,500 in additional living expenses. Additional coverages may be available from individual insurers.

Obviously, this measure, which takes effect January 1, 1996, will have an overall mitigating effect on the current earthquake insurance exposure of insurers in California. It is however, no guarantee that insurers will re-enter the homeowners insurance marketplace by selling new policies as the measure does not broaden the spread of risk. On January 1, 1996, insurers will have the option of adopting the mini-policy. Each company will have to receive approval from the Insurance Department before placing the policy in effect.

The CEA bill, as proposed by Insurance Commissioner Chuck Quackenbush, would be a publicly run/privately financed venture designed to meet the earthquake insurance needs of homeowners, mobilehome owners, and renters in the state. Its ultimate purpose is to produce a broader spread of risk, thus making the impact of loss less severe in future disasters.

The CEA bill authorizes the commissioner to begin setting up four major parts of the CEA that must be finalized before the Legislature reconvenes in January. If the four parts are completed, the next session of the Legislature will consider passage of a bill that will allow implementation of the CEA. When operational, all earthquake policies written by participating insurers will be transferred into the CEA upon renewal. Participation by insurers is voluntary and some insurers will choose to continue writing earthquake policies on their own. However, operation of the CEA is contingent on the participation of insurers representing at least 75% of the residential property insurance market. In addition, the CEA will then begin selling earthquake insurance policies throughout the state to homeowners whose residential property insurance is provided by a company that is a participating member of the CEA.

The passage of these two measures are small steps towards helping to re-open the homeowners market in California, but do not even begin to solve the threats of mega-disasters that plague our country. The ultimate solution lies in a federal government/private industry partnership that will eventually provide insurance coverage for disasters to all Americans. The Natural Disaster Protection Partnership Act (NDPPA), currently being considered by Congress, will help reduce the increasing costs of taxpayer-subsidized federal disaster assistance by promoting greater personal responsibility by those living in risk-prone areas.

Two bills, HR-1856 and a companion, S-1043, have been introduced into the U.S. House and Senate. The bills would condition federal disaster assistance on the purchase of insurance offered by a new, private non-profit corporation known as the Natural Disaster Insurance Corporation (NDIC). The corporation would provide direct coverage to homeowners for residential losses caused by earthquakes. It is possible that the corporation could also become a direct writer for flood insurance which is currently administered by the Federal Emergency Management Agency (FEMA).

Meanwhile, the unavailability of homeowners insurance will in time have a profound effect on the economy of California. Real estate markets in some areas of the state are becoming restricted, and construction, banking, finance, employment, and taxes collected by the state will all eventually be affected if we don't find ways to address the issue.

## Summary

The concept of sharing risk isn't terribly complex. But it is widely misunderstood. It doesn't mean absolute transfer or betterment. Perhaps the insurance industry has not done a good enough job in educating its customers, because then we would realize that how and where we live frequently puts us and our possessions in harms way.

Life is a series of choices. Everyday we make choices about how we will deal with risk. We cross streets in the middle, we choose to earn money in a passbook account or stock market, or we invest in commodity futures. Unfortunately, we may give more thought to those decisions than where or how we build our homes.

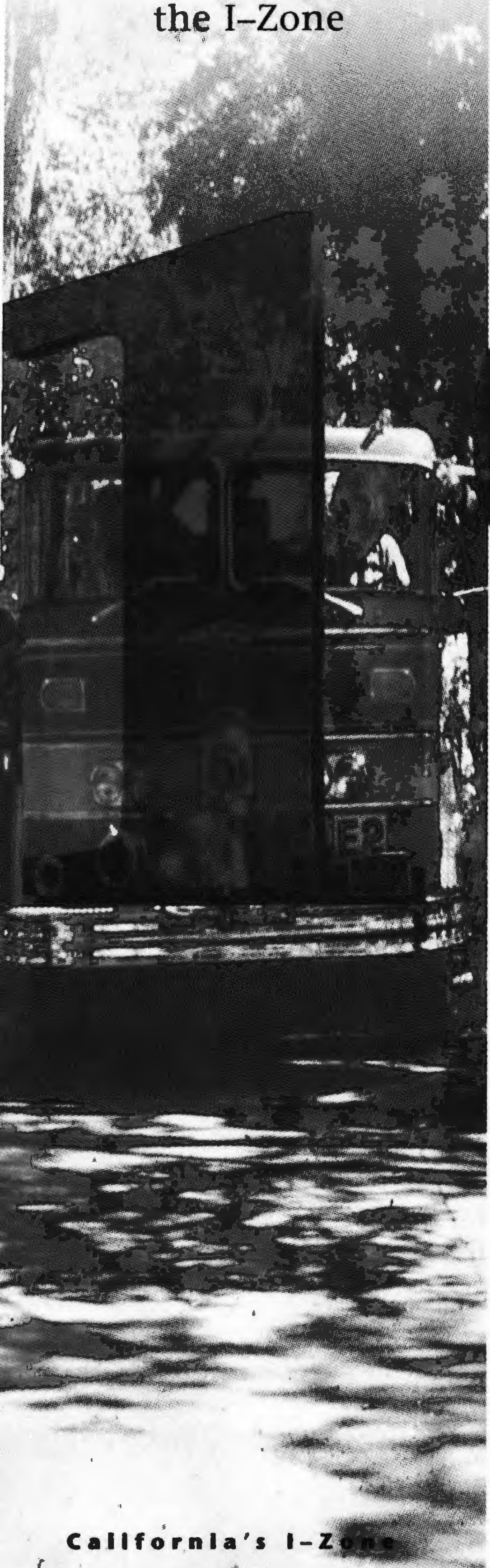
At the second annual Congress on Natural Disaster Loss Reduction, Professor Haresh C. Shah Obayuashi, professor of engineering at Stanford University and director of Risk Management Solutions, said Americans have been used to building "what they like, where they like and how they like, without ever considering the risk and cost of mitigating that risk."

Insurers and the fire services of California must work together to educate citizens who ignore warnings and invite disaster. The costs for such actions in the future may be a greater share of the responsibility for loss by the homeowner who chooses to live in disaster-prone areas.

Regardless, we have a big job to do in educating the public on nature and the inevitable consequences of risk— and the value of preventing and/or mitigating risk before the disaster.

# Becoming aware of regional watershed management may be useful to understanding the I–Zone

By **Glenda Humiston**



Watershed-based planning is not a particularly new or exotic approach to natural resource management. Some State and Federal Agencies— notably local Resource Conservation Districts and the US Departments of Interior and Agriculture— have sposored watershed-based projects for decades.Unfortunately, fuel load management has rarely been an importantgoal of such efforts. Watershed-based management is the most effective way to enhance water quality and natural resources, protect critical terrestrial and aquatic habitat, prevent soil erosion, and sustain resource-based economic activities while concurrently managing the pressures of an increasingly urbanized landscape.

Watershed planning encourages an understanding of the full magnitude of various natural resource characteristics that may affect ecosystem viability and human health. Local watershed efforts also facilitate site-specific solutions rather than the "one-size-fits-all" programs typically mandated by state or federal government. As these diverse issues and the resource base itself are understood, agencies and local interest groups are better able to prioritize and implement management practices that will produce measurable improvements.

Administratively, watershed planning can greatly improve efficiencies. It encourages organizations to focus staff and financial resources on prioritized problems, promote preventative efforts and facilitate cooperation as well as coordination of resources among interested parties. It also offers an opportunity for the local community, local agencies and interest groups to take leadership roles in resource protection and develop a long-term stewardship ethic.

Experience clearly shows that public education and outreach coupled with widespread community participation will strongly determine the success of a watershed effort. Without public understanding and support, projects rarely get past the planning stage. Implementation requires that local government and affected citizens have "ownership" of any recommended projects and long-term resource management efforts. For example, it can be virtually impossible to implement best management practices (BMPs) for nonpoint source pollution control without the support and cooperation of private land owners. Additionally, use of extensive volunteer networks can significantly reduce the demand for shrinking government dollars and leverage agency staff expertise into much broader implementation effort.

### Fuel Load Management:The Big Picture

Although watershed management has traditionally been utilized for dealing with water quality and/or endangered species concerns, there are also significant forest health problems and concern with wildfire effects that would benefit from such large-scale planning and community involvement. These problems are substantially increased as more and more people build homes in the "urban/ wildland interface zone", hereafter called the "I-Zone". Not only do fires historically burn every few decades in this I-Zone, greater demands on the natural resource base and shrinking fire protection budgets greatly magnify the issues and concerns.

In deciding where to use limited firefighting resources, current policy is to focus first on protecting life and property. However, the training received by most wildland firefighting personnel emphasizes protection of natural resources; these crews typically do not have the equipment or other equipment to effectively fight numerous structural fires during large wildland fires in the I-Zone. Under such circumstances, city and county fire departments cannot realistically be expected to protect every home either. It is vital that the general public begin to understand and implement basic fire prevention and fuel load reduction strategies.

A watershed management approach should include fuel load management as a integral piece of overall resource management — thereby reducing duplication in data collection, planning efforts and development of funding sources. Conversely, any attempt at developing a fuel load management strategy should operate in the context of the larger watershed issues. This would ensure that actions taken to resolve current forest health and fire risk problems do not result in a different set of resource problems in the future. Additionally, any entities working to improve water quality, enhance wildlife habitats or operate agricultural operations should then be able to simultaneously accomplish fuel load strategy goals with reduced cost and effort.

### Putting the Effort Together

A common theme among successful watershed efforts is the involvement of personnel from multiple agencies and organizations in decision making roles and subsequent implementation activities. However, the structure that evolves to manage watershed projects can vary significantly from site to site. For example, project administration may be centralized in a single agency — such as the Coastal Conservancy or the Bureau of Reclamation — or run at the local level with the support of numerous agencies and organizations. Plan development may be highly formalized, with contractual agreements and strict legal requirements, or may be organized around informal networks of citizens with local officials ensuring coordination.

Creating a formal action plan clarifies for everyone involved exactly what problems have been identified, which actions will provide solutions, and how implementation will be accomplished. Such a plan also allows all affected parties (e.g., industrial dischargers, farm groups, urban developers, etc.) to see that they are not the only individuals who are being asked to change management practices or pay for resource enhancement activities. More importantly, a clearly defined action plan also demonstrates to the public and political interests that viable natural resource management is feasible - thereby reducing calls for more regulatory action and encouraging cooperation and public participation.

Regardless of how the watershed effort is organized, the key is to involve the public extensively in all aspects of a watershed project; roles and responsibilities must be clearly defined and partnerships forged. For example, the formation of citizen review groups and technical advisory committees will assist in identifying the diverse interests and needs throughout a community and promote support for future recommendations and their implementation. These participants will also provide a core group of knowledgeable community leaders to keep the project going once agreements have been reached and implementation begins. Furthermore, widespread community support for a watershed effort is often very important to secure funding and other forms of assistance from various sources.

An extensive watershed management effort, even within a small watershed, will require significant funding from multiple sources. Few watershed efforts can access sufficient federal and/or state funding for all phases of the project. It is best to organize recommended activities into distinct categories, then to target funds that match that category. Not all activities require "cash" funding; some may be completed by the work of cooperating agency staff, in-kind donations from local businesses or through the use of volunteers.

Citizens can provide valuable support to the project through a variety of activities. For example, citizen monitoring programs have recently achieved widespread acceptance by most agencies and have moved into the realm of biological monitoring with training from experts. Guidance and technical transfer information is available from a variety of sources for many activities. In addition to citizen review committees, a well organized watershed effort can utilize volunteers for many important activities.

### Watershed Management Basics

Which methodology will work best for a particular watershed depends on many factors. The size and complexity of resource problems will suggest what administrative model might work best. The presence of specific issues will require participation by affected interest groups and responsible regulatory agencies. Political pressures will dictate the degree and patterns of public involvement as well as future support for any recommendations. Different efforts will:

> work exclusively to develop a very detailed plan, with specific projects called out, then go through an extensive public review process to adopt the plan but leave the actual document for others (usually local lead agencies) to implement
>
> divide planning and implementation into two very distinct phases yet keep an advisory committee of agencies and interest groups together for both phases
>
> act as a "lead agency" for all aspects of the effort, including planning, outreach, technical expertise, developing funding sources, managing projects, monitoring, etc.; or
>
> coordinate a large coalition of local, state and federal agencies, special interest and private sector groups that work cooperatively to study, plan, implement and build support for ongoing watershed enhancement efforts.

It is very important to realize that there are limitless variations on how an individual effort can be organized. There is no absolute "right" or "wrong" way to organize, facilitate or implement a watershed management effort. However, although each watershed management plan will be unique, there are some important steps that are universal. These items are presented in a roughly chronological order although they typically overlap each other a great deal. There may also be different lead agencies, or facilitators, for the various activities and timelines can vary widely — for example, some studies may have been done years earlier but still remain valid.

### Organize Administrative Structure

Prepare a plan for how you will proceed with your effort. Make sure it includes measurable milestones, to ensure that the project moves forward on schedule and within available budgets. The plan should contain a description of the reporting and communication procedures, potential funding sources and methods for managing the project on schedule. Particular funding sources may dictate how some aspects of your management and administration is organized; this will be very important during grantwriting.

### Involve Key Stakeholders

A Task Force (i.e. Advisory Committee, Steering Committee, Board of Directors, etc.) should include representatives of all organizations concerned with use and management of the watershed. The Task Force can be supplemented by several technical committees assigned to assess specific issues (e.g. cattle grazing, recreation, timber production, fisheries, endangered species, etc.). Such committees can compile information, analyze technical issues, evaluate management options, and make recommendations to the Task Force for ratification. Ultimately, a consensus plan should be agreed upon. Key tasks that must be accomplished include:

Provide Consensus Training Meeting

Conduct a Stakeholder Analysis

Prepare Ground Rules, a Mission Statement and Sequence of Meetings

Prepare Agenda and Briefing Materials

Facilitate Task Force Meetings and Selected Technical Committee Meetings

Debrief Meetings and Identify Technical Information Needs

Provide Guidance and Information for Technical Committees

Prepare a Draft of the Proposed Recommendations for Public Review

Conduct Watershed-Specific or Issue-Specific Workshops for the Public

Process Comments Received and Make Appropriate Changes to Draft Plan

Document Ratification of the Draft Plan and Begin to Obtain Official Sanction

### Technical Data and Field Surveys

Field surveys should identify and qualitatively evaluate current watershed conditions including location and extent of problems, nature and extent of natural resource habitat, and effectiveness of existing management strategies and practices. Much of this data may already be available from various government or private sources; other information may be outdated or need to be collected. It is best to utilize a central Geographic Information System (GIS) to store and process all technical information collected. A thorough natural resources assessment is very important; it will support the concurrent preparation of an Environmental Impact Report (EIR) as well as affect the future selection of appropriate resource management practices. Some of the information that should be collected and considered includes:

**The waterbodies:**
Biological: pathogens, aquatic organisms, species composition, etc.
Chemical: nitrogen, nitrates, phosphorus, minerals, toxics, pH, etc.
Physical: temperature, turbidity, velocity, width/depth ratio, channel morphology, etc.

**The flora and fauna:**
types of upland and riparian vegetation, percent of ground cover, native vs. non-native vegetation, species mix and composition, existing and historic wildlife patterns, numbers, etc.

**The natural resource base elements:**
topography, ground water basins, earthquake faults, fire or flood zones, soil types, mineral deposits, wind and weather patterns, temperatures, etc.

**The managed landscape:**
ownership, zoning, resource uses, infrastructure, population, political subdivisions, etc.

It is also important to identify data gaps and additional assessment needs that may have to be postponed temporarily. Concentrating efforts in a specific area can allow smaller projects to move forward while other information is being processed.

### Analyze Watershed Use and Activity

Watershed management practices and policies will depend, in large part, on land uses, economic activities and political realities occurring in the watershed. These various factors must be clearly identified and understood before policy changes or agency coordination can be considered. Fuel load management and associated resource issues should pay particular attention to:

water quality planning and control actions;

habitat and species concerns and needs;

potential economic development options for biomass produced;

Fire protection/prevention needs of structures; and

Opportunities for incentives for homeowner implementation: insurance rates, economic development, enhanced tourism appeal, jobs, etc.

In addition to the above areas, it is also important to gather information on the following items and analyze it for implementation options:

identification of existing effort and opportunities for coordination

methods to appropriately allocate organizational resources within the watershed

methods to prioritize sites for local action and encourage voluntary implementation

One method of accomplishing this task is to utilize the Task Force in creating a matrix of the various agencies and organizations in the watershed. Gathering the information will allow all participants to better understand the function and resources of the various entities. Once collected, this information can then be used to identify duplication of effort, opportunities for collaboration and sharing of resources. An example of this type of matrix, being developed on the Russian River Watershed Effort.

Development of this planning matrix is an opportunity to build relationships between agency partners and local watershed groups. The information is invaluable when coordinating the myriad of activities that will be necessary for successful implementation of future projects. It can also significantly reduce duplication of efforts while making optimum usage of limited human and financial resources. After identifying the various agencies and interest groups that will need to participate in the watershed effort, it will be necessary to interview them and gather the following information: (questions may differ due to special circumstances)

**Project Management:** What projects and/or facilities in the watershed are you currently managing, operating or constructing? What future projects are planned?

**Resources Inventory:** Are you currently conducting any inventory, surveys or other data collection in this watershed? Have you done any of these activities in the past?

**Resources Data / Information:** What information and/or data do you already have available concerning natural resources in the watershed (including tributaries)? How can this information be accessed? Location? Cost? Contact? Catalog / List?

**GIS Capability:** Is this information available electronically? How can we access?

**Education Outreach:** Do you conduct any educational outreach? Does your staff give public presentations? What is the name and phone number of the best contact?

**Education Materials:** Do you produce educational materials or public information?

**Technical Assistance:** What technical assistance do you provide watershed efforts?

**Financial Assistance:** Do you offer any grants to agencies and/or non-profits?

**Staff:** Do you have any staff working on resource related issues in the watershed? Have you entered into any Interagency Personnel Agreements?

**Permits:** Are you responsible for administration of any permits or regulatory actions? Who is the best contact person(s) for specific information regarding this?

**Resource Conservation and/or Preservation:** Do you purchase and/or accept donations of conservation easements or land for preservation purposes? Do you have future plans for this? Do mitigation conditions you impose preserve resources?

**Monitoring:** Do you monitor natural resource conditions and/or compliance?

**Volunteers:** Do you utilize and/or provide volunteers for watershed related work?

**Advocacy:** Does your agency monitor legislation or other public policy discussions? Would you be able to write letters of support for appropriate grant applications?

**General Questions:** In general, is your agency supportive of locally-led, watershed based resource management? Are you interested in participating in a partnership for the Watershed Effort? Are there any internal issues, specific to your agency or group, that would affect your ability to be a committed partner in the Watershed Effort?

### Develop Watershed Management Policies

The evaluation of a watershed should lead to the development and selection of watershed management policies and recommended practices, such as shown in figure 5. Some policies will require new structures and/or legislation. Such policies should include:

A description of identified implementation procedures and programs of Federal, State and Local agencies, and other potential implementing organizations, and of each identified potential funding source.

A brief explanation and justification as to recommended fuel load management practices and why or how any factors constrain potential effectiveness and feasibility of implementation.

Any changes in legislation, regulation, agency guidelines, administration, policy, financing, inspection, enforcement, surveillance, education, research and technical assistance that are needed to make the procedure or program work effectively.

All organizations, programs, and procedures which are recommended for implementation, including recommended approaches for:

> Individual homeowners and/or local groups to participate.
>
> Developing and implementing local tributary watershed management projects.
>
> Incentive programs, including but not limited to: reduced insurance rates, jobs creation, economic development, enhancement of natural resources, etc.

Recommendations for interorganization reporting, coordination, and administration.

A proposed continuous planning process and monitoring program for:

> Evaluating the success of program and implementation procedures;
>
> Adjusting the plan and implementation procedures as necessary; and
>
> Any further studies that will be needed.

### Draft Plan for Public Review

To ensure future support for the recommended practices and projects it is of vital importance that the report also receive widespread circulation throughout the general public. This should include public meetings, fact sheets, newspaper articles and other media coverage. In addition to general public review there are legal review requirements that must be followed in order to receive required permits and governmental funding.

Based on preliminary description of watershed management practices, a Notice of Preparation (NOP) should be drafted which includes a list of environmental impacts to be addressed in the program EIR using the State Clearinghouse format. The NOP should then be distributed to a mailing list formulated by the lead agency and supplement with names of property owners in the vicinity of the project potentially affected by the watershed management practices. It must also be sent to the State Clearinghouse for distribution to all potential affected state agencies. Scoping meetings should arranged to allow opportunity for all potentially affected parties to request that the EIR include a discussion of matters of concern to them.

The draft EIR should be mailed to the above noted persons and agencies requesting written comments be submitted within a 45-day period. CEQA guidelines require public hearings be held on EIR's. The draft EIR together with the comments, both written and from the hearings, and their responses will constitute the final EIR document. Although this process is specific to California law, satisfying requirements under the National Environmental Protection Act (NEPA) is very similar. There are variations in terminology and timelines.

**Implement Recommended Practices**

Management practices can be any practices or methods that suitably address the goal of maintaining or enhancing the sustainable health of our natural resources. The diversity of natural resources and types of land uses within California make it impossible to set specific standards and specifications for these practices at the state or, often, even regional level. In selecting which management practices to use, the overall objectives of the watershed must be taken into consideration and standards must be established at the most local level possible.

These practices may come from established management approaches, such as those found within the USDA Natural Resources Conservation Service (NRCS) Field Office Technical Guides, or from the landowner's own initiative. The following practices include some examples of management activities typically utilized:

Management of resource-related operations

This includes practices which affect the control, time, frequency, or intensity of agriculture, silviculture, commercial fisheries, mining or recreation to protect soil, water quality, air quality, wildlife species and maintain or improve the quantity and quality of desired vegetation. Siting buildings, and other facilities, in appropriate locations can also produce beneficial results as can controls on recreational activities.

Structural improvements

Infrastructure includes bank stabilization devices, water development, exclusion fencing, erosion control structures, road repair, fish ladders, etc. These practices should be constructed, and used in a manner that enhances or maintains multiple resource benefits.

Land treatment

Land treatments, such as burning, mechanical manipulation, seeding, weed control, fertilization, etc., may be used to manage vegetation, reduce erosion, improve wildlife habitat and/or reduce fuel loads for both public and private lands.

A viable watershed management plan must also include any necessary changes to policy and legislation that will encourage implementation. For example, state and local governments need to address building codes necessary for "firewise" construction and for providing adequate access into the I-Zone areas for evacuations and fire equipment. There may be need for agreement between CalTrans, local Public Works Departments and fire prevention agencies on how roadside vegetation is to be managed. Land use policies and provisions for rural road construction may require some modifications.

Coordination between various agencies should be established to reduce confusion and incompatible policies. Questions concerning whether a required firebreak can be also be considered an illegal "take" of endangered species, or a contributor to water quality degradation, should be resolved between the respective agencies before individual homeowners become entangled. All parties involved with fuel load management need to increase public education outreach to assure better understanding of fire prevention needs and how fuel load management fits within the watershed's efforts.

Funding for recommended implementation is a continuous problem. A mix of local, state and federal funding sources will usually be required and must often be matched by significant dollars from the private sector and/or individual landowners. To access state or federal sources typically requires preparation of a proposal for some form of competitive grant process. Those programs supporting watershed activities include:

California Coastal Conservancy
Coastal Zone Habitat Enhancement

*Purpose:* To enhance and restore habitat through a variety of measures and physical enhancement of the sites either through grants or directly by the Conservancy.

*Information*: Sites must be in the California coastal zone or in the jurisdiction of the San Francisco Bay Conservation and Development Commission. $100,000 maximum for enhancement plan preparation with at least 50% funding match.

California Department of Fish and Game
Inland Fisheries Division Grant Program

*Purpose:* Grants for fishery restoration work to enhance, develop or restore flowing waterways for the management of fish and outside the coastal zone.

*Information:* Anyone may apply, action projects preferred to studies, evaluations or monitoring. Approximately $250,000 available per fiscal year.

California Department of Forestry and Fire Protection
Stewardship Incentive Program

*Purpose*: Assist landowners to improve forest land.
*Information*: Landowners cannot have over 5,000 acres; most are given to owners of 1,000 acres or less. Not available to large corporations. Cost-share grants, 75% to 25%.

California Department of Parks and Recreation
Habitat Conservation Fund Program

*Purpose:* Provide funds for a variety of habitat conservation projects. Eligible projects include: habitat for rare and endangered, threatened and fully protected species; wildlife corridors and urban trails; wetlands; aquatic habitat for spawning and rearing anadromous salmonids and trout species; and riparian habitat.
Information: 50/50 matching program and the match must come from a non-state source. $2 million available through FY 2020.

California Wildlife Conservation Board
California Riparian Habitat Conservation Program

*Purpose:* Protect, preserve, restore and enhance riparian habitat throughout California.
*Information:* The program can use fee acquisition, easements, management agreements, exchanges, gifts, and grants to meet the program goals.

United State Department of Agriculture, Consolidated Farm Services Agency, Agricultural Conservation Program

*Purpose:* To protect farmland from erosion and provide cover or food for wildlife.
*Information:* Participants receive cost-share payments up to 64% of projects on eligible land with a maximum of $3,500 annually. Match may be in labor, materials, or cash.

United State Department of Agriculture, Natural Resource Conservation Service, Emergency Watershed Program

*Purpose:* The Emergency Watershed Protection Program, EWP for short, was set up by Congress to respond to emergencies created by natural disasters. It is designed to relieve imminent hazards to life and property caused by flooding, fire, earthquakes, etc.
*Information:* All projects undertaken must be sponsored by a political subdivision of the State such as a city, county, or a special district. EWP funds cannot be used to solve problems that existed before the disaster nor can they be used to improve the level of protection above that which existed prior to the disaster. All work must reduce threats to life and property, be economically and environmentally defensible as well as sound from an engineering standpoint.

United State Department of Agriculture, Natural Resource Conservation Service, Water Bank Program

*Purpose:* Preservation, maintenance and improvement of important migratory waterfowl, nesting breeding and feeding wildlife habitat

areas in flyways through long-term agreements with landowners.
*Information:* Land eligible for the program must be privately owned inland fresh water wetlands suitable for migratory waterfowl habitat. Adjacent privately owned land may be included in program. Participants agree not to burn, fill or destroy wetland character of area, or use for agricultural purposes.

United State Department of Agriculture, Natural Resource Conservation Service, Wetlands Reserve Program
*Purpose:* Restoration and protection of farmed wetlands on private property. Through this program, the USDA plans to restore and protect at least one million acres.
*Information:* This a voluntary program offering farmers an opportunity to retire marginal cropland by establishing permanent or 30 year conservation easements on farmed wetlands and wetlands converted to cropland prior to December 23, 1985. Farmers receive cost share payments equal to 75% of the cost of restoring wetlands on farmland.

United State Environmental Protection Agency
Clean Water Act
Section 604(b) Title VI Water Quality Management Planning:
*Purpose:* To carry out water quality management planning.
*Information:* Funds can be used to determine the nature, extent, and causes of water quality problems. Funds can be used in identifying cost effective and locally acceptable nonpoint measures to develop an implementation plan to implement such measures.

United State Environmental Protection Agency
Section 319(h) Nonpoint Source Implementation
*Purpose:* To implement the nonpoint source management program.
*Information:* This section awards fund implementation of approved NPS Management Programs, and can be targeted at particular watersheds. Activities can include post-implementation monitoring. A portion of 319(h) grants may be used for ground water assessment as part of an approved comprehensive NPS pollution control program.

United State Environmental Protection Agency
Wetlands Protection Program
*Purpose*: To protect and enhance wetlands
*Information:* Funds can be used to provide technical assistance on effective river corridor/watershed management planning. Wetlands protection funds can be used for activities involving targeted watershed such as advance identification, targeted Section 404 enforcement actions and education/outreach programs. Funds can be used for Section 404 compliance monitoring programs for specific priority watersheds.

Full implementation of a far-reaching watershed plan will also require private funding sources such as foundation grants, private donations, landowner contributions and volunteer time. Various types of assessment districts can provide a mechanism to generate local funding for long-term or large-scale projects. Well-organized administrative structures will allow for extensive use of volunteer efforts.

### Monitor Progress and Revise Plan

As implementation proceeds, it is extremely important that adequate monitoring be performed at all levels to:

Categorize current status/condition of waterbodies, riparian areas, upland vegetation, infrastructure, etc.

Disclose off-site uses and unplanned disturbances (fire, floods, drought, insects, freezes, etc.) that influence natural resource conditions.

Document implementation of management strategies and/or management practices;

Measure the effectiveness of management practices over time (trend) for use in an adaptive process where monitoring may indicate a need for management changes to meet desired objectives (plan - implement - monitor - replan).

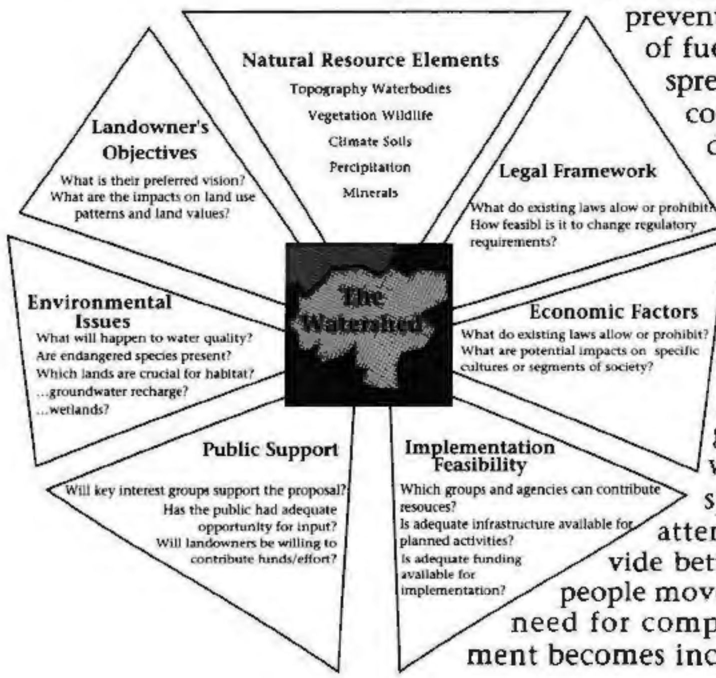
The key to monitoring success is consistency of measurements and a commitment to long-term monitoring. Watershed-based efforts must agree on common criteria and methodology for all participants to utilize. It is usually best to utilize simple monitoring processes and move to more complex or detailed programs as required by specific situations. For example, systematic use of photographs and recording observations can often provide inexpensive yet adequate documentation for riparian areas, vegetation status, and structural effectiveness.

Key indicator sites can provide multiple stakeholders with detailed information necessary to understand changes and conditions throughout the watershed. "When" and "how" decisions must be made after identifying "why" and "where" and should fit each individual case. It is reasonable to assume that the process of testing and revising of monitoring approaches will continue as knowledge and experience increases. Locally suited monitoring approaches and materials are generally available from local Cooperative Extension and NRCS offices.

### Summary

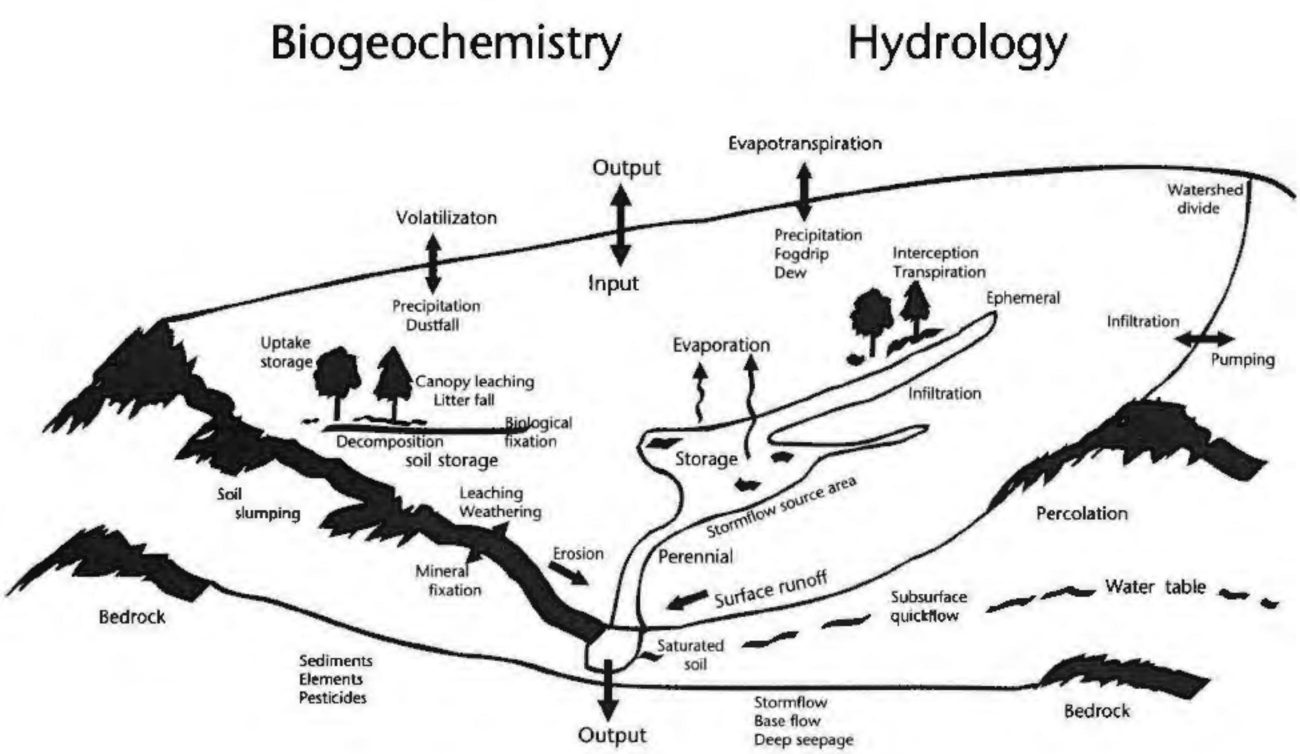
Watershed management is not a panacea for all the ills facing our natural resources, nor will it completely resolve the problems associated with shrinking budgets and an increasing demand for

**Figure 1:**Factors influencing Watershed Management




fire protection services. Used effectively, watershed planning and management can increase the level of participation and understanding from landowners, and other agencies, for preventative efforts. It can also improve understanding of fuel load management issues and generate widespread public support for recommendations. Better coordination between public agencies can reduce duplication and contradictory mandates,thereby more efficiently using limited resources.

This chapter lays out the basic guidelines for a successful watershed effort. The success of any such attempt will depend on the willingness of the affected interest groups and the responsible agencies to sit down and discuss competing needs and creative solutions. Avoiding turf battles among agencies, or interest groups, concerned with habitat enhancement, water quality, threatened and endangered species, visual aesthetics and air quality will make attempts to manage fuel load more viable and provide better utilization of firefighting resources. As more people move into the wildland areas of California, the need for comprehensive fuel load and watershed management becomes increasingly unavoidable.



Understanding the application of marketing and psycho-social behavior is key to developing community based I-Zone mitigation.

By **Ronald Hodgson**

# 20

Among the 10 Standard fire fighting orders one finds the command, "initiate all action based on current and expected fire behavior." Effective fire management depends on how well strategy and tactics conform to the specific situation of weather, topography and fuels. The wise fire manager gets to know fire very well. Large wildland fires cannot be overpowered. They are contained only by knowing how they will behave and where that behavior can be turned to the fire fighters advantage.

Human behavior is as complex and variable as fire behavior. Fortunately, at least in the applied behavioral science- areas of social marketing, public communication campaigns, and innovation diffusion, we know about as much of human behavior as we do of fire behavior. We can predict the spread of new ideas and practices (like defensible space) through social systems (such as communities in the I-Zone) and we can prescribe actions to accelerate or reduce the rate of spread of the idea, or alter the effects of adoption of the idea on the community.

Just as fire management is done best when strategy and tactics are based on known and predicted fire behavior given the principles of fire behavior and the particulars of the situation, marketing of wildfire defenses is best done when the strategy and tactics are adapted to the special nature of the target communities and based on sound principles of human behavior.

In this chapter, some guidelines are discussed for successfully promoting the adoption of vegetation management and structural defense. The guidelines are based on theory but they have all been tested in real communities with real people and shown to work. The US Forest Service and California Department of Forestry and Fire Protection are using these principles successfully in communities like O'Brien Mountain, Smiley Park, Sierra Springs, and Shingletown.

**Identiyfy & Solve The Real Problem**

Almost every year, California television screens boil with images of towering flames, burning buildings, and devastated people amid the ruins of their homes. The scenes are dramatic, riveting; they grab your attention. They appear on prime time television, on the front pages of newspapers, and are featured in weekly news magazines.

It is difficult to believe that, in this age of instant electronic communications there can be anyone who lives in the I-Zone, unaware of the wildland fire threat and the potential losses they face. Nevertheless, a visit to any I-Zone neighborhood reveals very few, if any, efforts by residents to protect themselves and their property from wildfire. Homes are constructed in dangerous places. They are built of flammable material. And, most importantly, the wildland vegetation surrounding the homes grows thick, often choked with dead material, and arranged in fire ladders. Flames from a structural fire can quickly escape into the dense vegetation and crowns of the trees. Almost nowhere are complete neighborhoods protected so that fire starting in them will not spread easily to the wildland or fires originating in the wildland will not spread to the neighborhood destroying homes and valued landscapes.

I-Zone Research and experience working with communities, confirms the impression that people know about the fire threat, that they believe that they can do something about the threat by modifying the vegetation, and that they are not fatalistic about the possibilities of saving their homes and landscapes in the event of a wildfire. People are not creating fire safe landscapes and fire safe neighborhoods but it is not an attitude problem. Something else is preventing I-Zone residents from preparing fire safe communities.

Of course, there may be places where a neighborhood is unconcerned about causing fires that burn into the forest or where the danger of a fire burning out of the forest to threaten lives and homes is dismissed. However, do not assume that lack of action in wildfire defense preparation indicates a lack of motive on the part of the residents. Action requires opportunity, means, and motive. If the motivation is there and the action does not take place, most likely there is a problem with either the means for taking that action or the opportunity. When devising strategies to promote the adoption of wildfire defenses among people who live in the I-Zone, be sure you are addressing the real problem.

A motive is a felt need that pushes or pulls one toward an action. Hunger motivates one to seek food and eat. But, if there is no opportunity to eat because there is no food to be found or if there is food but one cannot get to it, one will not eat no matter how hungry one gets. People lost in a strange environment such as flyers downed in the jungle sometimes starve where native people thrive because the flyer does not recognize the edible from the inedible. People may die on life rafts at sea because they lack the means to catch fish or desalinate water for drinking. Unless means and opportunity accompany motive, action does not occur.

In an I-Zone community, an older couple may have listened to all that was said about wildfire threats and wildfire defense preparations. They may have the opportunity to manage the vegetation around their home to make it more fire safe. However, age and illness or the lack of money may prevent them from doing much of the necessary work. Another resident may be young, strong, and capable of doing the work but may be a renter who has no say about vegetation management on the property they rent. In another community, deed restrictions, property owner association rules, or forest practices laws and rules may restrict opportunity.

Before deciding that people do not care enough, and before you launch a persuasive enforcement campaign, be sure means and opportunity have been considered. All that may be needed to release a flood of pent up motivation and convert it into action may be the removal of some barriers.

### Segment the Market & Target Market Segments

Perhaps nowhere in the world is cultural and socio-economic diversity greater than it is in California. It is estimated that within a few years, no cultural minority will make up more than 50 percent of the California population. Given such diversity, it is difficult to find or create products or messages that would appeal effectively to everyone. A campaign to promote wildfire defense directed at the general population is almost certain to fail. Products and messages designed for one group's needs, tastes, and preferences will almost certainly miss the mark for most other groups.

Segmentation is marketing's solution to the problem of diversity. The markets one wishes to reach are first divided into smaller groups in which people are very much like each other in terms of those things that are relevant to the product being promoted and communication behavior. Good market segments are homogeneous in needs, tastes, and preferences relevant to the product. People in the same market segment tune to the same media and interpersonal channels. The members of a market segments should also have similar education levels, incomes, family status, and occupations.

Once the market has been segmented, fire protection officers can work closely with those who represent the community of interest to develop wildfire defense variations that will appeal to local needs, tastes, and preferences. Communication campaigns can be developed that take advantage of the natural communication patterns of the target market segment. Ways can be found more easily to overcome barriers that might arise, such as the lack of financial resources, time, or ability to do the necessary work, because those barriers will tend to be faced more or less equally by all members of the segment.

Fortunately, neighborhoods in the I-Zone make very good market segments. From the fire protection planning perspective, neighborhoods are ideal because all of the structures and landscapes one might wish to protect will be threatened by the same fire. Neighborhoods tend to be contained within the same fuel type, located on similar topography, and experience similar weather. A fire burning out of the wildlands into the community will behave pretty much the same way throughout the neighborhood. Fire fighters are likely to attempt to protect the neighborhood as a unit if fuel and weather conditions permit.

If the wildfire defenses prepared on one piece of property are linked together strategically with wildfire defenses prepared on other properties in the neighborhood, a significant impact can be had on local fire behavior. From a fire protection standpoint, it is much more effective to prepare wildfire defenses on one hundred neighboring homes than on one hundred homes scattered throughout the I-Zone

Neighborhoods also tend to be homogenous in socioeconomic terms, the use of mass media, as well as tastes and preferences with respect to the landscape. Furthermore, neighborhoods tend to be integrated into an informal communication network through which neighbors communicate with each other about common concerns and issues. Typically there is a well developed neighborhood decision making process in which the various neighbors play roles they have worked out over time. These informal communication networks are critical to the success of campaigns to introduce new ideas into social systems.

Especially in the I-Zone, people are attracted to live where they do by the setting. Seldom are they forced to chose their neighborhoods by the circumstances of their work or other reasons that limit their choice of residential environments. It is likely that residents share similar tastes for wildlands and landscape aesthetics, architecture, climate, and culture. Because neighborhoods tend to be similar in the price range, in terms of homes and living expenses, neighbors are likely to have similar incomes. Incomes are closely related to occupations and occupations are closely related to education level. Through the process of selecting a place to live within the I-Zone, residents have pre-sorted themselves into homogenous groups that make excellent market segments.

The most appropriate market segments for fire protection officers to target are individual neighborhoods. However, within those neighborhoods, there are sub-market segments. There are those who are interested in landscaping, those who are interested in ecology, those who are interested in building, and those who are interested in public safety and well-being. Within a neighborhood these smaller groups of people may be organized into clubs, property owners associations, or Neighborhood Watch. Each of these subgroups within the neighborhood make up smaller market segments that might be targeted with specific kinds of information or through different channels of communication.

As described elsewhere in this paper, some kinds of people move through the decision process to adopt or reject new ideas or technology more quickly than do others (Rogers:1995). The early adopter may have different communication behaviors than do later adopters. They also tend to have different decision making capabilities, and different socio-economic characteristics. Those who work through the consumer decision making process faster than others form an important market segment to be targeted early with the information and education programs. Those who work through the process more slowly will rely on earlier adopters to help them make the decision. They will look at the experiences of earlier adopters with the new technology. They will need different kinds of information, more concrete information, and more hands-on experience with the technology to make their decisions (Rogers: 1995).

In summary, effective communication with the diverse population of California's I-Zone requires first that the larger population be segmented into smaller, more homogeneous groups; second that the wildfire defense product be adapted to the needs, tastes, and preferences of each of those market segments; and third that promotional communication be developed that matches the market segment's natural communication behavior. Neighborhoods tend to be homogeneous on most of the variables important to the adoption of vegetation management and architecture for wildfire defense. Fire protection officers should identify and target appropriate I-Zone neighborhoods as market segments in the campaign to promote the widespread adoption of wildfire defenses.

### Promote to the Community— Not the Individual

Perhaps the most common mistake made in fire prevention is to target individuals instead of social systems. Even Smokey Bear's famous message, "Only you...," is directed at individual responsibility. Of course, ultimately it is the action of a single person that results in a fire start or the implementation of some fire protection measure but human beings are social creatures and make very few choices without the support of their families, neighbors, coworkers, or other social groups. Important decisions such as making major modifications to homes and landscapes are virtually never made by individuals acting alone. The family, at least is involved, and usually the matter is discussed extensively with neighbors and others whose opinions are valued before work is done. Even if the land owner does not talk it over with the neighbors- the neighbors will talk about it and social pressures will be brought to bear if the idea is not approved of.

There are good practical reasons for people to consult with their neighbors before making decisions to adopt or reject new ideas. Neighborhoods and other social systems are webs of shared knowledge, influence, and resources (Rogers & Kincaid:1981). People rely on each other for help in many ways from borrowing tools to advice on how to do some task in which a neighbor is more expert. Neighbors watch each other's homes, and provide social support in times of personal trouble and distress. It would be very difficult for a person to live without ties to family and neighbors while good ties immeasurably improve the quality of life. One is not likely to risk such valuable associations by taking independent action on matters that will influence others.

Treat the neighborhood as if it were an organization that must decide to adopt or reject your new technology as a whole. That truly is the case. Focusing on individual land owners to change patterns in behavior, without involving their neighbors who are typically relied on to form a decision, will not be successful. The key to success is had working with whole neighborhoods.

### Work with Opinion Leaders

Within every social system there are those to whom people go more than others for advice about new ideas. These opinion leaders are influential because they are able to reliably and accurately predict the consequences of new ideas and because they are trusted and socially accessible to those who want the advice. In the modern communities of the I-Zone, opinion leaders are likely to be specialists. Some are expert in landscaping and horticulture, others in building, and still others in matters of public safety. A person wishing to discuss a new idea is likely to seek out the neighborhood influential in that subject rather than to look for a person influential in a broad range of subjects. In more traditional communities in less complex societies, opinion leadership for most ideas may be held by one or two key individuals. Such "monomorphic" opinion leadership may occasionally be encountered in rural areas of the United States or among some close knit ethnic communities but typically opinion leaders will exert influence in a relatively narrow range of topics (Rogers, 1995).

Failures of efforts to promote new ideas have often been traced to failure to work through community opinion leaders (Rogers, 1995). This is logical when one recognizes that new ideas are discussed before individuals make the decision to adopt them. If the persons whose opinions are valued has not heard of the new idea, or has not formed an opinion about the idea, there is little chance for a positive recommendation. If, on the other hand, an opinion leaders has not only heard of the idea, but has decided to adopt it themselves, a positive recommendation is assured. In the first case, one is likely to drop the idea altogether; in the second case, one will at least consider it further.

How do you identify an opinion leader? The easiest way is to ask people who are likely to know the neighborhood well. The school principal will know who opinion leaders are or will know someone else who does. Religious leaders typically know the influential people in the community. Elected officials depend on knowing who the influential people are to get elected. The officers of neighborhood and community organizations will know some of the influentials. The rural, volunteer fire company and auxiliary who depend on the community for fund raising can be important sources of information about who is and is not influential. In some places, the volunteers are the most important social organization in the community.

It is important to remember that while elected officials, school principles, and other public figures may be opinion leaders, they often are not the most influential people in the community. Sometimes, opinion leaders are relatively invisible. The elected officials and most visible people may be activists and innovators not necessarily well integrated into the community (Rogers:1995). It is especially important not to assume that people actively promoting an idea are opinion leaders. Real influence is usually wielded quietly. Opinion leaders usually exert their influence in response to questions from followers not by seeking out their followers and trying to persuade them to adopt the new idea.

The opinion leaders important to the promotion of defensible space and other wildfire defense preparations include those who are influential in landscaping and gardening, the environment, building and home design, public safety and security, and forestry and fire. If a garden club exists, its members are likely to be influential in their neighborhoods on landscape issues. The officers of the club can also identify businesses such as nurseries and individuals who are influential locally on landscaping matters. The neighborhood watch can serve the same purpose among those concerned with public safety. Similar groups may exist that represent those interested in architecture or home improvements.

### Work Existing Organizations

It is tempting to organize a special fire protection committee in a neighborhood to promote wildfire defenses and fire safety. Such committees may eventually be appropriate but in at least the first year or two, fire prevention officers should work through existing organizations such as property owners associations, the neighborhood watch, or garden clubs. Establishment of a new committee requires much work and time that could better be spent on establishing wildfire defenses. Furthermore, each organization in a social system has established its own niche. Organizations compete with each other for people's time and attention as well as financial support. New organizations must spend much of their energy early on establishing their place in the social system and their credibility with the public. They are not immediately effective.

On the other hand, existing organizations that have already established themselves as legitimate in the areas of public safety, land use, horticulture, and building or aesthetic issues and can easily adopt wildfire protection as part of their mission. They have an established membership, are typically interested in expanding their membership with appealing new projects, and have an infrastructure of leadership and a calendar of events into which wildfire defense promotion can be folded.

## Begin with Education

Very few people living in the I-Zone understand the principles of fire behavior and as a result, recommendations about landscaping and building for wildfire defense are not quickly understood and accepted. It is relatively easy to get on the agenda of a property owners association or garden club meeting to talk about fire behavior. The presentation can be made using slides or view graphs developed from available fire behavior instruction manuals used in the fire services. Demonstrations of the effects of fuel types, wind, and slope have been made to neighborhood groups using a burn table or by making small area demonstration burns of grass or bear clover.

Most of the people who live in the I-Zone are well educated and have experience in technical or managerial occupations. They easily grasp the principles demonstrated and are able to apply them to the situation in their neighborhoods.

It is also useful to teach residents the fundamentals of controlling wildfire using hand tools and a limited water supply. This information makes it easier for them to conduct their own dooryard debris burns with less chance of escape and helps them understand the kinds of actions fire fighters will have to take to combat a fire in their neighborhood.

Residents are likely to be as poorly informed about the principles of ecology and forest health as they are of fire behavior. Presentations on forest health, wildlife ecology, hydrology and underground water, soils, landscape design, and horticulture can all be used to provide the basis for landscaping for wildfire defense. It may be useful to provide residents with an herbarium collection that they can use to identify the different plants, brush, and trees in their area. If information about the flammability of the different species and how to manage them to make them less flammable is included, the collection will be particularly effective in advancing the cause of wildfire defense preparation.

It is important to establish the fundamental base of knowledge before getting too far with specific recommendations for wildfire defenses. At the most fundamental level, a resident cannot decide which tree to take and which to leave unless he or she can tell what species the trees are and which ones are preferred.

When working with communities, it is most effective to provide information and education as the residents feel the need for it. In the beginning that need is likely to be for knowledge of fire and the fire threat and how it is defended against. Later the need will move to information on which species to select for and against in landscaping and how to do vegetation management work properly.

When whole neighborhoods are involved, a large landscape will be modified. The effects on wildlife, aesthetics, and other values is likely to be significant. As they undertake wildfire defense preparations, neighbors will need to develop a shared image of the desired future condition of the forest they live in and that will require basic education and discussion about many matters not directly related to fire. However, to achieve the desired level of wildfire safety, the fire protection officer will need to arrange for that education when people feel the need for it.

## Communicate & Promote Each Market

As people in each neighborhood work through the consumer decision process to decide whether or not to prepare and maintain wildfire defenses, they will pass through several stages from initial awareness, through opinion formation, choice making, implementation, and confirmation (Rogers:1995). At each of these stages, they will want different kinds of information and look for it in different media and from different people. Promotional campaigns will be effective to the degree that fire protection officers provide the kinds of information people want, where they want it and when they are likely to look for it.

In general, people will use three types of communications. They will encounter or look for information in the mass media including television, radio, newspapers, and magazines. They will seek information face to face from experts. They will communicate with each other through their informal communication networks.

The mass media can be used effectively to create awareness of the wildfire threat and the possibilities of defending one's family, property, and neighborhood against it. Mass media reaches many people quickly and for a low cost. Some forms such as printed materials and video tapes are easy to keep, copy, share with others, and use when how-to information is needed. However, the mass media is relatively ineffective as a tool for opinion formation and confirmation of the wisdom of the decision.

Interpersonal networks linking members of the community with each other are very effectively used during the opinion formation stage of the consumer decision process but tend to be information poor about new technology. The networks can spread awareness about a new idea but depend on that information first being introduced by mass media or some other outside source.

The needs for information and its timing will vary from neighborhood to neighborhood. In any neighborhood some residents may be experts on wildfire and fire suppression. There may be those who are ecologists, landscape architects, or other professionals who can contribute formally and informally to the needed information. One cannot build a communication campaign that will work equally effectively in every neighborhood. It is necessary to learn that particular neighborhood well and to find out by constant listening to the residents as they work through the process what information they feel the need for. The effective strategy will make provisions for identification of information needs as they develop and rapid response to that need.

## Adapt Defenses to Market Segments

The attractiveness of a new technology depends heavily on how it is perceived compared to alternatives by those who will choose to adopt or reject it  Considerable research has been done the characteristics of new technologies that potential users consider (Rogers:1995). The important perceived characteristics include relative advantage, complexity, compatibility, observability, trialability, and plasticity.

Successful promotion of wildfire defenses will be enhanced to the extent that fire protection officers can:

Increase the degree to which landscaping and construction for wildfire defense is perceived to be better than the alternatives they will replace,

Reduce the perceived difficulty of implementing and using wildfire defenses,

Make wildfire defense technology more compatible with resident values.

Make the beneficial results and the technology itself more visible to potential users,

Arrange ways to try wildfire defense technology, before committing to total adoption, and

Keep wildfire defense technology flexible so that it can be reinvented easily by potential users without losing its effectiveness as a protection against wildfire losses.

### Increase Relative Advantage

Relative advantage is the degree to which a new technology is perceived to be better than alternatives. Costs, labor requirements, discomfort, and effectiveness for the intended purpose are all part of relative advantage (Rogers:1995). The following are the results of a survey of residents in communities located between Grass Valley and Paradise California.

Effectiveness

Four out of five people surveyed believed that defensible space would help save their property in the event of a wildfire. For most people, defensible space is perceived to be effective for its intended purposes. Still, one in five does not think it will help save their property. We don't know whether that is because they don't think it will save their homes or because they think of their property in a larger sense to include the landscape.

Fatalism

Lack of defensible space implementation is not because people are fatalistic. They don't believe that when your number is up- it is up. Less than one in ten thought that whether a house burns or not is a matter of luck.

Cost

About half of the respondents to the survey believed that defensible space would cost them more money in the long run than the alternative. Less than one in twenty thought defensible space would cost less. Clearly, defensible space is at a relative disadvantage with respect to costs. This is an important barrier to wide spread adoption. Increasing the number of people who implement defensible space in the I-Zone depends heavily on our ability to bring the perceived initial conversion and long term maintenance costs down.

Work

Almost two thirds thought the work required to maintain defensible space would be about the same as required of their current landscape. Nearly thirty percent, however, thought it would be harder and less than one in ten said it would be easier. Defensible space has no labor saving advantage to make it attractive to residents.

Time

More than half thought it would be difficult finding the time to do the things needed to make the landscape more fire safe while a quarter thought it would be easy. Defensible space has little relative advantage from reduced time demand in the minds of most residents but an important fraction may see potential benefits there or at least no barrier.

Discomfort

Although no question about the perceived discomfort of creating and maintaining defensible space was asked in the survey, later focus groups in Paradise raised concerns over poison oak, snakes and Lyme disease. Some residents may be reluctant to work on the undeveloped parts of their lots for these reasons. To the extent that they are barriers, finding ways to get the initial conversion work done for residents without requiring them to expose themselves to these perceived dangers could make defensible space more attractive.

Although defensible space is believed by four out of five people surveyed to help protect their property from wildfire, there remain an important number of skeptics. Perceived costs, labor, time requirements, and perhaps aversion to snakes, poison oak, and Lyme disease leave defensible space without a clear relative advantage. This, in part, accounts for the low level of implementation in the I-Zone in spite of sustained promotional efforts. To achieve greater adoption, costs, labor requirements, and time demands must be brought down.

One way to bring costs down is to achieve economies of scale by doing hazard reduction on relatively large areas- neighborhoods instead of individual lots. When that is done it is possible to bring in larger equipment and to spread the costs among landowners. Another approach is to subsidize the wildfire defense and forest health improvements by selling some timber or other forest product from the lands on which improvements are made. The easiest of these products is fuel wood either as chips to be used in wood fired power plants or firewood. When forest products are sold, exemptions to Forest Practices regulations need to be applied for through the California Department of Forestry and Fire Protection. In some cases, a timber harvest plan or other plan may be required. County regulations and local CC&R's may limit possibilities for this kind of subsidy.

Very limited amounts of money are available from state and federal cost sharing programs designed to improve forest quality. Again, the local CDF foresters are the appropriate contacts; they can identify other possible funding sources. Even a small subsidy can make a considerable difference in the perceived relative advantage.

### Increase Compatability with Local Values

Compatibility is the degree to which the new technology is perceived to fit with existing values, and ways of doing things (Rogers:1983).

Natural Beauty

> A little over forty percent believed that natural landscapes are more beautiful than planted landscapes while an almost equal number disagree.

Changes

> More than one third believe that one should make as few changes as possible in the natural landscape while more than half are willing to make changes.

Modifying what is seen as the natural landscape and replacing it with a planted landscape is not compatible with attitudes of many of the people who responded to the survey. It is important that defensible space and wildfire defenses in general be seen as compatible with natural landscape values. Landscaping for wildfire defense will be more attractive if it can be shown to restore and protect wildlife, watershed, aesthetics, air quality, and other values.

Improving compatibility is best done in cooperation with residents often through participatory programs such as focus groups and other techniques used by market researchers. The relevant values cannot be identified before the project is begun, typically, because residents do not know enough about wildfire defenses and forest health. Consequently, an adaptive approach must be used in which learning, doing, and planning are constantly cycled. As residents learn about wildfire defense and forest health, they will be able to come to a consensus about the desired future condition of the forest but that image will change as they learn more and gain more experience. Typically, however, the changes represent refinements, not revolutions in their thinking.

Fire protection officers marketing wildfire defenses need to be careful to abandon the usual linear approach to planning and project implementation for a more naturalistic, adaptive management approach.

## Reduce Complexity

Complexity is the degree to which people find the new technology difficult to understand and use (Rogers:1995).

### Changes Required

Two thirds of those surveyed believed that they would have to make more than a few changes in their landscape to make it fire safe. About 17 per cent thought they would have to make many changes.

### Understanding Defensible Space

Well over half of those surveyed thought it easy to understand how different kinds of landscape features work to protect property from wildfire. Only about 15 percent thought it hard to understand. In fact, we have found that people in the neighborhoods where we have worked learn the basic principles of fire behavior easily and can apply them to their landscaping decisions pretty well.

### Need to Learn

Somewhat less than two thirds said they would need to learn new things about landscaping to make the changes required for defensible space. The good news is that they would enjoy learning more about landscaping for the most part.

### Knowing Defensible Space

Considerably less than one in five thought it difficult knowing which things in a landscape make it more or less fire safe.

### What Kinds of Plants

About a third of the respondents said it would be hard to know what kinds of plants to grow in a fire safe landscape. Nearly another quarter were uncertain. Increasing the adoption of defensible space will require better and more available information on recommended plant materials and perhaps landscape designs that provide wildfire defense and will survive a wildfire. Knowing where to get the plants seems difficult to about one in five and another fifth are unsure.

### Maintenance

More than a quarter thought a defensible space landscape would be more complicated to maintain; Almost two thirds thought it would be about the same and less than one in ten thought it would be less complicated. Of those who thought it would be more complicated, few thought it would be much more complicated. Perceived complexity of maintenance is a barrier for a few but is not a major barrier to adoption.

Brush Disposal

> Although there is no survey data on this point, experience in the neighborhoods where we have promoted defensible space clearly demonstrates that difficulties in disposing of the large amounts of brush produced in the initial conversion to a fire safe landscape add significantly to the perceived complexity at the implementation stage. The amount of brush produced is dangerous to burn, it is costly and difficult to haul, and landfills won't take it anyway. This is a major barrier to widespread adoption.

People generally do not find it difficult to understand defensible space and how it works to protect their property. The major sources of complexity are the amount of work needed to make property fire safe, lack of certain how-to-do-it information, and, especially, the difficulty of disposing of the brush.

Brush disposal is perhaps the thing that fire protection officers need to pay the most attention to; it is the most difficult and dangerous of the problems land owners face in converting their property. As described under relative advantages above, however, the brush and wood removed as part of hazard reduction might be converted to an economic by-product in some cases. If it must be chipped or burned, expert advice will be needed to support the community's efforts.

### Increase Visibility

Observability is the degree to which people can "see" the technology and its positive effects (Rogers:1995). The more observable a new technology and its benefits are, the more quickly and widely it will be adopted in social systems.

In order to make wildfire defenses as compatible as possible with local values it is likely that those properties that have been landscaped for wildfire defense will look natural. They will be more open, the crowns of trees will be more separated and there will be less brush and reproduction that might create a fire ladder in the understory However, wildfire defense landscaping is likely to go unnoticed unless it is pointed out. It is typically necessary to draw attention to wildfire defense landscaping to take advantage of the growing social influence as the idea spreads.

In Shingletown it was the practice to have residents pile the brush from their lot clearance on the shoulder of the subdivision roads where it would be chipped. The growing number of piles and their size served to make wildfire defense preparations visible to anyone traveling through the neighborhood. Later, when the chippers were working, the noise and bright colors of the equipment, workers shirts and hard-hats added to the visibility and sense of things happening.

It has been suggested that signs be prepared that can be attached to mail box posts declaring the property a participant in the wildfire defense landscaping program and identifying for fire fighters the degree of preparation at the site and available water or other resources. As such signs appeared in the neighborhood they would demonstrate the rate of adoption and growing numbers, bringing influence on those who has not yet adopted.

Tours of the neighborhood for others interested in a wildfire defense campaign in their own neighborhoods, coverage of the project by the media, and visits by elected officials and dignitaries will all help make the project more visible and encourage adoption of wildfire defense preparations.

It is equally important to make the benefits of adopting wildfire defense visible. Sometimes that can be done by working with the media and information officers on fires in the general area of the community. Television and print stories describing the effects of fuel modifications on the fire behavior and of wildfire defense on neighborhood survivability help to make the effects visible in situations everyone hopes will not arise for themselves. Wildlife, forest health, and related benefits can be pointed out and illustrated with stories in the local newspaper with photos from project sites. Teaching programs about fire behavior and fire effects might use fire tables on which real fires are burned to show how changes in fuels and slope influence fire rate of spread and intensity. It may be possible to take residents to observe prescribed fire where the effects of vegetation management can be demonstrated.

### Encourage Experimentation

Often people find it too much to commit all at once to a large landscape change. They want to see how it looks and how it affects other important values they hold. Usually, the residents of a neighborhood will want to modify the wildfire defense idea to better fit their own situation. Such reinvention is a natural part of the consumer decision process (Rogers:1995). It should be encouraged because it makes the idea more attractive to those who modify it.

There are many different combinations of vegetation management, suppression, and prevention activities and many ways to do each of those, all of which would improve the wildfire defenses for a neighborhood. However, the resulting landscape design and combination of fire fighting methods must be technically appropriate for the conditions. To ensure that happens, the experimentation and modification should be done with assistance of fire behavior and fire fighting specialists. Protection of other values will require inputs from other experts, as well.

Demonstration sites where residents can be involved in the actual work provide opportunities for experimentation and trial. Often such demonstration sites can be established along main entrance roads, around public buildings and fire stations, in parks, or on the property of cooperative residents who would be pleased to serve as a showplace. Garden club members might be among those most willing to cooperate in that way. Projects to make roadways safer during evacuations by reducing the amount of brush in the right of way and making it less flammable provide demonstration opportunities.

### Keep Defenses Flexible

One of the disadvantages of legislation, that requires residents to prepare defensible space, is that it sets the same requirements for every home on every I-Zone lot in the State. The fire threat and the best way to deal with it, however, differs widely from lot to lot even in the same neighborhood as slope, aspect, and fuel types vary. For example, while a thirty foot clearance may be adequate in grass on a level lot, it is woefully inadequate in tall, decadent chaparral below a house at the top of a steep slope.

Avoid any actions that will reduce the resident's ability to reinvent wildfire defenses to fit their particular situation and conditions. Inflexibility limits the usefulness and acceptability of new technology intended for use under variable conditions.

### Combine Benefits With Prevention

Prevention technology and ideas are particularly slow to be adopted by most social systems (Rogers:1995). That is partly because it is difficult to experience the relative advantages of fire safe landscaping and ignition resistant structures compared to the alternatives. One can only experience the preventative benefits of wildfire defense preparations when a wildfire strikes. That is an almost unthinkable situation to most people and, although certain over a period of a quarter century or so, it is rare in most people's lives. Worse, when people experience the threat, the best they can do is break even.

There are other reasons why preventative innovations do not spread rapidly through social systems that range from calculations of the net present worth of investments compared to losses expected and the discount rate used, the time horizon of many residents, and psychological denial of the threat. In almost all cases, technology that promises to prevent losses is not nearly as attractive as technology that promises immediate improvement in the quality of life (Rogers:1995).

The best way to counteract the effects of a perceived preventative technology is to package the new technology with other compatible technologies that promise immediate satisfactions. In the case of vegetation management for wildfire defense, the finished landscape can be designed to not only be more fire safe but also to provide more opportunities to view wildlife and flowers, and experience other forest amenities

The best way to discover what kinds of benefits to attach to the preventative wildfire defense technology is to work with groups of residents in the target neighborhood, especially the opinion leaders. Their suggestions reworked by technical experts in the appropriate fields will allow the fire protection officer to provide the most attractive possible wildfire defense design and feature its benefits in promotion communication.

### Take Resident Orientation to Wildfire Defense

All of the above can be summarized in the recommendation that the fire protection officer approach the problem of promoting wildfire defense preparations by adopting the perspective of the resident in the target I-Zone neighborhoods. The technology should be modified to meet the resident's felt needs, tastes, and preferences. Their natural decision making processes should be supported and assisted with appropriate information in the media they use at the times they want it. They should be involved in designing the technology and helping to implement it.

The fire protection officer should recognize that the decision to make major changed in the landscape is not an easy one. Many secondary impacts must be considered. The reactions of one's neighbors and significant others are important. The relative advantages are not always clear. The technology can seem very complex— difficult to understand and use. Usually it will eventually be seen as compatible with the needs, tastes and preferences of the residents, but at first, there will be questions about the effects on other forest values. All concerns are legitimate no matter how often the fire protection officer has dealt with them in other places and times or how obvious the answers seem.

It is important to remember that the fire protection officer comes to the I-Zone fire problem with the perspective and biases of a fire fighter most of which the residents do not share. It is difficult for the fire fighter to empathize with the I-Zone resident. The fire fighter knows about fire better but the residents values less well. The fire fighter frequently sees I-Zone fires and their impacts while residents seldom see them except on television and in the newspaper. The fire protection officer cannot hope to have a perfect impression of the residents needs, tastes, and preferences. Therefore, the residents must be intimately involved in every step of the wildfire defense project. The task is to make wildfire defense exactly what the residents want while conserving its fire protection and forest health effectiveness.

Novato Fire Department's H.E.A.R.T. program is an example of problem specific marketing

# 21

By **Donna Darrow**

California is a unique place to live, encompassing every imaginable type of terrain: beaches, lakes, desert, mountains, and forests. The wildlife is diverse and abundant. But with the advantages of living alongside open space and wildlife come some major challenges. One of the greatest is managing that habitat so that people living close to nature neither destroy it, nor are destroyed by it. This chapter will present one fire district's response to I-Zone fire prevention and mitigation, and the desire of citizens to be better informed and better prepared.

## H.E.A.R.T. Background

The Novato Fire Protection District encompasses 75 square miles in northern Marin County in an area vulnerable to earthquake, floods, wildfire and hazardous materials releases. In 1991 the District's Disaster Preparedness Committee focused on updating its Emergency Operations Plan. In the process, committee members concluded that the weakest link in the plan was the number of professional emergency response providers available in a major disaster; it was believed that there would simply not be enough emergency care providers immediately following a large disaster. The committee strongly recommended that a key component of the E.O.P. should be training citizens to function independently and autonomously in the event of a disaster. Thus, H.E.A.R.T. was created.

H.E.A.R.T. (Homeowners Emergency Action Response Team) is a community-based education program designed to deliver disaster preparedness and life safety training to residents and businesses in the Novato Fire Protection District. H.E.A.R.T empowers people to make suitable choices in preparing for and responding to disasters, rather than relying solely on government institutions.

H.E.A.R.T. is an innovative approach to public education and disaster preparedness in two ways:

disaster preparedness in two ways:

First, H.E.A.R.T. encourages people to become more self-sufficient and less reliant on emergency services. Other community-based education programs the District reviewed emphasized the use of citizens as "volunteers" for the fire department in the event of an emergency. In Novato, it was felt that citizens will need to be able to function somewhat independently in disasters. Fire District response procedures are taught during H.E.A.R.T. in the event that citizens are actually recruited to assist in major disasters, but primarily these H.E.A.R.T. graduates should be able to help themselves and their communities to function as well as possible during a crisis.

Second, H.E.A.R.T. encourages people to make informed decisions and to take actions to increase their levels of safety and preparedness. Committee members believed that the most effective change comes from implementing broad-based, grass-roots programs in which District personnel work directly with homeowners. Thus, there will be greater "buy-in" and compliance as the local community determines and manages its own level of safety standards. The District facilitates and guides the identification of safety goals to make sure they are in alignment with District goals.

**Design & Developement**

H.E.A.R.T. utilizes proven techniques of instructional design for adults including group problem solving, "hands-on" skill development, demonstrations, audio-visual aids, drills and discussions. Its three major themes are:

preparing for disasters such as an earthquake or flood,

preventing others such as fires and hazardous materials spills, and

responding to disasters appropriately.

The H.E.A.R.T. curriculum focuses on eight subject areas:

1.Emergency Medical Aid
2.C.P.R.
3.Wildland/Urban Interface
4.Earthquake Preparedness
5.Urban Search and Rescue
6.Hazardous Materials and Floods
7.Fire and Burn Prevention

8.Injury Prevention and Loss Control

H.E.A.R.T. was pilot tested in 1991 in five communities and businesses and evolved into three custom versions: the original H.E.A.R.T., eight 3-hour training modules that address issues pertinent to residents; Business H.E.A.R.T., a condensed 8-hour version for business people in the workplace; and Wildland H.E.A.R.T., emphasizing wildfire mitigation and safety standards. This chapter will deal primarily with the development of the Wildland H.E.A.R.T. program.

## History

As early as 1983, the District hired a consultant to identify specific hazards (i.e. fuel loads, type of vegetation, terrain, etc.) in high wild-fire risk areas. In 1991 the same consultant was hired to perform fire modeling in the 10 high wildland fire-risk neighborhoods previously identified, and to analyze the progress made in them. In conducting the modeling, it was learned that several recommendations from the earlier report had been at least partially addressed. The goals that had not been addressed were those dealing with vegetation management and infrastructure issues in I-Zone areas.

Prior to the development of Wildland H.E.A.R.T., the District had implemented a company inspection program in high-fire risk neighborhoods. Violations were cited and forwarded to the Fire Prevention Division, where follow-up inspections were performed by the Deputy Fire Marshal. While some people complied, many did not. There was no "bite" in the legal system, and a great deal of frustration felt by fire fighters conducting the inspections, the Deputy Fire Marshal. and neighbors of homes that did not comply. The District wanted to try a more aggressive approach to dealing with this problem.

## Pilot Program

In reviewing the results compiled in the consultant's report, the District chose one of the communities, Blackpoint, to pilot test the Wildland H.E.A.R.T. program. Blackpoint is an area within the District with a significant I-Zone fire problem, diverse in its topography and layout. Blackpoint is a large hill with only one road in and out of the community. Some homes are situated on hilly terrain, others in the flood plain. Years ago small parcels of land in Blackpoint were given away as "gifts" for newspaper subscriptions. People collected two or three of the "free" parcels and built small hunting cabins or vacation homes. Many of these older "homes" are not built to code. This has resulted in many irregularly sized home sites and a poorly designed road structure. Each homeowner owns the section of the road in front of his/her home up to the dividing yellow line. The homeowner is responsible for road maintenance on his/her own section, creating much inconsistency in road conditions. The County of Marin does not maintain this area.

In keeping with the District's philosophy of community involvement, the Disaster Preparedness Committee and staff officers presented a two-hour workshop to the Blackpoint Improvement Club that covered:

the District's mission and the state of its operational readiness for disasters;

the nature of fire (including fire weather, fuels and ladders and chimneys, and the impact of terrain, slope and aspect on fires.);

the similarities and differences between Blackpoint and Oakland / Berkeley regarding the potential for wildland fires;

fuel and vegetation management principles;

fire safety and fire prevention recommendations;

appropriate building materials; and

evacuation procedures.

The program concluded with a request for volunteers to serve on one of two committees to address fire safety issues specific to Blackpoint.

A Vegetation Management Committee was formed to identify problem areas within the community, to establish a home inspection and education program, and to serve as liaison to the Fire District.

An Infrastructure Committee was formed to deal with issues such as ingress/egress, water availability, roadways, and appropriate evacuation routes for residents.

Once committee members were identified, meetings were held to develop specific goals, objectives and timelines for each committee. The first meetings were facilitated by Fire District personnel to ensure that the committees were working in alignment with the District's vision of a safer community. Within a month, the following goals and objectives were identified.

## Committee Goals and Objectives

Infrastructure Committee Purpose:

**Purpose:**
To identify infrastructure issues within Blackpoint to prevent and/or mitigate the effects of natural disasters.

**Objectives:**
perform a walk through of the Blackpoint area
identify escape routes, roads and gates

develop a map indicating the escape routes and the safety zones within the community
present education programs and distribute maps to the community
test the system with a "Community Fire Drill"

Vegetation Management Committee Purpose:

**Purpose:**
To begin and maintain the process of managing the fuel load in the Blackpoint Community to provide for a safer environment from fire.

**Objectives:**
establish a community wide clean up day
establish a clean up day
establish the primary roads (areas) to clean up first

H.E.A.R.T. spurs communities to action. Novato Fire District's Fire & Life Safety Specialist (Captain/Fire Prevention Division) seeks out neighborhood liaisons, schedules meetings and provides motivational talks to neighbors. Many of these meetings are held in the neighborhood's local fire house. As the H.E.A.R.T. training program gets underway, ideas are promoted to encourage neighbors to work together to mitigate hazards. The District provides guidance, support and information on how to clear vegetation and provide defensible space. The residents provide the financial means and the mechanism to achieve this end.

While H.E.A.R.T. encourages residents to meet and determine levels of safety that they are comfortable with, the District is careful to help them establish at least some goals that can be easily and quickly accomplished. The District also recognizes and celebrates the early successes each community achieves. People need to feel that they are jumping on a winning band-wagon and the "buy-in" is much greater when the residents feel that they are accomplishing some of their goals.

## Program Liaisons

Novato Fire District's Fire & Life Safety Education Specialist (Captain/Fire Prevention Division) was responsible for serving as liaison between committee members and the District. In addition, the Captains at the substation closest to Blackpoint serve as additional liaisons for the community. For information or guidance, the Blackpoint homeowners could contact either the Fire & Life Safety Education Specialist or go to the station. The Fire & Life Safety Education Specialist maintained close contact with Committee members, communicating with the Committee chairs at least once a week.

Local residents and fire department personnel with apparatus performed a "walk through" of the area in March. Representatives from the Infrastructure and Vegetation Management committees were present and toured the entire community to check for possible evacuation routes, trees overhanging the road, areas where dead limbs, leaves, etc. were dumped or had accumulated, roads in need of improvement, and so on. Road maps were updated. This walk-through provided the opportunity to put into practice what they had learned in the initial 2-hour forum. Having seen slides at the forum, residents now were able to see what an actual fuel ladder looked like. They could see the trouble the apparatus had maneuvering through narrow roads. They learned to "limb" trees. District personnel had the opportunity to meet the residents and to see the hazards throughout the neighborhood. Consequently some of the committees' goals were modified and new ones developed.

While the homeowners were working to accomplish their goals, the Fire District took the opportunity to enhance its knowledge of the community as well as to increase fire fighting skills. Operations personnel spent a week in April conducting I-zone fire drills in Blackpoint. Crews work on simulated fires that threatened structures in the area. Engine companies establish plans for structure protection, incident action plans, resources needed, safety routes, and evacuation routes. During the drill, they communicated this information to the Incident Commander and were assigned "phantom" companies to handle the incident. Now an annual training event, it serves several functions. Training incidents are staged in different locations every year to serve as pre-incident planning sessions, while sharpening the skills of District personnel. The companies are tested once a year on this critical size up and placement skill in wildland/urban interface areas.

In May approximately 34 residents participated in the neighborhood's first Clean-Up Day. The residents obtained a chipper from Marin County and a local tree service company donated personnel and equipment The project was so successful that an additional five days were necessary to clear and chip the amount of brush homeowners removed from their property. They were also successful in clearing brush and vegetation back from an abandoned access road that is now used as an emergency evacuation route in the event of a fire. As secondary evacuation route was also created when an access road that encompasses the area along the bay was widened and designated as a "safe-haven" in case the primary evacuation routes are blocked by fire.

Maps were created with evacuation procedures outlined. These have been distributed to all residents. A community fire drill was conducted in August. Over 20% of the homeowners participated in this drill. Afterwards, a potluck dinner was held at the local substation to foster the camaraderie that had begun to develop between the Fire District and the residents.

The District was extremely pleased with the progress made through Wildland H.E.A.R.T.. Although only a small percentage of residents are involved in the action planning and work projects, these individuals have excellent leadership skills, and they have kept the H.E.A.R.T. program progressing as planned.

The District gained the following benefits from working with the Blackpoint Regional Forum:

An increase in the homeowners' awareness of the fire danger and safety status of their community;

An increase in homeowner participation for increased safety standards for their community;

An increase in District personnel awareness of our operational capabilities by means of the "walk-through" tours and training drills performed in the area;

Clearly identified evacuation routes that have been tested;

Evacuation routes that are cleared and maintained by homeowners;

Improved infrastructure: cleared trees over the roadway, and brush cleared brush from the road shoulders;

Excess vegetation cleared (financed by the homeowners);

A staged "community fire drill" so residents know the identified escape routes; and

a "Red Flag" critical fire behavior warning system.

H.E.A.R.T.'s basic hypothesis, that with proper training residents can learn to take appropriate actions to prevent or minimize the impact of wildland fires, was proven by the pilot project at Blackpoint. H.E.A.R.T stresses cooperation, teaching people how to work together to solve problems related to a disaster. The training empowered people to make appropriate choices to improve the safety standards in their community. Residents of Blackpoint were eager to achieve goals and expressed a desire for taking a more active role in providing for their own well-being. The District's role has shifted from that of "enforcer" to that of "empowerer," a unique and positive position for a fire district.

### Cost/Benefits

In general, it is somewhat difficult to quantify the number of lives and the value of property saved as a result of public education programs. H.E.A.R.T. is no exception. The cost savings are indirect, e.g. time spent on inspection and enforcement activities and fire officers being able to reallocate fire fighters time to other necessary activities. In communities where H.E.A.R.T. was presented, the District experiences higher compliance with safety recommendations and fewer code violations. The District feels that service is "improved" because of the increased interaction with the people of the District. While the District will always respond to emergencies, this program allows personnel to modify the type of interaction they experience with the public. Success has been demonstrated in terms of increased rapport with members of participating communities, voter/taxpayer support (a tax-increase was approved by the voters), the number of requests from other neighborhoods for presentations of H.E.A.R.T, and on-going, long-term projects that communities have developed after completing H.E.A.R.T. training.

With its interactive approach, people in H.E.A.R.T. communities have a chance to ask questions and learn about the District in supportive, atmosphere. After the program was expanded to other communities additional benefits were realized:

Funds were pooled to purchase a disaster cache. Medical equipment, food, water, flood pumps, blankets, etc., are stored in this cache to help this community survive a disaster.

Red flags are raised at several communities to indicate days of high-wildfire risk.

Increased communication with the citizens of the District as a whole.

Citizen awareness of the Fire District, its operations and capabilities.

Community evacuation drills.

Communities changing by-laws and assessment fees to help them achieve safety goals.

Communities applying for and receiving grants to assist them with their safety programs.

Identification of neighbors with special skills or who work for agencies with resources that can be utilized to help in a disaster and to learn about neighbors who need special assistance.

Partnerships formed with allied industries such as Pacific Gas & Electric (who provides chippers and helps with cutting), tree chipping services (for fuel removal) and fire extinguisher companies (who refills extinguishers used in training).

The District incurs the cost of the training workbooks, a one-time only fee for visual aids, certificates and bump helmets distributed at H.E.A.R.T. graduation, and staff expenses for salaries. All other costs associated with completion of community goals are absorbed by the homeowners. Homeowners groups are responsible for purchasing any equipment and implementing all plans related to the information taught. Communities have performed brush cutting, widened roadways in high wild-fire risk areas, purchased and installed signage (no-parking) and purchased and installed house numbers. All of this was done as a direct result of the H.E.A.R.T. program using no District funds.

## Historical Information & The I-Zone Problem

One of the most important elements of Wildland H.E.A.R.T. is to educate the residents about the impending risk of not properly maintaining the vegetation in their areas. Much time is spent teaching people about the native vs. imported types of vegetation and what is currently growing.

In Novato, there are wildland areas with grass (fuel load of 1/4 - 1/2 tons per acre), chaparral (1 -2 tons per acre), to oak woodland (30 - 50 tons per acre). In many areas, there is a mixture of grass, chemise, and mixed chaparral with an oak woodland overstory. The chaparral is a fire responsive plant community which must experience fire to germinate a dormant seed bed. This is the only means of succession for many species.

Most of the chaparral species have a life span of approximately 50 years. However it is more important to remember that the chaparral becomes a serious fire problem after 20 years. Ideally, chaparral shouldn't be allowed to grow unchecked more than 10 years because of the decadent growth and dead wood accumulated. Chaparral in Novato includes chemise, manzanita, madrone, baccharis, coastal sage and toyon. Most of this chaparral is 30 - 40 years old. In some areas, it is well over 50 years. This growth indicates that there has been very little large acreage fire history; it also means that due to the large quantities of fuel, Novato could experience a fire of huge proportions. Most communities have significant quantities of down dead fuel.

In the past, fire was utilized in this area to manage the vegetation. These fires were either started naturally or by Native American Indians who lived in the area. These fires helped propagate healthy chaparral, kept the understory at a minimum, increased the amount of wildlife and elevated the water table.

As more people started moving into the area, the Indians were pushed back, natural fires curtailed, and burning ceased. Over time, the population increased and people began building closer to the woods. What's important for people to understand is the correlation between fires and a well managed fire ecology. When fires periodically burned through an area, the thermal output is relatively low and the fires are fairly fast burning. When people move in, fires are avoided or extinguished and the vegetation growth increases unchecked. This vegetation must be managed. When fires occur in unmanaged areas, the fires burn at significantly higher temperatures and tend to create environmental problems rather than beneficial results. If people aren't going to let fire manage the vegetation growth, they must remove the overgrowth manually. There is nothing natural about allowing vegetation to grow uncontrollably.

Unfortunately, people have failed to effectively manage the vegetation. People must learn to simulate the action that fire took, i.e. removing low lying limbs, clearing dead chaparral, keeping grass areas wild and propagating native species. Defensible spaces must be created around their homes. Understanding this history, and learning how to manage the vegetation more effectively are essential elements of H.E.A.R.T.

### Awards & Recognition

The Wildland H.E.A.R.T. program is fundamentally different as an approach to fire and life safety education. Rather than simply giving do's and don'ts to preserving life and property, it challenges citizens to adopt a more responsible role. Perhaps too often California's citizenry has looked to government and other institutions to solve disaster-related problems; through H.E.A.R.T., trained professionals share their expertise, empowering the members of participating neighborhoods to learn skills and to take actions to prevent (or significantly decrease the chance of) wildfires.

This success has been recognized by several agencies. In 1993, The Wildland H.E.A.R.T. program was awarded the Neighborhood Achievement Award. This award was a gift of $5,000 which was used to purchase equipment used in H.E.A.R.T. training and it is also used to match funds homeowners put up for safety equipment such as traffic signs. Two communities that completed and implemented H.E.A.R.T. training have also received these $5,000 awards.

Elements of the H.E.A.R.T. program have also been recognized by the Western Fire Chiefs Association. The Novato Fire District was presented with the Award of Distinction for Fire Service Excellence in 1993 and the International Association of Fire Chiefs presented the District with the Fire Service Award for Excellence, Honorable Mention. Neither of these awards were monetary.

Additionally, the Wildland H.E.A.R.T was so successful that the District was asked to make a presentation about it at the First Annual Wildland/Urban Intermix Conference in 1992.

### Summary

Since I-Zone areas in California are particularly prone to wildland fires, it is vital to educate people about the risks associated with their communities and the actions they must take to prepare for or mitigate these problems. H.E.A.R.T. was developed as a response to the logical needs of the District and the citizenry. H.E.A.R.T. helps alleviate I-Zone problems by working with communities as a whole. After all, it only takes one home to put the entire community at risk. Through H.E.A.R.T., communities at greatest wildland fire-risk are identified, then approached and offered the opportunity to participate in this program. Since the program is based on homeowners' ability to work together to resolve problems, there must be some structure already in place for neighborhood communication and information dissemination. The structure can be as formal as homeowner's associations or as informal as a group of concerned neighbors willing to work together on the project. Based on Novato's success in improving the safety standards of these high fire-risk communities, it is strongly believed that the best results can be obtained by getting people involved and designing a program that people will participate in and support. In Novato, H.E.A.R.T. meets this end.

A survivor of the Southern California Firestorm has developed great insight for living on the rim of the I-Zone.

By **Theodora Poloynis-Engen ©**

I was asked to write this piece, knowing that to do so would demand that I re-live the indelible terror of the fires. The fires which scarred the hills, cauterized my soul and burned my house to the ground. I had no choice but to write this. Writing for me, when I am ready, means I can begin the process of healing. Others who lived it call themselves "victims" not really understanding that word and its implications, selecting that term to conveniently abbreviate the pain which shadows its survivors.

In only the most limited sense was I a "victim" of the fires of October, 1993; in only the most limited sense was I subjected to fire's will. The word "victim" as defined in the Oxford English Dictionary is "one who is reduced or destined to suffer under an oppressive or destructive agency." Ancient alchemists considered fire one of the four elements making up the physical world. It was not a separate force, but part of the bundle of life itself. The ancient Greeks believed Prometheus stole fire from the gods for fire is a giver of light, heat and life. The Victorians, knowing their vulnerability to fire, contained its force in the hearth at the center of the house, always aware that power so contained might leap, if unleashed from the hearth to destroy the city.

We Californians, arrogant in our synthesized knowledge, live in the hills knowing of fire as an object which burns someone else's house until we experience its rage. We dilute it by repeating platitudes about fire like an often repeated prayer to protect ourselves from knowledge of it. We cant the words that fire is nature's cyclical way of replenishing the hillside chaparral as if incantation can protect us. We ignore the plain fact that we could be caught in the center of the vortex of heat and destruction— the foreseeability of the destructive agency that makes victims of us all. We fail to recognize that so long as we have taken no practical measures to protect ourselves, we are self-designated victims.

### On the Rim the View is Panoramic

Fire is oppressive and destructive but I was not destined to suffer under it; a victim is the subject of destiny. Destiny did not chose the house I lived in; destiny did not create my desire to live in the hills. I worked toward the goal I wanted. Whether consciously or not, to live on the hillside at the rim of the world is a luxury I wanted. Only in retrospect do I recall the few times I heard about the fires, the knowledge of the possibility of losing it all to the fire never reached me. I was nestled in the arms of the Sierra Madre mountains. Like a Victorian, I kept fire confined in my mind's hearth because fire was not our destiny,... yet.

We lived above the smog line at 1,700 feet above sea level. At night, the view from the house was a panorama of lights spanning the city below us. Above the smog line, the sky is blue. There are stars in the sky. Below the smog line the sky is a muddy brown hole. You can't see the hawks in flight. By mid-morning in Los Angeles, the smog closes over the sky dividing it into separate worlds; one world of birds in flight, of clouds and stars and another world of perpetually brown sky to match your mood when you're below the smog line.

### When the Hand of Destiny Knocks

On the morning of October 27, 1993 destiny arrived at my door. The door I left open knowing I would never pass that threshold again. The house was burning and I didn't know it. I was at my desk in a bedroom looking out over the pool facing the city, the mountains were behind me and the canyons were to the side. I could not see them from where I sat.

The sky over Los Angeles had a dark gray-green tinge. Though I usually read in silence, I had learned of the fires in Eaton Canyon to the east, so I listen to the radio. I listen for where the fire was, not knowing it had jumped several canyons and was at our house. Blithely I read and listened to the radio, oblivious to the fire.

Several people, more aware than I, called to see if I was all right and I said, "Of course" not knowing that as I said it, the fire was running down over the ice plant on the hillside to the north of the house. Not knowing it had leaped into the rafters of the roof. I was worried about friends who lived in Eaton Canyon. Later, I learned while I was worrying they were being fished from their pool by fire fighters.

It was not until my husband came back to the house having dropped-off our daughter at school, I realized that the fires were very close. Ordinarily, he goes straight to his office. That day he came home first. He was concerned that the heat of the Santa Ana's and the fires would cause the Sub-Zero refrigerator to leak on the hardwood floors in the kitchen. That refrigerator is responsible for saving my life. It is also a concrete demonstration of how those of who live in areas vulnerable to fire can mentally obliterate the risk of where we choose to live. After he got to the house, having looked at the canyons beside us he said, `I think we've got 15 minutes.' We didn't, we had five. Then we got down to it. `Let's pack some stuff in the car. What's in this drawer? What's in that suit case? I had forgotten my study drugs in the freezer of the Sub-Zero, I ran back into a dark burning house to get the drug vials. When you are a human subject of an double-blind study of experimental drug for Multiple Sclerosis, the drug count is critical. It was all I could think of. At the time I didn't know I was on the placebo. Two years later, I learned I had run back into a burning house to get the equivalent of distilled water.

As I was almost out the door of the house, my husband yelled "Hurry, Don't shut it!." I didn't. There wasn't enough time. He told me to leave my car and get into his. I said "no". I had just had a new stereo system put into it, and I didn't want to lose my car. I followed him down the hill through branches falling from burning trees above me. They dropped on to my car, I heard the sound and felt the heat, heat so extreme that the dash board cracked. I don't think I have ever driven that well. I knew that to get through it, I had to concentrate. As I followed my husband's car, I saw my neighbor's car explode, she sprinted up her driveway and jumped into my husband's car. I remember thinking "damn she has a great stride."

As I followed his car, an older neighbor who had built the first house on our hillside about 30 years before, was trying to put out patches of flames with a garden hose. He had survived the 1970 fires and mud slides. He told me about the wall of mud which came down the mountain side that year. On top of the 100 feet of mud was a fire truck being slowly moved by the mud under it. I rolled down my window yelled,"Get in!". He hollered back "No! I'm staying 'til the end." In the midst of all that heat, I was chilled by fear for him.

### Rearview Memories

As I looked up from my rear view mirror to the hillside, I saw fire burning through ice plant. We, who live in the hills believed ice plant prevents fires from spreading. That's not true. As I watched the growth being swallowed by fire, none of the rules about what will burn and what won't, held. The true rule on plantings is: those plants and trees which you have never liked or block your view are immune to fire; those plants and trees you really love, burn. This rule applies to all plants whether they are classified as flammable or not.

The vivid colors of the fire will cling to me forever. I was stunned to recognize, through the horror, relentless beauty in the destruction. The sky was grey pooled with yellow and red. The fire had different undertones, orange, yellow and green. The only true red I saw was at the rim of my eyes through the smoke and tears.

A Sour Note
A lived-in house makes strange sounds as it burns. When we got back up the hill, the fire fighters were standing back, hesitant. The house sounded like an ammunition factory exploding. Neighbors were shocked by the sounds coming from the house. One fire fighter asked whether we had firearms. We don't. Then, finally I figured it out, it was the grand piano playing its last song, one of death by fire. A grand piano has over two hundred strings. There is about 23 tons of tension on the strings. When the sounding board collapses the strings as they snap free, sound like rapidly repeating gun fire. No, they are no longer in tune.

### The Start of a New Beginning

Even in hell there is irony. When we bought the house, I joked that we were in an area where people got on T.V. and said, "we'll rebuild." My husband drove me back to the rubble, the remnants of the house. Somebody shoved a microphone at my face and said `How do you feel?' How in the hell are you supposed to feel? At that point I was having an out-of-body experience. Your history and life, present and past, are in real ruins not metaphorical ruins, and at that moment I couldn't understand it. So, I just looked at him and I heard myself say it. "We'll re-build".

No other house on our hillside burned to the ground. Only our house. We were the fire break. We drove back up the hill and I watched it as it burned. I saw it burn again and again on television that night. I saw it burn on the cover of Time Magazine.

Losing your home in a fire is just the beginning. Whether it is a good beginning or the beginning of the end rests solely within each persons control. Rick, my husband of 21 years made it a good beginning. When we first got down the hill and had parked my car, he hugged me and recited some lines from the Rubiyat;

"Come fill the cup and in the fire of spring,
The winter garment of the repentance fling
The bird of time has but little way to fly
And, lo the bird is on the wing."

With those lines, lines he had cited to me 25 years ago when we met, I knew that we could begin again. We drove back to watch the end.

### Reconstructing Life and Memories

After the stunning event what do you do? How do you start? What's the first step? It doesn't really hit you immediately, but when it does, you almost have to remind yourself to breathe. Since then, we have learned that there are several phases to re-building a new life.

The first step was to tell Marina, our twelve year old daughter, that the house was gone along with the artifacts of her infancy. Together we went to her school. We asked that she be brought from class. I remember holding her and saying, "You know that room you didn't pick up? Well, it's okay. The house burned down." First I saw the signs of a giggle in her expression, then tears. The only way I could tell her was with some humor, for I had no scarlet ribbons for her hair.

We were lucky, we had a credit card. Then "The Mother" took over. We had dinner, went next door and each bought one book. I needed to have one book. I lost a 4,000 volume library in the house. Neighbors complained after the fire about raking up pages from the books. For some it was the closest they had come to the printed word in years. We bought tooth brushes, combs, daily items so basic we forget them— this includes underwear because you have lost everything including your underwear in the fire. You haven't lost your shirt, however, until you take stock of your finances.

We took a hotel room. The only room left was on the 14th floor with a balcony and a view of the mountains. It was a picture of hell. Every town against the mountain was aflame through the night. The sky glowed red and gold against the mountain side.

The days that followed are still a blur. I remember spending a day going through FEMA to sign forms in case we needed disaster relief. It was helpful. We filled out forms. Forms to re-appraise the land for its new value without a structure, forms for an extension for filing tax returns, forms to see a counselor, forms for temporary housing, if necessary, forms for immediate cash grants. We were introduced to the State Contractor's Licensing Board representatives for advice on selecting a contractor. The nicest people were the state tax representatives. One offered to re-tape some of the classical C.D.'s I had lost, from his own collection. This was the information gathering period. Without that initial introduction, I don't think we would have had a ready source of critical information.

## Sifting Through the Ashes

By the time we had finished at FEMA we were growing quite aware of how bad it was going to be and most important, that there was assistance. We had gathered the information now we had to process it to make choices. We had entered the sifting period.

The sifting period took two forms: the first is the actual sifting of the dirt and ashes to find anything which might not have burned. I, personally, was sifting for diamonds. The second is the sifting of the options to make decisions about the remnants of your life. We were sifting for hope. We found it.

As an infant my daughter was baptized. Her Godparents, our closest friends, had given her a filigree 18 carat gold cross. The cross used in the ceremony had been blessed by the priest. In sifting through the ashes we found the cross. It was slightly blackened, but somehow, it had not melted from the heat. The cross was the beginning of hope.

## A Word of Advice

Looking back, there are so many preventative things we could have done had we understood the price of living at the rim of world. We did not think about it, read about it or understand what could be done to limit the effect on our lives— so it would not have been as paralysing as it was. We were lulled by the mountains into believing it wouldn't happen to us. In hindsight, now I know what we should have done. Perhaps this essay will help others not to make our mistakes in the future. These same measures apply to fires in the city as well as to fire prone areas in the I-Zone.

Keep your fire insurance at the level it will cost to re-build the same size house on the same lot. Just because the cost of single family housing decreased in the last five years in California does mean that the cost to replace the house went down. Lumber, for instance, is a commodity governed by different market forces than houses. Lumber goes up, even though the price of houses goes down. The same is true of appliances, fixtures and flooring. The best policy is a replacement policy.

After a disaster such as the 1993 California fires followed by the earthquake, the county changed the codes to increase safety. Code up-grades increase the cost of re-building and can make that process more difficult. For instance, Los Angeles county required that fire victims provide a fire truck turn-around as pre-requisite to a building permit. On a hillside lot the pad is not that big. The choice comes down to either putting a fire-truck turn around on the lot, or re-building a house. Fortunately, the fire marshal was willing to accept two out of three accommodations in exchange for the turn around. The first was to require fire sprinklers in the house. The second was to require that the hydrant have enough water pressure. I am thankful that it did. Had it not had sufficient pressure we would have been required to re-pipe the hydrant, or to replace it. Either alternative would have kept us from re-building; we just could not afford it.

The important documents should be kept in a bank safety deposit box. These documents are fire insurance policies, life insurance policies, appraisal records of art, jewelry, silver, antiques and other valuables. I went to an appraiser for tax and insurance purposes, who told me many actors and business people maintain an annual appraisal in case of loss or theft. It is a record of what valuables they own for insurance or tax purposes. If you don't keep a written record, video tape everything in your house. Keep the video tape in the bank safety deposit box. I was surprised by the value of what we lost. Neither my husband or I ever stopped to think about how much stuff we had acquired in that last 25 years and what its value was. We were under insured.

Be prepared to list everything you own. If your house burns down along with the contents, you lose all receipts. You're left with compiling lists for the insurance company and for the tax loss. It took us a year to document what we lost.  It was the constant pressure of remembering that hurt so much.

What you lose in a fire that cannot be replaced by insurance are the pictures from the important times in your life, photographs, your children's drawings, the plaster hand print every kindergarten teacher makes at Christmas. Keep these, the most valuable things in a place where you can quickly grab them, if you're lucky enough to have a minute in the house you are losing.

Re-building is the final phase. This isn't just the house, its your credit. A mortgage and rent are hard to meet. Something has to give. Had I known the house was going to burn down, I would not have used the credit cards like I did.

As I write this, we are almost finished re-building the house on the same lot. To do so means all hope has returned. We will make it because we survived the worst. How, I don't know, but we did it.

The most important thing to keep in a safe place deep inside of you, is your humor. As your life degenerates from the distress and financial catastrophe you have lived through, only humor and perspective keep you from losing your mind. If I am writing this, we must have lived through it. Ultimately, that's enough.

Beyond ignition resistant structures and defensible space there are preparations that the homeowner can take to improve their chances of having a home to return to.

By **Rodney Slaughter**

# 23

The link to effective I-Zone defenses is the active participation of the people who actually have the most to lose- the homeowner. What does the homeowner really need to know about the I-Zone fire problem? Do they need to know that unless their home appears to be defensible, fire fighting crews may pass their house up for one that can be saved? Does the homeowner need to know that most fire agencies have too few resources to handle any large conflagration by themselves? Shouldn't willing homeowners be allowed to assist fire fighters in saving their own neighborhoods and homes? This chapter will explore the progressive policies that would allow able bodied homeowners to assist fire agencies as opposed to complete evacuation.

**Global View**

Wildland fires are not only a California problem, or a western states problem, but also a national concern as witnessed in the 1994 Long Island Firestorm. A global view of wildland fires also demonstrates that it is an International concern as well. A report from the French Ministry of the Interior documents the wildland fire threat in countries around the mediterranean. The report entitled "Feux de Forêt" or Wildfire, documents the loss of natural resources. In Spain 1.2 million acres of forest were lost with 12,284 separate fires (1985), in Greece, 273,000 acres lost with 1,898 separate fires (1988), in Portugal the loss of 450,000 acres with 13,118 fires (1991) was reported, and in Italy over 525,000 acres with 7,956 fires (1983), and again ten years later, Italy hit over 500,000 acres with 15,322 fires (1993). France reports its 1992 losses of 41,000 acres with over 4,000 fire starts. The California cliche, is that we have a mediterranean climate- which translates into a mediterranean fire problem as well.

In China a wind driven forest fire in the north central province of Shanxi killed 29 elementary school children and injured four others. The class was on a field trip when a small fire was lit to make tea and ended up engulfing the forest around them. Only 13.92% of China's total land area is covered with forest. China with its minimal forest resource averages 14,000 fires annually or about 14% of the worlds total forest fires. Even though China's forest area is only 1/30 of that of the rest of the world- wildland fire occurrence is twice as high as that of any other country. Large wildland fires have also been reported in Russia, Indonesia, South America, and Australia.

The bushfires in Australia approximate the experiences and conditions found here in California. Similarities in topography, weather, and fuels also threaten Australian I-Zones. Fire research in both countries parallels one another in terms of ignition resistant construction and fuel modification. But the remoteness of many settlements in Australia's outback has developed into unique survival mechanisms that involve sheltering-in-place.

**Ash Wednesday**

The most infamous of the Australian fires was Ash Wednesday, which occurred on February 16, 1983 in the States of South Australia and Victoria. Once the smoke cleared 76 people died and 2,463 houses and 1,000 farm buildings were destroyed. Research scientist converged on the fire ravaged areas to understand the fire deaths and the phenomena of structural loss and survival.

The Ash Wednesday fire investigation concluded with a number of reasons why so many people died. Categorically, victims perished in the fire because even though they recognized the threat, and had enough time to save their lives, they choose an inappropriate survival strategy. Many victims did not recognize the threat to their lives in time to implement a successful survival strategy. And then, some victims were physically incapable of effecting a survival strategy. In most cases, each of these victims were caught outdoors with nowhere to shelter themselves safely from the flame front. A key point in this research identifies communication. Victims were unaware of the changes in wind direction or where the advancing flame front was coming from. Research also demonstrates that the appropriate survival mechanism would have been to stay indoors. Staying indoors not only saved lives but was key to structural survival as well.

In the Township of Mount Macedon, Ash Wednesday fires took six lives and 234 houses. Researchers discovered that, at 65 houses (14% of those that survived), when the homeowner was present, the fire did not inflict significant damage. The houses that were attended by the homeowner were saved because once the main fire front passed over they were available to extinguish small spot fires. In many cases, the homeowner salvaged their own homes and once secure, the homes of their neighbors. Unattended houses, where the owners returned immediately after the fire front passed over, were also saved from total destruction. Personal interviews shows that the able-bodied homeowner played a significant role in structural survivability and that the well prepared homes provided a safe shelter. The County Fire Authority recommended that unless you are elderly or disabled, you would actually be better off staying in your home.

### Shelter-In-Place & Safe-To-Stay

The Australian concept of staying with your home is called "shelter in place". Here in California, this concept is termed "safe-to-stay" by its advocates. The application of this concept would only be effective if; 1) the rules and recommendations for ignition resistant structures and vegetation clearance and maintenance have been adhered to, 2) the homeowner recognizes, prepares, and is trained effectively, and 3) the fire authority in command of the emergency recognizes the potential of homeowner involvement.

Fire fighting resources reach critical levels during large I-Zone conflagrations necessitating structural triage. This concept, structural triage, evaluates whether or not a structure or property is defensible before or during an emergency. Obviously, an indefensible structure would not be the best location to shelter-in-place. The concept gains merit, however, when the community collectively prepares and maintains wildland defenses, has an adequate infrastructure and fire protection plans, as well as being properly trained in the basics of fire behavior and suppression.

### Historical Precedence

Prior to the professionalization of the fire service, able bodied people were expected to assist in the fire fighting effort. In 1872, California lawmakers passed regulations restricting burning and making it a crime to fail to aid in efforts to prevent the spread of fire. The law empowered justices of the peace and constables to order able bodied men to fight fires. Many of the conscripted fire fighters of this era were found in local pubs and saloons- drifters and tourist were also pressed into service. Fire suppression efforts were limited to lighting backfires, shovels of dirt, and wet barley sacks. While the 1872 law specified able bodied men- women were also crucial to the fire fighting effort. Women would drive wagon loads of water containers, food, coffee, and barley sacks to the men on the fireline, and in a pinch, the women would also work the fireline.

But the wildland fire threat in the late 1800's and early 1900's was much different than it is today. Large expanses of forest had not yet become overgrown with vegetation as Indians were still burning into the 1840's. Also many forested areas were completely denuded for lumber, grazing, and mining. Fire fighting in the wilderness of California during the late 1800's was accomplished by a handful of untrained able bodied citizens. Today this is not necessarily the case. Legions of professionally trained fire fighters are needed to effect containment, control, and extinguishment. The Elephant Fire for example, in Plumas County in the early 1980's had amassed approximately 10,000 fire fighters. The fire camp had become so large that it was split to accommodate the population. At the time Plumas County only had a permanent population of about 9,000 residents. The fire camp of 10,000 people became the largest and most densely populated area in the entire county.

The conscription of citizens for fire fighting has been replaced by professionally trained fire fighters and private contractors. Assisting today's fire fighting effort, private contractors are hired to supply heavy equipment, water tenders, helicopters, and aircraft. Nonetheless, if a property or community has been prepared and maintained with the wildland fire threat in mind, then citizen fire fighters can shelter in place and be available to help defend their homes and communities.

## Preparing for the Siege

An emerging school of thought suggests that wildland fires could become a target of low level aggression and terrorist activities— that U.S. citizens must be trained and prepared to deal with this threat, if not for their own safety and survival, but for national security as well! There is an old maxim that says "everyman's home is his castle." If that were the case, then wildland fires could be viewed as a siege. The definition, according to Webster's Dictionary, of siege is a diligent, persistent, or serious attack. Certainly, wildfires fall within this definition. Medieval castles were built with the knowledge that they too would one day come under a diligent, persistent, and serious attack. Typically built from stone, with small narrow openings, these castles were sited on knolls and hilltops to take advantage of position and view. Vegetation was cleared from around the fortress to watch for an impending attack.

Similarly, homes need to be properly sited and constructed. Vegetation must be well planned and maintained to effectively prepare for the siege of a wildland fire. The homeowner can emerge from their ignition resistant shelter after the initial attack and extinguish the small spot fires left once the flame front passes. But there are caveats to this strategy. The homeowner must first be trained in the basics of fire behavior and suppression. The City of Berkeley's Office of Emergency Services has developed Citizen Emergency Response Training (CERT) to train citizens in the basics of fire suppression and fire behavior. Empowering local citizens to become self-reliant is in part, Berkeley's strategy to deal not only with the I-Zone fire threat, but earthquake emergencies as well. Organizing local or community fire brigades can become a function of the fire departments public education activities in areas of high risk. But, regardless of whether a homeowner shelters in place, or evacuates, there are a number of activities the homeowner can do realizing the fire front is heading toward them.

### Preparation Activity

The most important activity begins with a plan of action. The plan must be prioritized to include the amount of time notification is given. What would you do first if you had a two hour notice, a one hour notice, or a five minute notice? These questions can only be answered by the homeowner given their circumstance and prior preparation. Preparation includes personal protection, outdoor defense, and indoor defense activities.

### Personal Protection

Regardless if you plan on sheltering in place, or if you intend to evacuate, personal protection should be given the highest priority if you are operating in an extreme fire environment. Long hair should be pinned-up and a safety helmet or hat should be worn. Safety goggles or glasses would protect your eyes from burning embers and flying ash, and a bandanna or surgical mask would also filter these large particles, and make breathing easier. Cotton or wool fabrics are recommended for overalls, long sleeved shirts, and pants. Boots and leather gloves would complete the attire for personal protection. Avoid as much as possible any synthetic, nubby, or loosely woven fabrics. To avoid dehydration drink plenty of fluids and watch for signs of fatigue.

### Indoor Defense Activities

When sheltering in place, close but unlock all doors and windows. To prevent the spread of an interior fire close all interior doors as well. Place damp cloths around gaps in exterior doors and windows. Be sure all family pets and people are accounted for. Check flashlights for batteries and keep them handy. If you have metal mini-blinds close them. All curtains, drapes, and other fabrics should be removed from around the window, this includes all upholstered furniture, bedding, areas rugs, and wall hangings. Place a ladder at the attic crawl hole so you can periodically check for attic fires. Fill bathtubs, sinks, and other containers with water. Shut-off LPG valves. Check around the inside of the house, especially the side facing the fire front, for any signs of combustion. Park your vehicle facing out in the garage, and leave the keys in the ignition switch.

The interior of the house will heat-up. Remember that if it's hot and uncomfortable inside, it is much worse outside. Keep to the interior core of the house and away from the exterior walls and windows. Importantly stay calm. Once the fire front has passed over, go outside and check the roof for any possible ignitions and extinguish them. Check around the house and yard area extinguishing all spot fires with water or shovels of dirt. Keep rechecking the house and property and look for burning embers for about 12 hours after the fire front has passed over.

### Outdoor Defense Activities

Recommendations from a variety of sources, predicated on diligent maintenance and housekeeping, suggest that you remove all combustible material from outside. This would include, lawn furniture, potted plants, plastic toys, yard decorations, trash cans, door mats, etc. Knock-down wooden wing fences connected to the house and open gates. This will reduce the combustibles next to the house and allow easy access around the house for fire fighters. Wood piles stacked close to the structure should also be knocked down and spread out as much as possible. Ladders should be extended and left in the most advantageous location to access the roof. Down spouts can be plugged and rain gutters filled with water. Windows should be covered with fire resistive shutters. If this material was not already on hand then shutter windows with metal mesh screens or 1/2 inch plywood. Overlapping sheets of aluminum foil secured with duct tape may also be used as a last resort. Similar to a fire fighters crash/rescue proximity suit, aluminum reflects 90% of the radiant heat. Check the perimeter of the house to be sure you have removed all potential combustibles from under the eaves. Shovels and rakes should also be left in an accessible location.

Fire suppression support activities would also include marking hydrants and water supply points for the fire service. Buckets, trash cans, and similar containers should be filled with water. All hoses should be connected and played out around the property. Permanent pumps for wells and pools, as well as portable pumps and emergency generators should also be protected from the advancing flame front as much as possible.

### Class "A" Foam

Borrowing an example from the nature, the spittle bug surrounds itself with a foamy blanket. The foam acts as an insulator for extremes in climate and temperature. Similarly, the use of class "A" foam has gained acceptance for many wildland/structural fire applications. The foam is used on the structure and surrounding vegetation to cool and moisten combustible fuels. The foam penetrates the surface of most combustible fuels, and unlike water which evaporates quickly, foam has more staying power.

Class "A" foam technology involves metering valves, induction devices, hoses, and specialized nozzles. Entire foam systems can be purchased from a variety of fire protection vendors. But when you have only an hour or so before the main flame front hits your property you may need to improvise. Class "A" foam is similar in composition to many dishwashing liquids. With many surplus materials around the house, you could effectively build your own foam system. The homeowner would want to amass and assemble this material long before a fire threatens their home. This would require an aerated nozzle, garden hose, and induction device. If your are using pool or other static water source simply proportion the dishwashing liquid directly into the water supply (although not as effective as using an inductor). Other induction devices, like the one used for liquid fertilizers, are attached to the end of the hose. Simple but effective aerating nozzles can be made from PVC piping and fittings with holes drilled into the nozzle. For the foam technology to be effective you need to create and apply a thick blanket of foam. The application should first begin on the exposed windward side (direction of fire front) of the property and house.

Each of these additional recommendations are offered over and above that which is prescribed by codes and local ordinances. They can be used effectively to shelter-in-place, or they can be applied as time permits to assist fire fighters defend your home. In either case the homeowner may increase the homes defensible posture by preparing and applying some common sense to the emergency.

### Interface With Local Agencies

The safe-to-stay, or shelter-in-place, concept has merit for those fire agencies whose initial response capabilities are limited. Roadways will clear faster with fewer people evacuating allowing less congestion for responding fire apparatus. When trained by local fire agencies, homeowners represent a large workforce familiar with the surrounding environment and hazards. Citizens as fire fighters would need to become familiar with common fire ground terminology and command structure to be effective. Employing the techniques discussed in previous chapters, this information could be communicated while working directly with the homeowners on their mitigation strategies and projects. Local law enforcement agencies need to be informed of what communities or subdivisions are prepared to be pressed into service. To facilitate and identify homeowner fire fighters, identification cards, badges, or brush jackets could be employed. When evacuation is necessitated by an intense firestorm, allowing homeowners back into the fire area immediately after the fire front passes could also reduce the loss of structures.

### Summary

Certainly, only able bodied homeowners should be allowed to shelter-in-place. The elderly, sick, handicapped, and young should evacuate to an area of safe refuge. But the decision to stay and fight or to evacuate must occur at several decision making levels. The homeowner has to determine their own willingness and stamina to stay with their property. The fire command must recognize the citizens right to do so and support that effort before the fire with training and education. The ultimate decision to retreat from a deteriorating situation must come the Incident Commander. Information about citizen fire fighters should be relayed to law enforcement agencies to reduce conflict at roadblocks. An identification system needs to be established to separate the homeowner fire fighter from the curious and opportunistic.

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**Robert W. Cermak,** a native of San Diego, California, who served in the U.S. Navy during WWII. He received a B.S. in Forestry in 1950, and worked for private industry in California and Alaska. Bob served the U.S. Forest Service for 30 years where his career spanned 7 National Forest in 10 States. After retirement in 1982, as Deputy Regional Forester in California, Bob returned to school at C.S.U., Chico to receive his M.A. in History. Bob applies his wealth of knowledge and experience as a fire management consultant. He and his wife Ethel live on 450 acre tree farm.

**Ronny J. Coleman,** is both Chief Deputy Director of the California Department of Forestry and Fire Protection and California's State Fire Marshal. He is a Master Instructor in California Fire Service Training and Education System. Chief Coleman has lectured extensively throughout the country and is also a prolific writer. Prior to his State appointment he served as Fire Chief of Fullerton and San Clemente Fire Departments. Ron holds an A.A. in Fire Science, a B.A. in Political Science, and an M.A. in Vocational Education.

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**Scott E. Franklin,** owns and operates a consulting firm that specializes in complex I-Zone fire management projects. His experience includes 36 years with the L.A. County Fire Department. He participated in the assessment and impact of both "Firestorm-93" and the catastrophic Oakland Hills fire of 1991. Scott has also provided fire behavior training to national park officials in Brazil.

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**Maureen Gilmer,** owns her own company Professional Landscape Design, she has not only worked in virtually all aspects of California horticulture and landscape design, but is also an accomplished photographer and freelance writer. She has written extensively on the unique aesthetic of California- its history, plants, and habitats. Maureen is a frequently featured writer for the Sacramento Bee, Better Homes and Gardens, Garden Design, Country Living, Victorian Homes, and many others. Maureen's books include "California Wildfire Landscaping (Taylor:1994)" and "The Wildfire Survival Guide (Taylor:1995)".

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**Jim Hunt,** the president of Hunt Research Corporation, has 32 years of extensive experience in the wildland-interface areas of California both as a fire fighter, chief officer, fire code official, and fire protection consultant. He co-authored the book "Development Strategies in the Wildland-Urban Interface" (Western Fire Chiefs Assoc) and is a member of the "Urban-Wildland Interface Code Committee (International Fire Code Institute).

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**Robert Irby,** for the past five years has been Deputy Chief of Fire Prevention Engineering for the California Department of Forestry and Fire Prevention. Working-up through the ranks of his 30 year career he has been a fire fighter, fire apparatus engineer, fire captain, battalion chief and division chief. His field experience extends across the Mother Lode from Tulare County to El Dorado County. Bob holds an A.A. in Fire Science from San Jouaquin Delta College, and a B.S. in Business Administration from C.S.U. Fresno.

**Robert L. Irwin,** has 50 years of wildland fire suppression and planning experience. He has worked throughout the western states during his 35 year career with the U.S. Forest Service. Bob directed the multi-agency effort that developed and implemented the Incident Command System (ICS). He also contributed to what is now the Statewide Emergency Management System (SEMS). As a Tuolumne County Planning Commissioner he developed the County General Plan for wildland protection and mitigation. Bob has authored five publications concerning land use planning and wildland fire safety.

**Juri Kommendant, Ph.D.,** born in Estonia, Juri and his family emigrated to the U.S. in 1950. He is a licensed Structural Engineer in California. Juri holds a B.S. from the University of Pennsylvania, an M.S. from the Georgia Institute of Technology, and his Doctorate from Berkeley all in Civil Engineering. His experience is in the design of residential and commercial structures, working with a variety of materials including architectural composites. Juri has lectured and written about the performance of concrete under high temperature, as well as testing polymer concrete beams.

**Don Oaks,** is the Division Chief/Fire Marshal for Santa Barbara County Fire Department and is also a practicing Attorney. His law practice specializes in a blend of administrative law and liability management. He has represented and been an active member of various statewide committees and organizations. Don has a California Teaching Credential and has lectured around the country as well written for a number of text. Don holds a B.A. in Public Administration from C.S.U., Long Beach and a Doctorate in Law from the California Law Institute at Santa Barbara.

**Brenda Pace,** is the Administrative Director for the Center of Natural Lands Management. She holds an M.S. Degree in Regional Economics and is a specialist in real estate, land economics, and finance. The Center has utilized her expertise to help produce and review mitigation proposals, develop property assessment computer software, and evaluate the variety of requirements and activities necessary to maintain site specific biological resources.

**Theodora Polynis-Engen,** is an attorney married to an attorney, who wishes she were something else. She attributes that desire solely to the fires. She is currently President of the Structural Pest Control Board, an agency within the Department of Consumer Affairs, appointed by the Senate Rules Committee. She is the mother of Marina her 14 year old daughter. If you have lived through the fires you can survive a 14 year old, says the author.

**Carol Rice,** owns the Wildland Resource Management consulting firm, which for the past 17 years emphasize wildland fire management particularly in the I-Zone. She prepares fire management plans, conducts investigations regarding fire behavior, ecology, economics, technology, and fire histories through tree-ring analysis. She holds a B.S. and M.S. in Fire Science Management from the Department of Forestry and Resource Management at the University of California Berkeley. Carol is past chair of the California-Nevada-Hawaii Fire Council.

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**James Snyder,** was instrumental in forming the Personal Insurance Federation of California and has served as President since 1989. Prior to that, Jim was Executive Director of Western Insurance Information Service, an Officer of the St.Paul Fire & Marine Insurance Company, and also the Executive Assistant to the Florida Insurance Commissioner. Jim has written many articles and made many television appearances including the "MacNiell-Lehrer News Hour" and "Firing Line". Jim has a B.A in Political Science from the University of Miami, Florida.

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**Kenneth Topping,** is Principal with Topping Jaquess Consultants, and is former Director of Planning for the City of Los Angeles. Ken has pioneered many innovations involving city planning, disaster management, government streamlining, and information technology. He has worked with FEMA and the American Planning Association in developing the Oakland Hills case study and model recovery ordinance. Ken has prepared the "GIS Strategic Plan" and "The Disaster Field Office Information Management Plan" for O.E.S. and participated in international advisory teams on the reconstruction of Kobe, Japan, and on safety management issues for Seoul Korea.

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