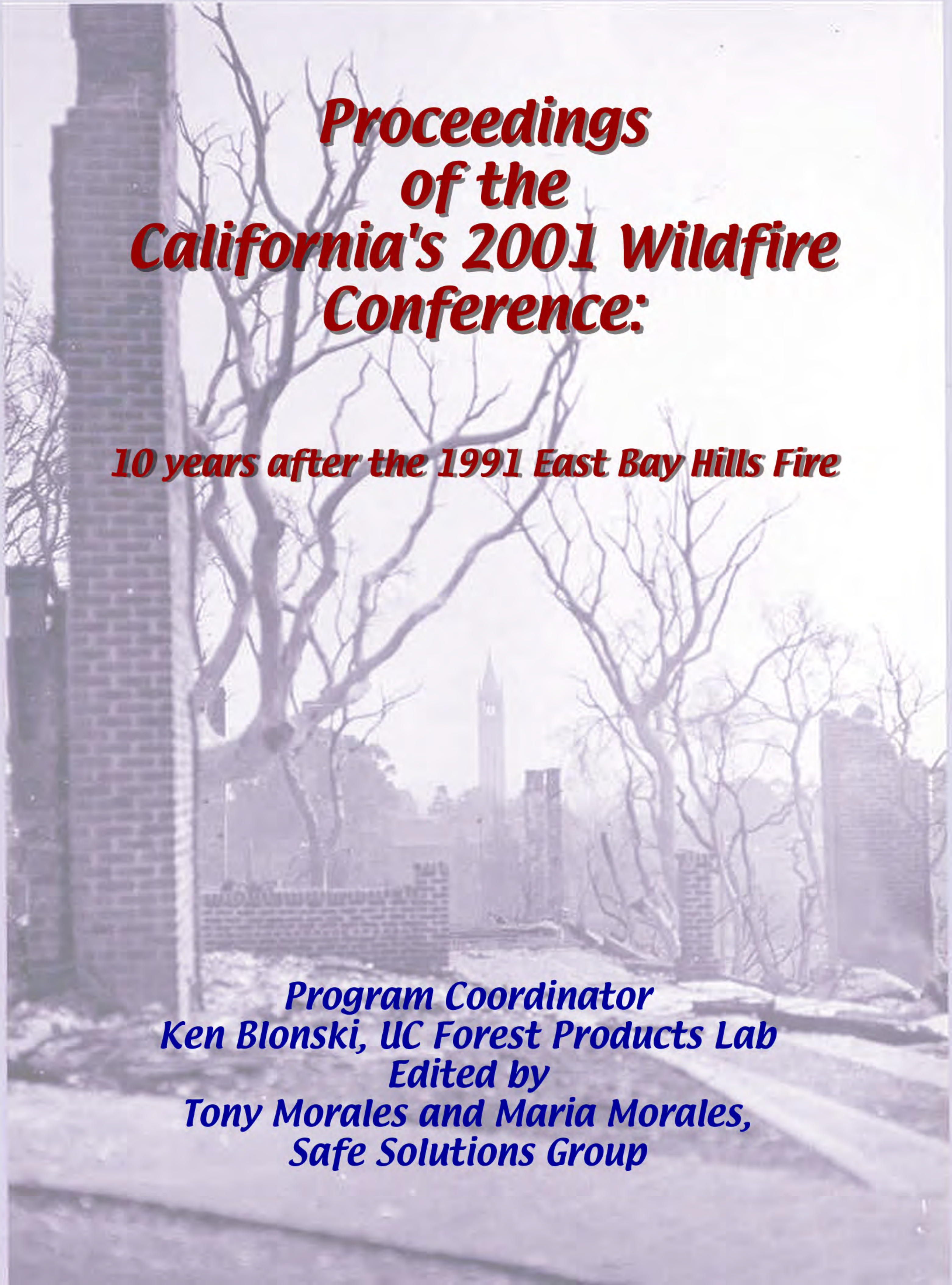

Proceedings of the California's 2001 Wildfire Conference:

10 years after the 1991 East Bay Hills Fire

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Edited by
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RECOMMENDED CITATION FORMAT

Blonksi, K.S., M.E. Morales, and T.J. Morales. 2002. Proceedings of the California's 2001 Wildfire Conference: Ten Years After the East Bay Hills Fire; October 10-12, 2001; Oakland California. Technical Report 35.01.462. Richmond CA: University of California Forest Products Laboratory.

Key words: East Bay Hill's fire, fire modeling, fire analysis, community planning/permitting, fire behavior, vegetation management, fuels management, Hills Emergency Forum, incident perspectives, homeowners' hazards, insurance

Published by:
University of California
Agriculture & Natural Resources
Forest Products Laboratory
1301 South 46th Street, Richmond, CA 94804
www.ucfpl.ucop.edu

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Special thanks to:
Miriam Aroner for comments
& Ariel Power for technical suggestions.

SPECIAL RECOGNITION GOES TO OUR SUPPORTERS FOR THEIR DONATION OF TIME, MONEY AND SERVICES

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SPECIAL RECOGNITION GOES TO THOSE INDIVIDUALS LISTED BELOW WHO DONATED THEIR TIME AND EFFORT TO MAKE THIS A SUCCESSFUL PROGRAM

Christopher Adams
Program Manager
Governor's Office of
Emergency Services
Disaster Assistance Division

Dennis Babson
Governor's Office of Emergency Services
Hazard Mitigation Section

Brian Barrette
Society of American Foresters
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Gilbert Bendix
Society of Fire Protection Engineers

Bethallyn Black Rogers
Contra Costa Master Gardners

Ken Blonski
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Barry Callenberger
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UC Forest Product Laboratory and
Office of the State Fire Marshall

Robin Freeman
Merritt College Environmental Science
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Scott Keller
Personal Business Manager
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Don K. Kendall
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Special Recognition to Individuals (continued)

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Assistant General Manager
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Pat Kidder
California Fire Alliance
Bureau of Land Management

Chuck Kovely
Master Gardeners Association-UCCE

Susanna Laaksonen-Craig
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FireSafe Council, and CDF

Jerita Wallace
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OPENING COMMENTS

In May 2000, at the annual University of California Forest Products Laboratory (UCFPL) Open House, a colleague of mine mentioned that October 2001 would mark the ten year anniversary of the Oakland Hills Tunnel Fire. He suggested that a conference or other event could be organized during that month to highlight and reinforce the continuing need to mitigate Urban-Wildland Interface (UWI) fire issues.

Over the following months the possible event was discussed with a number of individuals from government, academia, the private sector and the public. They all suggested possible approaches. I took their collective suggestions and decided to make it happen. However I soon realized that it would be necessary to focus the scope of the event, if it was to be successful.

The course of these discussions led me to a number of conclusions: 1) There was a widespread agreement that the UWI problem was getting worse. 2) There continues to be a considerable and growing concern in many circles about the UWI issues. 3) A tremendous amount of energy is spent in groups of like-minded individuals discussing aspects of the UWI with each other…preaching to the choir! And lastly, 4) A number of people were willing to commit time and energy to making a change in the UWI.

With the support of Dr. Frank Beall at the UCFPL, Cheryl Miller of the Hills Emergency Forum, Melissa Frago of the Office of the State Fire Marshal, Sandy Cooper of the University Extension -UC Davis and Carol Rice of Wildland Resource Management and we initiated a planning team that met once a month up until October 10th, the beginning of the Conference.

The planning team consisted of over 52 people. Together we developed the following Mission Statement, Goals and Themes:

Mission:

We will conduct a conference and public awareness events in the East Bay Hills during October 2001, addressing fire related issues in California's urban-wildland interface. We will bring together residents with members of the fire service, government officials, academics and the media for the purpose of empowering people and agencies to break the cycle of repetitive loss.

Goals:

- To educate and motivate homeowners to adopt fire safe behaviors.
- To motivate administrators to support long-term views on environmental health and public safety.
- To expand lines of communication between agencies and their publics.
- To exchange new research findings.
- To discuss common ground between fire safety and environmental concerns.

Themes:

- Breaking the cycle of Repetitive Loss in the Urban-Wildland Interface.
- People and Agencies Empowered.

As the Conference took shape, nine specific sessions were identified: 1) Plenary Session 2) Modeling and Analysis 3) Community Planning and Permitting 4) Fire Behavior 5) Vegetation and Fuels Management 6) Hills Emergency Forum 7) Incident Perspectives and Case Studies 8) Homeowners' Hazards and Insurance 9) Closing Plenary Session/Wrap-up. Additionally there was a vendor display and poster session with over 44 exhibits.

A review of the Conference evaluations indicated that the five Conference Goals were clearly met. The renewed sense of commitment to make the UWI safer for everybody is apparent and will continue to develop in both the Bay Area and California as a whole.

The Conference was made possible by the generous donations from 20 Sponsors and 28 Co-sponsors. Sponsors donated $2,500.00 dollars or more, or provided some other significant contribution. Co-Sponsors donated money, mailing lists, logistical help or other support.

The first statewide meeting of the FireSafe Councils was organized concurrently as a part of the Conference. This one-day meeting was envisioned by Bruce Turbeville (CDF-Ret) and developed into successful one-day workshop by Brian Zollnar of CDF and Jill Rushing of Manning, Selvage and Lee.

Lastly, the Conference was only one of a number of public events in the East Bay Hills area. These events were held over a two-week period in mid-October, which partially overlapped National Fire Prevention week. The 2001 Fire Conference, and public events served as an on-going reminder of the importance of Fire Safety generally and the need to be ever mindful of the UWI and the many complex issues surrounding it!

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HOMEOWNER PERSPECTIVES: HOUSEWARMINGS

Barbara Westover
Fire Survivor
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For over 20 years our family of four lived at 5929 Acacia Avenue, a beautiful craftsman home 3 miles from the origin of the fire and less than 100 feet from where it ended. When the fire occurred I had recently received a M.Arch from UCB. We watched our home burn on television. I did not want to rebuild. My husband, however, saw it as our chance to get exactly what we wanted-- he loved our location which is so convenient to San Francisco where he works. Less than 100' from our property line trees grew and gardens flourished. We were not set in a "moonscape" like so many others. I agreed to rebuild.

The documentary is a lantern show of images from the former house in the inferno through all the phases of rebuilding. I documented it with the forethought of making a presentation that would serve to inspire young women to enter the profession of architecture and related fields. A few months ago I presented it to a group of mothers and offspring--boys wanted to come as well. It is moving to re-experience the fire, energizing to see the industry that went into the reconstruction and healing to see the final form.

Housewarmings is about life after death. The total loss of our homes and neighborhoods was devastating. But now 10 years later much good has come about. Whereas all but one of our near neighbors moved away the new homes have sprouted young and wonderfully enthusiastic families with diversely beautiful gardens. For myself I have a new life as an aspiring architect. The doghouse which I built with my own hands out of construction scraps is featured on the cover of a successful little book: BARKITECTURE (go to Amazon. com to see it) and our house has been featured in the Williams-Sonoma catalog et. al

After the fire Mayor Harris appointed me a Fire Commissioner. The commission was short lived, voted out by the constituents who objected to the assessment. My service on that commission was enlightening and demoralizing. I commend you on your goal to break the cycle of repetitive loss. History has a way of repeating itself . . .

CALIFORNIA WILDLAND AND INTERFACE FIRES: PREHISTORIC, RECENT, AND POTENTIAL

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ABSTRACT

Fires have been a part of California wildlands prehistorically and continue today. They were started prehistorically primarily by lightning and Native Americans. Recently, under fire protection, lightning has continued to be an important source of wildland fires, and accidental and arson fires are increasingly significant ignition sources. Covering three-quarters of the State, we attempted to estimate how much area burned prehistorically, area burned recently under the regime of fire suppression, and how the fire regime characteristics have changed.

Using the area of each vegetation type divided by the low and high fire return intervals (FRI), we obtained estimates of 5.5 to over 19 million acres of California burning annually in prehistoric times. Recent burn areas were obtained from Federal and State wildfire records, beginning in the early 1930's. The data indicate great success in reducing wildfires until the late 1960's, reaching a low of about 2.3 acres burned per 1,000 acres protected for the period from 1965 through 1969. This figure rose to 8.1 acres for the period of 1992 through 1996.

Structure loss has increased dramatically over time. California lost 1.37 times as many homes to interface fires in the 1990's as were recorded in the previous seven decades, including the disastrous 1923 Berkeley fire. There is no trend to the loss of human lives lost in California, averaging about 22 individuals per decade, but the loss of any lives is tragic.

The difference in fire occurrence between prehistoric and recent times means a change in the four aspects of fire regimes -- period between fires, severity, seasonality, and dimensionality. Today there is less pyrodiversity, leading to a potential decrease in biodiversity. It is this long period without fire, or other adequate fuels management, that has been instrumental in making fires less controllable, more damaging, and more dangerous.

Managing the fuels and making structures less fire prone are the keys to reduced losses of wildland, structures, and lives to fire. Both domestic and wild plants must be managed, and structures must have fire resistant surfaces in both materials and design. Priority should be given to management of fuels in the structure/vegetation interface. Evacuation plans should be in place. Independent fire fighting systems should be available, such as compressed gas driven foam or gas-powered pumps.

KEYWORDS: California, Prehistoric fire, Recent fire, Urban/wildland interface, structures burned, fuels management, fire protection.

INTRODUCTION

The timing of this conference is appropriate as a ten-year commemoration of the Oakland-Berkeley Hills "Tunnel " Fire and to celebrate National Fire Prevention Week. We might ask if conditions are any better for preventing another such disaster or for reducing losses to wildfire in wildlands. The issues will be discussed at length from many different viewpoints during the conference.

Our purpose in this discussion is to set the background for the conference. We'll do this by first looking at the history of wildland and interface fires in California. We'll then look at information on the specifics of structural fire losses from some fires. The effectiveness of laws and programs to promote fire-safe interfaces will be covered as well as the prospects of preventing future disasters.

Whereas total fire suppression had been the goal of land management and fire protection agencies for decades, there has been a gradual trend toward recognition of the role of fire in maintaining healthy ecosystems and in lowering the fuel loads. Today, agencies are looking more and more to reducing fuel loads through prescribed fire or other means and to using fire as a land management tool.

Recent wildfire history from State and Federal records indicate a decrease in acreage per year per 1,000 acres protected, until the late 1960's, but an increasing trend since that time. Increasing fuel loads are a major reason for the increase in area burned, as there has not been a consistent trend in the number of fire starts. The number of structures lost to interface fires has increased dramatically in the last three decades, and particularly in the 1990's, with more structures lost in the last decade of the 20th century than in the previous seven decades.

PREHISTORIC FIRE

The prehistoric presence of fire in many of California's ecosystems has been documented extensively, through fire history studies and studies of Native American use of fire. We presented estimates of prehistoric burn acreages at a conference on California fire ecology in 1997 (Proceedings of the California fire ecology in progress).

We used the acreages of different vegetation types from Barbour and Majors' 1977 summary of Kuchler's 1964 vegetation map of California. Next, we summarized all the fire history information available in the literature, from various workers, and added information on Native American burning to arrive at long and short fire return intervals (FRI). Some vegetation types were combined because of similarities and sparse data. There is little information on fire occurrence in the drier southeastern quarter of the state, and this area was left out of the analysis. In some cases, educated guesses were used to estimate FRI. Dividing the high and low FRI into the acreage of each vegetation type produced the low and high estimates of annual burn areas, respectively.

For the fire return interval information, we used the extensive listing in Skinner and Chang (1996) in addition to information cited here. (We have not repeated their citations in the interest of brevity). Information was obtained from Lewis (1973), Johnson and Smathers (1976), Olson and Martin (1981), Greenlee (1983), Rice (1983), Sugnet (1985), Finney and Martin (1989, 1992), Anderson (1993), Brown and Swetnam (1994), and Stephens (1996a, 1996b) as well as personal communications and our own knowledge.

Various methods were used by different researchers in estimating the fire return interval (FRI), resulting in widely varying estimates. For example, some used lake deposits some the age of various-aged cohorts in a stand, some the years between fire scars from a point source (single tree), and some the composite fire return interval taken from fire scars on several trees in a selected area (Dieterich 1980). Composite fire interval dates were often determined with estimates of fire acreages. For example, in any vegetation type, workers might have determined the age by cross-dating using pyro-dendrochronological techniques. Studies sometimes gave only an average or median period between fires, whereas others gave ranges of periods between fires without further statistical analysis.

We used or estimated the high and low medians for the period between fires for each type. Using the high and low end of the ranges would yield very high and low estimates of FRI's and of acreages burned. Where ranges, but no mean or median fire intervals were given, we estimated the median to be one-third of the way from the low interval to the high interval to the nearest year. The rationale for this is that fire intervals in most or all types are skewed toward the low intervals within the range (Finney and Martin 1989). Since the state consists of about 100 million acres, it is easy to convert acres to percent of the state land area. Little information was available from the desert types of southeastern California, which comprise about 26 million acres or 26 percent of the state, and these were left out of the estimates.

Thus, the area actually covered by fire might be somewhat less than the estimates given here. First, within any burn area there are usually unburned "islands". Second, the sampled area might not have been representative of the type. Third, most likely not all the types, or all of any type, would burn their maximum in the same year.

Prehistoric fires varied greatly in their FRI's, and the incidence of lightning and Native American fires were important factors in the variations (Table 1). FRI's were shortest in areas where lightning and Native American ignitions were combined. The shortest estimated FRI's were in the grass and oak dominated types, where not only was lightning often important, but also where Native Americans used fires to cultivate and ease the collection of the crop, such as grains or acorns.

Table 1. Summary of California vegetation types, acreages, and numbers from Barbour and Majors (1977) and estimates of fire return intervals and average annual acreages burned for California.

Vegetation Type	Number	Acres	Median Period Between Fires		Acres Burned per Year	
			Low	High	High	Low
Forest Types						
Spruce/Cedar/Hemlock	1	5,009	50	100	100	50
Cedar/Hemlock/D-fir	2	2,015,696	9	27	223,966	74,655
Mixed Conifer	5	13,641,010	5	16	2,728,202	852,563
Redwood	6	2,320,254	9	27	257,806	85,935
Red Fir	7	1,903,490	16	20	118,968	95,174
Pico/Subalpine	8	2,150,944	50	100	43,019	21,509
Pine-Cypress	9	123,226	25	25	4,929	4,929
Ponderosa/Shrub	10	1,695,108	5	16	339,022	105,944
Great Basin Pine	22	49,090	5	16	9,818	3,068
Juniper-Pinyon	23	2,463,517	5	16	492,703	153,970
Cal. Mixed Evergreen	29	3,399,232	9	27	377,692	125,897
Total Forest Types		29,766,576			4,5596,225	1,523,694
Shrub Fuel Types						
Chaparral	33	8,500,585	15	30	566,706	283,353
Montane Chaparral	34	573,051	5	16	114,610	35,816
Coastal Sagebrush	35	2,473,535	5	20	494,707	123,677
Mosaic of 30 and 35		641,175	2	12	320,588	53,431
Total Shrub Fuel Types		12,188,346			1,496,611	496,277
Herbaceous Fuel Types						
California Oakwoods	30	9,554,518	2	8	4,777,259	1,194,315
Great Basin Sagebrush	38	1,851,394	5	12	370,279	154,283
Fescue-Oatgrass	47	878,711	5	12	175,742	73,226
California Steppe	48	13,222,242	2	8	6,611,121	1,652,780
Tule Marshes	49	1,859,409	5	12	371,882	154,951
Alpine Meadows	52	747,370	7	20	106,767	37,368
Sagebrush Steppe	55	3,245,951	5	12	649,190	270,496
Total Herbaceous Fuel		31,359,595			13,062,240	3,537,419
No Fire Records						
Saltbush-Greasewood	40	3,104,692				
Creosote Bush	41	16,355,988				
Creosote Bush-Bur Sage	42	5,330,774				
Paloverde-Cactus Shrub	43	1,052,930				
Desert Sparse Vegetation	46	115,211				
Total No Records		25,959,595				
Total All Vegetation		**99,274,112**			**19,155,076**	**5,557,390**

In the Modoc Plateau, dominating much of the northeast corner of the state, lightning fires are common, resulting in around 40 fires per million acres per year (Johnson and Smathers 1976, Olson and Martin 1981). Native Americans contributed fires for management, hunting, and protection purposes. From photos of the 1873 Modoc Indian War, what is today a juniper/sagebrush/grass range was then primarily grass.

FRI in coast redwood was amazingly short. Whereas Jacobs, Cole and McBride (1985) came up with an average of 22 years using point source sampling, Finney and Martin (1989) and Brown and Swetnam (1994) arrived at a composite FRI of 8 to 12 years. In the wetter or cooler vegetation types, such as redwoods and associated types, lightning fires would have been far less common or have covered much less area, and Native American use of fire more important than in the Sierra or eastside types. In northwestern California, Native Americans used fire extensively to improve fiber and acorn production (Michele Lee personal communication).

Of special interest is the 1935 report of L. A. Barrett of the U. S. Forest Service in San Francisco on his own work and that of others. He reported "conflagrations" occurring on the average every 5.8 years between 1700 and 1930 in the northern pine types of California. Smaller fires occurred almost every year in between the "fires which covered big areas and burned with unusual severity." No methods or definite area of the research were given. In support of the no-burn policy, he stated that prehistoric fires were nowhere near as common as some had claimed.

From the above, we know California has had a lot of fire prehistorically. We have to expect the vegetation and climate to lend themselves to fire. We no longer have the extensive use of fire by Native Americans, but we still have lightning. To this we've added a huge human population that is inclined to carve out their little niche in the wildlands in order to "live with nature." Part of that nature is fire. Humans add to the problems by starting fires either accidentally through carelessness or intentionally by arsonists.

RECENT FIRE HISTORY

The approach to wildland fire by Europeans has varied widely. The Spaniards had an extensive array of missions, and some of the governors issued proclamations to halt Native American burning. The Spanish period was followed by the gold rush and extensive burning by the stockmen. Finally, as logging and then forest management came into being, it became important to control wildland fires. Although there was a contingent of people who believed in "light" or "Paiute" burning, the prevailing philosophy among biologists and foresters was that fire did not belong in the forest and other wildlands. A total fire exclusion policy was adopted, although it was done so based on who held the political clout in the nation's capital. Advocates for no burning approached the fire prevention program with a religious fervor. Accounts of the conflict can be found in Schiff (1962) and Pyne (1984).

In California, powerful firefighting organizations were developed over the years - - by counties, by the State, and by the Federal land-holding agencies. They appeared to meet with tremendous success in the first two-thirds of the 20th century. However, in the late 60's the slope of the line changed as wildfires became larger, on the average.

Recent fire history in California was obtained from various USDA Forest Service (USFS) and California Department of Forestry and Fire Protection (CDF) documents. Over the years, reports on fire occurrence have been issued annually, although the format and data covered by the agencies varied over the years. We began with 1931 and continued through 1996. Over the years, the documents and the acres protected changed, sometimes drastically, although it has been relatively constant for the last several years. Most of the data on structures and human lives lost came from the CDF guide by Imboden (1991) and later CDF reports. We have used "Acres Burned Per 1,000 Acres Protected" as the most consistent statistic. Since acreage burned varies wildly from year to year, we used a five-year moving average to smooth the curve.

WILDFIRE ACREAGE

Recent fire history indicates a large decline in acreage burned until the late 1960's, but an increase in acreage burned per 1,000 acres protected since that time (figure 1). In the last five years of the 1960's, about 2.3 acres burned per 1,000 acres protected. In contrast, in the last five years of the 1990's for which we have data (the 1996 running average), about 8.1 acres burned per 1,000 acres protected. In the figure, any year labeled is the average for that year and the previous four years. The figure, even though it is a moving 5-year average to smooth the line, indicates large jumps. These jumps are caused by high fire years, such as occurred in 1987 and 1996. Their effects on the moving average carries through for five years. Often the large fire years are years of high lightning fire occurrence, when multiple ignitions, sometimes numbering into the hundreds, immediately overwhelm the local fire fighting resources.

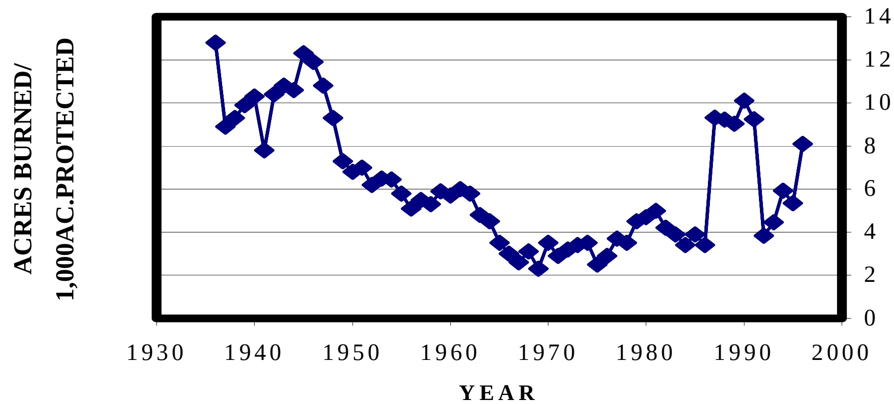

Figure 1. Recent wildfire acreage per 1,000 acres protected taken from CDF and USFS annual fire reports. Data points represent a running five year average with the date representing the last year entered. Data for 1987, 1988, and 1989 are USFS data only.

Table 2. Summary by decades of structures and human lives lost in wildland-based wildfires in California using data from Imboden (1991), CDF reports, and personal knowledge.

Decade	Structures Lost	Human Lives Lost
1920's	701	0
1930's	47	25
1940's	0	11
1950's	105	35
1960's	1,065	33
1970's	1,218	27
1980's	1,599	16
1990's	4,803 (through 1996)	27 (through 1991)
Totals	**9,421**	**174**

Additional data for CDF-protected lands for 1996 through 2000 were not included in the Figure 1 in order not to distort the trend. However the acres burned per 1,000 acres protected for the CDF-protected lands for this period were over 10.

There may be multiple reasons contributing to the increased loss of structures. First is the generally increasing fuel hazard in most wildland areas. Thus wildfires burning under severe weather conditions are less likely to be suppressed at a small size. Second is the increasing number of people living in wildland areas without the benefit of managing their surroundings. In the past, many people living in such situations were ranchers or farmers, aware of fire problems and often protected by their agricultural practices.

It is interesting to note the acreages involved in structure/vegetation fires. Structure-destroying fires in southern California have tended to be large fires covering thousands of acres. In contrast, the two most destructive fires in the Bay area have been small. The 1923 Berkeley fire covered only 120 acres after encountering the urban area, but this does not include the acreage burned in the wildlands. The total area of the 1991 Tunnel was only 1,500 to 1,600acres.

LOSS OF HUMAN LIFE

Loss of human life has not displayed a trend in the period from the 1930's into the 1990's, in spite of the great increase in structure loss. This is probably attributable to better communications and evacuation potential, particularly by the firefighting and law enforcement organizations. In comparison, no one was killed in the Berkeley Fire of 1923, one of the worst single interface fire structure losses until the 1991 Oakland/Berkeley Tunnel Fire, where 26 people were killed. An average of about 22 people have died from wildfires each decade.

One might argue that any loss of human life to wildfire is too much. However, it is far less than the loss of life in some of the disastrous wildfires of the 19th and early 20th centuries. Deaths in some of the large fires, particularly in the Lake States, numbered in the hundreds. In the Peshtigo, Wisconsin, of 1871,1200 to 1300 people died. In the Edo (Tokyo) earthquake and fire of 1923, 69,000 people perished (some reports say over 100,000 died), mostly from fire

(Martin and Sapsis 1995). The number of lives lost in wildland interface fires is also far less than the human loss of life in dwelling and urban fires each year.

BAY AREA FIRES

The Bay area and northern California have had their share of fires. The Berkeley fire of 1923 ranks 2nd in structure loss from a single wildland fire, outranked only by the Tunnel fire of 1991. Mill Valley was heavily hit by fires from Mount Tamalpais, losing 117 structures, in 1929.

Fires in the East Bay hills have been recorded since the late 1700's, when fire and smoke were seen from the San Francisco area. These fires "were thought to be started by Indians." Since that time around 40 "major" fires have been recorded, and Jerry Kent will be discussing those of the 20th century in his paper. We heard rumors of a fire that spread from Walnut Creek to the crest of the East Bay hills, or in the other direction, but could find no evidence of such a fire. Needless to say, the East Bay Hills have had their share of fires.

The Oakland/Berkeley Tunnel Fire of 1991 threatened 2770 structures and 3379 dwelling units and destroyed 2103 structures and 2475 dwelling units, the difference in numbers being primarily due to a large apartment complex. There were additionally 231 structures and 475 dwelling units damaged to a greater or lesser degree by the fire. (Data in this paragraph are from a table copyrighted by the City of Oakland. Used by permission. Also in Don Gordon's Thesis (2000))

DISCUSSION

Prehistoric fire occurrence covered about 5.5 to 19 million acres (2.25 to 7.75 million hectares) each year in California, according to the estimates presented, or roughly 5.5 to 19 percent of the area of the state. If one considers that only three quarters of the State were considered in the estimates, then the figures represent 7.6 and 26.1 percent of the area studied. Although the lower figure seems reasonable, the higher figure seems high. Estimates made of the area burned may be in error for more than one reason. First, the study areas for individual fire histories might not have been representative of the entire vegetation type. Second, the estimates we used for FRI in some types may be low. Third, as studies are done to develop the composite FRI, all fires probably did not cover the entire area of that vegetation type. Fourth, all vegetation types most likely not burn their maximum area in the same years. Regardless of the possible errors in the study, even using the lower figure for area burned per year, we have to conclude that much of California burned every year, on the average.

The recent fire history of California indicates a reduction in acres burned per 1,000 acres protected until the late 1960's, when the trend reversed itself. This is a pattern common to all other regions of the United States except for the South. Over the years, more money, equipment, and human resources were put into the effort to suppress wildfires, with apparent success. In the meantime, fuels were accumulating in the wildlands and around structures. Vegetation changes were taking place. Eventually, the effect of suppression led to a point where fires occurring under severe fire weather conditions in the accumulated fuels were catastrophic. Today, although most wildfires are still controlled at a small size by initial attack, a small percentage of wildfires occurring under severe conditions are controlled only after weather or fuel conditions change. These fires do most of the damage.

In addition to the recorded damage caused by this latter group of fires, there is a change in the biota, caused both by the longer FRI's and the greater average severity of wildfires. The fire regimes before suppression had lower average FRI's, burned in less fuel, often under moderate weather conditions, and were lighted during a fairly broad range of seasons. Today, the large, uncontrollable fires burn mostly under very severe weather conditions in high fuels loads. The season is usually quite narrow. The large, severe stand removal fires (in contrast to stand replacement fires for species adapted to high severity fires) are removing species adapted to short FRI's and fires burning in light fuels under moderate conditions.

Throughout California and most of the United States, not only has the wildfire acreage changed, but also the nature of the fires, bringing about changes in the nature of the fire regimes. Using fire return interval, seasonality, severity, and dimensionality to describe fire regimes (Martin and Sapsis 1992), we can see that most of these have been modified. The fires are now generally farther apart, allowing more accumulation of fuel and burn under more extreme fire conditions. Thus they burn with greater severity and size, and are more likely to occur in a narrow season of the year, the time when fire fighters are unable to suppress them quickly. Fires of low or moderate severity are more numerous than the severe fires, but they are easily suppressed and cover very little area. All these changes result in a narrowing of the pyrodiversity, with potentially a narrowing of biodiversity.

Many scientists and land managers have recognized the problem of strict fire suppression going back to the early 1900's (Schiff 1962, Pyne 1982). Some who carried the torch for prescribed burning were Herbert Stoddard and the Komareks in the southeast, and Harold Biswell, Harold Weaver, and Harry Kallender in the West. Over the years, evidence has accumulated to support the use of fire for many purposes. Now, with increasing awareness of the extensive use of fire by Native Americans, and the increasing problems of controlling fires and protecting people and structures, fire protection agencies are changing to a fire management mode with prescribed fire and other fuel management methods. Some are quite well along in practicing prescribed burning; others are just now shifting emphasis.

In our approach to reducing wildfire potential, we should address not only the use of fire, but also the use of other tools at our disposal - - mechanical, manual, chemical and biological. Amongst the mechanical and manual treatments, utilization of the material for its highest value should be among the options. Optimal combinations of treatments should be sought.

As we move toward more prescribed fire, the costs of doing so, as well as atmospheric emissions and water quality, are major problems. Fire suppression funds cannot be reduced for some time, until the effects of prescribed fire and other treatments on fuels become widespread. Thus, funds for prescribed fire will be needed in addition to suppression funds. Looking for ways to reduce the costs is important, and approaching the problem with the "Florida" solution is one way (Wade and Brenner 1995). The State of Florida enacted a law, since copied by many other states, which basically says they will certify prescribed burners, approve prescribed burning plans, and assume responsibility if a properly conducted burn does damage. Weatherspoon and Skinner (1996) discuss strategies for dealing with fuels management throughout the Sierra Nevada area.

The effect on humans of smoke from fires is probably the single greatest problem in increasing the use of prescribed fire. No matter how well we manage smoke, there will be a tremendous amount. Dealing with a public that is demanding cleaner air will require extensive education and public relations, and still might not be successful. Thus utilization of much of this biomass for such purposes as cogeneration is imperative.

The problem of structural fires connected to wildfires, including human safety, will be the highest priority. Humans might also be evacuated for their safety. To protect structures and thus humans, a structure must be defensible. To be defensible, it must have clearance from flammable vegetation and its exposed surfaces constructed of low flammability materials. Ethan Foote (1994), in his analysis of structure loss in the1990 Santa Barbara Paint Fire found the factors most important in structural survival were: roofing material, flammable vegetation clearance, and a defending person. The statistics from his thesis are amazing and are given below:

Conditional Structural Survival Probability

	Present	**Absent**
Nonflammable Roof Covering	70%	19%
Non flammable Roof covering <u>And</u> 30 ft Vegetation Clearance	90%	15%
Nonflammable Roof Covering <u>And</u> 30 ft Vegetation Clearance <u>And</u> Defensive Actions by Anyone	99%	4%

Foote also presented data showing that survival increased as the distance of flammable vegetation from the structure increased to over 40 feet. He also showed that survival increased as the taller vegetation was kept farther away. Survival increased from 36 percent where vegetation less than three feet high was less than ten feet away from the structure to 86 percent where all flammable vegetation was kept over 40 feet away.

Don Gordon's thesis (2000) analyzes the structure loss in the Oakland/Berkeley Hills Tunnel Fire of 1991. He found that 76 of 109 variables were significant in structure survival or loss at a p value less than 0.25. A final 5-factor model included:

- Floor vents
+ Heavy tile roofs
- Heavy fuel loads in proximity to the structure
+Slope of the hill
+Defensive action using water.

The plus and minus signs indicate that floor vents and heavy fuel loads had negative effect on survival, whereas the other factors had a positive effect on survival. He will be presenting the results in this conference.

The papers in this conference will discuss many aspects of interface fires, and fires in general. Past fires and losses will be presented; some with data on factors important in survival. These will be concentrated on California and the Bay area, but with papers presenting input from around the country. Modeling and prediction of fires and losses will be presented. Concerns about managing fuels while maintaining habitat for wildlife, especially listed species, will be addressed. There will be input from fire practitioners and residents and their outlook on the interface fire problem.

One object that continues to surface is the question of what we should call the delineation between structures and vegetation. Is it an interface or intermix? We suggest calling it an interface with categories such as simple where there is a relatively straight line between the two, convoluted where fingers of each extend into the others, and disjunct where islands of either are located within a continuum of the other. These could further be considered at the micro-level where one or a few structures are involved, the meso-level where neighborhoods are involved, and the macro-level where communities are involved. An alpha-numeric code, along with fire fighting capability, could be developed to rate these so people living or owning property in an area would know what the probability of survival would be.

With the knowledge we have today, and probably just the knowledge of the people here, we could prevent most of the loss of life and structures - -if we applied that knowledge! The problem is the lack of resources in some cases and the lack of conviction in others. For the local, state, or federal government to try to protect every human and substantial structure from wildfire hazard is impossible without that person taking action around his or her dwelling. The senior author had calls after the Tunnel Fire, while on the Oakland commission charged with overseeing fire hazard reduction, from people who did not want to reduce the vegetative fire hazard around their property. They said they were willing to live with the risk. My reply was that they might be able to do that if they lived in a remote area, but living in a city they didn't have the right to endanger other people's lives and property.

In making legislation such as the Bates Bill effective, it is also important that areas or subdivisions are evaluated evenly for fire safety. Since the responsibility for evaluation was shifted to the local fire agencies, there have been instances where the danger from interface fires appeared to be underestimated.

There are other factors to consider. Loss of firefighting water occurred on the 1923 Berkeley Fire (National Board of Fire Underwriters 1923) and the 1991 Tunnel Fire. Part of the problem was all the water thousands of residents, some living miles from the fire, were spraying on their homes and surrounding vegetation. Contributing to this particular problem were the multitude of hoses left on as residents fled the fire. When the hoses that burned up it left a free flow of water. What is needed would be an outdoor spigot system that would turn itself off when water flows freely and it is exposed to high temperatures.

Another factor to consider in Berkeley, Oakland, and other cities straddling a major fault, is the concern for water lines crossing those faults. Without shutoff valves, probably automatic, and/or flexible pipes that could bend and stretch or compact with movement of the earth, it is possible that all the water needed for firefighting could drain down the Hayward Fault.

Terrorism is a new factor to consider. Not only do we have the pseudo-environmentalists in this country who burn resources of any organization that uses or sells the fiber resources of our forests, but we now have international terrorists who might use fire as a weapon. We have seen this in the incidents of September 11 this year, and it's feasible they might use fire in wildlands and the structure/vegetation interface area as well. For example, Israel contacted the United States many years ago concerning expertise in prescribed fire and hazard reduction as they feared the terrorists would destroy the conifer plantations they had worked so hard to establish. We do not know the final outcome of this contact.

Terrorists might use fire directly to destroy wildland resources, structures and take lives, or indirectly as a diversion or cover-up. Looking at the effects of single fires burning under severe conditions, we have to consider the results of multiple fires started by dedicated arsonists under severe conditions. By a dedicated arsonist, we mean one who had studied the condition of wildlands and structure/vegetation interfaces in the area as well as the potential fire behavior under severe burning conditions. It's frightening to look at the potential for much of the forest- and shrub-covered areas, including the Bay area. These might be low on the priority lists of terrorists, but they certainly are of concern.

Fires started by terrorists could be used to raise the costs of wildland and interface protection, or as diversionary or cover-up tactics. Perhaps the use would be to concentrate attention on the fires before carrying out another act, or possibly using the smoke to disguise chemical or biological agents. We don't want to seem paranoid about the terrorism potential, but feel it should be mentioned as one potential scenario for the future.

SUMMARY

Estimates for the prehistoric areas of California burned per year are several times the areas burned today by wild and prescribed fires. The exclusion of fires from wildlands has led to extensive fuel buildup, and large, damaging wildfires. Area of wildfires and number of structures lost to wildfires each year has increased since the 1960's, and the nature of fire regimes has changed. For most of the area burned in wildfires, fire regimes have changed, with a resultant change in the biota. Agencies today are moving away from strict fire suppression policies toward fuel and fire management strategies. Costs of the management as well as the increased smoke from prescribed fires present major challenges to fire managers. The future of wildland and structure/vegetation fires will depend on how we prepare for them, whether they result from natural or human causes, including the acts of terrorists. We can solve the vegetation/structure problem with our present knowledge, but it will take conviction and dedication.

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DEVELOP A LANDSCAPE-SCALE FRAMEWORK FOR INTERAGENCY WILDLAND FUELS MANAGEMENT PLANNING

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This presentation centers on describing the development of an interagency organization called the Southern Sierra Geographic Information Cooperative. This organization is focused on developing and testing an approach to incorporate wildland fuels information management into an interagency, landscape-scale planning framework. The project area includes six major watersheds (Kaweah, Kern, Kings, Caliente, Mojave, and Tule watersheds) covering an area of about 4.7 million acres. This large geographic area includes a variety of land uses ranging from wilderness areas to rural communities with higher population densities. The major stakeholder agencies include: Sequoia and Kings Canyon National Parks, Sequoia National Forest, Bureau of Land Management – Bakersfield District, California Department of Forestry – Tulare Ranger Unit, and Kern County Fire Department.

A spatial and attribute information system is being created for coordinated fuels management planning within an integrated Geographic Information System (GIS) framework. The primary goals are to reduce fiscal costs to both government agencies and the public and to improve attainment of ecological and hazard reduction goals across jurisdictional boundaries. The project focuses on utilizing geographic information and related technologies including the Internet to overcome institutional and organizational barriers to interagency fuels management within very large, diverse ecosystems. The framework is designed to meet the varied long-range ecological, fire hazard, and risk reduction goals of all impacted agencies. Common geographic data is being developed including comprehensive planning maps and analyses that prioritize areas for treatment based on value, hazard, and risk criteria. This framework will develop and test procedures to manage and update complex spatial information and to institutionalize the coordinated planning efforts. This project is now near the mid-point of its three-year project cycle and is being funded by the Joint Fire Sciences Program.

FIRELINE PROGRAM

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In its efforts to focus public attention on the wildland-urban interface and to protect home buyers, the state of California uses competing definitions of where the wildfire exposure actually exists--one for assisting the real estate transfer transaction and one for fire insurance. Few observers would agree that either definition adequately defines the geographic areas of the state that are exposed to the hazard. Yet these definitions persist.

ISO presents an alternative definition based on satelite observations of fuel, slope, and road access variables. This work stems from search conducted by the NFIP and is an attempt at a state-of-science definition that represents actual conditions in the physical world without political oversight. The result is a geographic database called Fireline(tm) that has been used for several years by insurers who, combined, write more than half of the Homeowners insurance in the state.

This presentation will review the various approaches currently used to define the wildfire hazard exposure areas in California and psit Fireline as a standard.

ASSESSING FIRE RISK IN FLORIDA USING INTEGRATED GIS AND REMOTE SENSING APPROACHES

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Florida possesses a unique set of characteristics that make much of the state highly susceptible to wildfire: the state is blessed with an abundance of wildlands, Florida's weather is conducive to starting and spreading numerous and sometimes large wildfires, and Florida's wildland vegetation evolved in a fire ecosystem.

To reduce the loss of life and property due to wildfire, communities and fire management organizations need to actively manage fire risk. However, managing fire risk is extremely difficult because fuel hazard constantly changes across the landscape and through time, and fire behavior is extremely sensitive to changes in land development, fuel hazard, weather conditions, and topography. In addition, many social, technical and institutional barriers exist to proactive fire risk management and planning.

The Florida Division of Forestry in corporation with Pacific Meridian Resources is developing a GIS based Fire Risk Assessment System (FRAS). This system will assist fire managers with the mitigation of the harmful effects of wildfire and will function as a valuable planning tool for local fuel reduction efforts.

GIS layers of wildland fire susceptibility, population density, land value, and fire response accessibility will be weighted, ranked, and combined to develop estimates of "Levels of Concern". The FRAS application will be flexible, such that the input values can be easily adjusted and the model re-run to produce new estimates of risk.

MODELING FIRE LOSS INTO THE FUTURE USING COUNTY GENERAL PLANS AND GIS

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This analysis presents the procedures used to identify areas that pose significant threats from wildfire to the people of California. It was prepared under the auspices of the California Fire Alliance -- a coalition of representatives from State and Federal Fire Agencies, originally formed in 1996, who have collaborated on integrating fire management and planning across jurisdictional boundaries. While much of the basic premise and data for the development of this analysis has a beginning in the California Department of Forestry and Fire Protection's California Fire Plan, this work represents new and original work that is sanctioned by the USDA Forest Service, the USDI Bureau of Land Management and National Park Service, in addition to CDF. The Fire Alliance views the issue of the wildland interface as a natural area for collaboration, and is optimistic that the following analysis can be a model for other areas. The analysis was prepared in response to a mandate from Congress in the 2000-2001 Interior Appropriations bill establishing the National Fire Plan.

Utilizing a Geographic Information System (GIS) approach that is at the heart of the California Fire Plan, the three main components in the assessment of threat from wildland fire to Wildland-Urban Interface areas of California are:

- Ranking fuel hazard
- Assessing the probability of wildland fire
- Defining areas of suitable housing density that lead to Wildland-Urban Interface fire protection strategy situations

These three independent components were then combined using GIS capabilities to identify wildland interface areas threatened by wildfire. In addition to mapping these areas, a list of communities was developed that summarized a non-spatial assessment of key areas within the vicinity of significant threat from wildland fire. A subset of that list was made that includes those communities that have a significant fire threat from nearby Federal lands. A buffer distance of 1.5 miles was used in the analysis to define "nearby" federal lands.

VEGETATION CHANGE AND FIRE HAZARD IN THE SAN FRANCISCO BAY AREA OPEN SPACES

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ABSTRACT

Vegetation changes due to fire suppression and reduced grazing have resulted in increased fire hazard in the open spaces surrounding the urbanized areas of the San Francisco Bay area. Coverage of various vegetation types were sampled on seven sites using a chronosequence of remote images in order to measure change over time. Results suggest a significant conversion of grassland to shrubland dominated by *Baccharis pilularis* on five of the seven sites sampled. An increase in *Pseudotsuga menziesii* coverage was also measured on the sites where it was present. Increases fuel and fire hazard were determined through field sampling and use of the FARSITE fire area simulator. A significant increase in biomass resulting from succession of grass dominated to shrub dominated communities was evident. In addition, results from the FARSITE simulations indicated a significantly higher fireline intensity and flame length associated with shrublands over all other vegetation types sampled. These results indicate that the replacement of grass dominated with a shrub dominated landscapes has increased the probability of high intensity fires.

Keywords: Fire suppression; Succession; Fire intensity; Urban-Wildland interface.

INTRODUCTION

The vegetation of the hills of the San Francisco Bay area is a mosaic of grasslands, shrublands, and various forest types. The dominant vegetation type is a mixed evergreen forest (Kuechler 1977). This association includes Douglas-fir (*Pseudotsuga menziesii*), tanoak

(*Lithocarpus densiflorus*), canyon live oak (*Quercus crysolepis*), California buckeye (*Aesculus californica*), (*Umbellularis californica*), madrone (*Arbutus menziesii*), big leaf maple (A*cer macrophyllum*), and coast live oak (*Quercus agrifolia*). The dominance of individual species within this association varies form site to site. For example, in hills east of the San Francisco Bay mixed evergreen forests are dominated by coast live oak and California bay, and in some cases give way to forests dominated by coast redwood (*Sequoia sempervirens*) (McBride 1974, Safford 1995). In addition to the mixed evergreen forests, large areas are covered by coastal scrub which is dominated by coyote brush (*Baccharis pilularis*), but also includes species such as California coffeeberry (*Rhamnus californica*), California blackberry (*Rubus ursinus*), and poison oak (*Toxicodendron diversilobum*). Grasslands once dominated by native perennials cover an ever dwindling proportion of the landscape and are currently dominated by exotic annuals such as wild oat (*Avena fatua*), brome (*Bromus mollis*), and ryegrass (*Lolium multiflorum*). Scattered oaks, in some areas, are common among the grasses. Where the canopy of the oaks grow together they are referred to as oak woodland and are dominated by coast live oak, though California bay and madrone are associated in some cases. On poorly drained acidic soils where fire is common bishop pine (*Pinus muricata*) exists in dense stands along the coast (Vogt et al. 1988). Exotic forest types such as Monterey Pine (*Pinus radiata*) and Eucalyptus (*Eucalyptus globulus*) also exist as scattered plantations.

The distribution of vegetation types over the landscape is by no means static. These vegetation types have undergone successional changes resulting from fire suppression and reduction of grazing pressure (Hall et al 1994). Vegetation within this area has shown a tendency toward proliferation of shrub onto sites that were previously dominated by grasses. Frequent fire or livestock pressure, when present, act to keep these areas in a grassland state. A reduction of these pressures, however, can facilitate the proliferation of shrub into grassland areas (McBride and Heady 1968). In areas where grazing continues, the shift from grassland to shrubland does not occur as readily (Elliot and Wehausen 1974). In some cases an increase in forest cover has been noted on sites previously dominated by grasses and shrubs. Examples of these trends include the invasion of *Baccharis pilularis* dominated shrub communities into grasslands in the Oakland/Berkeley hills (Kent et al 1977, Martinez 1993, McBride 1960, McBride and Heady 1968, McBride 1974) and invasion of *Pseudotsuga menziesii* into grasslands and shrub communities in Marin County (Dunne and Parker 1999).

Changes in the dominance of vegetation types over the landscape are accompanied by changes in fire hazard. For instance, fuel load and structural conditions vary widely between annual grasslands, coastal scrub, and mixed evergreen forest (Sapsis 1991). Because the San Francisco Bay area open spaces are essentially imbedded in an urban matrix the propensity of these areas to carry and spread fire are of concern. In order to better understand the nature of vegetation change in this region, and its importance in altering potential fire conditions, vegetation change and potential fire hazard were measured over time. A combination of remote sensing images, fuel sampling in the field, and the FARSITE fire area simulator (Finney 1995) were used to address the following questions: 1. What general trends in vegetation change can be discerned at a landscape level over the last 60 years. 2. How do changes in the dominance of various vegetation types relate to fuel load and potential fire hazard.

METHODS

Remote Sensing

Changes in the relative dominance of the vegetation types present within the study areas were measured using random point sampling on aerial photographs. A chronosequence of relative community dominance was developed by sampling aerial photos taken between 1939 and 1997, with a scale of 1:20,000 or less, for the six study areas. Four separate sampling years were used for each area dependent on photo availability (table 1).

Table 1. Location of study sites and date of photographs used in sampling.

Study Site	Dates of Aerial Photos			
Chabot Regional Park	1939	1968	1983	1997
Redwood Regional Park	1939	1968	1983	1997
Tilden Regional Park	1939	1968	1983	1997
Bolinas Ridge	1952	1969	1984	1991
Point Reyes	1952	1971	1987	1993
Skyline	1948	1968	1987	1993

Six open space areas were selected as study sites in order to compare successional trends within various vegetation types. The areas sampled included three East Bay Regional Parks including Chabot, Redwood, and Tilden. Three sites were also selected within the north and peninsula regions including Bolinas Ridge, Point Reyes and a site near Woodside off of Skyline Blvd.

Fuel and Fire Hazard

The relative fire hazard of the most common vegetation types found within the study sites was determined through two methods: 1. The measurement of surface biomass was conducted for each vegetation type. 2. Fire spread simulation for each of the vegetation types using the FARSITE fire area simulator (Finney 1995).

Surface fuel was measured for each the most common vegetation types with the exception of grass (coastal scrub, oaks woodlands, Monterey pine, bishop pine, and Douglas-fir) using the line intercept method (Brown 1971, 1974) resulting in a tons/hectare fuel estimate for each type. The live biomass associated with areas dominated by grass was measured by clipping, drying and weighing small plot samples (Brown and Marsden 1976). In addition, clipping, drying and weighing was conducted on shrub-dominated sites in a similar manner. Results from this sampling were then included with the estimates for shrub surface fuels to give a total estimate for biomass.

Fire spread simulations were conducted using the FARSITE fire area simulator in order to determine the average rate of spread, flame length, and fire line intensity for each of the vegetation types listed above. A hypothetical landscape provided within the program was used for each simulation in order to eliminate confounding factors related to site variability.

RESULTS

Vegetation Changes

Results from the sampling of aerial photographs indicate a number of significant changes in the dominant vegetation of open spaces surrounding the San Francisco Bay. Many of these trends are site specific, however some generalities can be made. The relative cover of grassland, with all sites included, exhibited a strong negative linear correlation with years (P = 0.003) indicating a general decline grassland acreage (fig. 1.a). In contrast the relative shrub cover was positively correlated to years (P = 0.025) indicating a general increase in shrubland acreage (figure 1.b). The relative cover of trees appeared to exhibit an increase as well, however the correlation with years was not strong (P = 0.070) (figure 1.c).

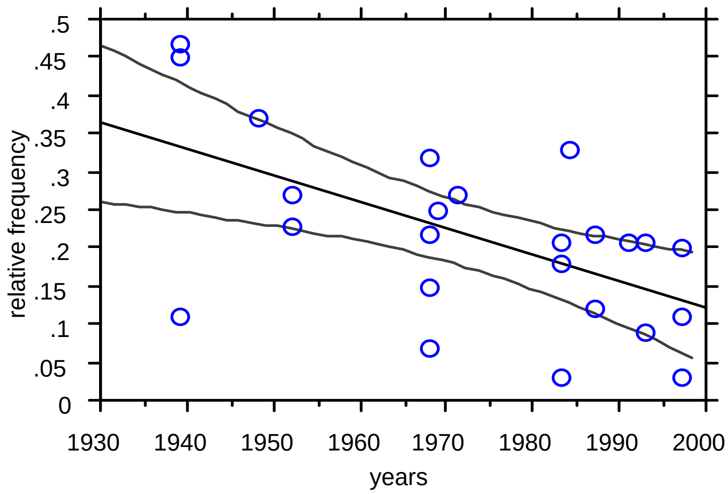

Figure 1.a. Cover of grassland.

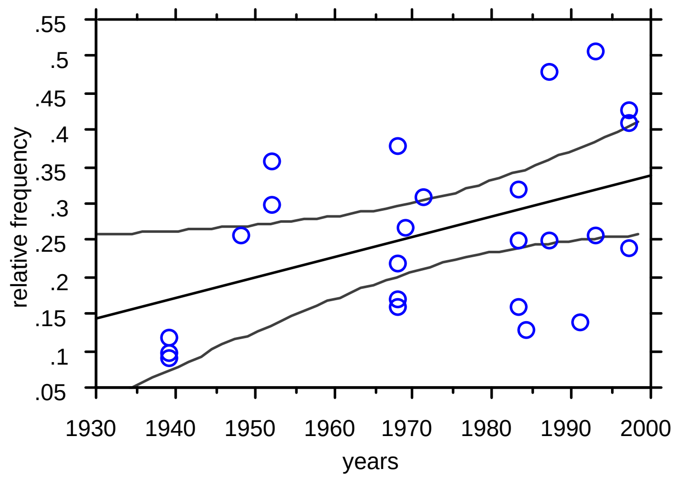

Figure 1.b. Cover of shrubs.

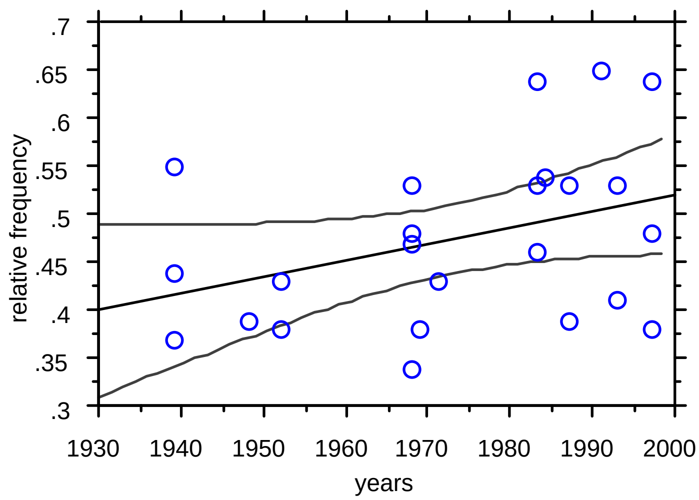

Figure 1.c. Cover of trees.

Analysis of each site individually illustrates trends that are more specific to the vegetation types found in each of the study areas. In addition, the division of the category of tree coverage into various forest and woodland classifications leads to a more precise understanding of the observed vegetation dynamics.

Vegetation change within Chabot Regional Park exhibited similar trends as those discussed in the general analysis (figure 2). Grassland coverage declined dramatically where shrub cover

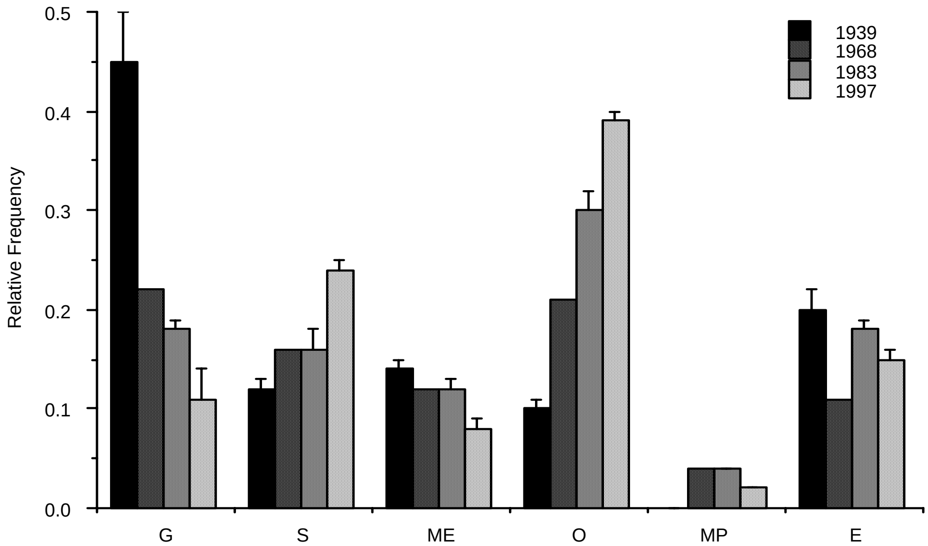

Figure 2. Chabot Regional Park. G = grass, S = shrub, ME = mixed evergreen, O = oak woodlands and savannas, MP = Monterey pine, E = eucalyptus

appeared to increase. As was indicated in the general analysis, trends in forest cover were more complex. The relative cover of the mixed evergreen, Monterey pine and eucalyptus forest types declined somewhat. In contrast, the relative cover of oak woodland and savanna increased

The relative cover of grass and shrubs within Redwood Regional Park followed the same trends described in the previous analysis (figure 3). However, in contrast to Chabot Regional Park oak woodland cover appeared to decline. All other forest types remained relatively stable with no significant variation.

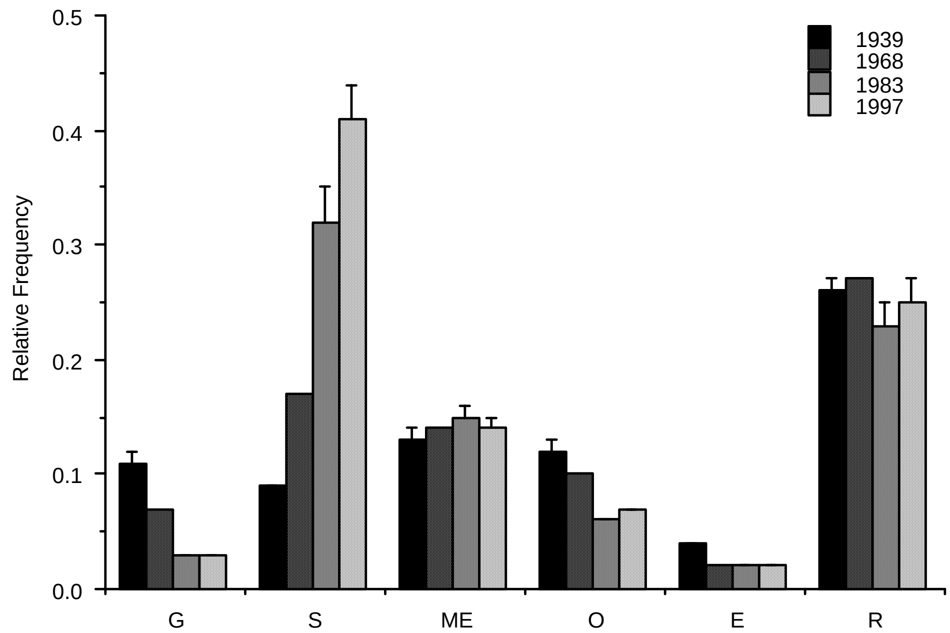

Figure 3. Redwood Regional Park G = grass, S = shrub, ME = mixed evergreen, O = oak woodlands and savannas, E = eucalyptus, R = redwood

Vegetation dynamics within Tilden Regional Park featured similar trends in grass and shrub cover as described above (figure 4). Oak cover appeared to increase slightly and Eucalyptus to decrease. The relative cover of mixed evergreen forest remained relatively stable.

Vegetation trends on the Bolinas ridge site were quite different from those found in the East Bay Regional Parks (figure 5). The relative cover of shrubs appeared to decrease on this site, where it increased on all previous sites. A general decline in grassland cover was observed, however, the high variation between years makes this determination questionable. The most apparent trend on this site was a significant increase in the relative cover of Douglas-fir (*Pseudotsuga menziesii*) forest. The mixed evergreen forest that included evergreen hardwoods such as *Quercus* and *Umbellularia californica* (bay laurel) remained stable.

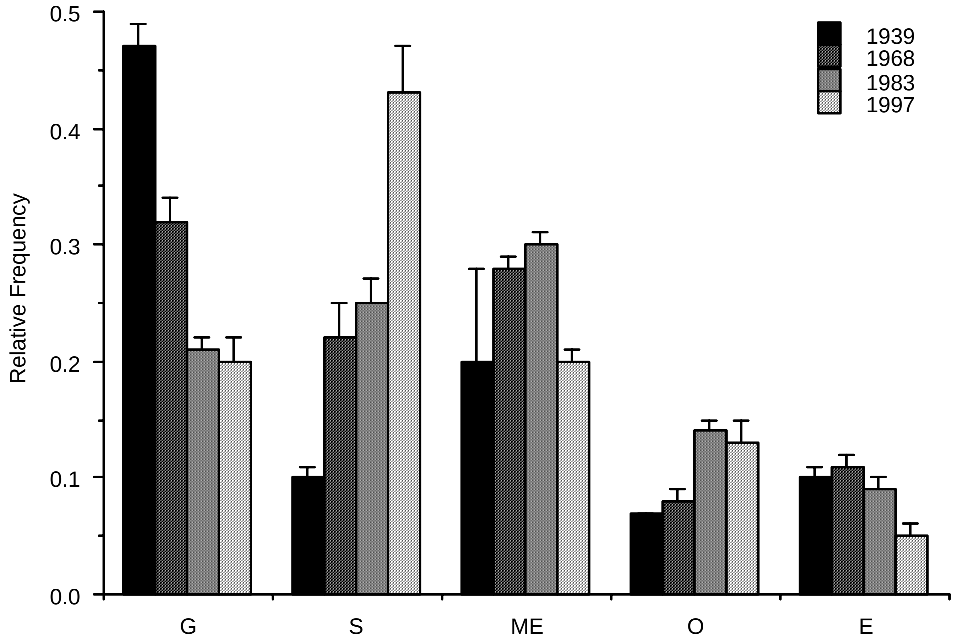

Figure 4. Tilden Regional Park. G = grass, S = shrub, ME = mixed evergreen, O = oak woodlands and savannas, E = eucalyptus.

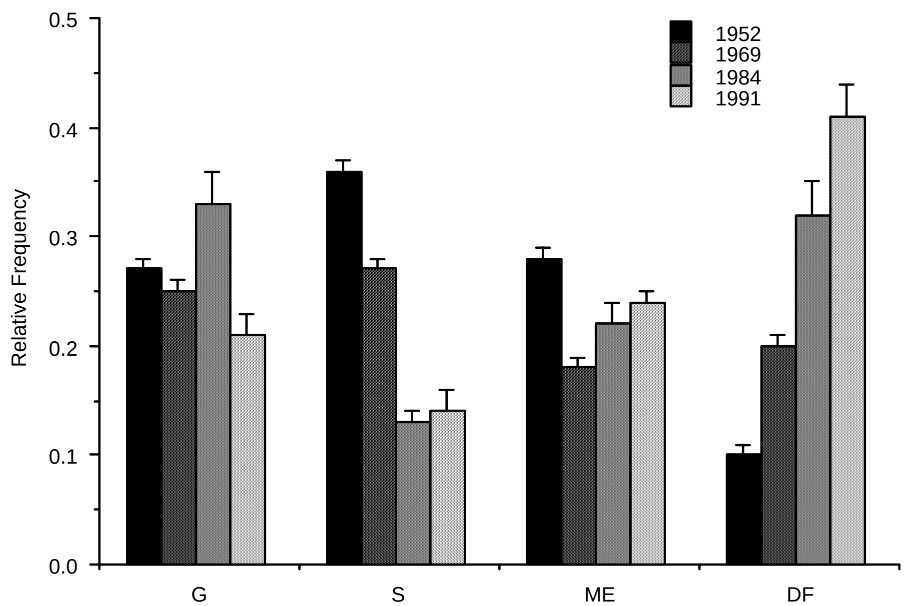

Figure 5. Bolinas Ridge. G = grass, S = shrub, ME = mixed evergreen, DF = Douglas-fir.

Vegetation at the Point Reyes site exhibited limited variation within the time period of this study (figure 6). Analysis of the data sampled yielded little of significance in relation to the relative cover of grassland and shrubland, though a slight decline in grassland cover is discernible. Domination by oak woodland and savanna increased somewhat as did the cover of Monterey pine. The mixed evergreen component exhibited a slight decline.

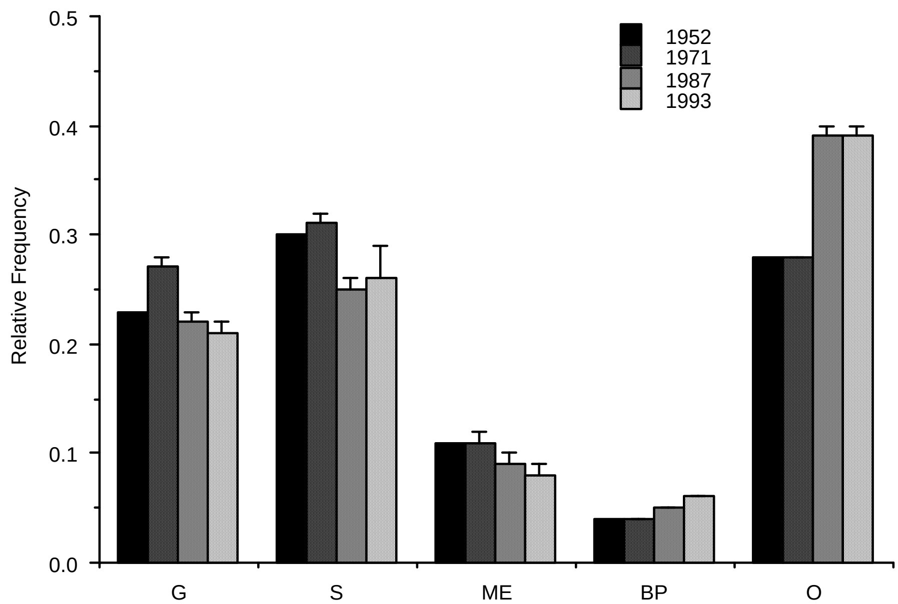

Figure 6. Point Reyes. G = grass, S = shrub, ME = mixed evergreen, BP = bishop pine, O = oak woodland and savanna.

Several significant changes in the relative cover of vegetation types were apparent on the Skyline site (figure 7). Grassland cover decreased markedly with a comparable increase in shrubland cover. Though both the mixed evergreen and redwood forest types remained relatively stable, Douglas-fir forest cover increased significantly.

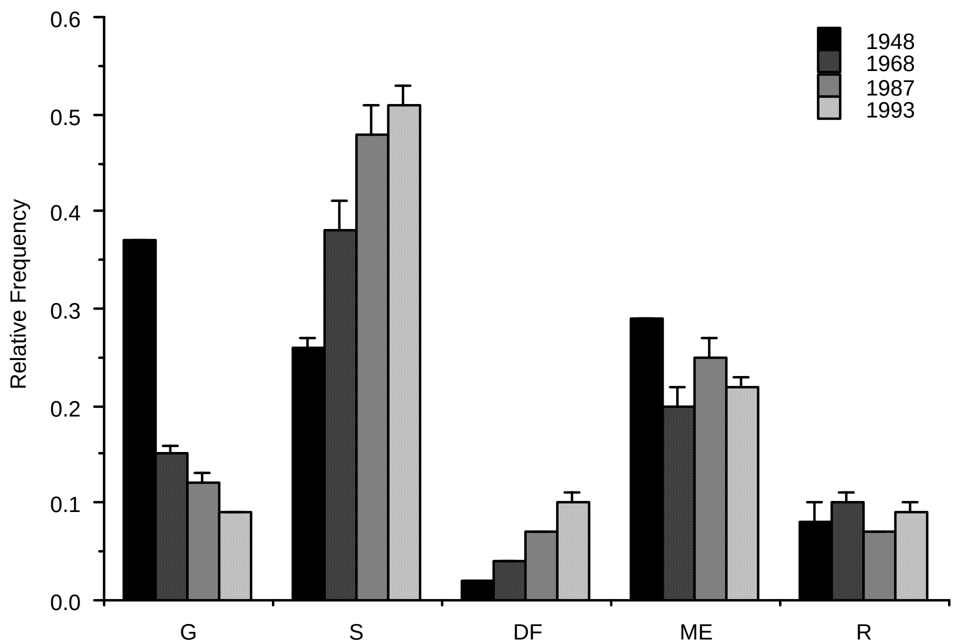

Figure 7. Skyline. G = grass, S = shrub, DF = Douglas-fir, ME = mixed evergreen, R = redwood.

Fuel and Fire Hazard

Fuel sampling of the vegetation types common to the sites sampled indicated a wide variation in surface biomass between types (table 2). The lowest surface biomass was found for grassland and oak woodlands. In contrast, the *Baccharis* dominated shrublands exhibited surface fuels five times greater than oak and more than ten times greater than that found for grasslands. The surface biomass found for forested landscapes was greater still and was somewhat higher for bishop pine and Monterey pine than it was for Douglas-fir.

Results from the FARSITE simulations indicate the greatest average flame length and fire line intensity for the shrub dominated sites while the lowest for the oak woodlands (table 2). The highest rate of spread was found for the grass dominated landscapes and the lowest for the forested landscapes.

Table 2. Measured biomass and predicted fire characteristics using the FASITE fire simulation model.

	Grass	Shrub	Oak	Doug-fir	Bishop Pine	Monterey Pine
Biomass (tons/hectare)	1.506	18.726	3.665	37.45	48.345	40.69
Rate of spread (m/min)	3.770	1.60	0.600	0.56	0.560	0.57
Fire line intensity (kW/m)	66.500	197.000	36.000	139.88	157.4000	157.89
Average Flame length (m)	0.47	0.80	0.400	0.69	0.74	0.73

CONCLUSIONS

The analysis resulting from this study indicates that there have been significant changes in vegetation within the study areas and that these changes suggest a general increase in fire hazard within the open spaces of the San Francisco Bay Area.

A significant increase in the cover of shrublands was apparent in the general analysis, and in all but two of the study sites. An inverse relationship was found for the cover of grass dominated landscapes with the exception of the same two sites. The results from the fuel and fire hazard analysis suggest that the succession from grasslands to *Baccharis* shrublands indicates dramatic increase in fire hazard for those areas. Fire line intensity, flame length, and total biomass were found to be significantly higher within the shrub dominated areas. In the context of the landscape matrix as a whole this increased hazard indicates a greater possibility of fire being spread into adjacent forested areas and residential communities.

In contrast to grasslands and shrublands the relative cover of most forest types appeared to be relatively stable over the time period of this study with the exception of Douglas-fir which increased significantly on every site on which it was present. The relevance of this increase to fire hazard is not clear however. On the Bolinas Ridge site the increase in Douglas-fir cover was accompanied by a decrease in shrub cover. This pattern would appear to suggest that Douglas-fir is replacing shrublands which would tend to reduce fire hazard on that site. However, the pattern is reversed on the Skyline site. Though Douglas-fir exhibits a significant increase shrub cover appears to increase as well and the cover of grassland appears to decline. It may be that we are observing an earlier stage in the succession from grassland to *Baccharis* brushland to Douglas-fir forest at the Skyline site.

The vegetation change and accompanying fire hazard increase noted in this study have occurred within a management regime under which fire has been generally excluded and grazing pressure has been reduced. Without modifications to our current management strategies fire hazard will likely continue to increase.

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GIS AND REMOTE SENSING APPLICATIONS FOR FIRE FUEL MANAGEMENT

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Increasing populations and their resulting encroachment into wilderness areas, coupled with the technological demands of a modern lifestyle, increases the danger of catastrophic wildfires. These challenges require the development of new methods to assess and manage wildfire risk.

In the decade since the Oakland Hills fire, Geographic Information Systems and satellite and airborne imagery have been applied to problems of fire and fire fuels management. This presentation will review how these new technologies are being used by government and private organizations to quantify wildfire risk, prioritize management efforts, respond to active wildfires, and aid in post-fire rehabilitation of watersheds.

SINGLE FACTOR CATEGORICAL DATA ANALYSIS OF THE 1991 OAKLAND/BERKELEY "TUNNEL" FIRE

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ABSTRACT

Analysis of data collected after the devastating 1991 Tunnel has provided interesting insight into factors contributing to the probability of a home surviving a wildland fire. Utilizing a GIS database to select structures for analysis based on geography allowed an analysis to be conducted in which there existed a variety of structure conditions. Once records were selected, contingency table analyses were performed on the 100 variables. Preliminary results from the data indicate that civilian presence at a structure can have a large impact on the likelihood of structure survival. Other factors contributing to the survivability of a structure include structural characteristics such as the presence of double pane windows, screened eave vents and decks made of nonflammable materials. Defensive actions by either fire personnel or civilians were also associated with structure survival. Factors such as helicopter drops, civilian use of hoses or sprinklers after the passage of the fire front, and removal of vegetation by firefighters prior to the arrival of the fire were at least ten times more likely to be associated with structure survival than in their absence. Once single factor analysis has been completed, a similar examination of factors on a group, or neighborhood, level will be done to try to identify factors significant for a group of structures to survive a wildland fire. Identification of factors using statistical models can allow more efficient and accurate development of a more systematic and quantitative model for structure survival in a wildland fire.

Keywords: Logistic regression, urban/wildland, Berkeley, fire, structure survival

INTRODUCTION

In 1989, the California Department of Forestry and Fire Protection (CDF) recognized two disturbing trends based on numerous studies and reports (CDF 1980a, 1980b and 1986). One was the increase in size and frequency of large wildland fires and the second was the migration and dispersion of urban Americans into more rural settings. In an effort to quantify and describe the impacts of structure loss in wildland areas, CDF instituted the Defensible Space Factor Study (DSFS). First used in 1989 on the 49er Fire and, subsequently, the 1990 Santa Barbara "Paint" Fire, it provides a detailed methodology of data capture for use in statistical analysis (Foote 1994).

The goal of this study was to identify significant factors associated with the loss of structures from an urban/wildland interface fire utilizing the DSFS methodology. Originally the scope of the DSFS was to look at variables associated with structure damage such as fire intensity, roof type, and vegetation clearance. The study has since been expanded to include defensive actions of civilians and fire agencies, other structural characteristics, and other policy requirements as well. The interaction of these factors was examined in a retrospective study to elucidate the most significant factors responsible for the loss of structures as a result of the 1991 Oakland/Berkeley Tunnel Fire.

The losses due to this fire are staggering: 1,600 acres consumed, 25 lives lost (including an Oakland Battalion Chief and police officer), 2,103 structures containing 2,475 dwelling units destroyed, 302 structures suffering major damage and a total dollar value loss estimated at $1.5 billion (OES 1992). To date, it is the worst urban/wildland fire to strike California. However, it is not the first. Fires of similar nature occurred in the same general location as the Tunnel fire. The 1970 Berkeley Hills fire that destroyed 37 structures overlaps the Tunnel fire on its northern edge. Perhaps better known is the 1923 Oakland/Berkeley Hills fire, which until 1991, was the single most destructive urban/wildland fire in California.

DATA COLLECTION

Data for each structure were collected immediately following the fire. A revised edition of the Defensible Space Factor Study data collection form was created by the California Department of Forestry and Fire Protection (CDF) and the University of California, at Berkeley (UCB), which addressed concerns expressed by the Federal Emergency Management Agency (FEMA) and the City of Oakland for their future information needs. Staff responsible for data collection was briefed on the data collection procedures and each survey underwent a rigorous quality check for accuracy and completeness. Survey responses were then entered into a database where automated procedures were used to verify accurate data entry were employed. The database comprised 222 fields that consisted of many variable types for 2,976 records.

The survey instrument was designed to collect information describing a number of conditions present at each structure. These factors included information about the structure itself, fire behavior before, during, and after passage of the fire front at the structure, surrounding fuel loading, and defensive actions by residents and firefighters. In addition, the survey also recorded data for quality control, biasness resulting from different data collectors, and documentation of the survey instrument.

The DSFS database contains a wide variety of data elements and data attributes. Data were measured on different scales depending on their characteristics. These scales include nominal, ordinal, binomial, and interval. Psuedovariables were created from continuous, categorical, and other smaller population data elements to facilitate analysis of certain characteristics.

ANALYSIS

The variable STRCON was used to create a dichotomous variable STRSURYN which indicated whether a structure had or had not survived the fire. The distribution of the damage to homes was heavily skewed towards complete destruction. Figure 1 illustrates the distribution of damage to structures while Figure 2 describes the population distribution of the dichotomized variable STRSURYN.

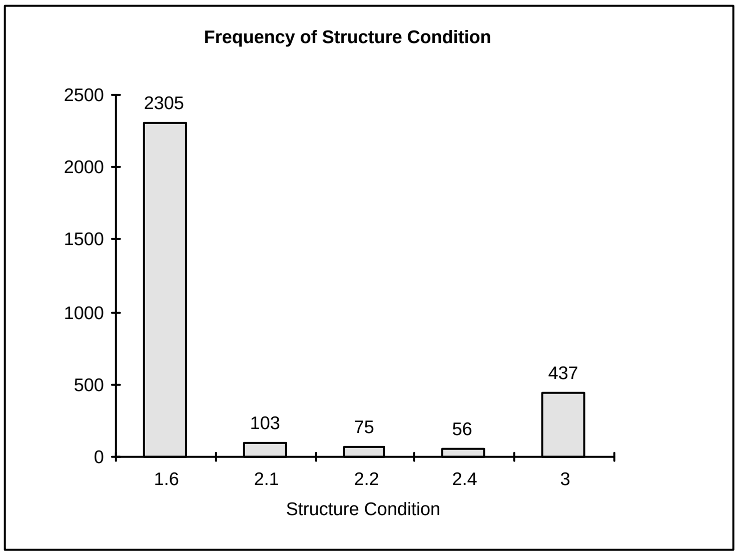

Figure 1. Distribution of structure damage codes

A total of 2,976 dwelling units were surveyed within the fire perimeter. Of those surveyed, 77.4% of the homes were destroyed by the fire. The response variable STRSURYN was defined as those homes surviving the fire received a positive response and those that were destroyed a negative response. Figure 2 illustrates the population distribution of homes once dichotomized.

The resulting aggregation demonstrates that 22.5% of the homes did survive the fire. While the fire was very destructive for a majority of the homes, a significant number did survive. Because a sufficient population of homes survived the fire, this variable was used as the response variable during the remainder of the analysis.

Condition variables were selected based upon their ability to provide adequate sample size, contribution to testing the hypothesis, and ability to dichotomize for use in the logistic regression analysis. Variables with a sample population too small to support statistical analysis were excluded from further analysis.

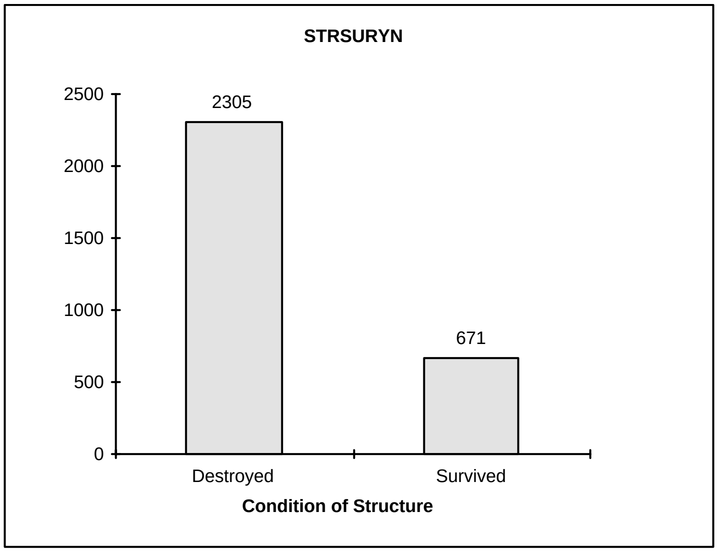

Figure 2. Distribution of structures surviving versus those that did not.

Condition variables were cross tabulated and categorized according to the component they were describing. Four broad based categories were designated to help organize and segregate variable responses. They are Fire Intensity, Building Construction, Ignition Factors, and Defensive Actions. Variables significantly associated with structure survival will be presented within these classifications.

RESULTS

FIRE INTENSITY

The category of fire intensity describes and categorizes characteristics associated with the behavior, duration and intensity of the fire. These included topographic factors, vegetation and fuels, and weather conditions. Table 3 lists the variables that are associated with fire intensity. Of the 26 intensity variables, twenty produced significant results.

Table 3. Factors Associated with Fire Intensity

Va riable Name	Variable Definition
HFUELY	Presence of ladder fuels and heavy fuel loads
WINDCL4	Wind class greater than 4
CHIMNEY	Structure situated in a chimney
ABVSTRYN	Structure located above street
BELOSTR	Structure located below street
SLOPE20	Percent slope greater than 20%
TOPSLOP	Structure situated on top of slope
MIDTHRD	Structure situated on middle third of slope
ROLLING	Structure situated on rolling terrain
LOTHRD	Structure situated on lower third of slope
UPTHRD	Structure situated on upper third of slope

Va riable Name	Variable Definition
VALLEY	Structure situated in a valley
SADDLE	Structure situated in a saddle
TRE30YN	Vegetation >10 ft. tall cleared 30 ft. from structure
HVYVEGFL	NFFL models 4, 8, 9, 10, 49 for heavy fuels
HILLSLOP	Structure situated on a hillside slope
STRSETYN	Structure setback more than zero feet
RIDGE	Structure situated on a ridge
NTONSTR	Structure not located on a slope
VEG30YN	Vegetation cleared 30 ft. from structure
GRA30YN	Vegetation <1.5 ft. tall cleared 30 ft. from structure
TEMP85	Air temperature greater than 85° F

Variable Name	Variable Definition
SHR30YN	Vegetation 1.5 to 3 ft. tall cleared 30 ft. from structure
CFWTHR	Contributing factor weather related

Variable Name	Variable Definition
BRU30YN	Vegetation 3 to 10 ft. tall cleared 30 ft. from structure
FLAM20	Flame length observed >20 ft.

The elements most highly associated with structure survival were primarily topographic factors. Virtually all categories describing site topographic conditions were found to influence structure survival. The location of the site on the slope appears to have played an important role in structure survival. Homes situated on level or gently rolling terrain fared much better than those homes in chimneys. A consistent result was also observed for the position of a home on the slope. Homes positioned lower on the slope survived more often than those located farther up the slope.

Structures positioned above the street fared better than those below. Structures located above the street recorded a 25.5% survival rate compared to a 17% survival rate for those structures located below a street. Structures set back from the street fared a little better than those below. However, these structures were still below the average for all structures by 2%, averaging 20.8% survival.

Slope played an important role in structure survival. Analysis of structures located on a slope greater than 20% showed 19.5% survival, while on a less than 20% slope survived 26.9% of the time. This survival is higher than the total population average of 22.5%, indicating a strong relationship between structure survival and slope. The location of the structure in relation to the slope was also very significant. Structures on the lower two thirds of a slope had at least a 27% survival rate, compared to those on the upper third and top of the slope at 19% survival. A distinct trend in structure survival can be observed starting at the bottom of the slope, with 28% structure survival, and ending at the top of slope with 15% structure survival. Similar results were observed from variables recording whether or not the structure was located on a hill slope or at the top of the slope. Hill slope structure survival averaged 23.7%, while structures at the top of the slope averaged 15.2%. Specific geographic features also influenced structure survival. Structures located in a saddle or chimney had a dismal 8% survival compared to structures located on rolling terrain.

Another significant factor was the presence of heavy fuels at or near the structure. Three of the four significant variables describing vegetation referenced heavy fuel loads. The survival of structures with cleared trees and heavier fuels thirty feet from the structures was 32.4%, compared to 22% survival for structures without clearance. The most significant variable of these was HFUELY, where there was a 20% increase in structure survival in the absence of ladder fuels and heavy fuel loads ranging from 41% survival in the absence of heavy fuel loads to 20% survival in their presence. This variable captured the presence of any large combustible fuels including woodpiles and vehicles that were closer than fifty feet to the structure. None of the variables describing clearance for lighter fuels were statistically significant.

BUILDING CHARACTERISTICS

Building characteristic variables describe factors that are associated with the construction of a home, its relation to other structures near it, and how the structure is situated on the building site (Table 4). Many different aspects of building construction resulted in significant associations with structure survival. Of the 36 variables describing structural components, 23 were significant.

Table 4. Variables Associated with Building Characteristics

Variable Name	Variable Definition
SFLVN	Presence of floor level vents
HVYTILE	Heavy concrete or clay tile
VNTPRYN	Vent of any type present
WDWALYN	Exterior walls burn readily, wood
EVECOV	Boxed in overhanging eaves flammable
EVEBOX	Presence of boxed in overhanging eaves
SHAKE	Wood shake fire retardant untreated or unknown
RFFLAMYN	Roof flammable Y/N
WLBRNYN	Exterior wall burns readily
WLNTBRN	Walls made of nonflammable materials
TARGRAV	Built-up (Tar and gravel)
COMP	Composition shingle
INTSPKYN	Recode of INTSPK to binary
GABVN	Presence of screened gable vents
CONSHAK	Lt. weight cement or concrete flat shake/shingle
EVNTSC	Boxed in eave vents screened
OUTBPR	Presence of an outbuilding
OVERHG	Structure overhanging slope

Variable Name	Variable Definition
DPANEW	Presence of double pane windows
SVNTSC	Presence of screened floor level vents
DEXFLMYN	Deck made of flammable material
MULTISTO	Structure more than one story
STLTILE	Steel metal tiles
DECKYN	Presence of decks
ROOFAG10	Age of roof greater than 10 yrs.
MAXDIS10	At least 10 ft. between structures
REROOF	Last roof reroofed over existing wood roof
DFLAMY	Presence of flammable deck surface
DENCLO	Underside of overhanging deck enclosed
DOVERS	Decks overhanging slope
GABVNT	Presence of gable vents
RETSHAK	Wood shake fire retardant pressure treated
CORRMET	Corrugated and other metal
EVEPRS	Presence of overhanging eaves
EVENTY	Presence of boxed in eave vents
ESPKPR	Presence of perm. ext. sprinkler system

Two categories of building construction were predominant – roofs and vents. When each roof type was examined independently, several roof types indicated significant statistical variation from the norm. The roof types associated with structure survival include concrete shake, steel tile, heavy clay tile and composition roofs. The greatest rate of survival (52%) was associated with heavy tile roofs versus only 20% survival for structures without tile roofs. Steel tile and concrete shake roofs averaged 43% and 41% survival, while composition roofs averaged 25% survival. Roof types that negatively affected structure survival were wood shake and tar and gravel roofs. Both types showed around 16% survival relative to 24% survival for other structures. In the presence of a combustible roof, the average structure survival was 8% lower than in its absence. Overall, a structure with a nonflammable roof had a 2% better chance of surviving when compared to population survival rate of 22.55%.

Three different types of vents found on a structure were surveyed in this study – the subfloor vent, the gable vent, and the eave vent. All were found to have statistically significant characteristics about them. The average survival of homes without vents was 34%, about 12% higher than the average overall. Vents above the ground floor, however, were very significant in structure survival. Structures with eave vents had an equal chance of survival. However, this changed dramatically depending upon whether or not the eave vent was screened. Structures without screened eave vents survived 37% of the time while those that were screened survived 54% of the time. Gable vents exhibited a similar, but opposite, behavior. There existed an equal chance of survival for structures with or without gable vents. However, survival of a structure without screened gable vents was 40% while those that were screened survived 29% of the time. The presence of subfloor vents in a structure resulted in a survival rate of 19.4%. Subfloor vents that were screened decreased survival an additional one half percent to 18.9%. Boxed in eave vents averaged 38% survival and covered eave vents resulted in an increase survival rate more than double than population average. In fact, the presence of covered eave vents, structure survival averaged 68%.

Other structural characteristics associated with survival included the presence of double pane windows (39%) and the presence of interior sprinklers (41%). Structures without an interior sprinkler system survived 18.7% of the time, representing a four percent decrease from the average survival rate. A total of 32 structures had interior sprinkler systems. Of these, 13 (40.6%) survived the fire while 19 (59.4%) were destroyed.

The presence of outbuildings on the site had a negative impact on structure survival decreasing the survival rate to 18%. Structures without an outbuilding present survived 23% of the time, slightly higher than the population average. Structures with an exterior wall composed of wood had a survival rate of only 18.5% in its presence compared to 27% for those that did not. This trend was evident even when structure survival was examined using any type of flammable exterior siding. Structure survival for nonflammable exterior siding was 26.6% and only 19.8% for structures with flammable exterior siding.

STRUCTURE IGNITION

Structural ignition factors describe the location of ignition, the source of heat, its source of ignition and other contributing factors (Table 5). Nine of the thirteen ignition variables had a p-value of 0.25 or lower.

Table 5. Variables Associated with Structural Ignition

Variable Name	Variable Definition
DBURNY	Did decks burn?
EMBERYN	Known form of ignition from flying embers
ORNVEGYN	Heat source from ornamental vegetation Y/N
DFSIDE	Decks on side of fire approach
VEGSCYN	Heat source from any type of vegetation Y/N
STRUCYN	Heat source from structure Y/N
FBRAND	Entrance of fire brands through opening

Variable Name	Variable Definition
EXTORIYN	Origin of heat on exterior of structure Y/N
CFINFRA	Contributing factor infrastructure related
INTORIYN	Interior origin of fire
WOPENY	Openings in str. at time of fire front passage
WLDVEGYN	Est. source of ignition from wildland veg.
CFSTRUC	Contributing factor structurally related

The most significant variable of this study was combustion of a structure's deck, DBURNY. Also significant was another variable DFSIDE, referring to the approach on the deck-side of a structure. Structures whose decks did not burn survived of 63% of the time, while those homes whose deck did burn had only 4% survival. However, structures where the fire approached from the deck side survived 18% of the time when compared to homes where the fire did not approach from the side of the deck (29%). Overall, the survival for both variables was nearly identical to the survival for the entire population.

The ignition source of a structure was determined to be a significant factor to its survival. Of the ignition sources characterized in this study, those originating from a structure or ornamental vegetation surrounding a structure were found to be significant, averaging only 9% survival. However, the population of structures with ornamental vegetation was very low with only 3% of the population presenting this condition. These data were combined with wildland vegetation ignition sources to create a variable that examined ignition sources originating from any type of vegetation. Results of this analysis indicated a 22% survival rate for a structure when the ignition source was vegetative versus 9.3% survival when the ignition source was not vegetation.

Another interesting result was the significance of firebrands entering a structure as a source of ignition. The overall structure survival for this category was found to be 62%. In the absence of firebrands entering the structure, homes averaged 64% survival, but only 40% when a firebrand successfully entered a structure. Conversely, when flying embers caused ignition, survival averaged only 10% when compared to the population average. Within this sample, 27% of the structures survived where ignition could be attributed to flying embers as the known form of ignition as compared to 7% when ignition could not be attributed to flying embers. Additionally, if the known form of heat of ignition was produced from the exterior of the house, these structures survived on the average 22% better than the entire population. In the presence of this characteristic, 48% of the homes survived while 37% survived in its absence.

In conjunction with the type of ignition, the source of heat for the fire was found to be highly associated with structures. This may be due to the fact that this fire was located in a more urbanized environment where the density of homes is higher than what one might expect from a more typical "rural" urban/wildland setting and, thus, the probability of the source of heat originating from nearby structures is much higher. Where the source of heat could be attributed to another structure, structures survived 8.5% of the time as opposed to 11.7% for structures with a different heat source.

DEFENSIVE ACTIONS

Variables falling in this category include suppression efforts by both civilian and professional forces, the location and effectiveness of fire suppression resources, fire safety regulations, and evacuation proceedings (Table 6). Variables related to defensive actions taken to prevent a structure from being lost to the fire dominated the ranked list of p-values. Of the 36 factors in this category, 23 were found to be significantly associated with structure survival.

Table 6. Variables Associated with Defensive Actions

Variable Name	Variable Definition
DAFTAKYN	Fire agency defensive action taken at structure
DACTAKYN	Defensive action by civilians Y/N
DAFH2X	Application of water by fire agency
DACOFYN	Defensive action by firefighters or civs Y/N
ENGPRE	Engine at str. at time of fire front passage
EVACOW	Residents evacuated on their own
DACHND	Civilian veg. clearance by hand
DAFHEL	Water drops completed by helicopter
DAFTNK	Retardant drops completed by airtanker
DAFOTH	Other fire agency defensive actions
DACAFT	Civ. at str. after passage of fire front
EVACYN	Residents advised to evacuate
INSPEC	Ability of str. to pass PRC 4291 inspection
DAXH2O	Civ. app. of water after fire front passage
DCH2PM	Water supply probs. exp. by civilians
DAFHND	Fire agency veg. clearance by hand
DAFH2Z	Water supply probs. exp. by fire agency

Variable Name	Variable Definition
BACKFI	Fire agency backfired
FAACPB	Access probs. exp. by fire agency
DACDUR	Civ. at str. during passage of fire front
DACH2Q	Civ. app. of water during fire front passage
STKTMYN	Strike team present
DACH20	Civ. app. of water before fire front passage
DACBEF	Civ. at str. before passage of fire front
DACH2O	Application of water by civilians
DAFDOZ	Fire agency veg. clearance by dozer
H2OTYP	Primary water supply source for fire agency
ESPKDU	Ext. sprinkler used during fire front passage
ESPKBE	Ext. sprinkler used before fire front passage
ESPKUS	Exterior sprinkler system used
DACDOZ	Civilian veg. clearance by dozer
CIVINJ	Civilians injured requiring M.D. attention
CIVPRE	Civ. present at str. at time of fire front passage
DCH2OT	Source of civilian water supply

The variables describing evacuation status were significant to structure survival. When the occupant did not evacuate voluntarily, the structure survival rate reached 66.7%, compared to 25.2% when occupants voluntarily evacuated. However, the outcome of this variable is tempered by the results of the variable EVACYN that measured the survival of structures where evacuations were either mandatory or voluntary. For the residents that did evacuate, their homes survived 36% of the time compared to 21.6% for those residents that did not. The average survival within this population was 31.6%. The results of the two variables have very profound implications for public safety and the efficacy of evacuation. The differences in these two measures are probably due to the extreme conditions this fire exhibited and the timing of evacuations.

Of the seven civilian defensive actions that were reported significant, the highest-ranking variable described any defensive action taken by a civilian as being significant. This category represented all defensive actions taken by a civilian that were reported in the survey and was superseded only by any type of defensive action taken by a fire agency. The presence of civilians at a structure to take defensive actions during passage of the fire front and after it had passed were significant contributors to structure survival. When civilians were present at a structure during the passage of the fire front, the structure survived 59% of the time compared to 70% for those structures with a civilian presence after the fire had passed. Both subgroups averaged 53% survival overall, a 31% increase over the population average. For those structures where civilians were not present during fire front passage, the survival rate was 48%. This figure dropped 2% for structures with no civilian presence at the structure after the fire front passed.

The application of water to a structure by civilians before, during and after fire front passage resulted in survival rates much higher than the population average. For structures where water was applied before fire front passage overall survival averaged 49% compared to 65% when water was not applied prior to the fire. If water was applied during the passage of the fire front structure survival increased to 60% compared to 49% for those to which it was not. This trend continued with the greatest survival of structures occurring when water was applied after the passage of the fire front. Structure survival averaged 71% for structures when water was applied after the passage of the fire front, but only 48% for structures for which it was not. Again average survival for this sample population increased to 57% demonstrating a clear trend in structure survival dependent upon the timing of the application of water.

Representing well over half of the total sample population, structures where civilian defensive actions occurred by hand survived 62% of the time, compared to 22% when it did not occur. Undocumented reports of civilians removing ignited shingles by hand after the passage of the fire front lend credence to this notion of effective fire suppression. Finally, if water was not available, civilian defensive actions by hand played an important role in structure survival. These activities included the construction of fire line and the removal of flammable vegetation away from a structure. Water supply problems were a significant factor in structure survival. When civilians experienced water supply problems, structures averaged a 36% survival rate, compared to 60% in the absence of water supply problems.

Defensive actions by fire agencies were also significant with structure survival. When any type of defensive action taken by a fire agency was taken into account, structure survival was 52.6%. Virtually every defensive action taken by a fire agency resulted in significant changes in structure survival compared to the population. Survival increased to 70% when an engine was present at the structure, compared to 20% when there was no engine present. In the two instances where fire agencies backfired around a structure, each structure survived. Other defensive actions had similar outcomes.

Aerial defensive actions showed strong effects on a structure's ability to survive the fire. Defensive actions by air tankers resulted in 49% of the structures surviving when drops by air tankers were made. The survival rate increased to 81% when helicopters were responsible for the aerial assault. The helicopter's success can probably be attributed to its greater accuracy. Several other defensive actions were combined into a catch-all "other" category. These defensive actions were also significant resulting in a structure survival rate of 71%.

As with the civilian defensive actions, defensive actions by fire agencies through the application of water and by hand resulted in significant increases in structure survival. Further, problems by fire agencies included water supply problems and access to structures causing a decrease in structure survival where these problems existed. Defensive actions by hand increased structure survival to 75%, the same success attained by civilians. In fact, nearly all factors were equal in this category for manual defensive actions. Overall, each group survived 23% of the time, while in the absence of defensive actions by hand, structures survived at a rate equal to the overall population survival rate.

The application of water to a structure was ranked as one of the most significant factors in structure survival for the entire study. When fire agencies applied water to a structure the chances of it surviving increased to 75% and dropped to 19% in its absence. Even in the presence of water supply problems, structure survival was 23% higher when water supply problems were experienced by fire agencies and 44% when no water supply problems were experienced. The timing of the application of water by fire agencies was not measured in this study. Other problems by fire agencies that were significant included access problems. In the presence of access problems by a fire agency, structure survival dropped to 19% and increased to 29% in the absence of access problems.

CONCLUSION

This study presents several compelling conclusions that support current policy. As the data presents, building construction, site topographic features, land management, and defensive actions play a very important role in the survival of structure during a wildland fire. Homes situated on the lower two-thirds of a slope with heavy fuels removed within fifty feet of the structure experience significant increases in their ability to survive an exposure to a wildland fire. Building construction materials and techniques can further reinforce a structure's ability to withstand a wildland fire. Noncombustible roofs and siding in conjunction with protected vents have demonstrated their ability to reduce the probability of ignition due to embers or brands. Finally, the ability to take defensive actions by either civilians or professional firefighters against a fire following the passage of a fire front can only be accomplished if the premises are safe. Reducing the sources of radiant heat and ignition sources through proper removal of heavy fuels and fire-safe building construction will provide the opportunity to take defensive action against a wildland fire.

This study has also demonstrated that logistic regression can be used on large data sets with an automated set of tools to quantify and identify statistical associations and their magnitudes. With better data collection, better models could be developed that identify in greater detail temporal effects. Validation of other models will continue as related factors continue to appear in each model independent of time and researcher. These indications such as the presence of nonflammable roofing, vegetation clearance, and defensive actions cannot be ignored.

The Tunnel Fire represented an extreme instance of an urban/wildland fire, in which several factors lead to the catastrophic results witnessed. Unprecedented fuel loads and extreme weather created conditions under which structures characterized as low risk were destroyed in the early stages of the fire. The proportion of ignition opportunities were so great that homes with adequate vegetation clearance, appropriate roofing, screened vents, and nonflammable exterior walls ignited with conditions so untenable that no one could have survived attempting to protect the structure.

Prefire planning and accurate base data, such as parcels, roads, topography, and compliance with fire safety regulations can provide critical data for an accurate post fire analysis. Consistent data collection with clear concise instructions and responses can eliminate much bias and incomplete data collection. With proper planning, the destructiveness of these fires can be greatly reduced while our understanding of the interactions between a structure and an urban/wildland fire better understood.

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DEVELOPMENT OF A SEASONAL FIRE SEVERITY FORECAST FOR THE CONTIGUOUS US: WEATHER FORECAST AND VALIDATION.

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INTRODUCTION

The Scripps Experimental Climate Prediction Center (ECPC) has been making experimental, near real-time seasonal global forecasts since Sept. 26, 1997 with the NCEP global spectral model (GSM) used for the reanalysis (Kalnay et al. 1996). Images of the ECPC forecasts, at daily to seasonal time scales, are provided on the world wide web (http://ecpc.ucsd.edu/ and digital forecast products are provided on the ECPC anonymous ftp site to interested researchers. These forecasts are increasingly being used to drive regional models at the ECPC and elsewhere as well as various application models.

7-day GSM forecasts are made everyday in order to provide general information to interested researchers as well as to develop the basic 1-day validating analysis (V1) described below. 12-week GSM forecasts are made once a week (every weekend when the greatest computer capacity is available). These 12-week forecasts are then archived into weekly averages, which can be further averaged into 3 monthly (4-week) averages and a seasonal (12-week) average. Because of limited archive capacity, we decided not to evaluate time scales of less than a week, at least initially.

The purpose of this paper is to describe the various biases and errors in the global forecasts, as well as the significant skill of the forecasts. Our next goal will be to compare these global forecasts to regional forecasts driven by the global forecasts in order to determine what additional information might be provided by the regional forecasts.

INITIAL AND VALIDATING ANALYSIS

The initial conditions for the GSM forecasts come from the NCEP Global Data Assimilation System (GDAS) operational analysis (L28T126), which are posted in a timely fashion on a rotating disk archive at NCEP.

Although the operational GDAS analyses are sufficient to start our GSM forecasts, they are not sufficient to evaluate the desired forecast variables. For example, only atmospheric state variables such as temperature, humidity, winds, surface pressure, and surface state variables such as soil moisture and snow, are available in the GDAS sigma files and surface files. Another file, the so-called flux file, developed from 6 hour forecasts with the medium range forecast (MRF) or Aviation model contains near surface information such as max, min 2 m temperature, humidity, 10 m winds, surface latent, sensible, radiative fluxes and top of atmosphere radiation fluxes, and precipitation. These flux files were more difficult to access initially and it was not until Mar. 15, 1998 that we were successful in getting the 4xdaily flux files to evaluate our forecasts. These operational flux files (referred to as VO here) then formed our basic validation data set until the NCEP fire (Sept. 27, 1999) at which point only 2xdaily flux files became available and adversely affected the daily averages we were making from the 4xdaily forecasts. Although we could have also used the NCEP reanalysis files to validate the model (and we did use these to develop preliminary climatologies before we had the aviation files), we were never able to access these files in as timely a manner as the aviation files.

In order to extend backward the validation forecast period to the time when we first started archiving initial states, to extend a consistent validation beyond the NCEP fire, and to have available in near real time validating observations, we ultimately decided to develop our own flux files. Therefore, for our main validation effort, we now use one-day forecasts made every day from 00 UTC analysis initial conditions. This 1-day forecast analysis validation set will hereafter be referred to as (V1).

EVALUATIONS

As an example of our evaluation, we show here the global and US forecast fire weather index (FWI), and a fire weather index, which is a nonlinear combination of weather variables). Roads et al. (2001a,c,d) and Chen et al. (2001) describe forecasts for other regions and other variables. Some of these other regions and variables are discussed in the talk.

The GSM seasonal forecast fire weather index (FWI), which basically reflects wind speed and relative humidity, is the inverse of the relative humidity and soil moisture and is relatively high in those regions of low soil moisture and relative humidity (Figs. 1a,b). Although variations in the FWI are also reflected by the wind speed, it does not include vegetation stress, which must somehow be related to soil moisture, and which is better incorporated in standard fire danger indices (See e.g. Roads et al. 2000). There is a tendency for the forecasts to have a negative bias (Figs. 1c,d), which can be traced to the tendency for the model to have relatively high relative humidity over the land regions and a negative wind bias. Still, seasonal forecast correlations (Figs. 1e,f) are high over much of the US, except for the front range of the Rocky Mountains. Globally the highest forecast correlations are found over most land regions with the major exceptions being the northwestern US, Africa, and South America regions. The correlation pattern resembles more the relative humidity correlation pattern (instead of the wind speed correlation pattern), indicating that it is the relatively accurate forecasts of relative humidity, more than windspeed, that provide some skill for the forecast FWI at long (seasonal) time scales.

Fig. 2 shows temporal characteristics of global and US (land only) FWI variations. Like the soil. moisture, there is a distinct interannual variation with lower FWI during the first part of the period and higher FWI during the latter part of the period (Figs. 2a,b). This variation is notable, despite there being a substantial bias in the FWI, especially with regard to the operational analysis (Figs. 2c,d). This bias is due mainly to the substantial bias in the relative

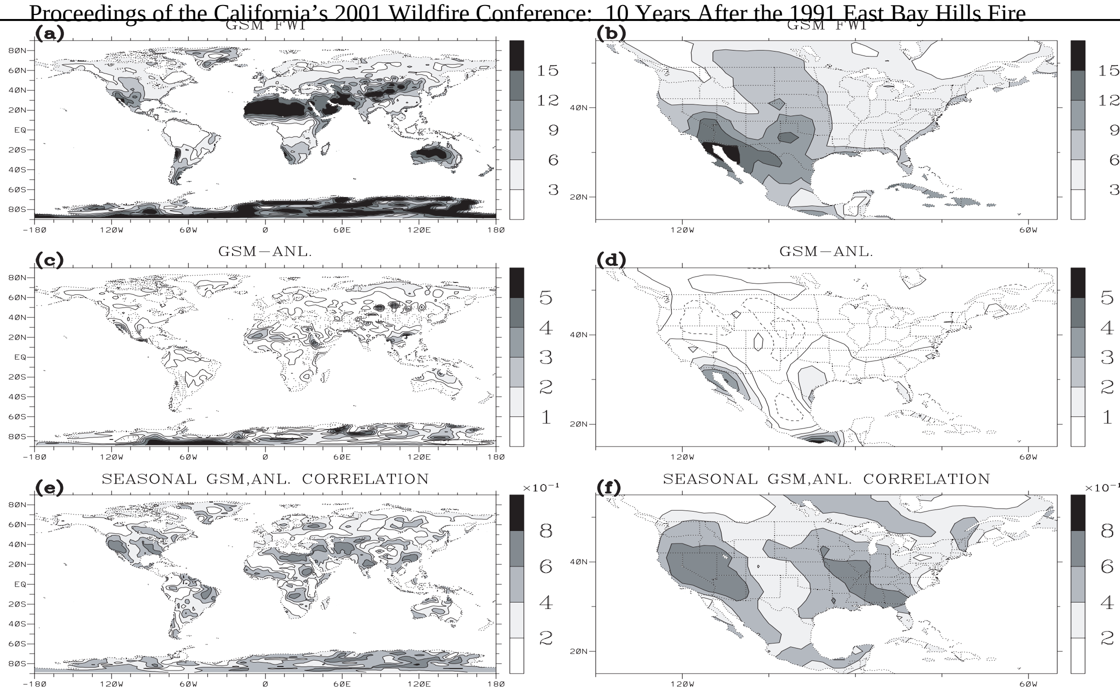

Fig. 1 FWI seasonal predictions (97/10-99/10; 104 forecasts): (a) GSM seasonal mean; (b) US focus; (c) GSM - V1 analysis mean; (d) US focus; (e) Global correlation [GSM, V1 analysis]; (f) US focus.

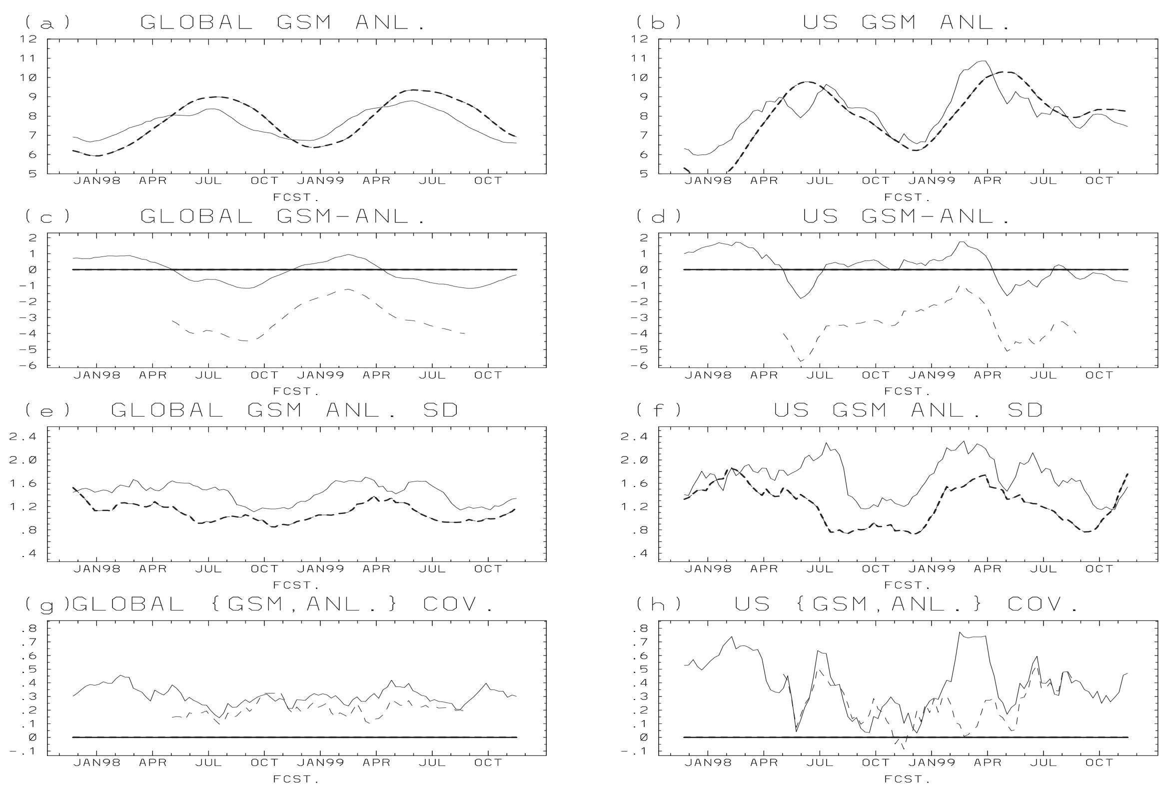

Fig. 2 FWI seasonal forecast temporal variations (97/10-99/10; 104 forecasts; smoothed by 5 forecast running mean). (a) Global, GSM (solid), V1 (dashed); (b) US; (c) Global GSM – V1 (solid), GSM-VO (dashed); (d) US; (e) Global GSM (solid), V1 (dashed) RMS; (f) US; (g) Global {GSM, V1} (solid), GSM, VO} (dashed), normalized seasonal covariance; (h) US.

humidity although the models weaker wind speed also contributes. By contrast, the forecast model standard deviations are substantially stronger than the analysis standard deviations especially over the US during the springtime (Figs. 2e,f). The normalized covariance is fairly significant and shows little seasonal variation (Figs. 2g,h) but strong intraseasonal variation, especially over the US and especially when using the 1-day forecasts (V1) to validate the seasonal forecasts.

DISCUSSION

In addition to the FWI shown here, evaluations for many additional near surface meteorological parameters have been made. In brief, many relevant near-surface meteorological parameters (including temperature, precipitation, soil moisture, relative humidity, wind speed are skillful at weekly to seasonal time scales over much of the US and in many global regions. Surface temperature forecasts are the most skillful, with ensemble seasonal forecast correlations of .7 for the US and .62 for the globe. Precipitation has much lower forecast skill, .3 over the US and .24 globally. Relative humidity is a bit more skillful at seasonal time scales with correlations over the US of .5 and .3 globally. Windspeed forecasts are more problematic with seasonal forecast skill of .3 over the US and .27 globally. FWI, which is a nonlinear combination of windspeed and relative humidity, has higher forecast skill, which presumably arises from contribution of the relative humidity as well as wind speed to the FWI.

Finally, soil moisture forecasts are skillful but show little skill beyond what is available from simply persisting the initial state. Nonetheless, the strong persistence of the soil moisture is presumably one of the controlling features on the ability of the model to make skillful seasonal forecasts of temperature and other variables, like FWI. It should in fact be noted that for all other variables, the model forecast skill is generally greater than persistence.

It should also be noted that forecast skill almost always increases with averaging length. This is due in part to the inclusion of skillful initial forecasts; however, even monthly forecasts with two-month lags are more skillful than corresponding weekly forecasts with similar lags, indicating the positive influence of time averaging here.

Even better weekly to seasonal forecasts can probably be made. For example, a number of recent improvements have been implemented in NCEP models, which may ultimately prove useful in increasing the forecast skill (see e.g. Hong and Leetma, 1999; Kanamitsu, personal communication). In that regard, it is our intention to eventually transition our forecast system to a more recent version of the NCEP model and to re-examine the skill in the new system. It should also be noted that a regional spectral model (see Juang and Kanamitsu, 1994; Chen et al. 1999, Anderson et al. 2000; Roads and Chen, 2000), with the same basic parameterizations as the GSM, is also being used to make higher resolution forecasts for specific regions. The forecast skill of the higher resolution forecast model will eventually be compared to the forecast skill of this global model as soon as we can obtain a similar number of high-resolution regional forecasts.

The GSM output is also being used to force regional models at other application centers as well as specific application models. For example, the GSM now forces a single column model, as well as an ocean model, which will eventually be coupled to the atmospheric model. Limited output products from the GSM and RSM are also being used for a wide variety of experimental applications.

ACKNOWLEDGEMENTS

This research was funded by a cooperative agreement from NOAA-NA77RJ0453 and US Forest Service cooperative agreement USDA PSW-99-0017CA. The views expressed herein are those of the authors and do not necessarily reflect the views of NOAA, US Forest Service. Jack Ritchie has performed the Herculean task of maintaining this quasi-operational system since 1998. We are also grateful to M. Kanamitsu and H. Juang of NCEP for providing us the global model as well as many useful answers to many questions.

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OVERVIEW--TRANSITIONS, TESTING, AND POLITICS OF PERFORMANCE CODE DEVELOPMENT

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INTRODUCTION

Over the past four years, the University of California Forest products Laboratory (UCFPL) has been working in conjunction with the Office of the State Fire Marshal (OSFM) and the Governor's Office of Emergency Services (OES) to develop fire mitigation and engineering recommendations and techniques. The support for this effort originated from the Federal Emergency Management Agency mitigation funds after the California firestorm of 1993.

This approach determined separate and combined effects of vegetation and structural hazards. These studies have resulted in a number of reports and a new publication, the I-Zone Series. Included in the I-Zone series are updated articles in the 1996 publication, *California's I-Zone*, plus executive summaries of reports on:

Professional fire-safe inspector workshop
Fire-safe inspector (IFCI) workshop
Homeowner's survival guide
Fire-safe vegetation
Fire-safe structures
Environmental impact and fuel modification
Structural fire prevention field guide
Ignition field guides
Fire hazard assessment
Biomass utilization

Each of these reports are available in CD format from UCFPL.

Since the I-Zone Series publication, two other studies have been funded and are being concluded:

- Fire tests of structural subassemblies

- Development of a model fire performance code for UWI

COMPLEXITY OF FIRE THREATS TO STRUCTURES.

The expansion of residences into previously undeveloped areas creates a mix of structures and wildland vegetation that have become major fire risk areas in California. Two areas commonly defined are the urban-wildland intermix (e.g., a house every 5 acres) and the urban-wildland interface (e.g., a subdivision that abuts wildlands) These zones often exhibit all or most of the conditions that create a high fire hazard; that is, dry vegetation (fuel), sloping topography, dry weather, combustible building materials, and architectural designs that expose combustible materials to advancing fires. By late summer or early fall, much of the vegetation that covers wildland and urban/wildland areas in California has been stressed by drought, low humidity, or desiccating winds, creating a critical fuel condition that can ignite easily and rapidly build into a major fire.

In defining risk to structures, we recognized the following key issues:

- Vegetative fuels dominate hazard, but there was no means of using the standard fuel types (except in the intermix) to define the hazard level. Most interface fuels contain a wide range of species (often exotic), arrangements, topography, and local factors that affect their condition. The critical vegetation lies in the home zone, 0 to 6 ft of the structure. Ignition of this vegetation can be caused by radiation, flame impingement, or from brands.

- Many guidelines and recommendations for vegetation selection in high fire hazard areas are readily available, but close examination of these lists reveals little scientific basis and often conflicting information. It appears that many of the lists are primarily based on anecdotal information, and the terms used in the ranking are not defined.

- Plants with an unfavorable fire performance rating are characterized by: a high surface area to volume ratio, low moisture content, high percentage of dead matter or debris.

We approached the vegetation study with the following action plan:

- Survey all existing literature on fire-safe plants and organize this into a searchable and comprehensive reference that could be accessed on our web page.

- Develop a protocol to test a number of species under normal and moisture-stressed condition.

Ignition by brands is a special problem in that they can be lofted from great distances, or can originate from fragments of the immediate or adjacent structure or other fuels. Their inherent variability in size, shape, and heat content make it impractical to do laboratory fire testing; the only practical means of assessing their characteristics is through modeling. In addition, where a brand lands and/or enters a structure is difficult to predict or test. They can be primary or secondary sources of ignition, such as ignition of shakes (primary) or ignition of vegetation (secondary). In the case of secondary ignition, the result is most likely flaming combustion, such as might occur from fuels under a deck or vegetation near the structure. The ignition risk from brands increase dramatically in the nooks and crannies of structures.

Ignition from radiation can occur from dense vegetation or an adjacent structure (or deck fire). Since the radiation intensity changes exponentially with distance, a source of one-fourth the intensity would have the same effect on a structure as the same source at twice the distance. Also, radiation is a straight-line effect, meaning that it can have little impact on decks and roofs, which are particularly serious subassemblies in risk to the structure. On the other hand, radiation is an important mode of heat transfer in assessing the performance of windows.

Selection of structural subassemblies

In development of the I-Zone Series, it was recognized that it was impractical to develop performance fire tests for entire structures, therefore, preliminary work was done to determine "testable" subassemblies that collectively would represent the most vulnerable portions of structures. The subassemblies that were selected included: roofs, walls, decks, and windows. For each subassembly, a test configuration was designed to be scalable to an actual structure, but also small enough to be conducted at a laboratory level. Draft test protocols were then developed for each subassembly that included fabrication of the assembly, procedures, fire exposures, and measures of performance. Each protocol was then finalized through testing of representative materials and construction details. The outcomes have been reported as they were completed on the UCFPL web page: www.ucfpl.ucop.edu.

IFCI model code characteristics

In 1997, a Urban-Wildland Interface Code was produced by the International Fire Code Institute under FEMA funding. The IFCI code uses a linkage between the degree of fire hazard and the details of construction. The IFCI Code also contained excellent guidelines related to fire protection. It was anticipated that the IFCI Code would be widely adopted, however, apparently only one jurisdiction adopted the Code. Some of the shortcomings of the IFCI code are:

1. Virtually all of the construction details are prescriptive, whereas performance information has now been developed that can make the specifications more relevant.

2. Although the linkage is made between degree of hazard and class of construction, the hazard level is defined in a non-standard method that has not been validated or used.

3. The IFCI code does not take into account some of the more vulnerable construction details that have been discovered in recent performance testing. Also, there are requirements for "one-hour fire-resistive ratings," which relates to interior (compartment) fires, but is not relevant to UWI fire exposure that is typically up to ten minutes.

Despite the shortcomings of the IFCI model code, it has provided excellent information to critique and from which to build a performance code. It also included very useful information related to response and protection that could be adopted by AHJ.

What are appropriate codes?

The move toward performance codes for structures is an international effort, with the US being one of the last countries to address the change. We are actually in the transition now, and have a mixture of performance and prescriptive specifications. A *prescriptive* approach describes an acceptable solution while a *performance* approach describes the required performance. The performance approach is thinking and working in terms of the *ends* rather than the *means.* Performance codes have the advantage of removing barriers to innovation and permitting cost-optimization. Going from prescriptive to performance is not always easy; it requires much thought and experience to design test protocols to evaluate the materials under conditions that are applicable to the real world. Also, a clear understanding of the choice of materials is not always easily obtained.

UWI performance code considerations include:

1. The key is the required performance, not a method or material to achieve that.

2. There can be degrees of prescription in performance; performance does not have to be absolute. There must be prescriptive solutions if performance cannot be described.

3. Performance codes must have referenced test methods, acceptable means of calculating performance, or a combination of the two.

4. Model codes must not compromise other attributes of a structure. As an example, vents are required primarily to remove water vapor from houses; reducing the required venting can lead to serious decay problems.

Model performance code development

The development included recognition of certain attributes or constraints:

- The hazard level (very high, high, moderate) must be available from AHJ for the particular parcel. Global hazard levels are not necessarily applicable to one or a group of structures.

- Infrastructural issues (roads, water, response) must be addressed at the neighborhood level by personnel who are formally trained in this area.

- The focus was on structural subassemblies and integration of the protocols and test results; and

- The fire exposure intensities for the laboratory protocols were based on testing plants that had been water stressed in order to put them in a "very high hazard" condition. Based on this, a nominal fire output was determined for such plants in the "home zone."

FUTURE CONSIDERATIONS

To have effective and useful performance codes, there must be a continuing effort in the following areas:

- **Code training and support**

Performance codes are much more difficult to implement than perspective, and require specialized training for AHJ. This would include fire performance tests, results, and options for implementation, including: how to link performance level to hazard, how to assess new materials or different construction practices, and where to go for help, including web-based support.

- **Further development of testing protocols**

Laboratory test protocols always have limitations and require continual review to obtain results that are as meaningful as possible in terms of how structures perform. We are aware of the need to continue work on testing with brands and radiant sources, but this has not been done in the interest of getting the most information in the shortest period of time.

- **Definition of hazard**

A major weakness that everyone recognizes is the difficulty in applying a broad area classification of hazard to an individual structure. As was determined in one of our earlier studies, Fire Hazard Assessment is a very complex analysis, sometimes involving data that are not available. Furthermore, the "home zone" is typically not a part of such analysis, and yet it may be the most critical portion of hazard.

TRANSITION FROM PRESCRIPTIVE TO PERFORMANCE BASED CODES

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A review of the current status of prescriptive and performance codes in the United with a reference to the status in the rest of the world. There will a specific discussion of how the model codes have treated the urban/wildland interface and how the performance approach gives an improved framework. The discussion of the structure of the model performance code and how the University of California research can be incorporated into a comprehensive approach to the urban/wildland fire problems

TESTING PROTOCOLS AND FIRE TESTS IN SUPPORT OF THE PERFORMANCE - BASED CODES

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ABSTRACT

As part of the effort to develop performance-based codes for structures located in the urban wildland interface (UWI), UCFPL researchers developed protocols by which exterior materials and assemblies could be tested. The results of these tests have been provided to individuals involved in developing the code. The protocols addressed roof coverings and assemblies, attached deck boards, exterior wall claddings, and windows. The objectives of this paper is to present an overview of the fire testing protocols, and to discuss some of the test results and implications regarding the performance of a structure located in the UWI.

Solid wood and a number of plastic lumber composite products were evaluated using the protocol developed for attached decks. For this series of tests the decks were subjected to a flame impingement exposure from the underside of the deck. The results showed that performance of plastic lumber depended on the type of plastic used, the fiber-plastic ratio, and the shape of the cross-section of the boards. A flame impingement exposure was also used for the window tests. Glass breakage was the typical failure mode at the higher (300 kW) exposure; at the lower (150 kW) exposure, burn through in the frame was the more typical. Single pane units were more vulnerable to flame penetration through the glass than double pane. Several "Class A" rated roof coverings and assemblies (according to ASTM E108) were evaluated using a Class A brand. Results showed that some roof coverings that relied on an assembly rating were sensitive to the construction details used for installation, and substitutions made in the underlying (assembly) materials. Tests have not been completed on the wall cladding materials, but results to date show the vulnerability of the lap joint when walls are subjected to a flame impingement exposure.

Keywords: Decks, Roofs, Exterior Walls, Fire Testing, Urban Wildland Interface, Structures

INTRODUCTION

The degree of exposure of structures to fire in the Urban Wildland Interface (UWI) has been reasonably well defined, but the available model codes are largely prescriptive. In this work, with support from FEMA through the Office of Emergency Services and California

Department of Forestry and Fire Protection, the UCFPL research team developed a series of test protocols that represented fire exposure typical for structures located in the UWI. These protocols addressed roofs, decks, and wall systems, three of the major identifiable structural subassemblies that could be scaled down to laboratory tests. In parallel with the fire testing, a model performance code is being developed to serve as a resource for local fire authorities in California and other states where UWI fire occurs. The objective of this paper is to review the protocols that were developed to evaluate external coverings and subassemblies, and to summarize the results of the fire tests.

RESULTS AND DISCUSSION

Testing protocols were developed for exterior decks, roofs and walls (Beall et al. 2001, Quarles et al. 2001, Beall et al. 2001). A separate protocol was also developed for windows (Beall et al. 2001). The wall testing discussed here only addresses cladding, although the wall protocol includes procedures to evaluate gutters and overhangs. Results of fire tests on gutters and overhangs is given by Jennings (2000).

A flame impingement exposure, generated using a propane gas burner, was used for the deck, window and wall testing, and a burning brand (square sticks nailed together in a defined way) was used as the exposure for the roof tests. The flame source was intended to represent the exposure experienced by the component and assembly. The details and results of these tests will be addressed in the order of decks, roofs, windows and finally, walls.

Subassembly Testing – Decks

Twelve commercially available decking materials were evaluated during this series of tests. Eleven of these were plastic lumber composites, and one was a solid wood product (redwood). There are many plastic lumber composites currently available. The ones used in these tests were selected in order to evaluate the plastic materials commonly used (polyvinyl chloride and polyethylene) and the cross-sectional form (solid, hollow, and channeled). The test decks used to evaluate deck board materials were 600 x 700 mm (24 x 27 in), and were supported by 2 x 6 Douglas-fir joists. A 250-pound load was applied to one board of some decks, but otherwise the decks were tested without a load. The underside of the decks was exposed to an 80 kW burner flame, initially for 3 minutes, and if the decking material performed adequately, the burner was restarted for an additional 5-min exposure. The decking materials were evaluated based on three criteria: (1) The propensity of the decking material to drop flaming debris (figure 1); (2) the observance of accelerating flaming combustion (Figure 2); and (3) collapse of any deck board (either loaded or unloaded). If the decking exhibited either accelerated flaming combustion or collapse during the initial 3-min exposure or the following 4 minutes, then the test was terminated. If not, the deck was subjected to an additional 5-min exposure. The dropping of flaming debris was noted, but was not cause for terminating the test. Accelerated flaming combustion was typically associated with a net heat release rate (HRR) greater than 400 kW.

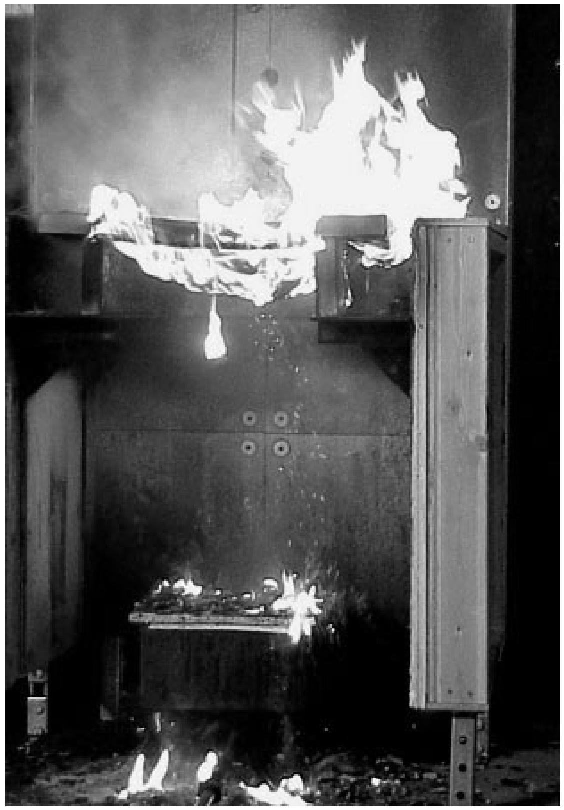

Figure 1. Dropping flaming embers from decks.

The performance of the plastic lumber composite materials appeared to depend on the plastic used in the composite (low or high density polyethylene, or polyvinyl chloride), the cross-section shape (or form), the reinforcement material (ligno-cellulosics or fiber glass), and on some unknown factors that may depend on additives used in the manufacturing process. The results of these tests demonstrated that a channeled form on the underside of the plastic composite made the deck more vulnerable. Since some plastic lumber products are heavy, a channeled or hollow configuration is used to make it easier for the end-user to carry. Deck boards made from polyvinyl chloride (PVC) collapsed quickly (in less than 3 minutes), but did not sustain combustion after the burner was extinguished. Polyethylene-based composites did exhibit sustained combustion after burner extinction, but generally performed overall better than the PVC deck boards. Most of the commercially available plastic composites contain polyethylene rather than PVC. Based on the flame exposure selected for these tests, and the evaluation criteria, the redwood deck performed better than all other materials tested, although a fiberglass reinforced polyethylene composite also performed well. Because redwood is a common deck board material used in California, it was the only solid wood material evaluated in this series of tests.

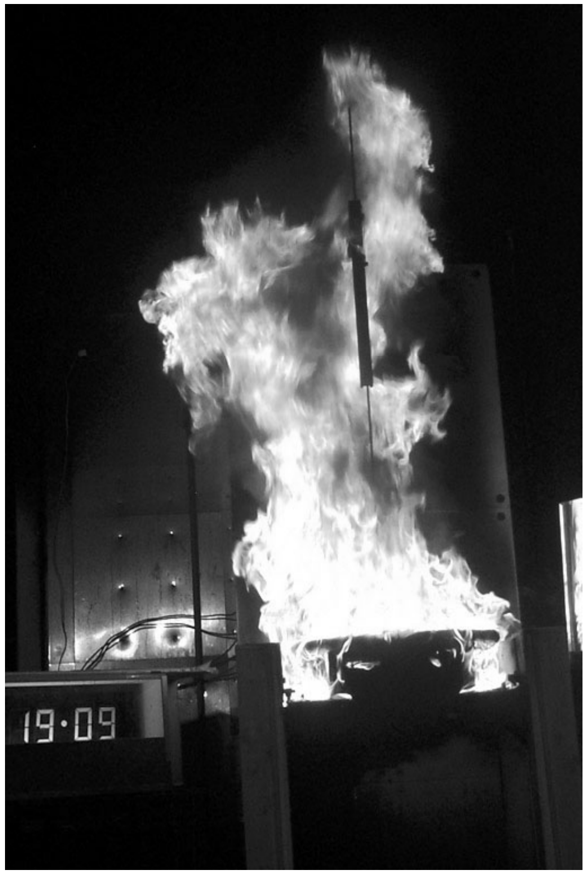

Figure 2. Accelerating flaming combustion observed during the testing of some decking materials.

Subassembly Testing – Roofs

The protocol used for testing the roof coverings was similar to the "brand" portion of American Society of Testing and Materials (ASTM) Standard E-108 (ASTM 2000). Only roof coverings and assemblies that had already received an "A" rating were considered for testing. The major difference between the procedures outlined in ASTM E-108, and those developed by the UCFPL is with the installation details used in the assembly of the 40 x 52 in. (1 x 1.3 m) test deck, particularly those details related to the materials used to obtain an assembly rating. A photograph of the "A", "B" and "C" brands is shown in Figure 3. An example of an "A" assembly is shown in Figure 4. Note that in this figure there is a joint in the DensDeck® fire barrier layer (the white colored sheet rock material containing fiberglass), located directly above the joint in the roof sheathing material. This location would be the most vulnerable from a fire performance perspective, and would be permitted with ASTM E-108, as would a deck without any joint in the fire barrier material. Since fire barrier panels are typically larger than the test deck specified in ASTM E-108 (and the UCFPL protocol), the manufacturer of a roof covering used in an "A" rated assembly, could just as easily test their covering material in a deck that does not incorporate a joint in the fire barrier material. Since roofs in residential construction would be larger than the fire barrier panel, thereby necessitating a joint somewhere on the roof, the UCFPL protocol specifies that one will be included in the test roof deck.

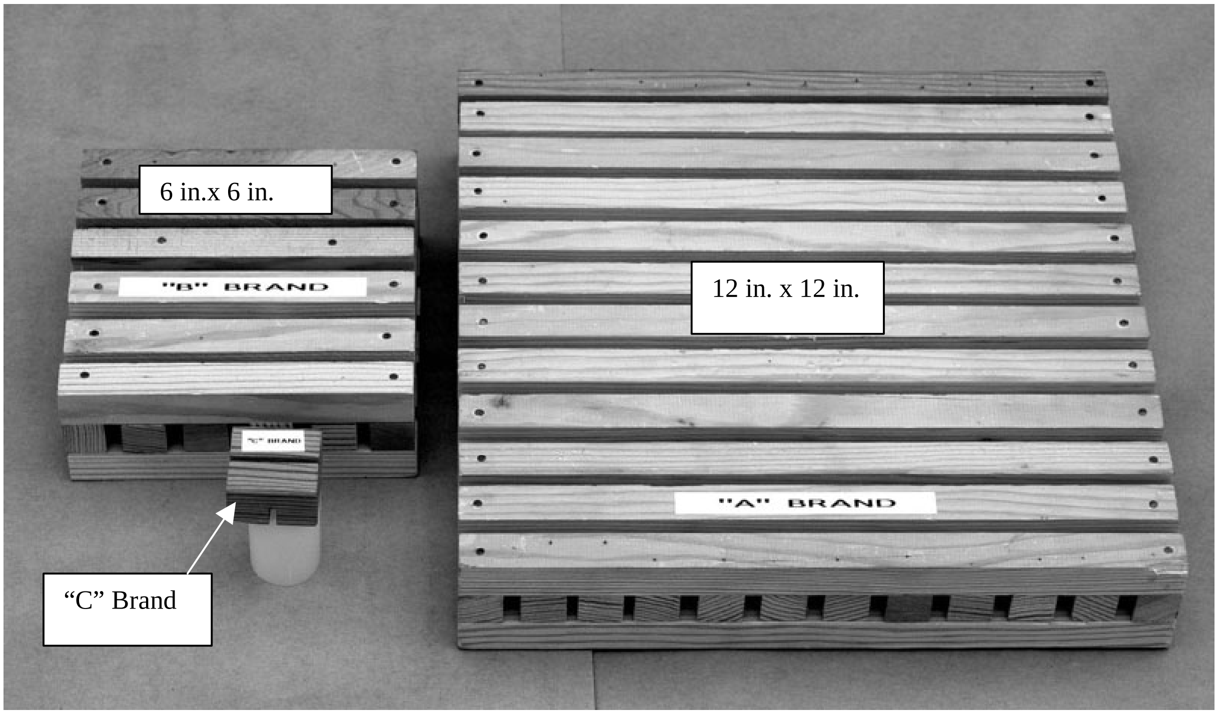

Figure 3. "A", "B" and "C" brands used to evaluate the fire performance of roof coverings and assemblies.

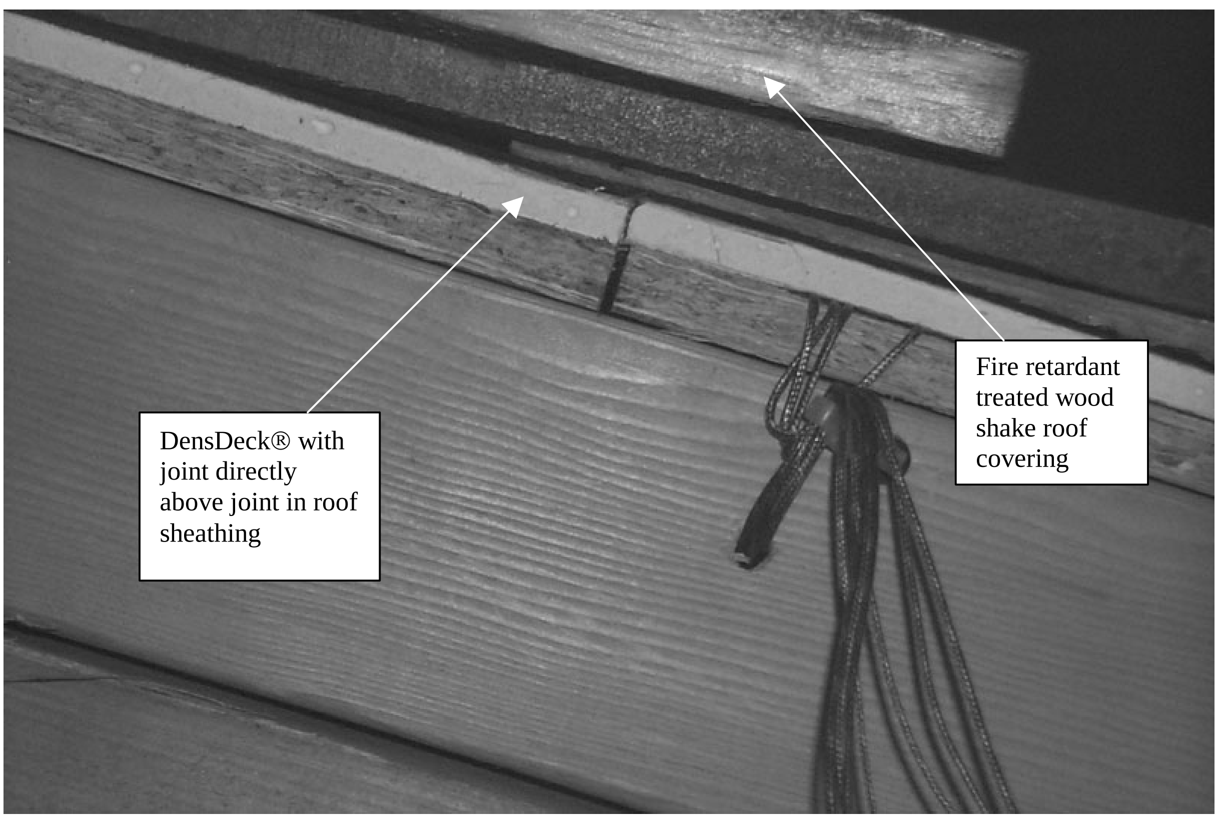

Figure 4. Fire rating based on the use of an additional fire barrier material.

The test apparatus for the roof testing consists of a rack to hold the roof deck, and a small wind tunnel positioned in front of the roof deck so that wind at a defined speed can be blown over the deck and the burning brand. The burning brand is ignited prior to the start of the test, and then placed on the roof deck. A 12 mile/hour wind blows over the roof deck and flaming brand during the course of the test. The 12 mile/hour wind speed is specified in both ASTM E-108 and the UCFPL protocol. If the flame penetrates through to the underside of the roof deck, the roof covering and/or assembly fails. However, if the brand and roof materials self extinguishes prior to flame penetration, then the roof covering and assembly passes.

Some fire officials argue that wind speeds greater than 12 miles/hour should be used in tests designed to evaluate roof coverings for structures located in the UWI, since winds can gust to speeds much greater than 12 miles/hour. We examined the effect of wind speed, and concluded that lower speeds were more severe since the residence time of the burning brand was longer. At higher speeds, the brand burns out quicker.

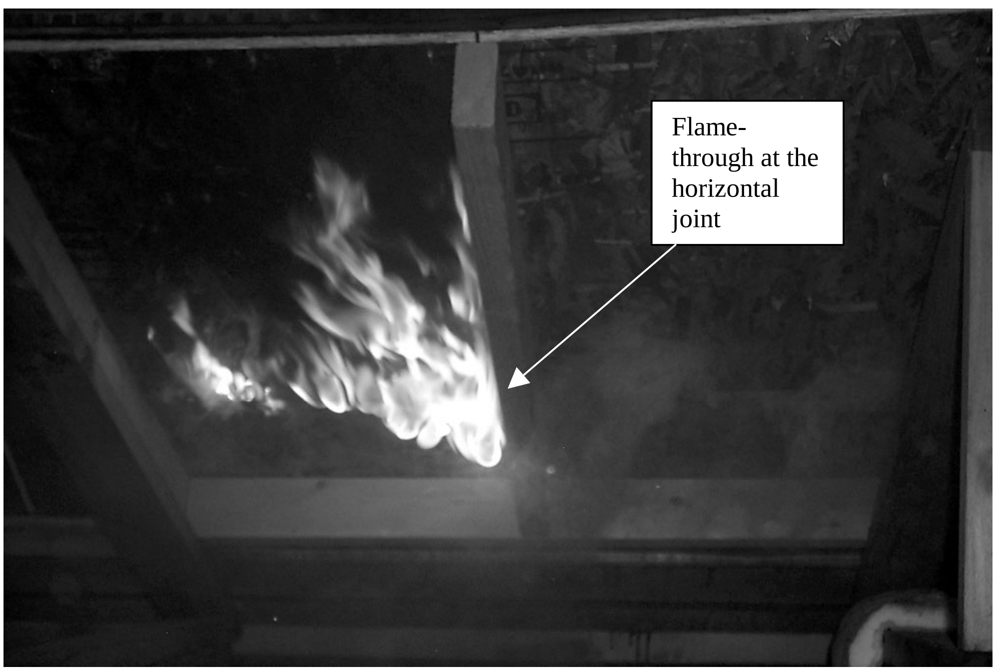

Figure 5. Flame through at the horizontal joint in the roof sheathing.

Results of the roof tests showed that both changes in materials within a fire rated assembly and installation details have a significant effect on fire performance. Specifically, materials that exhibited vulnerability included 72 lb capsheet (roll roofing) material and oriented strandboard (OSB) sheathing. Even though 72 lb capsheet is sold as a commodity material, assemblies that passed using a particular brand failed with another, with the only change in the entire assembly being the capsheet product. Similarly, "A" rated assemblies that used OSB as the sheathing material failed, whereas the same assembly passed when CDX plywood sheathing was used. OSB was used as the sheathing material because of its wide use in residential and commercial construction in California. Some manufacturers of roof coverings that have an assembly rating understand the vulnerably of their covering when used with OSB, and in these cases specify that the covering should be installed with an assembly containing plywood.

Subassembly Testing – Windows

A flame impingement exposure from a flame located directly under the window was used to evaluate the frame and glass materials of the window. The frame materials evaluated in this series of tests included wood, aluminum and vinyl clad wood, vinyl, fiberglass, and aluminum. Single and double pane glass, both annealed and tempered, were included in the tests. We examined mostly single- and double-hung windows, but did include a limited number of fixed windows. All windows were approximately the same dimensions. A diagram of the test apparatus is shown in Figure 6. A noncombustible material, such as sheetrock, was used for the sheathing and trim material surrounding the window. A 300 kW burner output was used to explore the effect of flame impingement on the performance of glass, and a 150 kW exposure was used to evaluate the combined effect of frame and glass on window performance. A 150 kW exposure was selected because if has been found to approximate the output of medium-sized ornamental plants that can be located beneath windows (Etlinger 2000). Failure was defined as flame through the window either as a result of window breakage or sustained ignition of the frame material with subsequent burn through. A photograph of flame through glass is shown in Figure 7.

Our results showed that glass failure consistently occurred at the 300 kW exposure, and double-pane glass performs better than single-pane glass. The horizontal interlock in single- and double-hung windows was the most vulnerable part of the frame – when burn-through occurred in frame material, it was always in this region. Results by Mowrer (1998) showed that the horizontal interlock of vinyl frames was vulnerable to radiant exposures (which is different from the flame impingement exposures used in these tests.) According to Mowrer, the interlock would deform and allow the glass to fall out of the frame at radiant exposures less than that required for glass breakage. Deformation of the interlock was not observed in our tests, most likely because of the use of a flame impingement exposure, but also because the vinyl frames included a steel reinforced interlock that may protect against this type of failure.

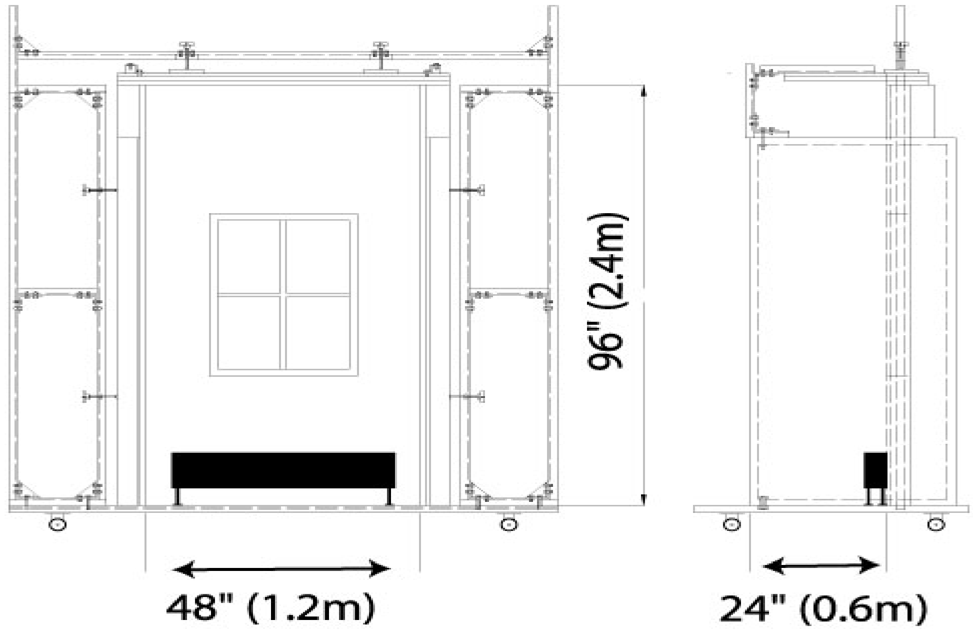

Figure 6. The apparatus used to evaluate the fire performance of windows, showing the line burner placed beneath the window, adjacent to the wall.

Figure 7. Glass breakage as a result of the flame exposure.

Subassembly Testing – Walls

The testing of sheathing and exterior claddings is currently in progress. The wall test apparatus is similar to that used for the window apparatus (figure 6), except that either the exterior cladding or the structural sheathing will cover the entire wall. A flame impingement exposure from a propane burner is used for these materials. A 40 kW burner output is used to evaluate flame spread over the cladding, and a 150 kW output is used to evaluate the potential for burn-through of the cladding and sheathing. An infrared (IR) camera monitored the temperatures on the back-side of the material during the course of the test. An example of the type of information available from an IR camera is shown in figure 8. In this case, the IR image clearly shows the vulnerability of lap joints in lapped siding. The lighter colors, located at the lap joints, are hotter. The dark vertical lines are the wood studs.

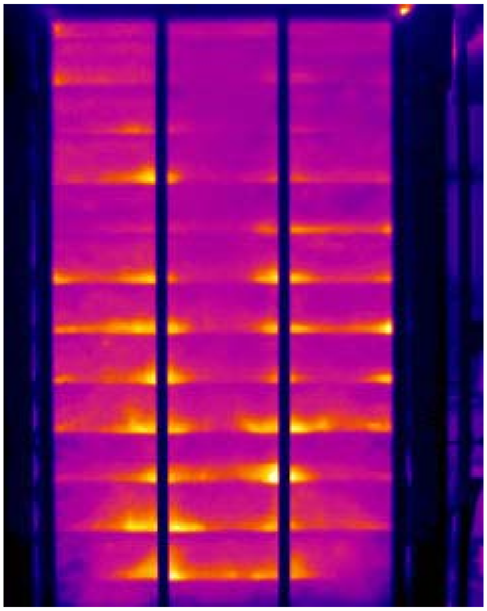

Figure 8. An IR image of the back-side of a lapped siding product during a fire test when the front of the cladding is exposed to a flame impingement exposure.

SUMMARY AND CONCLUSIONS

Our tests have shown that the fire performance of an assembly is dependent on both the properties of the materials used in the construction, and the installation details. This was most clearly seen in the roof covering tests, where a change sheathing material lowered the fire rating of an assembly. The interaction between the joints in DensDeck®, combined with the use of OSB sheathing, point to the need to modify installation details in order to improve fire performance. We also observed that manufacturing and end-use considerations can have unexpected impacts of the performance of materials. This was most clearly observed in the plastic lumber composites, where the channelized form on the underside of deck boards, incorporated into the manufacturing process to reduce the weight of the board, turned out to be a very vulnerable feature in terms of fire performance. The most up to date information on the fire testing can be found on the UCFPL webside, www.ucfpl.ucop.edu.

ACKNOWLEDGEMENTS

We gratefully acknowledge the help of Larry Cool and Tom Breiner, Research Associates at the UCFPL, for their help in conducting these tests, and in the design and construction of the apparatuses used. We also gratefully acknowledge the help of Janelle Hensley-Leafblad and Ian McCurley, graduate students in the Wood Science and Technology Program. The advice and assistance of Professor Emeritus R. Brady Williamson in planning this study is very much appreciated.

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POLITICS OF CODE

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It has been stated many times that the first person who decided there had to be a "structured" way we built buildings was King Hammurabi. Reportedly his code had severe punishments for those who broke it. For example if someone built a house that fell down and killed the owners the owner's relatives could kill the architect. If you fast-forward two thousand years the next concept of codes is in the very first colony in this country. According to the minutes of the first pilgrim colonies the first set of laws were put on the books in this country had to do with fire prevention.

A lot of things have changed since these two milestones were met. However the process has not changed a bit. In order for a set of requirements to be imposed a legal authority must adopt them. This is a political process. Today we are here to speak of a new concept in designing a minimum fire and life safety conditions in our community. It goes under the title of a performance code. There are politics in the performance code.

The purpose of this session is to talk about the perceptions, the priorities of government, and the problem that will likely occur if the concept of performance codes enters into the political process at the local, regional, state and federal level.

The emphasis in this workshop will not be on the negative aspects but rather the positive aspects that may lead to future successes to bringing performance codes to the forefront. Emphasis will be placed on the process to assure that the end result is politically acceptable to the authorities having jurisdiction.

WATER SUPPLY SYSTEMS AND FIRE FLOWS AT EAST BAY MUNICIPAL UTILITY DISTRICT OAKLAND, CALIFORNIA

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INTRODUCTION

Since the 1991 East Bay Hills Firestorm, there has been a growing public concern on minimizing losses during a fire event and, as a result, several local communities have expressed a desire to improve the water system to meet modern fire flow goals. Even though increasing fire flows in a community may be a good idea, the impact to the existing water system and the funding reality may not always make this feasible. The purpose of this paper is to describe some of the challenges and recent successes that East Bay Municipal Utility District (EBMUD) has faced in planning, coordinating and implementing water system improvements for increased fire flow in local communities.

BACKGROUND

EBMUD provides drinking water to approximately 1.3 million people in a 325 square-mile area covering 20 incorporated cities and 16 unincorporated communities in Alameda and Contra Costa Counties along the east side of the San Francisco Bay in Northern California. EBMUD's primary source of water supply is from the Mokelumne River watershed, a 577 square-mile area in the Sierra Nevada Mountains. The water is transported via three ninety-mile long aqueducts to EBMUD's service area, where it is treated at one of six treatment plants.

EBMUD's treated or potable water is distributed through approximately 4,000 miles of transmission and distribution system pipelines. Generally, the potable water is stored at one of the 170 local distribution storage reservoirs, whereby customers receive water by gravity from these storage facilities. EBMUD also has 130 pumping plants to replenish these storage facilities during off peak electrical demand periods. These storage and pumping facilities are located within 124 pressure zones ranging in elevation from sea level to 1,450 feet. These pressure zones typically provide water pressures of about 40 pounds per square inch (psi) for customers located near the top of each pressure zone and up to 130 psi for customers located at the bottom of the pressure zone.

ROLE OF THE WATER SYSTEM

EBMUD's primary mission is to provide high-quality water to its customers at a reasonable cost. In carrying out this mission, EBMUD endeavors, among other things, to exercise responsible financial management, ensure fair rates and charges, provide responsive customer service, and ensure a fair and open public process in discussing and making policy decisions.

As a water purveyor, providing potable water to its customers entails providing adequate flows and pressures. In a basic sense, flow and pressure are two different components that must be considered in the design of water distribution system pipelines as well as new services. Water system flows in a water distribution system typically consist of residential, commercial, industrial, irrigation, fire sprinkler and fire hydrant demands. The required flow for each demand category varies according to individual design requirements. Nevertheless, about 98 percent of the total metered water consumption for over 360,000 accounts at EBMUD is residential, institutional, or commercial use where potable quality is required.

Providing adequate water pressure in a water distribution system requires meeting standards such as the California Code of Regulations Title 22 and EBMUD engineering standards for various flow demands. These two design standards are fairly similar. For example, in California, design fire flows must be provided at a minimum residual pressure of 20 psi in the pipeline during maximum day demand periods. Another criteria for providing adequate water pressure in a water distribution system is to provide a minimum pressure of 30 psi during peak hour demand periods and about 40 psi is desirable where feasible. Actual customer flow and pressure available is dependent on several factors such as the elevation, proximity to the storage facility, water distribution system configuration, and pipeline size and condition.

Good water quality in a water system is another key EBMUD priority. Since EBMUD's primary source of water supply comes from the Mokelumne River watershed area with a small percentage coming from local terminal reservoir watersheds, EBMUD carefully manages its watershed lands to protect the water's high quality.

When EBMUD treats its water at a filter or treatment plant, the water is disinfected with chlorine and chloramines to reduce waterborne criteria, viruses or other pathogens. After treatment, EBMUD water is distributed to local neighborhood reservoirs where it is stored for consumer use. Typically, these reservoirs are sized to provide daily operational demands as well as an emergency supply equivalent to one maximum day demand. In smaller pressure zones, typically less than one million gallons, the reservoirs also contain a fire flow storage component. The fire flow requirement is set by the local fire agency with jurisdiction. For example, if the fire agency sets 1,000 gallons per minute (gpm) for two hours, the storage component would be 120,000 gallons.

EBMUD routinely samples and monitors the water by analyzing water samples collected throughout the service area. These water samples are analyzed daily in EBMUD's Environmental Laboratory. Today, monitoring is required for more than 100 constituents, of which very few are detected in EBMUD's drinking water. Further, the Environmental Protection

Agency and Department of Health Services continue to develop more stringent regulations and water agencies will continue to make changes in their ability meet new standards for water quality. For the most part, EBMUD is in a position to meet new monitoring requirements and be well below maximum contaminant levels. Nevertheless, as these changes evolve, EBMUD recognizes that maintaining good water quality in the water system will become more challenging over time.

COMPETING INTERESTS

One of the most important factors in maintaining good water quality is keeping the water age low, for example, avoiding stagnant water due to low demands or oversized facilities with little water turnover. Good turnover ensures that the water system can maintain sufficient disinfectant (chlorine) residuals as new water is replenished in the water distribution system as demands from customers and other water users draw from the water system. Minimum chlorine residuals must remain in the water system to protect against bacteriological growth. Stagnant water tends to dissipate the chlorine over time if water demands are low. So maintaining good water quality can be achieved better with smaller storage facilities and smaller pipelines. On the other hand, larger storage facilities and pipelines are usually required for increased fire flows. Clearly, these two goals compete with each other. Since safe drinking water and adequate fire protection are both public health and safety concerns, these two priorities need to be balanced in protecting the public.

As noted above, EBMUD's primary objective is to provide safe and clean drinking water to its customers. A very high percentage of this water can be consumed by the public at any moment and thus the high potable water standard. Fire sprinklers and fire hydrants use water as needed, typically in emergencies. These services are usually on standby and use a very small percentage of water, if any. Obviously, the greater dependency for water is for consumptive purposes.

RECENT PROJECT SPECIFIC CASES

EBMUD has encountered situations where increased fire flows conflicted with water quality goals. For example, in 1994, EBMUD completed a study to replace a 200,000 gallon redwood reservoir for seismic and water quality reasons. In the planning process, EBMUD determined the need to replace the existing reservoir, built in 1953, with a new steel tank with a capacity of 425,000 gallons to meet existing and future domestic water demands. Since the total storage required was less then one million gallons, EBMUD consulted with the local fire agency for their fire flow requirements. The local fire agency indicated a required fire flow of 2,250 gpm for two hours or an additional storage need of 275,000 gallons for a total of 700,000 gallons in storage. The fire flow requirement was much higher than anticipated based on recent history (typically 1,000 gpm for two hours or 120,000 gallons).

In short, the additional fire flow capacity accounted for about 40 percent of the new storage, a significant volume component not needed for daily customer potable demands.

Fortunately, the existing reservoir site had enough space and EBMUD built two side-by-side 350,000 gallon reservoirs. This provides EBMUD with the flexibility of taking one of the reservoirs out of service during the low winter demand periods, which helps preserve higher disinfectant residuals, ensures greater water turnover, and maintain good water quality.

In another recent case, EBMUD, as part of its $189 million Seismic Improvement Program[1], was planning to upgrade and seismically retrofit the existing Forestland Reservoir located in the East Bay Hills. In the process of reviewing existing and future water demands as well as the existing chlorine residuals, it was determined that the 3.4 million gallon reservoir was significantly oversized and suffering from low water turnover and degrading water quality. Significant manual labor and costly attention to the reservoir was required to maintain adequate water quality. The analysis indicated that only 750,000 gallons of storage was needed, which included a fire flow capacity of 1,500 gpm for two hours (180,000 gallons). The cost difference between upgrade and rebuild is negligible. So, rather than upgrading the facility, it was recommended to demolish and build a smaller reservoir to improve water quality by reducing the water age and ensuring greater turnover.

In discussing the reduced capacity with the local fire agency, they were concerned with the reduction of about 75 percent of the existing storage capacity for a reservoir located just south of the firestorm area. After further discussion, EBMUD explained the water quality impact in keeping such large storage in service and how part of the original water demands served by the Forestland Reservoir no longer existed due to a irreparable landslide in the vicinity. Those customers are now served from a different source and that reduced a large percentage of the demand on Forestland Reservoir. EBMUD explained that there were other water reserves available to the fire agency for fire fighting. Due to the interconnectivity of pipelines, regulators and other storage facilities further up the hill from Forestland Reservoir, more than ample fire flow storage was available to maximize fire flows in the area served by this reservoir. The local fire agency understood the concerns associated with maintaining water quality, higher chlorine residuals, and reducing the possibility of bacteriological growth and agreed to modify their approach and utilize the other resources rather than large fire flow storage at one reservoir location.

These two examples illustrate some of the challenges in attempting to balance sufficient storage to meet both fire flows and potable water demands. EBMUD is currently evaluating and updating its existing criteria for the total storage and pumping capacity required as it affects water quality and fire flow standards. The total capacity needed for operating and emergency purposes is under review. Further, the American Water Works Association Research Foundation[2] is in the midst of completing a research study on the impacts of fire flows to system design and storage. As these and other related and on-going studies are completed, EBMUD and other agencies will need to consider and address the water quality impacts associated with sizing and operating a water system in an increasingly stringent regulatory environment.

WATER SYSTEM POLICY ISSUES

Following the 1991 Firestorm, EBMUD conducted several studies of the water distribution system's fire suppression capabilities and evaluated policy regarding the water system's performance under normal and adverse conditions. As part of this process, an EBMUD Planning Committee of the Board of Directors conducted a 16-month study of infrastructure management and performance issues. The committee evaluated key findings of these previous studies and focused technical reports concerning: 1) inadequate system performance areas and low pressure service; 2) fire suppression issues; 3) seismic vulnerability; 4) pipeline maintenance; 5) water quality; and 6) infrastructure planning relationships with other agencies. The study culminated in April 1994 in a report entitled Infrastructure Policy Study[3]. The study included a series of policy and technical recommendations that were adopted by EBMUD's Board of Directors regarding the water distribution network system. Among the adopted recommendations was a provision to address situations where communities that desire to upgrade performance levels above the as-designed level and seek EBMUD help in completing system performance upgrades. Such situations typically develop when a change in standards and/or practice occurs over time, which in effect reduces the as-designed system performance to less than adequate based upon modern criteria or standards. Therefore, Infrastructure Policy Recommendation No. 4 was adopted and states that, "where the inadequacy is not solely EBMUD's responsibility, work with cities or residents to develop joint funding of improvements to the highest priority areas." To date, the performance element of local concern has been community fire flows.

EBMUD's Planning Committee also examined different fire flow performance objectives in the context of current practice, which is, that EBMUD does not undertake distribution system modifications solely to improve fire flows. A key finding was the high cost of upgrading the portions of the water system to achieve a minimum of 1,000 gpm (or 1,500 gpm in high hazard areas). The estimated cost is about $800 million in today's dollars and currently only 14 percent of the hydrants are below this standard; clearly, a very high cost that would benefit only a relatively small percentage of EBMUD's customers. To ask all EBMUD's customers to pay for such localized benefits raises important equity issues.

EBMUD is also not legally required or obligated to upgrade existing water mains when local communities change their fire flow standards. However, as EBMUD's policy acknowledges, when pipelines are replaced for maintenance reasons or relocated to accommodate road or other utility projects, the new pipeline replacements will be sized to provide the current desired fire flows (as established by the local fire agency) to the extent feasible. Over time, this practice will modernize the capacity of the pipelines that were designed under older standards. This is also consistent with water industry general practices for both private and public water agencies.

In light of the local community's desire to, in effect, accelerate pipeline replacements to improve the water system for higher fire flows, the questions regarding who pays for these improvements and the legal responsibilities for providing fire flows were addressed. For a water system that is performing as-designed and providing adequate water flows and pressures, upgrades for fire flow only is the responsibility of those that benefit from the improvements.

COMMUNITY FIRE FLOW PROJECTS

Over the past few years, EBMUD has been involved with three local agencies in evaluating water distribution system improvements and associated costs for increasing fire flows within certain communities. This has been a cooperative and successful effort between EBMUD and each of the local fire agencies, City agencies, elected officials, and local residents.

ROCKRIDGE AREA WATER SYSTEM IMPROVEMENTS PROJECT

Following the 1991 East Bay Hills firestorm, EBMUD completed an engineering study of the water distribution system serving the Rockridge area in Oakland in response to a request from residents in Rockridge[4]. The area includes about 750 parcels, primarily residential. The purpose of the study was to identify water distribution system improvements and overall cost to achieve a fire flow goal of 1,000 gpm for two hours from a single hydrant as selected by the Oakland Fire Department (OFD). The residents within the community, however, desired a fire flow goal of 1,500 gpm from a single hydrant. Existing fire hydrant flows ranged from 50 gpm to 1,500 gpm from a single hydrant flowing prior to installation of any improvements.

In 1994, upon completion of the engineering study, EBMUD and the City of Oakland entered into a cost-sharing agreement for the identified fire flow improvements consistent with adopted Policy No. 4 of the Infrastructure Policy Study. The Rockridge Area Water System Improvements Project increased the fire flow to all hydrants within the Rockridge Special Assessment District (RSAD) to 1,500 gpm from a single hydrant flowing. The water distribution improvements identified in the engineering study included installation of approximately 13,000 linear feet (LF) of 8-inch to 12-inch pipeline replacements. Most of the replaced pipes were old 4-inch and 6-inch unlined cast iron pipes; much of the pipes were tuberculated.

EBMUD's contribution in the cost-sharing model was based on providing a fire flow of 500 gpm, the typical fire flow a standard residential system would flow at the time the original distribution system was installed (circa 1910 to 1935) in Rockridge.

EBMUD's share, about 20 percent for pipeline replacements, was for the fire flow rate proportion of the proposed improvements to achieve 500 gpm where the then-existing system could not, and was based on achieving a fire flow of 1,000 gpm as set by the OFD. The residents paid the incremental cost for achieving a fire flow of 1,500 gpm via the RSAD. The project cost was estimated at $2,542,000 and the funding was provided as follows:

City of Oakland Bond Funds	$1,145,000
RSAD	$886,000
EBMUD	$511,000

The RSAD was formed specifically for this purpose and each parcel is assessed $135 per household per year for 30 years via the county tax rolls. Payment of special studies, legal, and county fees are separate and were paid by the City of Oakland.

The pipeline replacements were completed in 1997. Hydrant flow tests were conducted afterwards and test results confirmed the new improvements met the City's desired flow of 1,500 gpm.

ORINDA FIRE FLOW IMPROVEMENT STUDY

Beginning in August 1995, EBMUD began meeting with local homeowners groups, at their request, to discuss low fire flows within the City of Orinda. Following these initial meetings the Orinda Fire Protection District (OFPD), now the Moraga-Orinda Fire District (MOFD), and the City of Orinda requested that EBMUD complete a Fire Flow Reconnaissance Study[5]. The purpose of this study, funded by the OFPD and completed in December 1996, was to conceptually identify the magnitude of improvements and estimated cost to provide a fire flow of 2,250 gpm for two hours from three nearby hydrants flowing simultaneously within the City of Orinda. Identified improvements, estimated at $53 million, included pipeline replacements, and upgrades to storage facilities, regulators, and fire hydrants. As a result, a comprehensive hydraulic planning study for the City of Orinda was needed to refine improvement locations and costs and explore alternatives.

In February 1998, the Orinda Fire Safety Committee (OFSC) was formed to address policy level issues regarding fire safety concerns in Orinda and was comprised of elected representatives of the City of Orinda, MOFD and EBMUD. In May 1998, the City of Orinda, MOFD, and EBMUD agreed to jointly fund the comprehensive engineering study of the water distribution system serving the City of Orinda. The purpose of the study was to identify, in detail, water distribution system improvements and the overall cost to achieve various fire flow goals selected by the MOFD[6].

The fire flow goals selected by the MOFD were 2,250 gpm from three hydrants flowing simultaneously, 1,750 gpm from two hydrants flowing simultaneously, and 1,500 gpm from two hydrants flowing simultaneously with a minimum of 1,000 gpm from a single hydrant flowing. The results of the comprehensive engineering study yielded costs ranging from $36 million to $50 million. The water distribution improvements identified in the engineering study include installation of approximately 142,000 to 192,000 LF of 6-inch to 16-inch steel pipeline (depending on the selected fire flow goal), and upgrades to storage facilities, regulators, and fire hydrants in 14 pressure zones.

The OFSC adopted the comprehensive engineering study in April 1999. The MOFD also adopted the fire flow goal of 2,250 gpm from three hydrants flowing simultaneously as the long-range master plan goal for the City of Orinda. The next step was to prioritize the improvements using the master plan approach. In February 2000, EBMUD and the MOFD completed the Orinda Fire Flow Draft Master Plan that prioritized the $50 million in water distribution system improvements into 26 separate projects[7]. The prioritization criteria included identifying areas with fire flows below 1,000 gpm, identifying improvements that provide an additional source of water, identifying areas with high fire vulnerability, and identifying direct and indirect fire safety benefits. As part of the prioritization process, the MOFD developed a fire index for the City of Orinda and consolidated the results in a Fire Prevention Risk Assessment[8]. The MOFD created the fire index by categorizing the fire risk within the City of Orinda using such factors as access, construction type and materials, existing vegetation (type and quantity), response time to an area, and exposures.

Based on both the prioritization process and affordability issues, a first phase scope project was identified; about 30 percent of the pipelines in the master plan would be installed at a cost of about $13 million. EBMUD has tentatively determined that about $1.3 million is an appropriate EBMUD share based on benefit calculations which is similar to the cost-sharing model applied in Rockridge. This $13 million investment would provide 1,000 gpm from a single hydrant for about 90 percent of the hydrants within the City of Orinda. EBMUD, the City of Orinda, and MOFD have recently been discussing funding of these improvements. Currently, the City of Orinda and MOFD are exploring options and will advise EBMUD how they intend to proceed in early to mid 2002.

KENSINGTON WATER SYSTEM IMPROVEMENTS MASTER PLAN

In July 1998, the Kensington Fire Protection District (KFPD) requested and funded a comprehensive engineering study of the water distribution system serving Kensington to be completed by EBMUD[9]. The purpose of the study was to identify water distribution system improvements and overall cost to achieve a fire flow goal of 4,500 gpm from three hydrants flowing simultaneously along the urban/wildland interface for 20 minutes and 1,500 gpm for two hours elsewhere within Kensington. The El Cerrito Fire Department determined these fire flow ratings based on such factors as risk of ignition, fire weather conditions, fuel heat released, fire line impacts, access, and response times based on a potential conflagration threat from the adjacent Wildcat Canyon, which is on the eastern side of the East Bay Hills.

The engineering study was completed in December 1998 and a report delivered to the KFPD Board of Directors. The total project cost estimate was about $5.3 million and included about 20,000 LF of 8-inch to 12-inch pipeline, one new regulator, and several new hydrants.

In December 1999, the KFPD prepared and adopted the Kensington Water System Improvements Master Plan to upgrade the water supply system for fire flows in Kensington[10]. The Master Plan identifies a series of projects estimated at a total cost of $1 million that will improve the water system in the highest priority areas at a reasonable cost and based on available funding. The water distribution improvements identified in the Master Plan include approximately 4,000 LF of 8-inch to 12-inch pipeline, and approximately 15 new fire hydrants.

In August 2000, the KFPD Board entered into an agreement with EBMUD to begin design and construction of the first phase at an estimated cost of $400,000. These water system improvements were completed in July 2001. In October 2001, following an amendment to the agreement, the second phase of water system improvements is scheduled for completion at a cost of about $200,000. The KFPD is funding these improvements; however, the KFPD and EBMUD have agreed to reserve for further discussion the possibility that the parties may consider and consent to a cost-sharing proposal that would be retroactive should the long range project produce a direct water district benefit.

CONCLUSIONS

EBMUD, in conjunction with three local communities, has been able to implement water system improvements for fire flow, while balancing the need to maintain water quality. These improvements have been prioritized and implemented in a mutually agreeable and affordable fashion so that an adequate and appropriate water supply is provided for fire protection. Further, these improvements have been appropriately cost shared based upon benefit. Therefore, water system improvements for fire flow can be achieved, but local communities should also recognize the need to develop a comprehensive approach that considers all fire mitigations, such as reducing the fuel loads (i.e., vegetation, building materials and construction, etc), to enhance a fire safe community.

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FIRE, WATER AND POLITICS

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ABSTRACT

Kensington is an unincorporated residential community on the west slope of the Berkeley Hills, about four miles north of the point of origin of the 1991 fire. On the steep east slope of the hills lies Tilden Regional Park. This slope is densely covered with a mixture of brush and trees, constituting a good fire ladder.

In 1997, the Kensington Fire Protection District (KFPD) became aware that available fire flows from existing water mains along the urban/wildland interface were far from adequate. KFPD commissioned the East Bay Municipal Utility District (EBMUD) to use its computer model to determine the improvements necessary to guarantee a total fire flow of 4,500 gallons/minute for a minimum of 20 minutes from any three adjacent fire hydrants along the interface. EBMUD provided a report with that information, and the cost estimate was over $5 million. A $5 million program was not politically viable, but careful analysis of the EBMUD report revealed that an investment of a little more than one million dollars could provide the desired fire flow or something reasonably close to it. Revenue projections indicated that this work could be funded over a five-year period.

After the engineering and financing problems were solved; the political problems loomed ahead. The entire community had to be convinced that all of Kensington would benefit from the program. KFPD prepared a Water System Improvement Master Plan to give its citizens a broader picture. After that, Kensington was united behind the program. The construction contract with EBMUD for the first year's work was signed in 2000, and this work was completed in July 2001. Construction of the second year's work started in September of 2001.

This paper describes how KFPD determined and overcame the engineering, financing and political problems inherent in developing adequate fire flow capabilities at its urban/wildland interface.

Key words: fire flow, politics

INTRODUCTION

I'm going to present this as a first-person account because, when you get into politics, everything becomes personal. When you present a program, especially if it's going to be expensive, your constituents are as likely to question your motives as the worth of the program. When I was a bureaucrat, I considered elected and appointed politicians as the cross I had to bear for living in a democratic society. During my years with the San Francisco Fire Department, I designed three successful bond issues for improved water supplies for fire protection, and I assumed that those two-thirds majorities were strictly due to the virtues of the proposed projects. My only part in convincing the voters consisted of writing the blurb for the voter pamphlet. Nobody would ever consider voting against better fire protection. Now I know better.

When I moved to Kensington in 1994, three years after the big fire, some of my new neighbors who knew my professional background complained to me about the wildfire risk to the community and called upon me to get something done about it. So, two years later, I was elected to the Board of Directors of the Kensington Fire Protection District (KFPD).

SETTING

Kensington is an unincorporated residential community on the west slope of the Berkeley Hills, about four miles north of the point of origin of the 1991 fire. On the steep east slope of the hills lies Tilden Regional Park. This slope is densely covered with a mixture of brush and trees, constituting a good fire ladder (figure 1).

Figure 1. Tilden Park slope east of Kensington

WATER SYSTEM ANALYSIS

Upon attaining office, I obtained the water distribution system maps for Kensington from the East Bay Municipal Utility District (EBMUD) and fire flow test results from the fire department. I found long dead ends providing inadequate flows for even a single fire engine, particularly at the southern part of the park interface (figure 2). Inquiry revealed that EBMUD was in the process of developing a computer model of its distribution system, and KFPD decided to defer action until said model would be available to guide us.

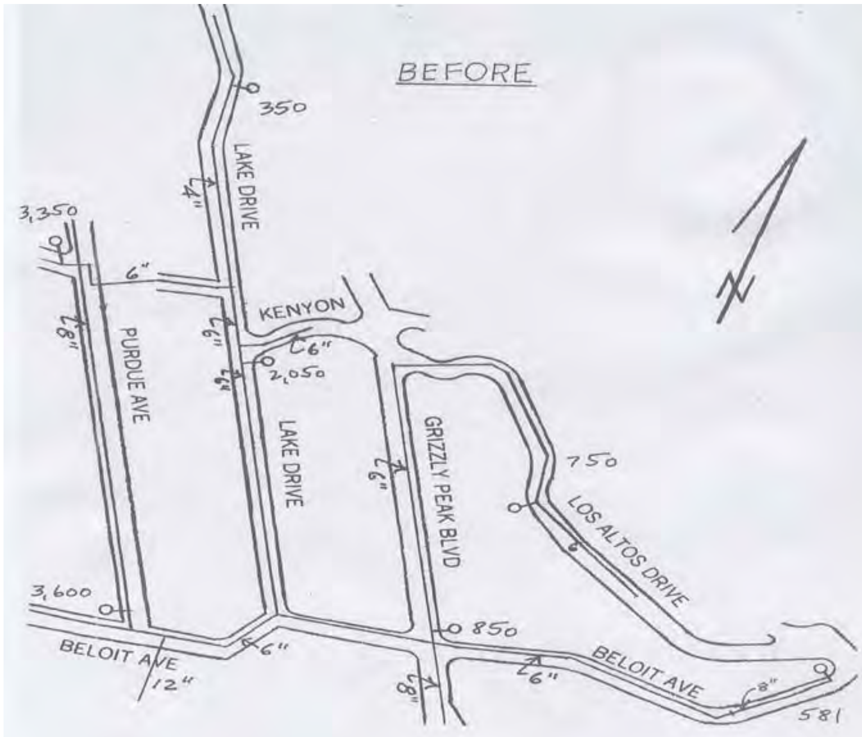

Figure 2. Southern section or interface area: Before

The model was completed on schedule, and EBMUD offered to conduct a study of Kensington's water distribution system and provide a report for $19,000. The KFPD Board agreed to commission such a study, and a contract to that effect was signed in July of 1998.

Establishing Criteria

The time had come to determine the appropriate criteria to use in the study. At this point I remembered my days as a bureaucrat dealing with ignorant political bosses and determined not to be one of the latter. I attended a fire department staff meeting and tossed out two questions: How would you fight the fire, and how much water would you want to have available?

It was decided that the Department's three engines would be able to reach the ridge in time to do some good, but that it was unlikely that any mutual aid would be able to arrive in time. Therefore, three engines, each pumping at rated capacity of 1,500 gallons per minute (gpm), would mean that up to 4,500 gpm could be put to effective use. Mutual aid engines would be directed to attack the fire from the side in order to pinch the fire and narrow the fire front that the engines on the ridge would have to face. EBMUD should therefore use its computer model to determine the improvements necessary to guarantee a total flow of 4,500 gpm for a minimum of 20 minutes from any three adjacent fire hydrants along the interface with the park. If the fire could not be contained within 20 minutes, there would be no chance of holding the line at the interface.

It was also decided that in the rest of Kensington, away from the wildland interface, a total of 1,500 gpm should be available from any two adjacent hydrants.

In December 1998, EBMUD provided a report with that information, and the cost estimate was over $5 million (EBMUD 1998).

PROGRAM DESIGN AND IMPLEMENTATION

FIRE FLOWS

A $5 million program was not politically viable, but careful analysis of the EBMUD report revealed that an investment of a little more than one million dollars could provide the desired fire flow, or something reasonably close to it, although some of the improvements would not be part of the EBMUD system. An evaluation of projected revenues and expenditures of KFPD indicated that this work could be funded over a five-year period. Figure 3 shows the proposed work for the fist phase (construction completed July 2001), the original fire flows (in black), the anticipated fire flows (in green, after the /), and the actual post-construction flows (also in green, circled).

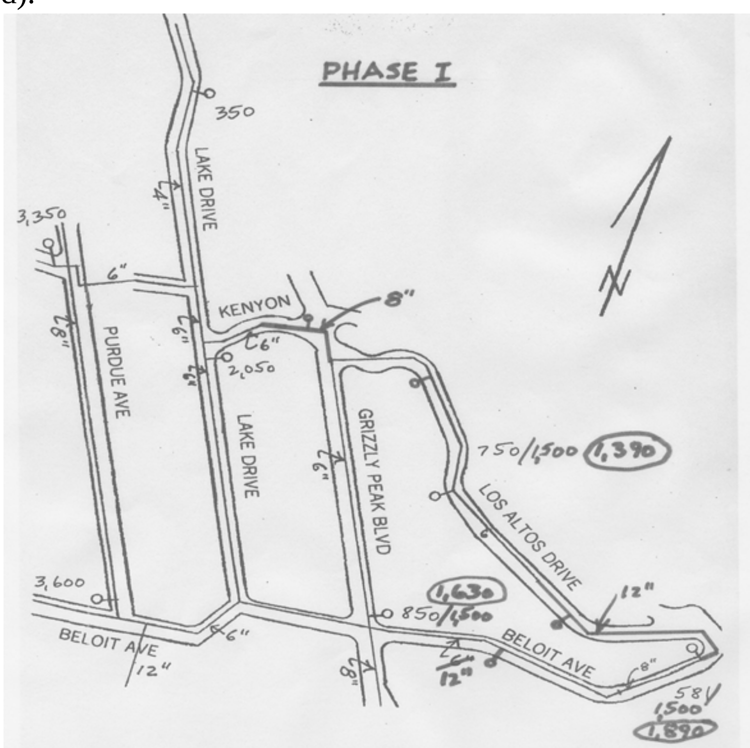

Figure 3. Southern section of interface area: Phase I

Figure 4 shows the proposed work for the second phase (construction in progress) and the original fire flows (in black) and anticipated fire flows (in red, after the /). Figure 5 shows the proposed work for the third phase and the original flows (in black) and newly anticipated flows (in blue, after the /). Once the third phase is completed, it will be possible to further increase fire flows in the entire area shown, without further capital cost, by activating a pumping station that feeds the 12-inch main coming in from the south and connecting to the main in Beloit Avenue opposite Purdue Avenue. Currently, those pumps operate only at night and are of no fire fighting utility, because the 6-inch main in Beloit cannot accommodate any additional flow. The fourth phase will be similar to the second one, but on a street further north.

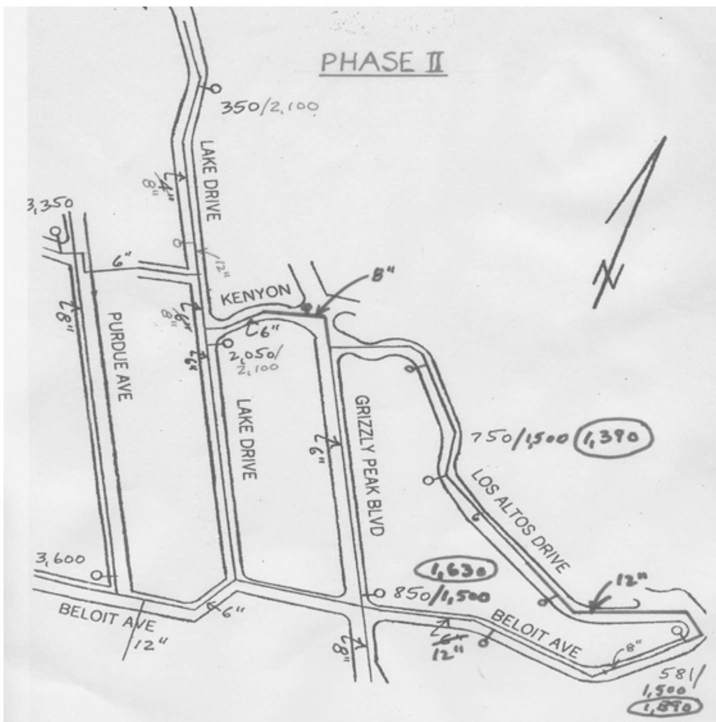

Figure 4. Southern section of interface area: Phase II

At the northern end of the interface (figure 6), the cost of new piping to meet the 4,500 gpm standard was not considered economically feasible, so an independent underground cistern with 75,000 gallons of water was proposed to make up for the EBMUD deficit (figures 7 & 8). It is anticipated that 60,000 gallons could actually be drawn out during a fire, so that the 1,500 gpm available from the existing hydrant would be supplemented by 3,000 gpm pumped out of the cistern for 20 minutes. Such a an underground cistern for fire protection is not Twenty-first Century technology; San Francisco has about two hundred of them, some dating back to the 1850s. Figure 8 is taken from the San Francisco Fire Department's Manual of Water Supplies.

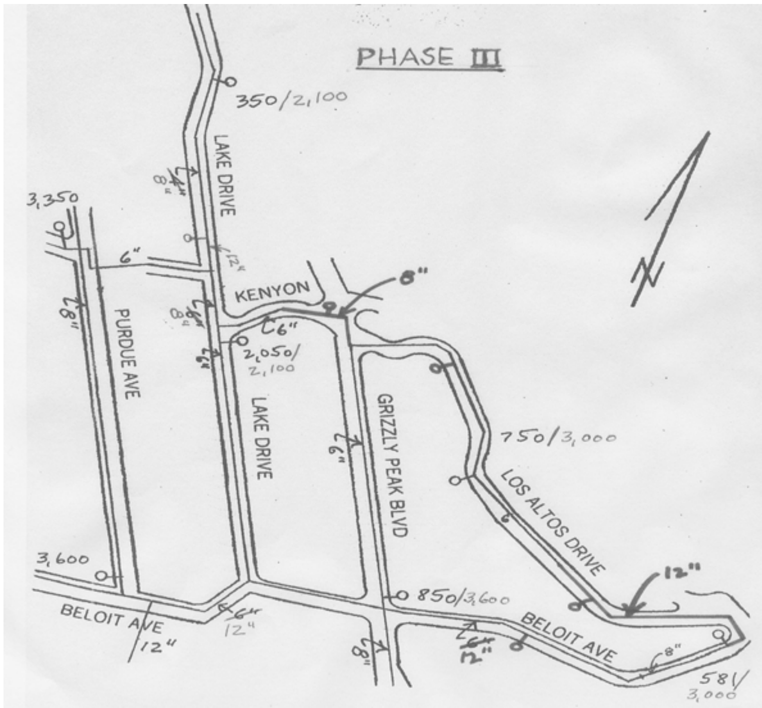

Figure 5. Southern section of interface area: Phase III

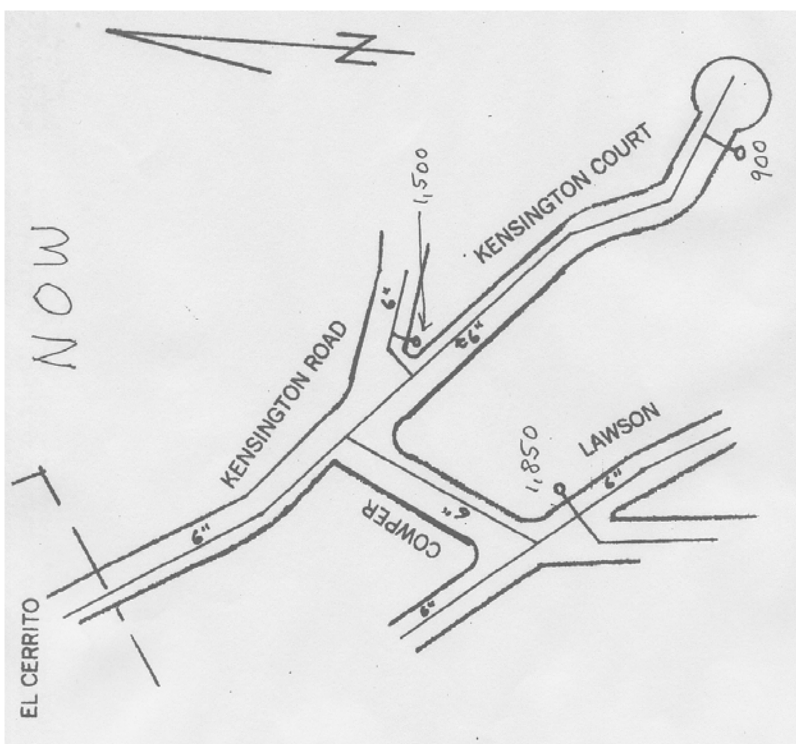

Figure 6. Northern end of interface area: Now

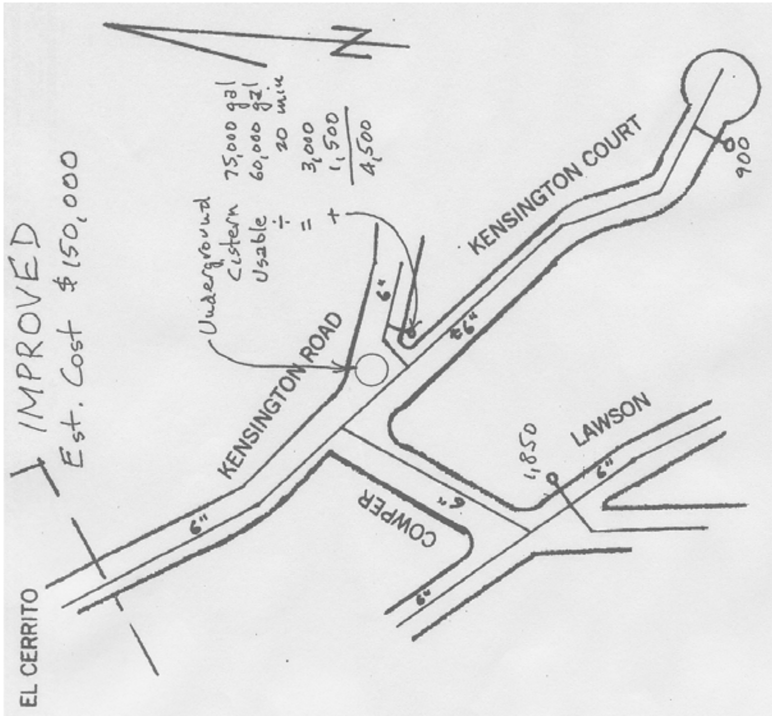

Figure 7. Northern end of interface area: Improved

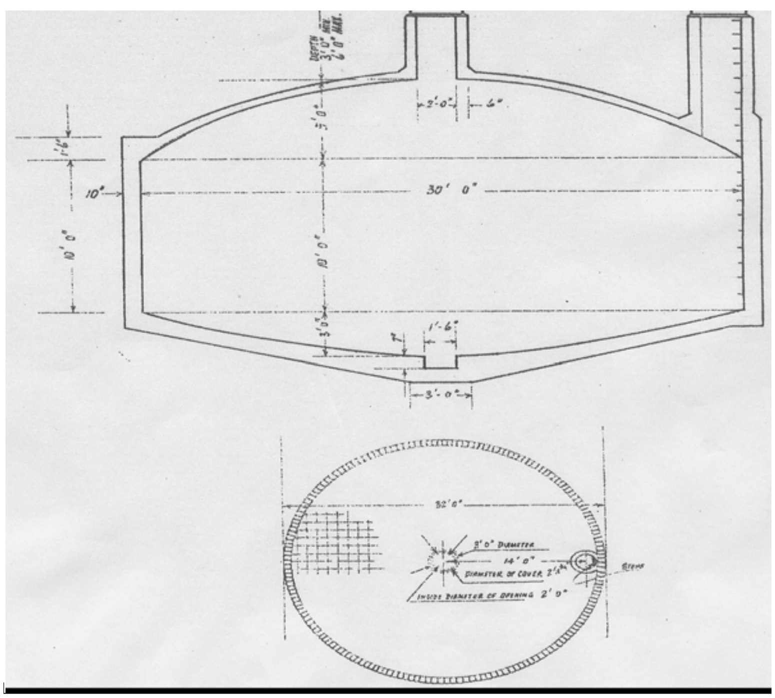

Figure 8. 75,000 Gallon underground cistern

POLITICS

With the engineering and financing problems were solved; the political problems loomed ahead. The entire community had to be convinced that all of Kensington would benefit from the program, and that took another year. It is one thing to get public support for schools and parks, something that everyone can see; it's something else again to line up taxpayers behind something buried in the ground. For that matter, many people could become avid supporters of new fire hydrants without ever questioning whether any water would come out of those hydrants.

I started out, early in 2000, by giving two workshops, one on the basics of fire and fire protection, and the second on the specific proposed improvements and their anticipated effects. Unfortunately, the first workshop did not arouse much curiosity in the audience, However, they certainly came alive during the second one.

Residents not living near the interface asked why their tax money should not be spread over all of Kensington. Others wanted to know what other jurisdictions were doing and why Kensington should invest in greater fire flows than neighboring communities. They also wanted to know how much EBMUD was going to chip in towards the cost, since we were going to be replacing some of their partly depreciated pipe with new pipe. More about that later. After the workshops and additional discussions at Board meetings, several members of the community submitted extensive lists of written questions, most of which I answered, but a few related to how a fire would be fought, and on those I made it a point to defer to the Chief.

Since my fellow KFPD directors were reluctant to commit to the first year's expenditures without assuring our constituents that all their concerns would be addressed, we prepared a Water System Improvement Master Plan to give the citizens a broader picture. This Master Plan, which resulted in another six-month delay, also provided for a sprinkling of additional fire hydrants in other parts of Kensington. After that, Kensington was united behind the program, although there was a continuing demand that EBMUD should participate in the cost of the program.

WHO PAYS?

From the very first time that the question was raised, EBMUD staff advised us that EBMUD would pay the cost for upgrading water mains to meet the fire flow standards in existence when those mains were first installed. That sounded reasonable, even generous. Unfortunately, this offer was followed by a statement to the effect that the original standard was 500 gpm. When that statement was repeated at a meeting of the Planning Committee of EBMUD's Board of Directors (EBMUD 1994), I asked for the source of that supposed standard. I stated my experience to be that the only standard at the time, set by the National Board of Fire Underwriters (NBFU), was considerably higher. Within a month of that meeting, I sent a letter (Bendix 2000) to EBMUD with documentation of my statement (Babbitt and Doland 1931, Insurance Services Office 1974) and an offer to discuss the subject. There was never a written reply to my letter, and their oral comments on the subject amounted to "don't confuse us with facts." As it happened, the City of Orinda had been going through a parallel process to

Kensington's, and they came up with additional documentation refuting EBMUD's 500 gpm (NBFU 1934). As it happened, Orinda was facing a considerably larger bill for upgrading their fire flow capabilities and they, unlike Kensington, were not in a position to raise the funds from current revenues over a relative short period of time.

Having reported our dispute about the past fire flow standards, I must now agree that it would not be feasible for EBMUD to pay for upgrading its water network system-wide to meet the real original standard. Like KFPD, EBMUD is a political entity, and its board of directors is elected by the rate payers. If EBMUD were to agree to pay for upgrading its mains throughout the system to the past fire flow standards, this would result in a politically unacceptable increase in water rates.

When it came time to negotiate a contract with EBMUD for the first construction phase, KFPD decided to insert a vague clause providing for future determination of any EBMUD financial contribution to the project. We decided that the most important thing was to go ahead with the project. I believe that our failure to adhere to a united front versus EBMUD was not appreciated in Orinda.

FROM PLANS TO GROUNDBREAKING

The construction contract with EBMUD for the first year's work was signed in 2000, for the second year's work in 2001. Construction of the first phase was started in May and completed in July of 2001. Construction of the second phase was started in September of 2001.

CONCLUSION

Community fire protection, in contrast to protection of individual premises, is a very complex enterprise. Besides diligent engineering analysis, planning and design, it requires education and involvement of the lay community, the tax payers who make the work possible. Kensington, California, will be at considerably reduced risk from wildfire because all of the above requirements were recognized and met.

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INTERVENING IN THE CATASTROPHIC RISK AND TRAUMA CYCLE

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INTRODUCTION

The themes of risk and trauma have become critical in large scale environmental and social catastrophes. Most of our modern urban systems are designed to function within a limited set of apparently normal conditions. Populations have become more concentrated and more dependent on management by experts and electronic mechanical systems. Because of an increasingly concentrated population which is decreasingly self-reliant, events outside the system design thresholds are more likely to be catastrophic. Are there ways to build reliable risk reduction and resiliency back into populated areas?

Catastrophe creates trauma, trauma creates stress, and stress creates denial. Denial narrows options and, in turn, increases risk of repeated catastrophe. This paper addresses some efforts my colleagues and I have undertaken to intervene in this cycle in order to encourage resilient responses to disaster. The East Bay Fire and Watershed Convention, has borrowed lessons from education and developmental psychology to apply to some of the social aftermath of the 1991 Oakland Firestorm. The convention was funded by the California Department of Forestry.

We are working with a simple formula of assumptions. The general goal is to reduce traumatic disasters in the Urban Wildland Interface. It is to increase resilient, sustained, self-regulating pre-fire mitigation activities undertaken by a broad representation of stakeholders; in particular towards reducing vegetation and building fuel loads. The method we are testing is to avoid re-stimulating traumatic memories, but to encourage appealing activities that also have the desired hazard reduction outcomes.

Recent understandings in the role of trauma in causing repetitive destructive behaviors may help in designing interventions in breaking the wildfire cycle.

TRAUMA AS A CAUSE OF REPEATED RISK BEHAVIOR.

The American Psychiatric Association's Diagnostic and Statistical Manual defines traumatic events as those that cause intense fear, terror, and helplessness in almost anyone. It suggests that post trauma stress symptoms typically include avoidance of stimuli associated with the event, detachment, loss of interest, difficulty in concentrating, increased aggressiveness or irritability, or in some people the opposite which is reluctance to express angry feelings. A foreshortened sense of the future is also associated with trauma. These symptoms increase when a person is exposed to stimuli or events that resemble or symbolize the original traumatic event. Adults may experience intrusive recollections and flashbacks. Children will repeat the event in their play. The psychiatrist Alice Miller also observed a compulsion in adults to repeat traumatic experiences from their childhood (Miller, 1990).

Brain research reported by Patricia Van Horn corroborates Miller's behavioral observations. Using brain scanning techniques and hormone measurements in blood chemistry, researchers have identified stress physiology and brain pathways that develop under fear conditions. In children and in adults who have been strongly traumatized as children, even a benign stimulus will bypass the sensory cortex where it would normally be evaluated. It will go directly to the "flight or fight" response, releasing fear and stress hormones. As a result an individual does not know where to turn for calmness (Van Horn, 2000).

Brain research shows that infants and young children who grow up with an empathic and available caregiver are resilient under stress and can better regulate their behavior. In contrast, if an individual experiences strong enough trauma, the resulting fright and aggressive patterns can stay in place throughout adulthood unless there is a stable, caring intervention (Psychiatric Grand Rounds).

Can these observations be applied to intervene in the cycle of allowing unnecessary risk and the resulting disaster in wildfire management?

THE PROBLEM OF VEGETATION MANAGEMENT IN THE EAST BAY HILLS

While our East Bay emergency management and response services have made significant improvements since the 1991 firestorm, vegetation management has not been as uniformly successful. A decade later, numerous areas have similar or worse fuel loads both on the structural and wildland sides of the interface.

The East Bay has a wealth of resources at its disposal. We have numerous Colleges a, major research University and a high income population. These resources may be part of the problem. We have multiple stakeholder groups each with enough resources to influence overall activities. This may have allowed even a mild background of controversy to slow vegetation management activities. In addition, and perhaps equally important, the psychology of trauma and stress may help explain some of the sluggish activity in vegetation management in the East Bay Hills.

Post traumatic stress symptoms are avoidance of stimuli associated with the event, loss of interest, difficulty in concentrating, increased irritability, and a foreshortened sense of the future. The suite of post traumatic stress feelings like avoidance, loss of interest and foreshortened sense of the future is not likely to lead to focused activities. It may be one cause of the seemingly mysterious inaction in an area which should have the resources to dramatically reduce its vulnerability to catastrophic wildfire.

In 1997 my Urban Ecology class at the Merritt College Environmental Sciences Department studied the fire management issue. We invited a number of stakeholders to present their point of view one at a time. The problem of the lack of funding for fire fuels management and consequent low level of activity revealed itself. It appeared to us that the primary stakeholders were the homeowners, the land managers, the fire agencies, the environmental organizations, and the environmental scientists. There had been a vegetation management plan primarily developed by two of the five stakeholder groups. Funding for it depended on the agreement of the other three. These, the homeowners, the environmental organizations, and the scientists were also the groups least involved in the plan and eventually did not support funding for it.

It also appeared to us that the similarities and common goals of each group were more striking than their differences. However, the differences were emphasized by the various groups; making coordinated action seem improbable.

The general tone of some of the agencies and perhaps many of the homeowners has been to disengage from one another and let the experts take care of fuels mitigation. These responses are consistent with post traumatic stress. One result has been that individuals have little knowledge or basis for judgment of proposed special tax districts or other legislation. Other funding sources which require partnerships and working relationships appear to diminish even in the face of plenty. The unintended consequence is that the area is at increased risk.

POSSIBLE SOLUTIONS

The solutions may lie in a mix of technical and social activities.

Technical advances have been hopeful. Methods to mimic the natural wildland fire regime have been developed to both reduce fuel load and improve habitat. Gardeners and landscapers have developed fire resistant landscaping, architects, building materials suppliers, engineers, and scientists know how to improve building performance. Fire fighters and responders have coordinated and improved their capabilities.

Societal factors have only been included in disaster planning relatively recently. The field has grown from "civil defense" organized by the military of a half century ago to a broader emergency response base. (Natural Hazards Observer, Sep. '01, p.2) Recent research findings show the importance of including population diversity and equity in making disaster plans. It has also shown that disasters are more likely where unsustainable development occurs. After disaster there is a pressure to re-build and live at risk with the previous level of vulnerability. This reaction may be attributable to the post traumatic stress reaction to avoid re-visiting the details of the original disaster. Direct restatement of the dangers by disaster planning personnel may actually increase the resistance of residents to respond favorably because the post traumatic reactions are brought up.

Both research reports and our own observations suggest combining disaster recovery interventions with other programs not meant for disaster recovery, but which have similar objectives. (Natural Hazards, July '01, p.10) Further, both our observations and research reports propose involving a full range of stakeholders in defining the quality of life that they wish and believe they can achieve; and to encourage partnerships with government, business, individuals, and non-profit organizations. Long term planning horizons are likely to be more successful if they are consistent with other planning efforts, have multiple objectives, and a vision shared with all types of residents and agency personnel.

The urban wildland interface here in the East Bay is also the headwaters of each of our creek watersheds. The creeks run through every neighborhood before they enter the Bay. Creek restoration has been successful at involving a diverse group of residents, agencies, professionals, scientists, schools, churches, and numerous volunteer organizations in stewardship of their local landscape. A culture has developed in which no player, agency, individual, or organization tends to dominate, but decisions are made through consensus building participatory efforts.

Outdoor environmental education has also proved to be an asset for building more knowledgeable relationships with the landscape. For example, researchers brought fire science into K-12 classrooms and measured student responses. In the school science lab, they had teachers model combustion and fire spread on flat and sloped land timing ignition speed of matches set head up on a board. They then went into the forest for field observation. They found students lost some irrational fears of fire (Smith, 1999).

The researchers also found that their young students rated the same science teacher as more attentive and effective in the-hands on and outdoor environmental science class than the control class did when the same teacher used the standard indoor science curriculum.

They also found that the children's parents would engage in discussions of the implications of wildfires when the parents had been reluctant to participate in adult community meetings for that purpose. (Smith, 1999)

Our observations are that subject matter considered in outdoor, or on site settings have lead to more subsequent related activities on the part of the participants than when similar subjects are addressed in a more formal lecture or meeting format.

CONCLUSION

These findings suggest to us that using what the Natural Hazard Observer has named quality of life activities in a post disaster area like the East Bay Hills might be an appropriate intervention towards breaking the cycle of wildfires.

The 1991 Firestorm traumatized our residents. Direct confrontation either with fire risk descriptions or compliance officers probably re-stimulates post traumatic stress feelings and diminishes the long range effectiveness of the residents' activities. The periodic direct mailings or media campaigns that Fire Departments have the resources for cannot develop lasting personal interactions with the residents of their districts.

Our project is in its second year of an experiment with a partnership which includes a community college as an ongoing delivery system for discussing and learning vegetation management in the East Bay urban wildlands interface. We are relying on outdoor environmental education, watershed, recreational, and aesthetic values to achieve overlapping goals to those set forth directly as fuel load reduction. We are making an effort to include as broad a range of stakeholders in the activities as possible. We will end our effort with the East Bay Fire and Watershed Convention; the goal of which is to provide a venue for multiple value and multiple stakeholder discussion. The question we will pose is; Do the participants wish to explore collaborative ways of using each other's resources to solve common problems, and, if so, what is a next step?

The ecosystems in the East Bay Hills are complex. They vary markedly in relatively small increments as aspect, elevation, and other factors change. We have one meadow which has the greatest variety of California Native grasses identified in one place. Not far from there is the remnant sucker grove of what probably was the largest Redwood and thus the largest organism on the surface face of the earth. Carefully managing and monitoring these microhabitats as they deserve would be an impossible task for any single agency; especially one responsible for fire control. Indeed, detailed information on actual fire behavior in different plant communities under various conditions and the same for building types needs further research as do societal attitudes. Fortunately we have the research capacity in the area and there also seems to be funding.

With some notable exceptions, fire zone homeowners have been the least involved in planning efforts to date. A preliminary finding shows that homeowners may need access to attractive and practical pre-developed fuel management package deals which they can buy into since most will not have the time or interest to become expert. To fill the fuel break and environmental monitoring needs, recreation, science, and aesthetics can possibly be harnessed into trained volunteer monitoring activities. Resident participation might have the added desirable benefit of reducing trauma and increasing knowledgeable resiliency where it is needed in the intermix area.

How agencies and citizens partner to reduce the frequency and effects of trauma may be and important disaster planning tool. By combining a number of innovative interventions that bypass fear, but rely on good will and discussion of planning decisions may help to increase cooperative activities that reduce fire and other risk factors. These hypotheses will be tested in the March 2002 East Bay Hills Fire and Watershed Convention.

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THE INTEGRATION OF FIREWISE PLANNING WITH FIRESAFE COMMUNITIES

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Despite public safety codes, increased awareness of fire hazard areas, and community Firesafe councils, no community is safe from wildfire. Firesafe Councils have effectively generated awareness of fire protection needs and fostered numerous fuel management activities for wildland/urban interface communities throughout California. This is an effective process for existing communities where environmental constraints and land management objectives are not in conflict. FIREWISE planning addresses these conflicts with a proactive approach to land use and watershed planning near wildland/urban communities.

During extreme weather events fire protection resources are easily overwhelmed, jeopardizing the protection of life, property and resources. The maximization fire protection for all values requires a more comprehensive approach that integrates fire management expertise throughout the planning process. By being wise about our community design and use of prescribed fire in the United States, we can reduce the staggering impact and costs of severe wildland fire.

Everyone on the planet has a relationship with fire, and so we all have a responsibility to it. The Firewise Communities Project reminds us of that responsibility. It presents the Earth as a fire planet and it describes the status quo of overgrown, fire-prone wildlands and an unprepared, burgeoning populace. Finally, it presents solutions and options for adopting a Firewise style of living.

The VISION OF FIREWISE COMMUNITIES is homes designed, built, and maintained to withstand a wildfire without the intervention of the local fire department.

Firewise Communities is a mitigation planning program, encouraging communities to include land use planning, building codes, landscaping codes, zoning, and fire protection into the development of new communities and the retrofit of existing communities.

WILDLAND FIRE FACTS

Since 1970, more than 15,200 American families have lost their homes to severe wildland fire. The NFPA® International, the Insurance Services Office and several other National organizations reports another 21,000 structures and facilities have been lost in that same time, all totaled costing our government agencies (local, state and federal) some $25 billion to suppress and the insurance industry another $10 billion in restitution. More than 620 wildland firefighters have been killed on duty since 1910.

NATIONAL FIREWISE COMMUNITIES WORKSHOPS

In 1999, the National Interface Fire Program launched a new project: the Firewise Communities Workshop Series. Workshops will be hosted in over two-dozen US communities over a three-year period. The three-day workshops feature dynamic presentations and state-of-the art GIS mapping and wildfire simulations. More than 3,000 community leaders and professionals will be asked to participate in the series, 100 per workshop. The goal is to introduce community leaders to Firewise concepts and workshop exercises which allow them to struggle through the professional complexities involved in building communities (and citizenries) prepared for the inevitable effects of unwanted wildland fire.

Workshop Coordinators have identified the following individuals as desired participants in the Firewise Communities Workshop series:

Wildland Fire Managers/Fire Fighters, Structural Chiefs/Fire Fighters, City/County Planners, City County Officials, Architects/ Landscape Architects, Emergency Managers, American Red Cross Workers, FEMA Project Impact, Rural Utilities Representatives, Congressional Representatives (CFSI), Real Estate Professionals, Mortgage Bankers, Home Builders/Developers, Insurance Agents (IBHS/ISO), Private Foresters, Conservationists/Environmentalists and Firewise Communities Recognition Program,

Knowing there are thousands of communities at risk from wildfire all across the country, the organizers of the Firewise Communities Project have initiated a new activity: working with at-risk communities to showcase their Firewise work.

EARTH, WIND, AND FIRE REVISITED

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Preface: This paper and presentation are the views of Erich Linse, as an individual meteorologist, and do not represent in any way the views or policy of the Air Resources Board.

This paper examines atmospheric causes of the long dry summers in California. The summer monsoon and attendant lightning storms are a source of ignition of dry fuel. A brief review of climate change offers no relief from the yearly fire challenge for California. The conclusion of the paper is a series of the author's personal suggestions for improving our ability to respond to fire.

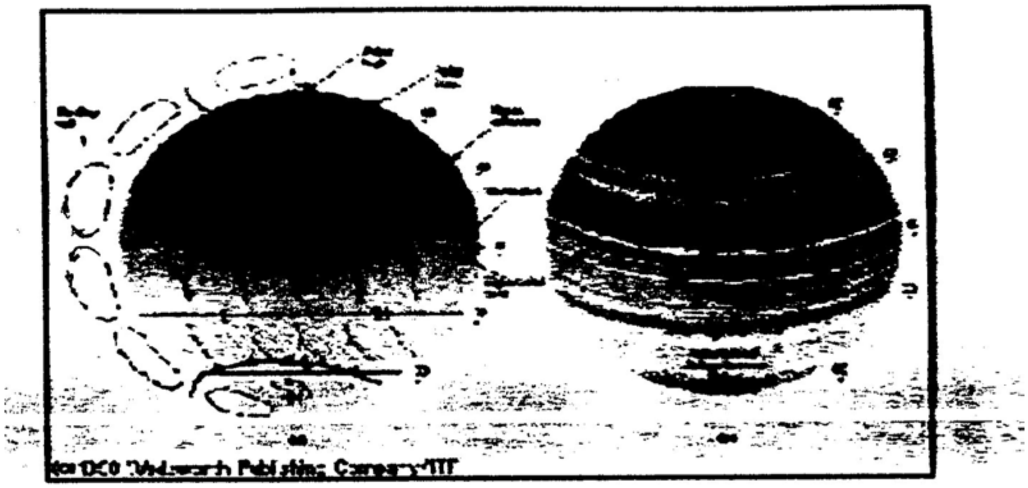
Earth is a planet and planet system, with oceans, terrain, and atmosphere. Fire is a rapid, persistent chemical reaction that releases heat and light; especially, the exothermic combination of a combustible substance with oxygen (The American Heritage Dictionary, 1981). Wind is simply the movement of air, generally in the horizontal direction.

The frequency of fires in California is a result of the planet system. One significant part of this system is dramatic topography and its control on microclimate, vegetation and wind. Another resolving part of the planet system is climate. The latitude and the potentially hot summer continental interior and close proximity to the cool Pacific Ocean have important roles in the climate system.

The goal of this paper is to describe the relationships of earth and wind that repeatedly create fire problems in California. The potential impacts of climate change on fire threats are briefly reviewed. A few personal ideas on how to use resources and change the way we use information to help save lives are also included.

As most are aware, the fire season in California is the result of wet winters and dry summers. In much of the state this is a Mediterranean Climate. Latitude and atmospheric circulation patterns are responsible for this particular climate. The latitude and tilt of the earth's axis are basic controls of solar radiation and heat reaching the surface of the earth. However, there is less awareness of a powerful part of the atmospheric circulation called the Hadley Cell. It has a great effect on the climate of California.

Figure 1 is an illustration of the Hadley Cell. Air rises above the thermal equator. Vertical motion is present since warm air is less dense than cold air and hot, moist air is less dense than warm air. Once the air rises a few thousand feet, clouds form over the ocean and moist land areas. There is often a very noticeable west to east line of clouds above this thermal



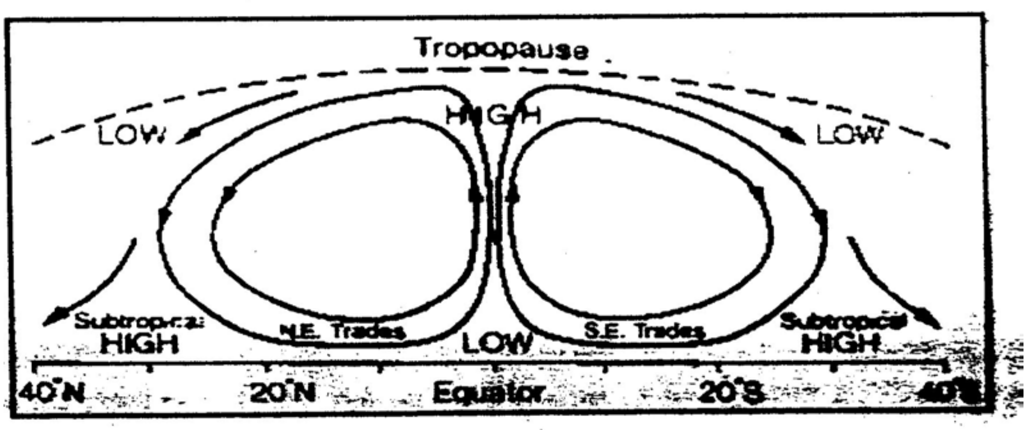


Figure 1. Illustration of the Hadley Cell

equator. As the clouds build, air rushes beneath the line of clouds from north and south. As moisture in the clouds condenses, the latent heat of condensation is released and the air becomes more buoyant. This latent energy continues to drive the Hadley Cell. The clouds may top out at 60,000 or 70,000 feet, but eventually the relatively warm and often subsiding air within the stratosphere caps the lift. The air is forced to move north or south, away from the equator. It travels to about 30°N and 30°S, where it descends, dries, and warms by compression. These latitudes are the common location of the world's deserts, and are often seen as a clear band on satellite images of water vapor. The dry, downward limb of the Hadley Cell leaves a signature on the continents, which is visible from space. The line of clouds approximately over the equator is also visible from space and has become known as the intertropical convergence zone (ITCZ). An image from a satellite showing the ITC over the eastern Pacific is figure 2.

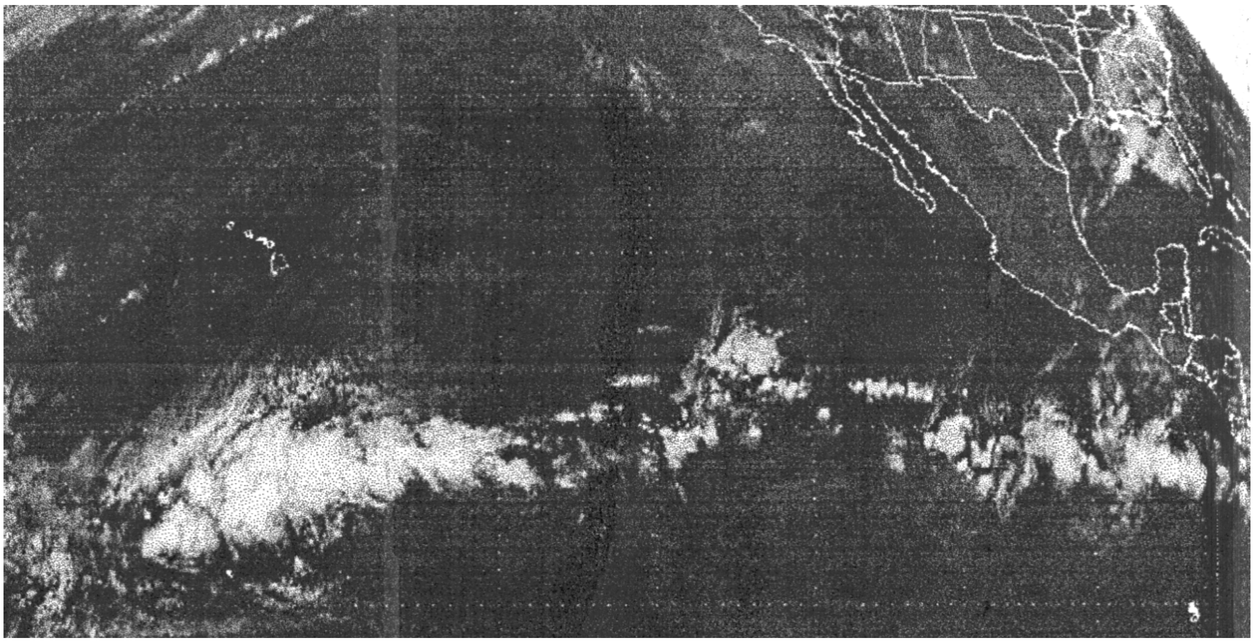


Figure 2. Satellite image showing the ITC over the eastern Pacific

During summer in the Northern Hemisphere, the thermal equator moves 15° to 20° north. The maximum subsidence moves north as well. This summer subsidence of the Hadley Cell over California is the hallmark of our golden summer. Unfortunately, the resulting temperature inversion gives rise to our pollution problems as well. The horizontal transport of air is also important to daily weather and climate, but generally, when those approaching weather fronts from the northwest dry out, the Hadley Cell has won again. The usual mid-latitude progression of weather is from west to east. During the summer, a strong wind flow pattern can occur in the Carquinez Strait or through the Altamont Pass. This is caused when hot air in the Central Valley rises and denser, cool air from the Pacific Ocean pushes in below.

When the atmospheric subsidence is quite strong the temperature inversion over Oakland may be at 1000 feet and occasionally less. The cool air pushing inland dramatically diverges as the restrictive coast range barrier is passed. Winds flare to the north and south after they pass through the openings. East of the barrier, the volume of the flow remains fairly constant, however, the horizontal spread is much greater, decreasing the depth of the flow. If the inversion is 1000 feet at Oakland, then it is usually only a few hundred feet at the Walnut Grove towers (located north of Stockton). On such a day, the mixing height for dispersion of smoke near these towers is very shallow. Gusty on-shore winds will blow the smoke across the ground and any tule burns will prompt complaints to the east.

Much of California has relatively wet winters and dry summers which is characteristic of a Mediterranean climate. That classification is appropriate for some of the state, but more careful observers note a much more complex climate mix. Figure 3 (from Westman and Malanson 1990 and found in the book, Global Climate Change in California, Knox and Scheuring, 1991) shows the relationship of vegetation types to average temperatures and precipitation. As noted in that figure, most forests are located where mean temperatures of the

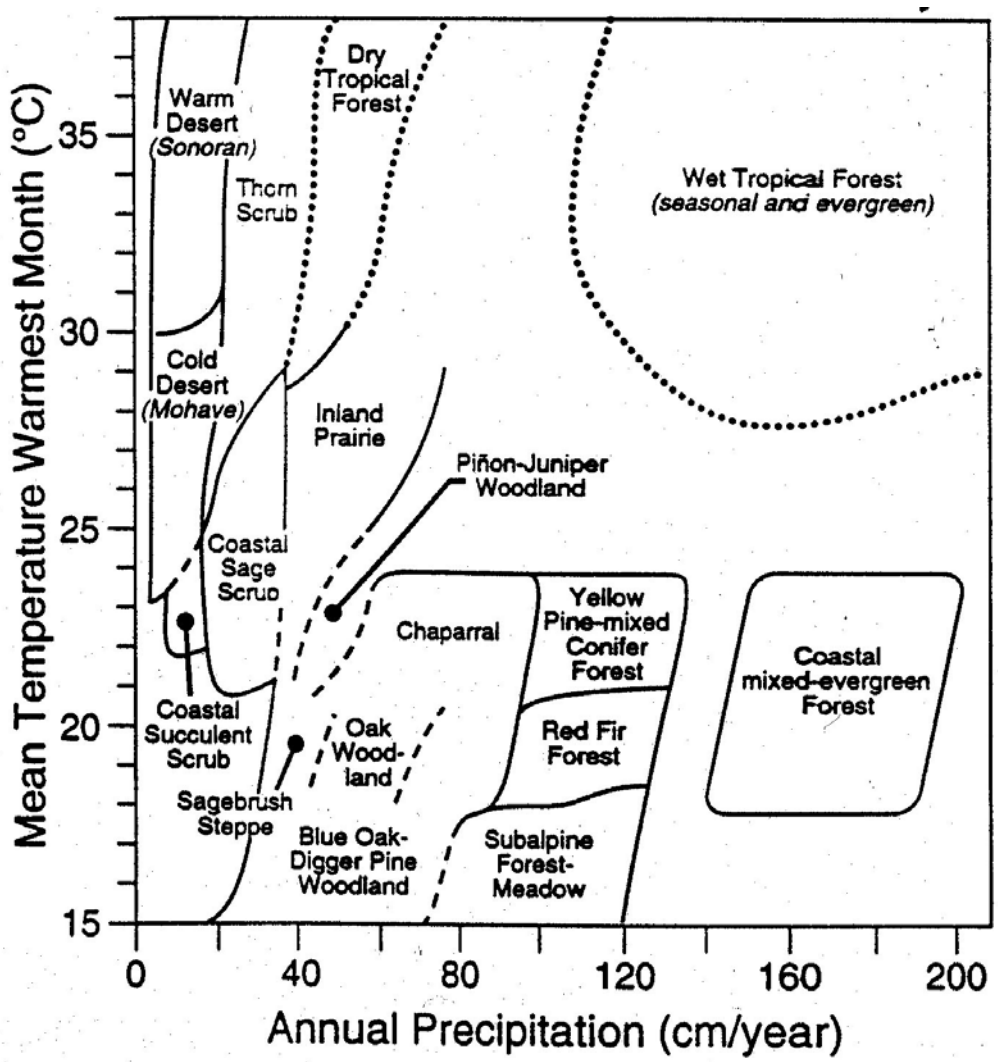


Figure 3. Classification of California vegetation types according to temperature and precipitation.

warmest month are between the mid-sixties and the mid- seventies. Annual precipitation ranges from about 35 to about 60 inches for most interior forests. Precipitation in the coastal mixed forest is much greater and the oak woodlands are drier.

A summary of California's climate from the California State Chamber of Commerce (1974) has climate data for 19 representative locations in the state. Soda Springs (elevation 6750 feet) is the only location that does not have at least one summer month with precipitation of less than 0.1 inch. Most stations show two dry summer months. The average precipitation for July and August in Soda Springs is 0.2 inches. That summer precipitation at Soda Springs is largely the result of the lightning producing summer monsoon.

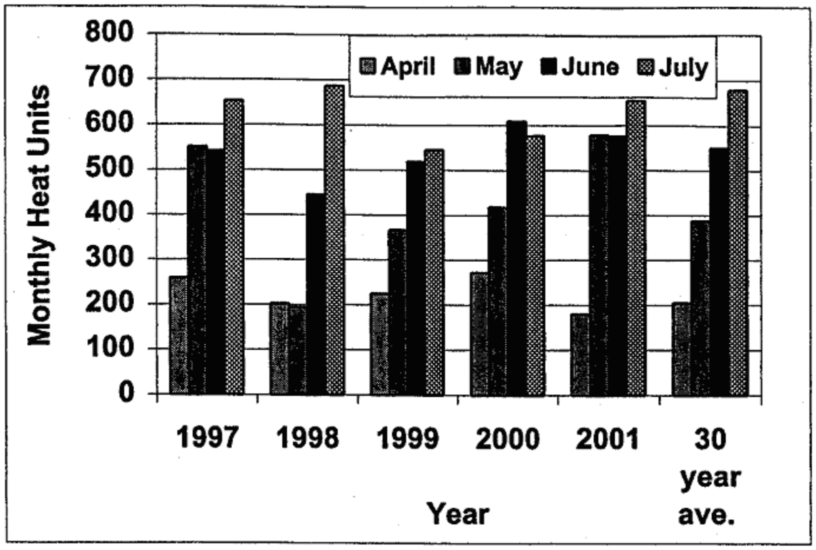
Summers in California are dry, however, summer thunderstorms often occur when a moisture layer (typically from 10,000 to 18,000 feet) is moved over the state by southeast winds. This set-up typically begins in early July when the "Four Corners high" (ridge of high pressure) becomes established. If the cloud bases of cumulonimbus clouds are high, there is opportunity for considerable evaporative cooling and the possible down rush of chilled air with significant wind gusts. When the winds from 10,000 feet to 18,000 feet are from the southwest the moisture layer is usually thin and there is too much subsidence for precipitation and thunderstorms seldom develop. The deep moist layer generally swings around the four-corners high pressure center from the Gulf of Mexico or moves northwest from the East Pacific or the Sea of Cortez.

At times, considerable moisture remains in the remnants of a tropical storm or a down-graded hurricane that has lost significant winds before reaching California. The passage of such remnants over the state usually guarantees "interesting" weather. The monsoon is not a steady state condition for California. It may pulse on and off through July, August, and September and the associated lightning causes many wildfires.

In many parts of the country two consecutive summer weeks without rain can raise an eye brow, three weeks without rain causes a rise in church attendance in farming areas, and a dry month is several states is critical. In California, two or three dry months are common for most regions every summer. It is no wonder we have a fire season! The dry summer climate causes fire-adapted and fire-dependant ecological communities in much of California.

Various efforts have been made to predict the severity of fire season because so many resources are needed for protection. Jack Williams, a University of California Extension scientist, has a monthly heat index used by the rice industry that flags an early fire season for the northern part of the state. Figure 4 shows totals for monthly heat unit accumulations above a 55 degrees Fahrenheit lower threshold.

MONTHLY HEAT UNIT ACCUMULATIONS FOR COLUSA, APRIL - JULY; 55°F LOWER THRESHOLD, NO UPPER THRESHOLD.



OVERNIGHT LOW TEMPERATURES IN JULY 2001 AT SACRAMENTO VALLEY STATIONS

	July date in 2001											
Location	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*	*21*	*22*	*23*
Arbuckle	53	57	59	54	55	52	57	58	55	54	56	58
Artois	51	56	60	55	56	53	57	58	55	54	55	58
Biggs	56	61	62	56	57	55	60	59	56	56	59	62
Durham	54	57	59	56	57	53	56	59	56	56	55	58
Kirkville	50	52	56	51	55	48	55	57	55	52	54	57
Lincoln	57	57	60	55	57	55	58	60	57	56	54	59
Maxwell	54	58	59	56	55	53	59	58	55	55	58	61
Natomas	56	57	58	55	57	55	59	58	57	56	56	59
N. Yuba	56	58	59	55	56	54	58	58	55	54	57	60
Buttes	59	69	65	52	47	56	64	57	58	53	65	70
Wheatland	56	55	58	54	57	53	57	60	56	56	53	58
Woodland	50	53	54	50	53	49	54	54	53	52	53	56

Figure 4. Early Fire Season Signature? Very warm nights, April & May.

In a recent book, The Little Ice Age: How Climate Made History, Brian Fagan views the little ice age as a caution for us. Climate instability during the period 1300-1850 may have been more problematic than the cooling although that was certainly a disaster for many. He also accepts more than greenhouse warming as a cause of global warming although he writes that humanly generated greenhouse gasses are "almost certainly the major agents." He gives examples of important volcanic eruptions. After big eruptions, layers of tiny particles shade the earth for months. He also notes that "present levels of solar irradiance are higher than periods of unusually low sunspot activity during the Sporer (1425-1575), Maunder (1645-1715), and Dalton Minima (1790-1820)." From other published sources, Professor Fagan concludes that changes in solar radiation account for less than half of 20th century global warming.

What do scientists suggest global warming will mean for individuals concerned about fire in California? First, the U.C. book edited by Knox and Scheuring notes, "the prospects of global warming and the consequences of such warming for California's water resources are highly uncertain." Global warming raises the prospects of significant changes in the timing and the magnitude of precipitation and run off. Also described are the possible effects on water resources, forests, and ecosystems. An increase in global warming would lead to a higher snow line, less run off, and a quicker run off process. Ultimately, more dead fuel and more intense fires may occur, especially for significant ecosystems.

From a meteorologists point of view, a warmer global climate suggests that summer monsoon could start earlier, last longer, and bring more lightning storms per year. By emphatically making available critical weather information to those most in need of it we can save lives. The following personal comments are a most sincere effort toward problem solving and life saving.

CONCLUSIONS

This paper examined atmospheric causes of the long dry summers in California. In turn, these droughts that last several months or more cause dangerous conditions known as "fire danger." In the natural system, lightning associated with the monsoon and summer thunderstorms provides ignition. With people involved, we have matches, sparks, cigarettes and other sources of fire.

The Oakland Hills firestorm of 1991 was a surprise of location, not of occurrence. We think of the fire as an accident, but it was the fulfillment of the planetary system of topography, dryness and wind. The spark was the accident.

The Friday afternoon before the fire I was working in our forecasting office. I saw the tight pressure gradient foretelling strong offshore winds on the weekend. I showed the chart to an old friend and co-worker and said "we will see fires on television or read about them in the newspaper. "

The weather tools and the fire weather forecasters did a good job. Unfortunately, there was not an adequate system to make sure everyone received the information about the imminent threat of "fire winds". That information needed to be top priority in the minds of all crewmembers taking part in any fire suppression in northern California that weekend.

The information did not reach the people who needed it.

In 1991, if the fire fighters who initially put down the fire by the tunnels had known extremely dry down-slope wind gusts greater than 30 knots would arrive later that night, history could have been different.

In Fire on the Mountain (1999), John N. Maclean points out a similar tragic failure of information flow in the South Canyon Fire early in July of 1994 in Colorado. Warnings included "a high potential for large fire growth." These warnings did not reach the young firefighters on the mountain. Fourteen died when the fire blowup caught them on the steep mountain slope.

All significant fire warnings must reach every fire fighter being placed in harms way.

This can only be assured by an active system. Placing a Red Flag Warning at the top of the fire weather warning is great, but it is passive. You only know about it if you see it. Measures can be taken to improve the system. One of the most effective methods is to require a chain of positive contacts to every likely user for every significant warning. With modern radio, telephones, and vehicles everyone can be contacted.

As an authentication that every person has received the message, each will in his or her own words respond with the "screaming message". Wind is the blast that creates most significant fire dangers. The time, speed, and direction of the winds are the usual "screaming message".

If we as a society and as managers put people in harms way, we surely can provide them with the latest information. Fire crews should know at what time they should receive weather updates. When that time arrives they have every right to demand the new weather forecast and any warnings. Those tools must be made available in a dependable and timely manner.

In Maclean's book he asks why the fire wasn't put out earlier, when it was small. The usual answer is limited resources. Because the number of fires varies so much from year to year, we need a very expandable force of well trained fire fighters.

As part of that force, we need to make the best possible use of local fire fighting volunteers, who are often nearest the scene when fire starts. Their training and equipment should be the best. Considering the recent response to the September 11 attacks, fire fighters should have a status like the National Guard, Army, or Air Force Reserves. Volunteers should have credit cards activated when needed by state or regional command so they can rent vehicles, purchase tools, or airline tickets to travel immediately to where they are needed.

These suggestions do not fault experienced professionals. We just need a trained force that can be greatly expanded and assigned within hours of fire emergencies. The United States is a rich country and can afford to spend money to protect lives and resources. With huge fuel accumulations in much of the western U.S. we need to make a more modern commitment.

We need to put out little fires during the fire season unless they are truly in the rocky, high country where they can't spread. Large fires with huge fire fighter commitments are dangerous and expensive. Some individual fire complexes in California in the last few years have cost $75,000,000. We need to be front-loaded to quickly respond to fires. Catch up is expensive, destructive, wasteful, and dangerous.

More research is needed on fire behavior in California. That cold ocean, hot interior and potentially strong inversion layer are significant. They are also different than conditions than exist in many other parts of the country. Monsoon moisture in the form of thunderstorms may bring a very quick and profound release of energy, especially above a hot fire. With heavy fuels, forest fire temperatures may be very, very hot. Heat released is very significant and the atmosphere may be destabilized. A firestorm with inward drafts of wind similar to a hurricane and with tornado like vortices may occur. The start of such a firestorm is difficult to forecast.

Satellite data are now used to pin point fire locations and early hot spots. Research on plume density, size, and location using satellite data may make it possible to better warn the public of significant particulate concentrations that may affect health. In a similar way computers are showing skill at forecasting movements of dust hundreds of miles from source areas.

At the Air Resources Board, we are testing a 35% reduction (it varies from month to month) in "no burn days" in the spring to allow more prescribed burning in areas that are not likely to cause smoke impacts. We are working closely with fire weather forecasters to avoid unnecessary no-burn decisions.

It is my view that we need to work together to modernize tools for fire weather forecasting and for smoke transport. We need to adapt and adopt tools pioneered in the state of Washington. Examples are refinement and use of the MM5 forecasting model, as well as tools like "Blue Sky" and Blue Sky PC".

As noted above, these views are my own and are not expressions of policy at the California Air Resources Board.

CAUSES AND PERIODICITY OF EAST BAY WILDLAND/URBAN INTERMIX CONFLAGRATIONS

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It is going to happen again. The meteorologic causes of the 20 October 1991 Oakland Hills conflagration appear to have a periodicity of approximately 22 years. Conflagrations have struck the East Bay Hills in 1923, 1945, 1970 and 1991. This ~20 year cycle coincides with the peaks in the sunspot cycle, which may influence our local weather. The magnetic poles of the sun flip every 11 years so that the north pole returns to the top of the sun every 22 years, with calendar dates closely approximating East Bay conflagrations. This suggests that the 1991 conflagration will be repeated in ~2013. Will we be prepared?

As each cycle has occurred, the increased urban development in the hills has produced more serious conflagrations. Historical meteorological studies by Monteverdi are described. The role of the Eucalyptus foliage killed in the severe freeze of December 1990 on the October 1991 conflagration is discussed. The fire safety attributes of double pane windows are examined. Burning brand deposition patterns obtained by Sapsis are presented and the role of Cedar shakes and shingles is examined. While building codes restrict the use of wooden roofs, that constraint is aimed primarily at the fire safety of the initially ignited structure. Of concern to us in these conflagrations are the downwind and downslope propagation of the fire by burning brands. This suggests that it is inappropriate to use Cedar shingles as exterior wall coverings on structures in critical upwind fire areas.

The scenario that emerges for October 1991 is a fire occurring after a very dry, hot, strong wind has desiccated vegetal and structural fuel. This fuel is initially dry from a long drought, an unusual freeze and a rainless extended summer. The altitude of the fire places it within a strong inversion layer so that brands are channelled downwind into a heavy fuel-load urban/wildland intermix. This intermix is elevated above the surrounding urban region so that brands have extended trajectories which aid the fire's rapid growth to conflagration. In hindsight, this fire may have been so severe because ordinary urban development was allowed to occur in an area which was meteorlogically and topographically inappropriate. Just as reserved water-shed lands surround reservoirs, protected fire-shed lands may be required upslope and upwind from cities at risk.

PROJECT FLAMBEAU

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ABSTRACT

Severe mass fires in forests and cities have occurred as a result of fire bombing in WWII, earthquakes and other natural disasters. Project Flambeau, and International Study of Firestorm Effects was formed in 1962 with the USDA Forest Service as the lead agency. Results indicate that combustible arrays can be modified to mitigate the firestorm hazard.

Keywords: Project Flambeau, Firestorm, Mass Fire, Conflagration, Project Euroka

INTRODUCTION

Project Flambeau was a cooperative project between the USDA Forest Service, the DOD and British Commonwealth countries. Its purpose was to investigate mass fires and the phenomenon associated with them. Examples of mass fires are fire storms in cities and wildlands. Causes of fire storms range from the fire bombings of WWII, earthquakes and strong dry winds. The Oakland fire of 1991 may have been an example of the latter.

Initial studies commenced in 1962. Initial experiments used logging slash, chaparral and similar types of fuel. They were mostly unsuccessful for various reasons the main one being the difficulty of instrumenting them.

Simulated city areas were then constructed using the plentiful pinyon pine and juniper stands in California and Nevada. As shown in figure 1, they were arranged in square arrays, varying from a single 15m x 15m, 20 ton piles to similar piles separated by 7.5 meter aisles in 50 acre experiments. The piles varied from two to three meters in height. Figure 1 is of one of the plots after snowfall. Some of the fuel arrays had piles separated by 35 meters.

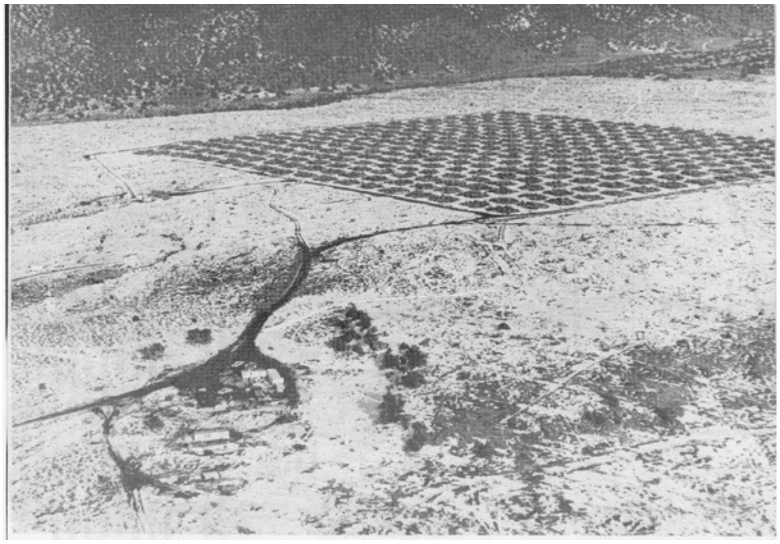

Figure 1. The large fuel arrays of Project Flambeau had from 18 to 20 tons of mixed Pinyon Pine and Juniper trees in 15 meter X 15 meter piles, 7.5 meters apart.

THE EXPERIMENTS

Several fuel arrays were rearranged in configurations designed to cause rotation of the winds in the burning area similar too much smaller firewhirls observed in burning areas and experimental laboratory fires. Large scale rotating single fire whirls were not observed. However, strong winds more than hurricane force (Beaufort 12, 82 mph) have been observed and efforts were made to explain why they did not occur in these experimental fires.

Close examination of the extensive photo and cine coverage of the fire showed that the probability of the formation of a vortex pair increased as the burning area became larger than two ha. Vortex pairs are a classical fluid dynamics problem, but it was believed that they could not form in the energetic environment of a large fire. Instrumentation configurations designed to study them were then designed. Figures 2,3 and 4 show the development of the vortex pair in a Project Flambeau fire. Maximum winds measured around the periphery of the experiment were 56 meters/sec (125 mph.)

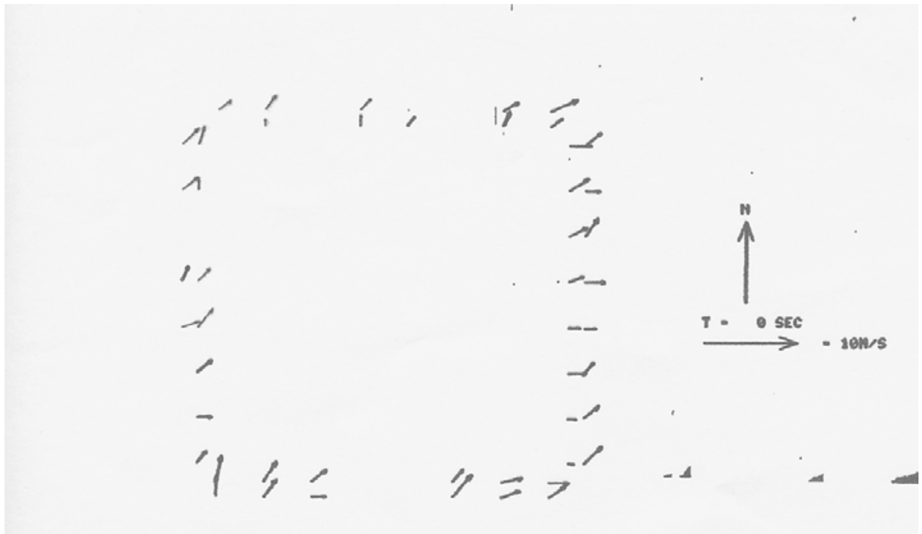

Figure 2. Winds around a 12 hectare experiment at ignition

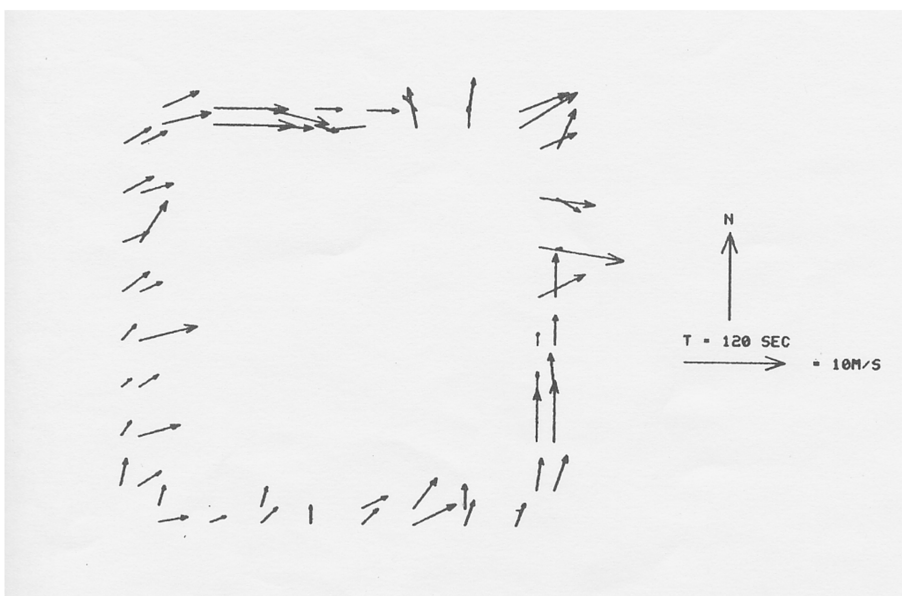

Figure 3. Winds around a 12 hectare experiment 120 seconds after ignition

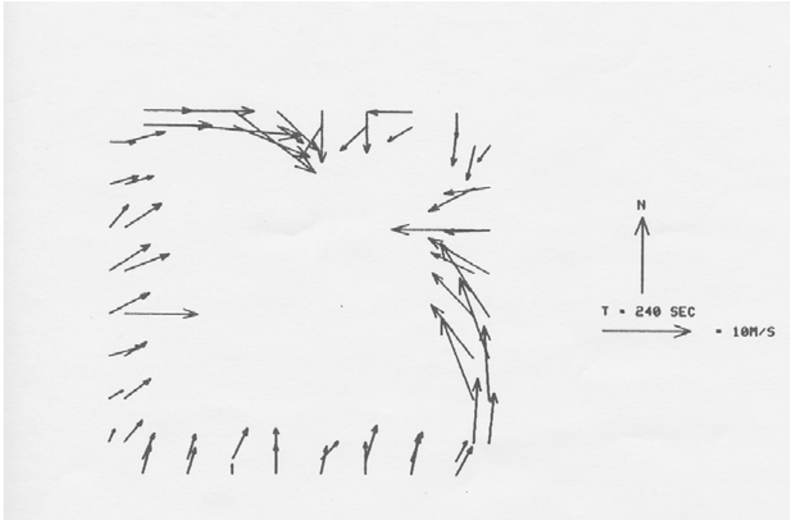

Figure 4. Winds around a 12 hectare experiment 240 seconds after ignition

Figure 5. Downflow winds of about 10 meters per second into a 20 hectare experiment on the downwind side.

The vortex pair's inflow was from the down wind side. Descending flow of about 10 meters/sec (20 mph) came from aloft as shown of fig. 5. Figure 6 is a closer view and illustrates the effect of the strong winds on the flames. If the rate of burning and heat production is sufficiently large, the hot gases break loose from the ground before a vertical interdigitated pair can form. A ring vortex (similar to a smoke ring) uses the vorticity of the surface vortex pair and propagates upward. Figure 7 shows that the strength of the vortices and indicates that the pulsing generation of ring vortices (like smoke rings) occurs about every two minutes. A single beam pulsed Doppler radar observed one of these large fires, Palmer (1981). However, the single beam was incapable of clearly defining the interaction between the vortex pair and vortex ring.

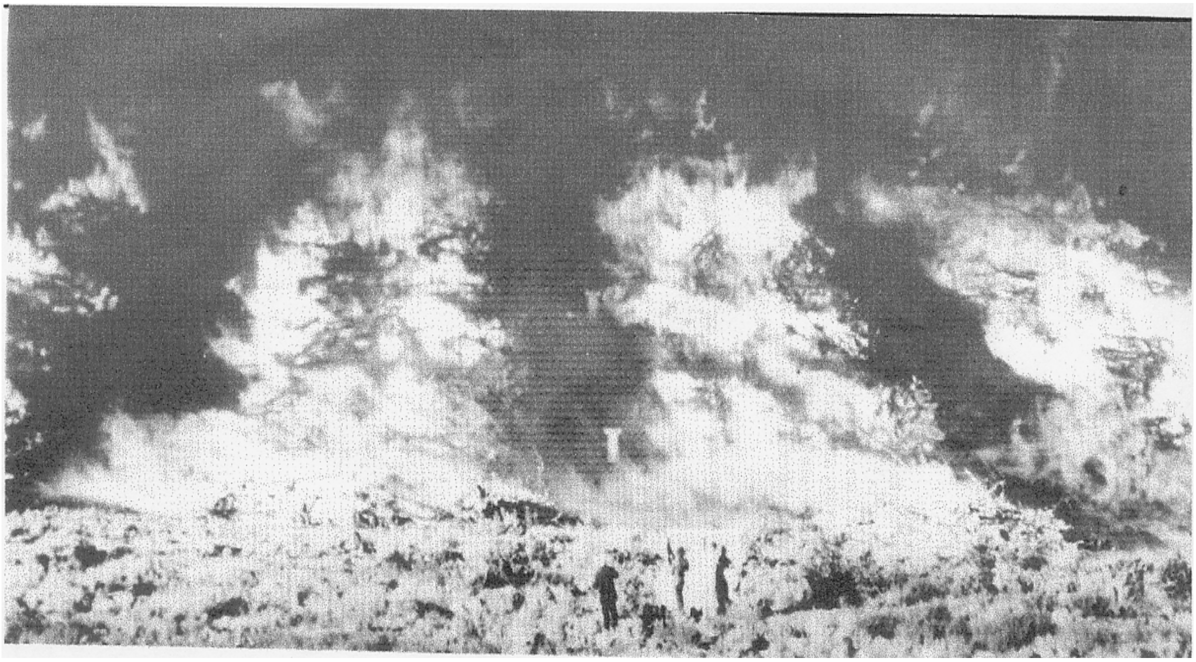

Figure 6. Closer depiction of observers of street signs in a 20 hectare experiment and the effect of the strong downdraft on the fire.

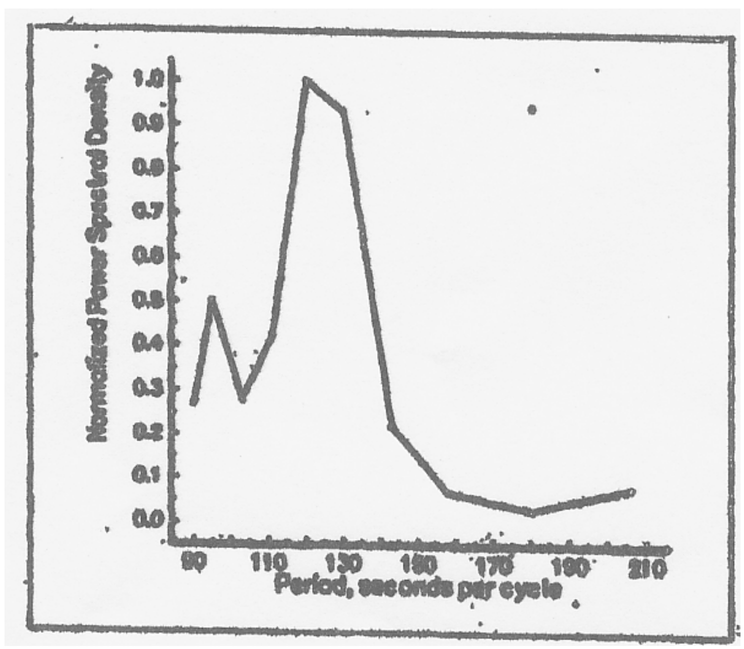

Figure 7. Normalized power spectral density of the integral of the flow around the west side of the 12 hectare experiment.

If the growth rate of a Project Flambeau fire was not great enough to develop a large bubble of hot air (the dimensions are uncertain) an interdigitated vortex pair developed as shown in Fig. 8. A more graphic depiction of this phenomenon is available at www.bfrl.nist.gov/864/baum.html. If the atmospheric wind is strong enough, the vortex pairs can be pushed down to the ground Haines (1982).

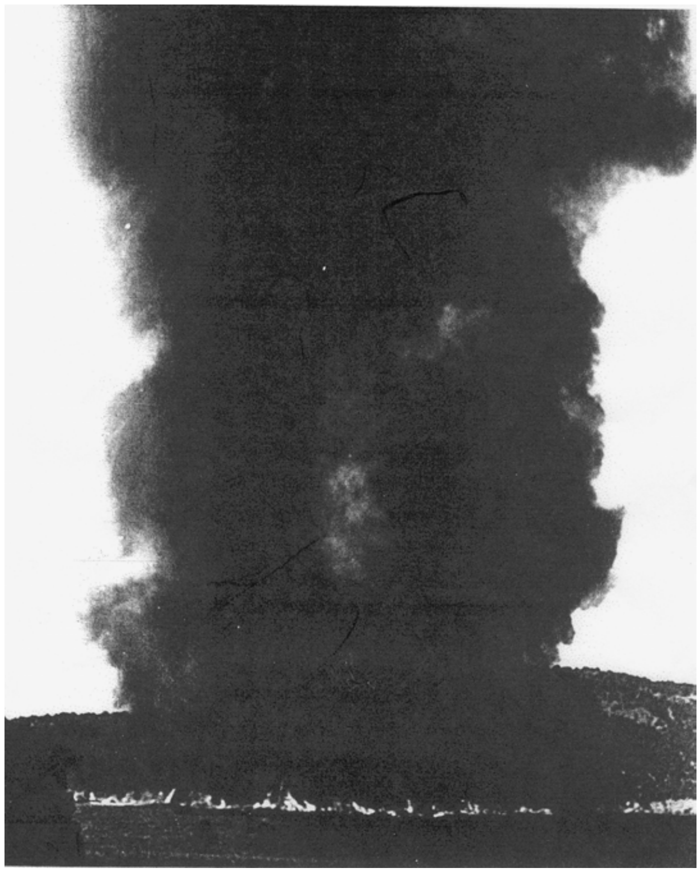

Figure 8. Interdigitated vortex pair columns in a 6 hectare experiment, strong downdraft on the fire.

CONCLUSIONS

Results presented here have considered only a small part of the Project Flambeau data. However, it seems clear that surface vortex pairs will develop in almost all fires that are larger than about two hectares with sufficiently close space fuel and energy output. Subsequent behaviour of the convection column depends upon the rate of energy release in the fire and strength of environmental winds. Recent laboratory experiments and the many fire experiments using liquid fuels do not scale properly to large ambient mass fires.

Almost every meeting on fire research has depictions of large fires from the ground and satellite. Models have been developed using the statistics of location as the fire spread. These technologies have made little progress in describing and predicting mass fires because there is a basic lack of information about what goes on inside large fires. Knowledge of basic fluid and thermodynamic properties is mostly limited to the data from Project Flambeau and Project Euroka in Australia. Much of these data has not been analyzed.

Examination of the data to date can provide a basis for the development of plans of housing spacing, road design and vegetation plantings. For instance spacing of buildings should be at least 30 meters and combustable vegetation that can produce fire brands should be avoided. It seems clear that closely spaced combustable building arrays greater than two ha will burn as a fire storm if ignited even in light wind conditions.

Pulsing by the vortices probably produces an infrasonic signal that could provide warning and information about the formation of firestorms.

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EMBER IGNITABILITY OF PINUS RADIATA AND SEQUOIA SEMPERVIRENS LITTER : METHODOLOGY AND RESULTS

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ABSTRACT

This paper addresses the development of a test protocol for use in the measurement of ignitability of flammable litter and duff layers by embers. The initial results of the tests, replicated over 140 times, indicate that the fine fuel litter from *Pinus radiata* was somewhat more ignitable than the coarser litter generated by *Sequoia sempervirens*. However, the litter of both species was lighted readily by small wood embers 0.95 x 0.95 x 0.48 cm (3/8 x 3/8 x 3/16 in.) in dimensions. Under the lowest humidities we could obtain with our equipment, (approximately 10 percent), an average of seven of ten Sequoia samples ignited, while all ten of the Pinus samples ignited.

The litter from the Sequoia *sempervirens* adsorbed moisture more slowly than did the litter of *Pinus radiata*.; increased moisture content would increase resistance to ignition. It is known that increased moisture content reduces the ignitability of fuels because of the increased thermal inertia and the additional heat flux (a function of duration and intensity) required to raise the temperature to the combustion temperature. As with the Schroeder, Martin, and Chambers vegetation study (1993), higher moisture content of the litter layers provides a significant resistance to ignition. That point is causally related to the ember's plume, the burrowing effect of the ember, and its ability to provide sustained heating to the litter material above.

Keywords: small scale; fire testing; ignitability

INTRODUCTION

The first objective of this research was to continue development of a methodology for testing the ember ignitability of vegetative fuels following our previous work (Schroeder, Martin and Chambers 1993). The second was to evaluate the comparative ember ignitability of *Pinus radiata* and *Sequoia sempervirens* litter beds, the null hypothesis being that there was no difference in the ember ignitability of the two under various conditions. The test methodology has its foundation in the ASTM E-108 standard for the fire testing of roof coverings/roofing systems. Specified within E-108 is a requirement that roofing systems be subjected to burning brands (embers) of various sizes. The fire response of the roofing system versus the flaming brands is the primary criterion for the classification of the roofing system as Class A, B,or C as set forth in ASTM E-108. We devised two smaller classes of brands and designated them as Class D and E, which are one half the dimensions of the next larger brand. Brand sizes D and E represent those mass sizes of fuel packages that would be lofted readily by crowning or torching trees and shrubs or easily blown by wind. The existence of these smaller brands effectively increases the potential for ignition of wildland and domestic vegetation and ground cover materials as well as flammable roof types, such as untreated wood.

FLAMMABILITY

The physical and chemical attributes of fuels or phytomass contribute to how well it ignites and burns. Anderson (1970) considered flammability to have three components: ignitability, sustainability, and combustibility. Extending those ideas, we added consumability, because of its importance in the total effect of fires on the biota with the components of flammability, as follows:

Ignitability – how easily a fuel ignites, by radiation, convection, or embers,
Sustainability – how well it continues to burn, spreading fire to the next fuel,
Combustibility – how rapidly it burns,
Consumability – how much of it burns.

Anderson (1970) defined ignitability as the ignition delay, which is in keeping with the results of many engineering ignition tests Lawson and Simms (1952), Tewarson and Pion (1978), Rabash and Drysdale (1983), Drysdale (1985), where time to ignition was used as a criterion. We must consider ignitability in the broader sense which would include the heat flux at the surface required to bring a material to combustion under various conditions. Ignitability of a fuel must be considered from the standpoint of radiant, convective, and firebrand (ember) sources. Our tests were a go-no go situation; it either ignited or it did not.

Whereas the studies cited considered ignition to require flaming combustion, both piloted and spontaneous (with and without a pilot flame), we must also consider the initiation of glowing combustion as part of the ignitability of vegetative fuels. Often wildland fires will remain in glowing combustion for days before breaking out as weather changes or it burns into a more combustible fuel.

MATERIALS AND PROCEDURES

SAMPLING

Samples of *Pinus radiata* and *Sequoia sempervirens* litter were collected in the East Bay Regional Parks. Using a multi-tined "comb" apparatus, the litter and duff layers could be effectively sampled down close to the mineral soil layer without causing change or compaction to the sampled layers. The comb consisted of multiple rods bolted through a 3.81cm. (1.5 inch) diameter PVC pipe. The tines could be slid under litter layer and a 35 by 50 cm.(14 by 20 inch) sample removed with little or no disturbance of the surface litter. The materials sampled were placed onto a 14" x 20" sheet of gypsum board for handling, conditioning, and later burning.

CONDITIONING

The sample size allowed for conditioning to be accomplished within a small conditioning oven, the test chamber, or within closed environments contained open vessels of water or saturated salt solutions with known relative humidities. Samples were allowed to undergo extended exposure to these conditions to ensure equilibrium.

In the laboratory a 1.2 x 2.4 x 0.6 meter (4 x 8 x 2 foot) conditioning chamber, originally constructed to evaluate moisture loss in live foliage under desiccating conditions (Gutierrez 1994), was modified to produce the controlled levels of wind speed, air temperature, and humidity, using a fan, dehumidifier, and air conditioner. The wind speed for the experiments was set at 19 and 30 kph (12 and 19 mph). Air temperature range was 22 and 32˚C (72 and 90˚F), and relative humidity averaged 10 and 28 percent. A high CO_2 concentration was prevented by circulation of the air conditioner. Fluorescent lamps provided sufficient light.

Embers were cut from Sugar pine *(Pinus lambertiana)* to reduce the effects of variation in ember density caused by the differences in springwood and summerwood. Ember sizes were:

CLASS A: 30.48 x 30.48 x 5.95 cm. Cross-piled wooden crib with stock end dimensions of 1.9 x 1.9 cm (12x12x2.25 inches of 0.75x0.75 inch stock; 3 tiers)

CLASS B: 15.24 x 15.24 x 5.95 cm. Cross-piled wooden crib with stock end dimensions of 1.9 x 1.9 cm (6x6x2.25 inches of 0.75x0.75 inch stock)

CLASS C: 3.81 x 3.81 x 1.98 cm. Solid block with 0.3175 cm saw kerfs at 90° on opposite sides (1.5x1.5x0.75 inch solid block with 0.125inch saw kerfs)

CLASS D: 1.9 x 1.9 x 0.95 cm. Solid block with a single centered saw kerf upon one side (0.75x0.75x0.375 inches)

CLASS E: 0.95 x 0.95 x 0.48 cm (0.375x0.375x0.188 inches)

A, B, and C size embers are the standard for rating roofing materials, and we developed the D and E classes, as the larger would surely light any litter that was not too wet to sustain combustion.

Prior to the initiation of each test, four sets of litter and duff samples were made from each source sample. These sub-samples were then weighed, oven-dried, and re-weighed to calculate the oven-dry moisture content. The dry weight basis was used, as is common in fire and wood technology.

TEST PROCEDURE

The samples were placed within the Gutierrez chamber which was used as the testing platform. A movable 1.5 inch ID PVC pipe inserted through the roof of the chamber provided the directional delivery system. The brands were ignited outside the chamber and then dropped through the tube into the chamber and onto the litter sample. The tube was moved about the sample to test ignition several times on one litter sample.

The tests were conducted one brand at a time. Using a tweezers, or small tongs, the brand was picked up and held by its opposite corners, thus maximizing its exposed surface area. The brand was then placed within the burning region of the partially pre-mixed propane flame. It was found that the optimum heating location in the flame was just above the stoichiometric cone, i.e., where the coloration goes from light blue to almost translucent. Once in the body of the flame, the brand was moved about in a rolling or rocking motion to achieve a uniform exposure to the flame. Both brands sizes were subjected to direct flame impingement for 15 seconds. Times were determined experimentally to achieve established ignition.

Upon the removal of the brand from the flame, it was dropped into the PVC pipe atop the chamber. The flaming brands would then exit onto the sample bed. The target points on the sampling bed were subjectively selected by the tester.In an effort to normalize the burning characteristics of the brands, all brands selected for use were placed in a drying oven at 70˚C for 24 hours prior to the testing to reduce their moisture content.

CRITERIA FOR DECLARING IGNITION

"Ignition" was defined as self-sustained flaming combustion of the litter sample. Once established, the free burning/flaming combustion also had to continue for 30 seconds after initial ignition, or, display a rapid rate of flame spread. If free burning was established (and the test met the defined ignition parameters,) the small regions of fire involvement were then extinguished using a small hand-operated atomizer containing water. Each sample was subjected to at least 5 ignition attempts. If ignition was not achieved with the smaller Class E brands, the sample would remain and Class D brands would then be used.

METHOD OF DATA GATHERING AND ANALYSIS

Given the simplicity of this test, the spectrum of data gathered was minimal and should be considered screening data. The data package contained:

1. Species type
2. Sample number
3. Moisture content of litter and duff
4. Data tested
5. Outcome of size D and E brand tests of the respective samples.

ANALYSIS OF DATA

The initial series of tests were conducted on the litter and duff beds beneath *Pinus Radiata* and *Sequoia Sempervirens*. The samples were collected along Skyline Drive in West Oakland, CA by Martin, Schroeder and Buteau in late March. During April, four series of tests were accomplished. The plotted results define a relationship between the relative fineness of the fuel package components and their ease of ignition. What is not so apparent in the results is the implied quickness or speed in which the subject fuels re-adsorbed the moisture of the closed environments containing the open water vessels. The fine needles of *Pinus radiata* readsorbed more than twice the moisture content as did the Sequoia Semperviren's large flat needles. The lag in moisture content recovery resulted in the 4-fold increase in the ease of ignition of the Sequoia litter.

Overall, the ignition resistance of the Sequoia was consistently greater than that of *Pinus radiata*. The observations of the means of ignition, as with the Schroeder and Martin study, once again found the need for the brands to imbed or burrow through heating into the fuel bed to insure the establishment of sustained flaming combustion. Brands which were held on the surface of the sample beds as a result of the packing density of the bed did not do well. The brand would cause the charring of the fuel beds surface which in turn would insulate the next layer of potential fuel from heating and thus ignition.

These tests did not introduce the effects of wind. It can be deduced however, that a relatively mild breeze across the flaming ember would enhance its rate of burning which in turn would increase the likelihood of establishing ignition of the fuel bed.

An important point to consider is that, even though the Sequoia litter didn't light as readily as the Pinus litter, it did light with very small embers. People should not expect Sequoia, and especially its litter, to be a hindrance to fire spread. As with other tree species, its litter should not be allowed to accumulate near or on structures.

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LOS ALAMOS, NEW MEXICO: LESSONS LEARNED

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Presenters spent several days, photographing losses and saves, at the fire that began as a controlled burn and ended by destroying 400 homes and threatening the National Laboratory at Los Alamos. Their primary interest was building construction, siting, and defensible space. They returned one year later to document physical and political change to the community and lessons learned.

COMMUNITY-SCALE FIRE SPREAD

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ABSTRACT

This paper addresses community-scale fires, which have also been called urban/wildland interface or intermix fires. These fires arise when wildland fires invade the built environment and attack structures as well as wildland fuels. The prediction of the spread of wildland fires, such as those occurring out West during the summer of 2000, has been accomplished through "operational" mathematical models. These models are based on empirical correlations for wildland fuels and have generally performed well. They fail, however, when the fire spreads to the built environment where the empirical correlations no longer apply and where there is greatly increased potential for property damage, injury and death. The Oakland and Berkeley Hills fire of October 21, 1991, and the Los Alamos fires of May 2000 are examples of community-scale fires. The potential fuel loadings for various land uses demonstrates that structures generally provide much higher loadings than wildlands do. While this comparison is useful, it could also be misleading since generally, not all of the potential fuel in either the wildland or the built environment will burn. Furthermore, often the time scales for ignition and the heat release rates for the wildland fuel and the fuel in the structures will be widely disparate, and these differences will influence both the spread rate of the fire and its persistence. Although the NIST computational model known as the Fire Dynamic Simulator (FDS) was developed to study building fires, it is now being extended to study community-scale fires. These extensions require much higher resolution data on local topography, buildings, vegetation, and meteorological conditions. They also require additional research on the mechanisms by which fires spread in the built environment between discrete elements, such as structures or structures and trees.

Keywords: Wildland/Urban Interface Fires; Mathematical Models; Computational Fluid Dynamics; Potential Fuel Loads;

INTRODUCTION

Fires in the West have been headlines in the news for most of the summer of 2000. Changes in the management of forested lands, the increasing intrusion of man into more remote areas and the cyclic dry periods produced by El Nino - La Nina have all increased the destruction of man-made structures by fires. Wildland fires now often spread into the built environment causing injury, death and property damage. Concern about wildland fires and their effects on man and the built environment has produced several recent conferences Livingston (2000), Keller (2000), Platt (2000). While these conferences acknowledge the need to address fire spread in a mixed environment containing both structures and wildland fuels, i.e., community-scale fires, they have continued to focus on wildland fires where understanding and predictive models of the fire spread are well developed.

Compared with wildland fires, those which impact the built environment are generally more costly, both in terms of loss of life and injury and also in terms of property damage. What characterizes fires in the built environment and how do they differ from wildland fires? By comparing and contrasting community fires and wildland fires, we hope to characterize conceptual differences between the two. Then, we suggest research areas needed to develop a mathematical model to describe fire spread in the built environment, where both individual structures and wildland fuels – trees, shrubs and ground litter – compose the fuel inventory.

Note first that the manner in which the fires are fought differs dramatically. Most communities have either professional or volunteer fire departments, which usually respond to individual structure fires in the built environment. Wildland fires, on the other hand, usually occur in federal or state owned land and are therefore the responsibility of one or more government agencies. Both the training and the response of community fire departments are very different from units trained to fight wildland fires, and only in a few locations are firefighters given cross training to fight both types of fires. Furthermore, the scientific communities which study each type of fire and the corresponding literatures are almost disjoint.

In 1998 there were 1.75 million responses by local fire departments, with about a half million being structures (others involving vehicles, materials outside of structures, etc.) Karter (1999). Over 4000 civilian deaths and 17,000 injuries occurred as a result of these fires, and the cost of the fires was about $ 8.6 billion. Significantly, the number of fires in various categories together with associated losses have either remained the same or decreased since 1977, the first year that the NFPA (National Fire Protection Administration) conducted its survey using current methodology.

In contrast, in the West during the summer of 2000, there were about 80,000 fires, which destroyed about 7 million acres and required about $ 1 billion in Federal funds for suppression costs. Expectations are that future wildland fires will continue at rates more like the summer of 2000 than those in recent summers past. The federal agencies responsible for control of these fires reside in the Department of Interior (DOI) and the Department of Agriculture. They are the National Park Service, the U.S. Geological Survey, the Bureau of Land Management, the Fish and Wildlife Service and the Bureau of Indian Affairs, all part of the DOI, and the Forest Service which is part of Agriculture.

The acreage of wildland destroyed by fires has undergone considerable variation during the twentieth century, and this variation has lead to substantial changes in forest management strategies. Recently for example, fires in wooded areas have begun to be viewed in much more ambivalent terms; it has been recognized that smaller and more frequent fires can clean out debris, thin woods and make them healthier and more resistant to large, catastrophic fires. The so-called "prescribed burn" has now become a tool by which wildlands are managed.

In the next section, we characterize the fuel load by land use. First, a brief review of the literature on the characterization of wildland fuels is presented. Then, we look at the corresponding literature concerning structural fires. In each case the emphasis is on the potential fuel loadings available for burning in various settings. In the third section, we examine differences arising from attempts to mathematically model each type of fire. A brief discussion of wind-driven fire spread models in wildlands is presented, since these models are relatively well developed. Furthermore, they have been used extensively for research, training, planning (for prescribed fires for example), and to provide real-time emergency-response predictions to guide fire fighting operations. The corresponding models are not available for multiple-structure community fires. Finally, we discuss extensions to a computational model developed by NIST which could be used to address the problem of predicting community-scale fire spread in areas containing both vegetation and structures (the so-called urban-wildland intermix).

POTENTIAL FUEL LOADINGS

The most basic characterization of land use relative to fire is the amount of fuel available on the land. Specifically, the potential fuel energy loading per unit area is a useful measure which allows a direct comparison between fuels in wildland settings and those in man-made structures. While this comparison is useful, it could also be misleading since generally, not all of the potential fuel in either the wildland or the built environment will burn. Furthermore, often the time scales for ignition and the heat release rates for the wildland fuel and the fuel in the man-made structures will be widely disparate, and these differences will influence both the spread rate of the fire and its persistence.

Wildland Fuels

Fuel characterization and fire behavior in wildlands is the subject of several books: Pyne et al (1996), Chandler et al (1983a), Chandler et al (1983b), Brown and Davis (1973) and Luke and McArthur (1973).

Chandler et al (1983a) describe the total amount of plant material, both living and dead, but excluding roots and animal matter as **phytomass**. They state that the total phytomass on any site has a physiological upper limit: $W = 23\sqrt{A} = (26\sqrt{A})$, where W is the total phytomass in newtons/m^2 (tons per hectare) and A is the stand age in years. The degree to which this limit is approached depends on the site quality, but is not dependent on the particular vegetation. **Potential fuel loading** is the maximum fuel available, or the amount of material that could be consumed in the most intense fire. **Available fuel loading** is the amount of fuel that is expected to burn under specified fire weather conditions, and is therefore widely used for planning prescribed fires where weather conditions are known in advance. Usually, foliage and small crown material (branches and twigs of 5 cm (2 inch) diameter or less) is what burns in tree crown fires.

Wildfires have been characterized in terms of 13 standard fire behavior fuel models, whose properties are tabulated by Pyne et al (1996). All fuel loads are given in terms of fuel mass per area (tons/acre), with a footnote stating that, for all fuel models, the energy content per mass is 18.6 MegaJoules (MJ)/kg (8000 Btu/lb). The data for fuel loadings are restated in Table 1, first in units of kilograms per hectare, and then, in GigaJoules (GJ) per hectare.

Wildland fuels are composed mostly of lignin and cellulose in both living (green) and dead forms and vary widely in distribution, physical characteristics and their effect on fire behavior. Chandler et al (1983a) give the composition, heat of combustion, and moisture content of living tree material. This information plus the composition and heat of combustion for "an average tree" are presented in Table 2 below. From this chart, we infer that average wildland fuels yield about 15-20 MJ/kg, a value consistent with that stated above by Pyne et al (1996).

Dry fuel characteristics for individual conifers can also be inferred from data in the NIST Report by D.W. Stroup et al. (1999) in which eight scotch pines were separately burned. Measurements included weight before and after each burn, height and width of each tree and moisture content before the test. During each burn, the oxygen consumption rate was inferred from captured combustion gases. The oxygen consumption can be related to the heat release rate (HRR), using a factor which is approximately constant for all fuels (oxygen calorimetry). The mass loss determines the total energy released, and agrees approximately with the integral of the HRR with respect to time. The initial mass of these trees ranged between 9.5 kg to 28.1 kg, and the energy per unit mass for complete consumption of these partially dried conifers was found to be about 17 MJ/kg, again confirming the values stated above.

No.	Fuel Complex	Load kg/hectare	Energy Load GJ/hectare
	Grass & grass dominated		
1	Short grass	1660	32
2	Timber (grass& understory)	1100-4400	21-84
3	Tall grass	6700	124
	Chaparral & Shrubs		
4	Chaparral	4400-11000	84-207
5	Brush	1100-2200	21-42
6	Dormant brush, wood slash	3500-5700	62-104
7	Southern rough	2400-4200	47-79
	Timber litter		
8	Closed timber litter	2400-5700	42-104
9	Hardwood litter	350-6400	6.2-120
10	Timber (litter & understory)	4400-11000	84-210
	Slash		
11	Light logging slash	3500-12400	62-230
12	Medium logging slash	8900-37000	168-690
13	Heavy logging slash	16000-62000	300-1100

Table 1: Potential mass and energy loading for the 13 standard fuel models, from Pyne et al. (1996).

Living Tree Fuel	H_c J/g	Dry Weight Composition		Ave. Tree Dry Weight	$< H_c >$ J/g
Cellulose Hemicelluloses	16170	50-75 %		65 %	10500
Lignin	24612	15-35 %		25 %	6200
Extractives	32424	.2-15 %		5 %	1600
Mineral	0	5-10 %		5 %	0
Total					18000
Moisture (foliage,twigs)	2400	100-250 %		150 %	-3600

Table 2: Living tree fuel composition: in the first two columns are shown the heat of combustion and the dry weight percentage range by component. (The last two rows show the heat of evaporation and the moisture content range.) Values are taken from Chandler et al. (1983). The last two columns display for an "average tree," a dry weight composition and the corresponding heat of combustion, with the moisture content and the heat of vaporization for this "average tree" being given in the last row.

Fuel Loading from Structures

Burning man-made fuels and fires in enclosures are the subject of books by Drysdale (1985) and Quintiere (1998). In addition, a review by Pitts (1991). deals with wind effects on urban mass fires.

In the suburban and urban setting, the key quantity is the density of houses – together with the combustible material in these houses – in determining fuel loading and fire behavior. The density of trees, shrubs and ground cover (grass) may still be important for determination of the fire behavior, but clearly house density is critical.

An estimate of the energy release rate during a house fire in the Oakland and Berkeley Hills fires was made by Trelles (1995) and by Trelles and Pagni (1997). According to these estimates, a house burns at a peak rate of 45 MW for 1 h (yielding about 160 GJ), and then dies down over another 6 h period. The die-down of the fire is approximated as two steps, one 10 MW for 3 h and the last as 5 MW for 3 more h. The total burn time is 7 h, and the total energy released by the house is 324 GJ. If, as assumed also, there is brush around each house which releases another 5 MW for one h, then an additional 18 GJ of energy will be released. If the house is assumed to be 15 m by 15 m by 5 m, then we estimate the total potential fuel loading per unit area to be of order 1.44 GJ/m^2, the peak HRR per unit area to be of order 0.2 MW/m^2, and the volumetric heat release rate to be of order 0.04 MW/m^3. For comparison, oil has an energy content of about 42 MJ/kg, and oil pool fires yield a heat release rate per unit area of approximately 2 MW/m^2, see McGrattan et al. (1996), Baum et al. (1994) and Baum (1999). Furthermore, Chandler et al (1983b) describe the concept of an "ideal" burning rate, which was first introduced by Tewarson and Pion (1976), and they tabulate the ideal burning rates for several fuels. Liquid hydrocarbons have ideal heat release rates per unit area ranging between 0.7 and 3.0 MW/m^2. The corresponding rate for wood is about 0.26 MW/m^2.

Wildland and Urban Fuel Loading

The only reference of which we are aware that discusses technical issues related to wildland and community fires is Chapter 8 of Chandler et al. (1983b). entitled, "Fire at the Urban-Forest Interface." This chapter makes several very important observations. First, the authors note that fuel loadings in buildings are typically many times those in a forest: "the heaviest likely fuel load in the forest is less than the lightest load for a structure." Next they observe that fuels in buildings include a variety of combustibles whereas forest fuels are exclusively cellulosic. The authors also point out several important differences between burning in a structure and burning forest fuels. Moisture, which is very important during burning, is controlled within a building, but is determined in wildlands by environmental factors such as the sun, wind and precipitation. Radiation from an indoor fire is trapped inside the building whereas most radiation in a wildland fire escapes. Similarly, most convective heat is trapped in an indoor fire whereas it is lofted into the atmosphere in a wildland fire. Finally, oxygen is severely limited in an indoor fire whereas it is virtually unlimited in a wildland fire.

The first point concerning the potential fuel loading differences between structural fires and wildland fires is illustrated in Table 8.1 of Chapter 8 of Chandler et al. (1983b). This table shows the land use (or area) in one column and the corresponding mass loading of fuel in the second; it is reproduced below with the addition of columns showing the potential mass load in kilograms per acre and the corresponding potential energy load in GJ per hectare. (Some of the numbers in this table appear large compared to those reported here and elsewhere.)

Area	Fuel Type	kg/hectare	Fuel Load/hectare (GJ/hectare)
Forest	Grass & sward (Tasmania)	4900	94
Forest	Heavy brush (Southern Cal.)	101,000	1680
Forest	Maximum	$27{,}000\times\sqrt{A}$	$490\times\sqrt{A}$
Urban	Dwellings, offices, schools	202,000-504,000	3700-9400
Urban	Apartments	$490{,}000\times N$	$8900\times N$
Urban	Shops	500,000-1,010,000	9400-18800
Urban	Industrial & storage	300,000-3,000,000 or more	5,700-57,000 or more

Table 3: Available Fuel Load (from "Fire at the Urban-Forest Interface," Chapter 8, Volume II, Chandler et al. (1983). Here A is the age of the forest in years and N is the number of floors in a multistory building.

Finally, the data from the past sections and the chart above are combined in Table 4, where the description of land use is presented with likely numbers of trees and houses per hectare. We have divided the description of the land use into four basic categories: wildland, rural, suburban and urban; and the wildland and rural categories have been further subdivided. This information can also be plotted as shown in Figure 1. In this figure, the number of structures per hectare is plotted as the abscissa and the ratio of the vegetation energy load to the structure energy load is the ordinate. In this diagram, wildland covers the upper left corner of the diagram, where the number of structures is small and the vegetation energy load is relatively high, whereas the urban area occupies the lower right corner. Also shown on this plot are several fires for which we estimated, from information available, the potential energy load per hectare where the fires did their greatest damage to the built environment, whether the fires began there or elsewhere. Note that the Oakland Hills Fire of 1991 and the Los Alamos/Cerro Grande Fire of 2000, fall directly in the category of suburban fires and are good examples of community-scale or urban-wildland interface fires.

Description	Tree Density (Trees/ hectare)	House Density (Houses/hectare)	Tree Fuel Load GJ/hectare	House Fuel Load GJ/hectare
Wildland Unhealthy Forest	740-2200 Nelson (2000)	0	37-111	0
Wildland Healthy Forest	49-124 Ponderosa Pines, Nelson (2000)	0	2.5-6.2	0
Rural Area 0-0.03 people/acre	0-74	0-0.05	0-3.7	0-16
Grass & Brush	0-25	0-0.05	0-0.12	0-16
Forested	25-74	0-0.05	0.12-3.7	0-16.
Suburban Area	25-74	2.5-9.9	1.2-3.7	815-3200
Urban Area	≈ 0	37-or more	0	12,000 or more

Table 4: Land use described by tree and housing density (units/hectare).

MODELING FIRE SPREAD

Wildland Fires

The types of wildfires, their spread rates and intensities were summarized in a review article by Albini (1984) and are presented in Table 5. The wildfire types are ground fires (which burn or smolder in the subsurface organic material at a very slow rate), surface fires (which are most common and variable, and which burn in the material on the ground surface, such as debris, grass or chaparral) and crown fires (which are relatively rare, but spectacular and highly dangerous). An additional column has been added to this table to show the energy density of the consumed fuel, which can be determined from the numbers given in by Albini: if I is the intensity of the fire, and v is the spread rate, then the energy density $E = I/v$.

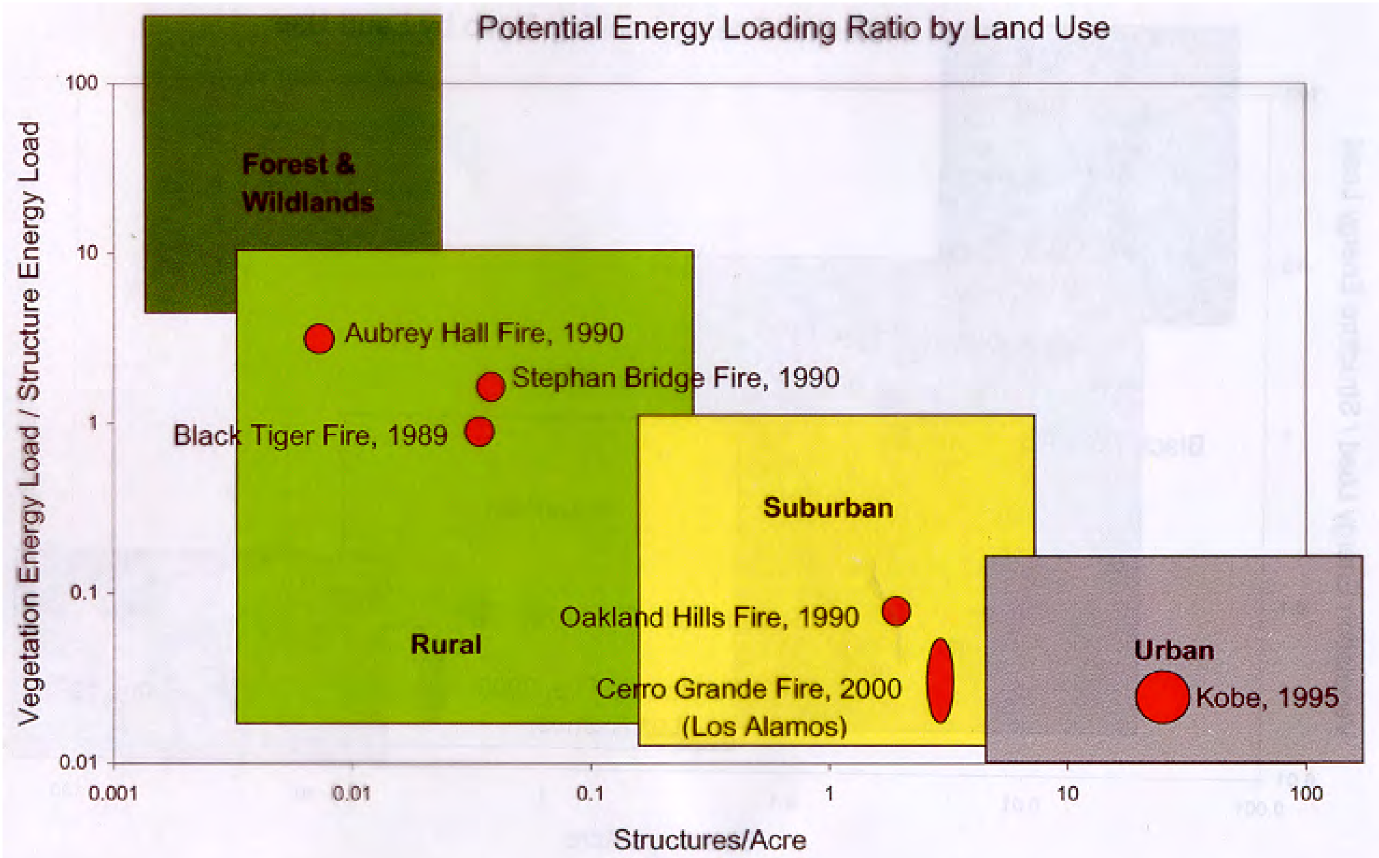

Figure 1 Potential energy loading by land use. Also shown are six specific fires including the Oakland Hills fire of 1991 and the Los Alamos/Cerro Grande fire of 2000.

Types of Wildfire	Spread Rate (m/h)	ROS (m/s)	Intensity (MW/m)	Fuel Energy Density (GJ/hectare)
Ground Fire	0.00003 m/hr	.0000083	0.00001	12
Surface Fires				
Marginal Conditions	0.01	0.003	1	3.7
"Good" Conditions	10	2.77	10	36
Grass Fires	20	5.54	1	1.8
Debris Fires	1	0.277	10	370
Crown Fires	3	0.833	10	121

Table 5: Types of Wildfires, Rate of Spread (ROS) and Intensities as reported by Albini (1984). Also shown are fuel energy density implied by these values.

Fuel moisture and continuity are primary factors in the behavior of wildfires and in the difficulty of bringing them under control. Other fuel properties described by Chandler et al. (1983a) and by Pyne et al. (1996), which influence fire spread, are size and shape distribution, compactness and arrangement of the fuel. Wind conditions and topography are non-fuel-related factors which also influence fire spread. Finally, spotting or branding of a fire is yet another factor which influences its spread Albini (1981), Albini (1983), Woycheese and Pagni (1999) and Woycheese et al. (1999). (Spotting or branding is airborn burning debris lofted by the fire and carried by both ambient and fire-induced winds to locations separate and often remote from the main flaming region; these brands generally ignite additional fires in the new locations.)

For wildland fires, mathematical models are regularly used to predict the likely burn development for expected meteorological conditions. These models, which are known as operational models, have largely developed through empirical correlations over the past few decades. In the United States, they include the Rothermel model, Rothermel (1972), and models known as BEHAVE, Andrews and Bevins (1999), and FARSITE, Finney and Andrews (1999), with the last one being the most recent and most highly developed.

Generally, these operational models have served well as long as the fires are confined to wildlands. They are based on the assumption that the fuels can be represented by continuum beds, which may be inhomogeneous and anisotropic, but nevertheless are continuous. They fail, however, when conditions lie outside of those for which the empirical relations were developed, such as when fires become very intense and induce significant buoyant plumes with resulting atmospheric convection, Clark (1996).

Fire Spread in the Built Environment

These operational models regard the meteorological conditions as prescribed, and have not considered the winds generated by the fire itself. However, for large fires, the self-generated winds may be significant and can even dominate the fire-spread behavior Clark (1996), Baum (2000). Furthermore, to our knowledge, the only studies to consider the discrete nature of fuel elements are the study by Carrier et al. (1991), which examined the effects of discrete fuel elements in a wildland fire, and the study by Himoto and Tanaka (1997), which examined fire spread by radiation between structures in an urban setting.

When the built environment becomes involved, as in the Oakland and Berkeley Hills fire of October 21, 1991, or more recently the Los Alamos fires of May 2000, these models are totally ineffective. They cannot predict the spread of fire because the building fuel loads are larger and discrete. In these community-scale fires, buildings, as well as large individual trees, must be regarded as discrete fuel elements. At a fundamental level, the physical mechanisms controlling fire spread are very different than those in wildland fires. The empirical correlations upon which the wildland-fire models have been developed are no longer valid. No validated predictive models of fires in an urban or urban/wildland setting exist to our knowledge.

The NIST computational code, known as the Fire Dynamics Simulator (FDS), was originally developed to predict fire spread within buildings. Over the past few years, it has also been used to predict smoke and hot gas plume behavior produced by outdoor fires. In addition, more recently, it has been used to predict wind fields in the built environment with one to ten meter resolution over regions measuring up to one kilometer or so on a side. All of these simulations require only a current high-end PC running overnight. The code can be downloaded free from the URL:

http://fire.nist.gov. It consists of two components, a computational fluid dynamics (CFD) code, called fds, written in Fortran 90 for computation of fire-driven flows, and an OpenGL graphics program known as smokeview for visualization of results, see McGrattan et al. (2000), McGrattan and Forney (2000), and Forney and McGrattan (2000).

The model has now been applied to several specific sites, including the NIST campus and individual plots of land in a small community, each of which includes at least one structure and many trees. At this time, the trees participate in the flow dynamics by providing wind resistance to the ambient or fire-driven flows, see Rehm et al. (2000); however, there is no submodel yet for tree burning in these simulations. The combustion is calculated using a mixture-fraction formulation, and radiation transport is also included, see McGrattan et al. (2000). In the simulation, brands, shown as black spots, are produced and carried by the wind in a dynamically simple, but correct manner. However, at present, there is no mechanism for the brands to ignite combustible material downstream of the fire.

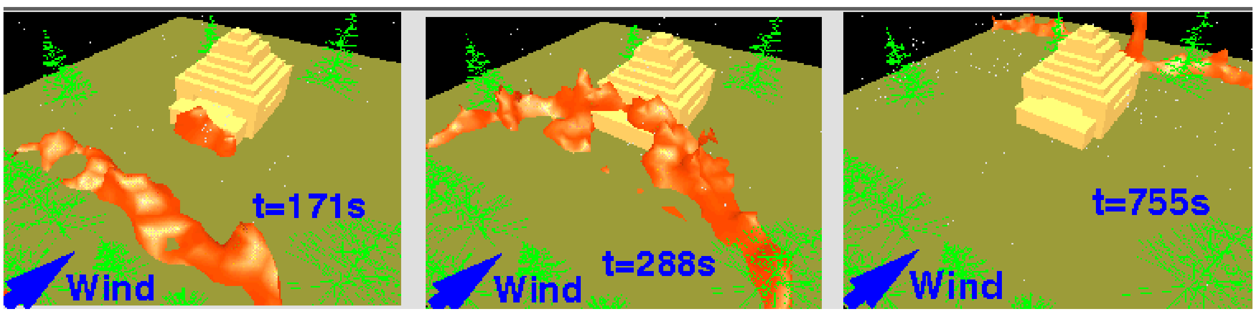

Figure 2: Three frames of a simulation of fire spread on a parcel of land containing a house, trees and dry grasses. These frames are taken at different times during the fire progression, and are qualitatively correct if the fire spread is primarily along the ground material. As noted in the body of this paper, several submodels must still be developed, tested experimentally and incorporated into these simulations. It is extremely important to note that the overall model must be able to describe the progression of a fire among discrete fuel elements, structures, trees and shrubs.

Figure 2 shows a composite of three frames from a simulation of wind-blown fire spread on a parcel of land on which there is a structure and wildland fuels (trees and dry grass). In this simulation, the fire (shown as red "flames") begins upwind of the building and progresses as a ground-fire toward the structure. The trees modify the incoming wind profile by providing drag, but, as noted above, the trees do not burn. The porch of the house is assumed to be made of easily ignitable material, while the house is not. Therefore, the porch, but not the house ignites. Submodels are still needed for burning of an individual tree, brand disributions produced by a tree or by a house, and brand spotting or ignition of downwind materials. All of these submodels must also be calibrated and validated through laboratory experiments, and probably later by limited full-scale burns.

Through these simulations, we are beginning to develop an understanding of the mechanisms by which fires progress in a community where both structures and wildland fuels coexist. Such an understanding will lead to a predictive capability using a model such as the one presented here. Propagation of fire by radiation, natural and fire-induced winds, brands and ground spread must all be examined both theoretically and experimentally to develop a verifiable predictive capability.

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A NATIONAL WILDFIRE BEHAVIOR PREDICTION INITIATIVE: FULL-PHYSICS MODELS ON SUPERCOMPUTERS

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Lawrence Livermore and Los Alamos National Laboratories have been working together for several years to develop a physics-based modeling system that will accurately predict the behavior of wildfires. Our primary goal is to protect lives, property, and natural resources. The emerging capability simulates not only wildfire behavior, but also the local weather and its important two-way interactions with the fire. In addition, the modeling system properly accounts for the effects of complex terrain on both the weather and the fire behavior, and can predict smoke dispersion and its impact on human health. A powerful geographic information system (GIS) interface will be employed to efficiently process model input data (for example, fuel and terrain information) and to analyze the human and economic consequences of the models' predictions. Because it is fully physics- (rather than empirically) based, the modeling system can simulate fire behavior for a much wider range of geographical locations and weather conditions than is possible with conventional tools. The new system could provide an unprecedented level of intelligence to fire managers, enabling them to more safely and efficiently utilize their limited firefighting resources. The project builds upon unique, existing resources at the two national laboratories, including advanced research programs, the proven emergency response infrastructure of the National Atmospheric Release Advisory Center, and the world's most powerful computers. Recently, the National Center for Atmospheric Research joined the collaborative effort.

The Lawrence Livermore Team is currently using the system to simulate the early stages of the tragic 1991 East Bay Hills fire. The presentation will provide an overview of the project and will include animated sequences from supercomputer fire simulations.

DEVELOPING A FIRE-SAFE SUSTAINABLE LANDSCAPE AT THE LAWRENCE BERKELEY NATIONAL LAB

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Berkeley Lab has established a wildland fire safety program designed to allow structures to survive a Diablo-wind driven firestorm. This program has been implemented in a way that works with successional plant communities and results in a natural-appearing composite of native and naturalized plants including grassland, scrubland and forested areas. As part of this program, the Laboratory has created a vegetation fuel break at the Urban-Wildland Interface on the eastern edge of the Laboratory. More significantly, in order to manage the ignitions caused by the firebrands that will cross over the fuel break, the Laboratory has also implemented a site-wide vegetation management program designed to protect all of its structures in the Urban-Wildland Intermix zone.

Berkeley Lab initiated this program through its participation in the East Bay Vegetation Management Consortium, which mapped and prioritized fire hazard in the East Bay Hills after the 1991 fire. Berkeley Lab refined the Consortium's vegetation type and fuel mapping for the area within and around the Lab, and used computer simulation programs (BEHAVE and FARSITE) to predict the fire behavior of existing vegetative fuels. Berkeley Lab then developed a program of treatment recommendations for each vegetation type with the objective of calming fire behavior in the landscape to acceptable characteristics. The vegetation treatment recommendations were based on several reasoned assumptions:

1. that vegetative cover is important to ecological and aesthetic objectives and slope stability,
2. that a blizzard of embers will be falling upon the Lab during a local wildland fire event,
3. that a wildland fire front could arrive before significant mutual aid resources are positioned,
4. that Laboratory buildings and research, should not be damaged during a wildland fire, and,
5. that opportunities to reduce or stabilize long-term maintenance costs should be explored.

Next, the fuel load of the various successional plant communities common to the general area were modeled. Using the fire behavior modeling programs, the Lab evaluated the fire behavior of the fuel conditions projected to exist if management actions were taken to accelerate or retard natural succession in order to manage fire risks. The simulation results confirmed treatment recommendations and affirmed the prospects of developing a vegetation management program focused on the successional state of plant communities.

In developing the program, Berkeley Lab staff solicited input from an array of sources: Lab employees, University of California professors, neighbors, and members of various conservation groups. Successive tweaking of the program tailored the project to local concerns without compromising the objective of improved fire safety in the landscape. Through this process, consideration was given to:

- the successional trends of the local vegetation
- presence of both native and invasive exotic plants
- wildlife habitat encroachment and management effects
- sensitive species habitat
- noise control
- nighttime light pollution
- slope stability and erosion control
- short and long-term maintenance procedures and costs.

Berkeley Lab has nearly completed the initial implementation phase of its program and is now acting to ensure that the prescribed level of protection is maintained in the long-term.

METHODOLOGY FOR DEVELOPING AND IMPLEMENTING A FIRE MANAGEMENT PLAN THAT PROTECTS WATER QUALITY AND BIODIVERSITY

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ABSTRACT

In January 2001, the East Bay Municipal Utility District (EBMUD) completed a Fire Management Plan (FMP) for 28,000 acres of owned watershed lands in the East Bay. The goals of the FMP are protection of human life and property, providing for public safety, and protecting and enhancing water quality, other natural resources, and watershed land uses. The FMP employs strategic planning and GIS-based analysis to ensure that fire and fuels management activities support other resource management objectives, especially the protection of water quality and biodiversity. Pre and post project monitoring of planned fire hazard mitigation activities is routinely performed to assess and mitigate resource impacts. This information is subsequently used to modify annual plans and adjust future fire hazard mitigation activities. This paper reviews the methodology EBMUD used to develop the FMP including identification of existing watershed conditions; determination of values at risk including life and property, water quality and biodiversity; modeling fire behavior under different climatic conditions; and development of a strategy to support wildland fire suppression and protect values at risk. GIS was used to produce detailed maps that highlight sensitive watershed resources. These maps were developed into a stand-alone Fire Atlas that is distributed to fire agencies in advance of fire season to enhance pre-suppression planning and suppression activities.

Keywords: fuels management, fire management unit, fire modeling, GIS, Fire Atlas, biodiversity, water quality.

INTRODUCTION

The East Bay Municipal Utility District (EBMUD) owns and actively manages more than 28,000 acres of watershed land surrounding 5 reservoirs in the San Francisco East Bay area. The watershed vegetation typical for central, coastal California is a mixture of oak woodlands, grasslands and brushlands within a Mediterranean climate. For the past 30 years, EBMUD has supported a multi-use watershed management program that encompasses water quality, grazing, fire control, forestry, wildlife, fisheries and recreation. Management of fire and fuels, in particular, has been emphasized due to the range of effects uncontrolled fire can have on the watersheds. Traditional fire planning, especially near urban areas, focuses on fire hazard mitigation, attack strategies and public safety, however important environmental considerations such as water quality and biodiversity may not receive adequate analysis. Increasingly, water utilities owning protected watershed lands are adopting a broader resource management perspective and are including this in watershed management planning.

In 1996, EBMUD adopted the East Bay Watershed Master Plan (EBWMP), which established new policy for each management program and placed the highest priority on the management and protection of water quality and biodiversity (EBMUD 1996). It was essential that the plan recognized the importance of protecting biodiversity along with water quality, since healthy, functioning ecosystems support the production and storage of high quality water (Stebbins 1995). As an added benefit, the management of highly regulated threatened and endangered species could now be systematically addressed within other watershed management programs. The Fire Management Plan (FMP), which is the subject of this paper, was the next priority for development and implementation because of the potential for wildland fires to impact water quality and the biota as well as public safety and agency liability. This paper describes how EBMUD developed the FMP to support the agency goals of protecting water quality and biodiversity. The planning parameters and methodologies for identifying watershed conditions, strategic planning, implementation and monitoring are described.

PLANNING PARAMETERS

The planning process included several steps, which ensured that initial policy decisions were followed through to implementation. These steps provided coordination and review between different areas of professional responsibility; program objectives that supported water quality and biodiversity protection; a mechanism for adjusting management priorities to changing conditions; and specific fire management planning assumptions.

Interdisciplinary Coordination and Review Requirements

The EBWMP contains important policy language that **requires** analysis of resource impacts as a part of project planning. Specifically, the EBWMP states:

> *Required Coordination with Other Resource Management Professionals because this master plan addresses a wide range of programs and disciplines, it is intended that those who use it will consult with the appropriate professionals where protection of resources may be an issue. During the early planning stages of resource management activities and where such activities can be reasonably anticipated to have an impact on sensitive resources (including rare, threatened, or endangered species, aquatic resources, and Native American sites), District staff will seek technical input from the appropriate district, regulatory or consultant specialists. The information thus obtained will be incorporated into the plans for management activities and used to minimize resource impacts.*

In addition to the required coordination, each program addressed in the EBWMP cross-references important elements of other programs within the plan. This requires staff to examine the impacts of implementing one program on the adopted management direction for other programs. For example, if a small fuel break needs to be constructed within a watershed, then staff will systematically examine the potential for impacts to water quality, biodiversity, cultural resources and other important resource attributes and will develop measures that mitigate and monitor the impacts of fuel break construction. This process also satisfies the legal environmental review requirements for projects having environmental impacts under the California Environmental Quality Act (CEQA). The National Environmental Policy Act (NEPA) has a similar process for projects with a Federal nexus.

Program Objectives

The following are representative examples of the objectives of the Fire and Fuels Management Program. They are a matter of EBMUD policy and show how coordination requirements with other programs having different objectives are identified:

- Implement measures to reduce fire hazard to protect water quality from wildfire-related soil erosion, sedimentation, and nutrient impacts.

- Provide an appropriate level of fire protection for all watershed lands, emphasizing protection of life, public safety, and property values in interface areas.

- Use a strategic planning approach to fire management that ensures fire and fuels management activities are consistent with the objectives for other resources to the extent practicable.

- Recognize the importance of fire as a natural ecological process, and use prescribed burning and other techniques to reduce hazardous fuel loads under carefully selected conditions to achieve long-term fire safety, water quality protection and biodiversity management objectives.

Priority Gradient

EBWMP management programs were developed and implemented according to a "priority gradient." For example, the most intensive fire and fuels management normally occurs at the urban interface or around facilities where life and property values are the highest priority. Grazing, mowing, disking and other fire hazard mitigation activities that do not necessarily support biodiversity and water quality are most intense in these areas because it is critical to stop fires as soon as possible or prevent them altogether. As one moves from the urban interface toward the reservoirs and undeveloped interior of the watersheds, water quality and biodiversity management ascend as priorities and the intensive fire hazard mitigation activities mentioned above are replaced with light to moderate grazing. This level of management is the minimum required to prevent brush encroachment in grassland communities, but is far less intense than the grazing which would occur at the urban interface. The fencing of riparian corridors, ponds and reservoirs to establish managed buffers becomes a high priority activity in the interior of the watersheds because of the well-known benefits to both reservoir water quality and biodiversity.

Planning Assumptions

Extensive public and agency comments during the EBWMP process generated a list of assumptions that guided planning and development of the FMP and were incorporated into the computer database for the project (EBMUD):

1. It is not economically feasible or practical to treat all wildland fuels that occur on EBMUD watershed lands.

2. The potential for ignitions is highest near the urban interface, within the developed recreation areas, and along transportation corridors.

3. Fire hazard mitigation activities on EBMUD watershed lands should be focused at the urban interface.

4. High intensity wildland fire is the greatest threat to the protection of life, property, reservoir water quality and biological and cultural resources.

5. Preventing ignitions during periods of extreme fire weather is essential to protect the watersheds from high intensity wildland fires.

6. Strategic linking of existing natural barriers to wildland fire with planned fuel management zones and low-volume fuel areas, will increase the effectiveness of fire suppression efforts and minimize watershed impacts.

7. Variations in seasonal, daily or hourly local weather conditions represent the most significant factor in determining the potential for high intensity wildfire.

8. Fire management unit planning must be based on logical wildland fire control and containment features such as watershed boundaries and, especially, ridge tops. These features are also common to the management of water quality and biodiversity.

IDENTIFICATION OF WATERSHED CONDITIONS

An accurate analysis of watershed resources and conditions was the next major step in FMP development after the planning assumptions were determined. The parameters selected for analysis and modeling and the computer platform used to analyze the data are described below.

Geographic Information System

The FMP relied on Geographic Information System (GIS) technology for data development, storage and analysis. GIS technology is based on "overlay analysis" where mappable attributes (e.g. surficial hydrology, vegetation, soil type or topography) are viewed simultaneously, to create a range of different effects. ArcView® GIS was chosen since this same platform was also used to develop the EBWMP.

It was important to acquire accurate baseline data to conduct fire modeling. The following data were obtained to meet that objective: (1) Topography; (2) Aspect (slope orientation) included within topography; (3) Fuels inventory; (4) Fire risk; (5) Values threatened; and (6) Weather.

The watershed land owned by EBMUD is predominantly undeveloped openspace. New, orthorectified, 1:9600 (or 1" = 800') scale black-and-white aerial photography of the watersheds was obtained to construct a digital elevation model (DEM) that accurately represents the elevation, slope (steepness) and aspect (compass orientation) of the landform. Vegetation coverage was developed and "ground-truthed" to verify plant community classifications for use in fuel modeling (EBMUD 1994). Sixty (60) cover types were identified and mapped. This level of detail was needed to define fuel types, delineate sensitive species habitat, and accurately depict watercourses leading to the reservoirs.

Topography

Topography is a key determinant of fire behavior and includes slope, aspect, elevation and configuration or "lay of the land" (Teie 1994). Slope affects the spread of fire by preheating the fuels and by creating a draft effect, similar to a chimney. In general, fires proceed uphill faster than they proceed downhill, so it is important to model watershed "steepness". Five slope categories were used to describe the watersheds: 0% - 5%; 5% -15%; 15%- 25%; 25% -35%, and >35%. Because fires on slopes ≥ 35% are extremely difficult to manage, these areas were mapped and later combined with other fire behavior parameters (Figure 1).

Aspect or the direction a slope faces affects the spread of fire by influencing temperature, humidity and vegetation type. South-facing slopes, which have the greatest exposure to the heating effects of the sun, are much hotter and drier than shaded north facing slopes. Thus, south-facing slopes tend to support grassland or brushland communities, which are classified as light to medium fuels, whereas north-facing slopes tend to support woodland communities, which are classified as heavy fuels. In central California, prevailing winds carrying marine air come from the south, southwest or west and "align" with the corresponding aspect that supports the growth of light and medium fuels. *Normal fire behavior* is expected under these conditions. However, when the winds carrying dry continental air from the north, northeast or east align with the corresponding aspect that supports heavy fuels, *extreme fire behavior* can occur because these heavier fuels are now able to burn. To understand and identify how alignment of aspect and wind direction influences fire behavior on the watersheds, eight aspects were modeled: N, NE, E, SE, S, SW, W, and NW. A comparison between north, northeast and east aspects and south, southwest and west aspects are shown for one planning area (Figure 2).

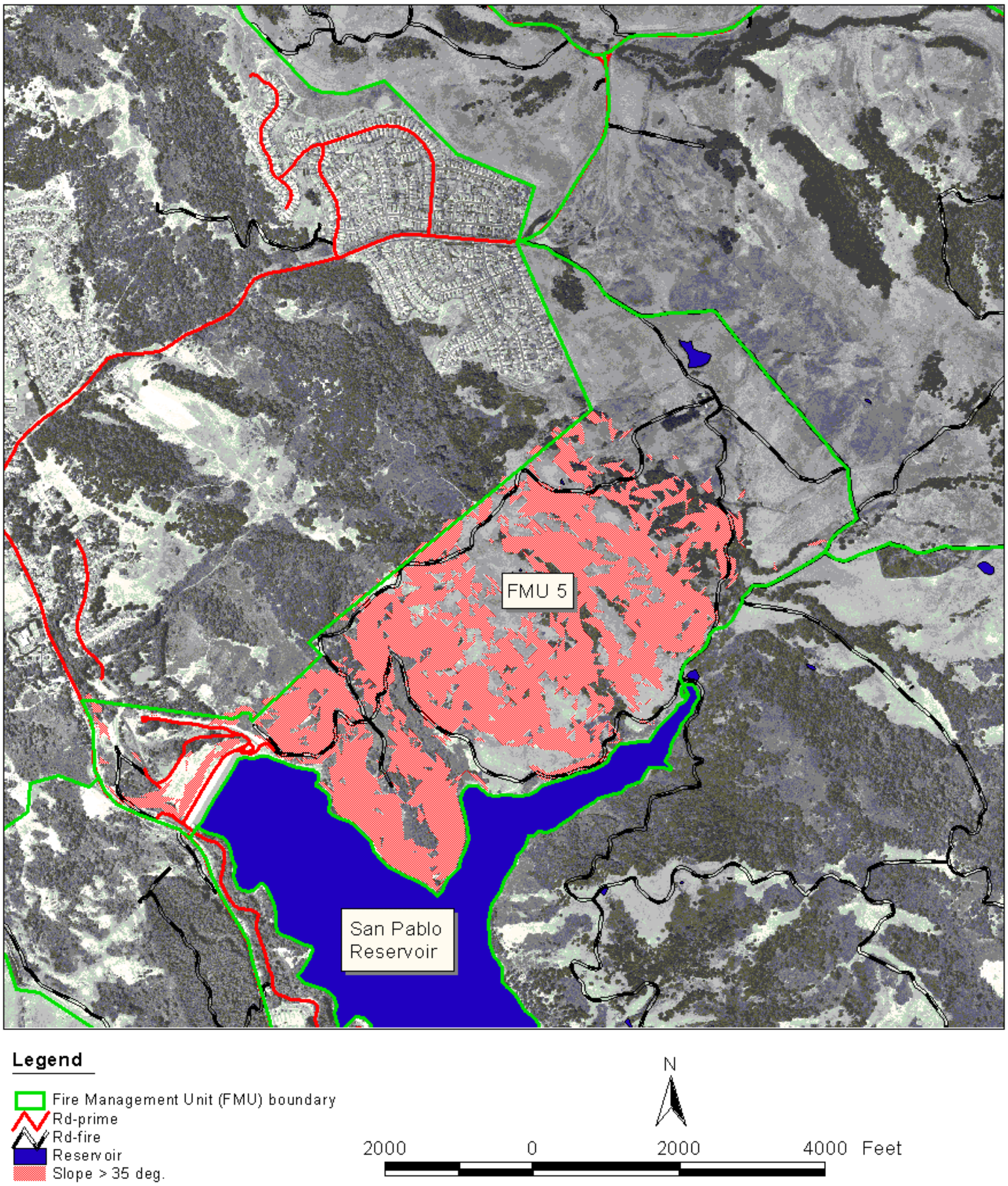


Figure 1

Slopes greater than and equal to 35 degrees.

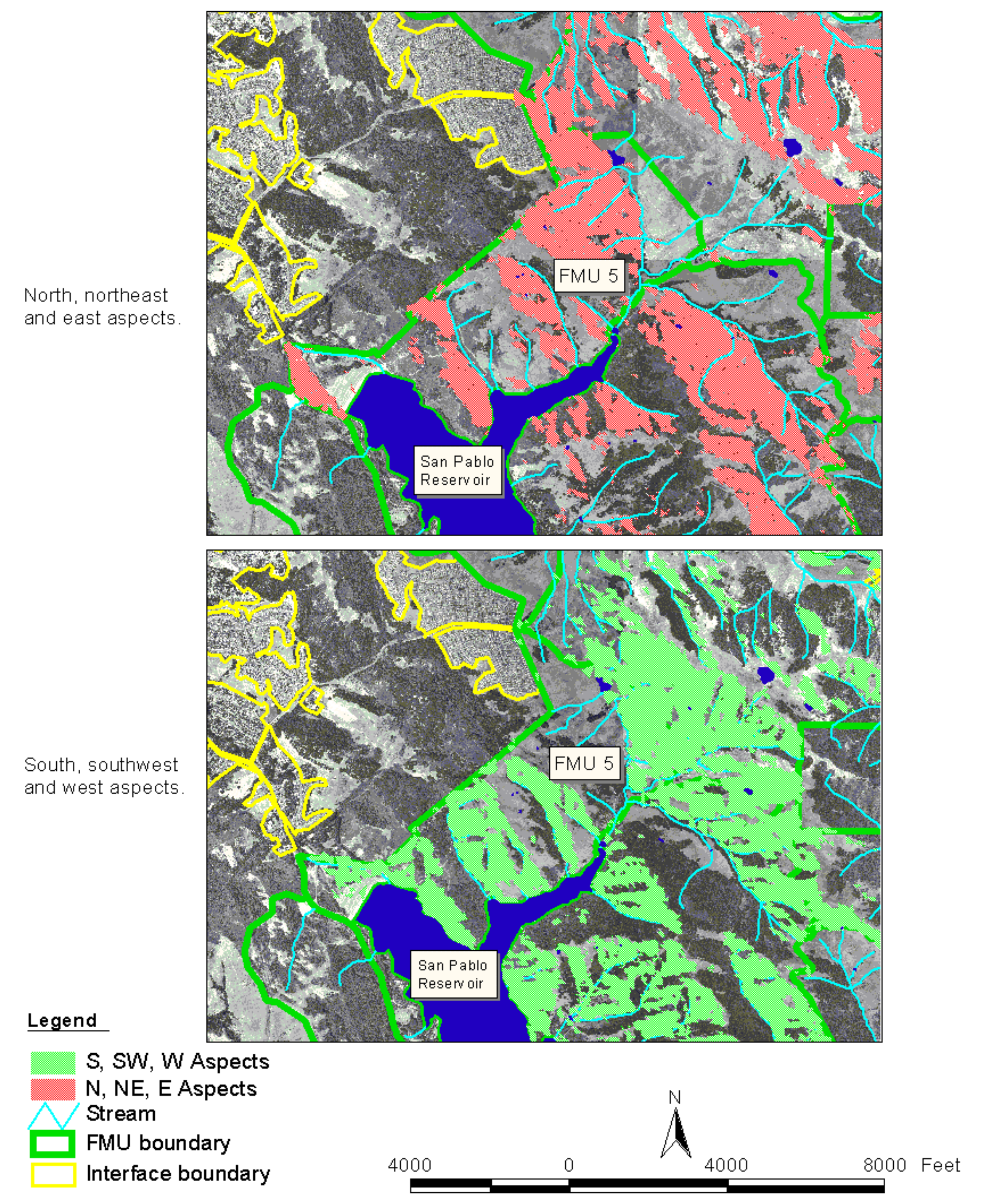


Figure 2
Modeled hillside aspects for FMU 5.
(north, northeast, and east aspects - red;
south, southwest and west aspects - green)

Fuels

Fuel categories were derived directly from the GIS coverage for vegetation types (plant communities). The 60 vegetation (cover) types were aggregated and assigned within 13 classification categories described in the National Forest Fire Laboratory fire behavior fuel model system. These data, in combination with slope and aspect, were the basis for constructing a Fire Hazard Model and are compatible with both the BEHAVE Fire Behavior Prediction and Fuel Modeling System and the $FARSITE_{TM}$ Fire Simulator (Figure 3).

Weather

Weather is the variable in fire behavior modeling, changing with the season, day, and hour of the day. The effect of weather on vegetation is monitored by recording changes in live fuel moisture, dead fuel moisture and fuel temperature. Fire modeling for the FMP was based on 90^{th} percentile weather conditions that incorporate the typical daily and hourly range when fire behavior is a significant concern. To develop the FMP, three (3) climatic cycles were used:

- *Early Fire Season Weather* – Growth of vegetation is rapid; live fuel moisture decreases as the dry season progresses.

- *Normal Fire Season Weather* – Growth of vegetation has ceased; live fuel moisture cycles in response to alternating high temperatures and cooling, fog-laden summer breezes.

- *Late Fire Season Weather* – Live fuel moisture in heavy fuels plummets in response to strong dry east-northeast winds creating extreme fire weather.

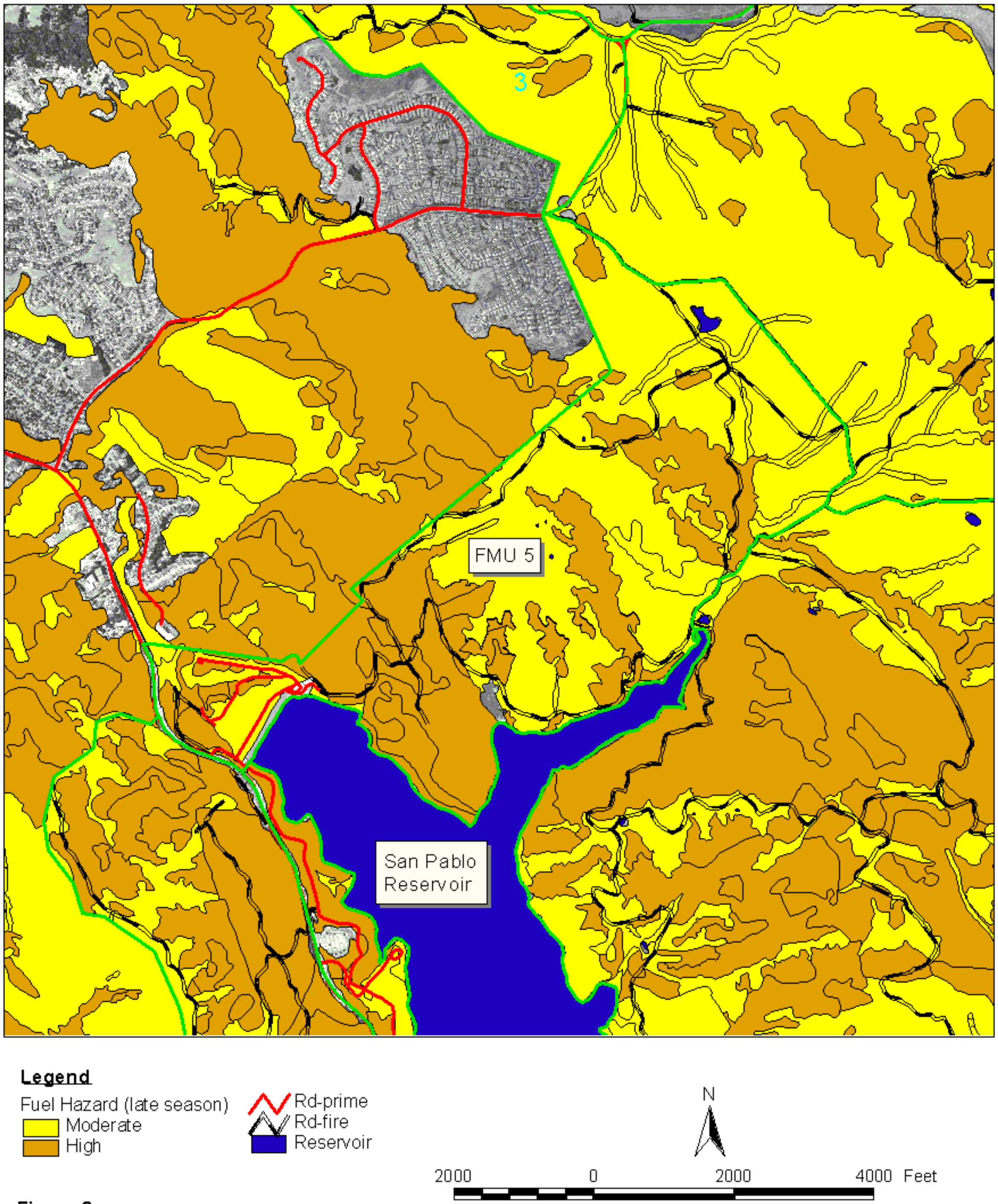
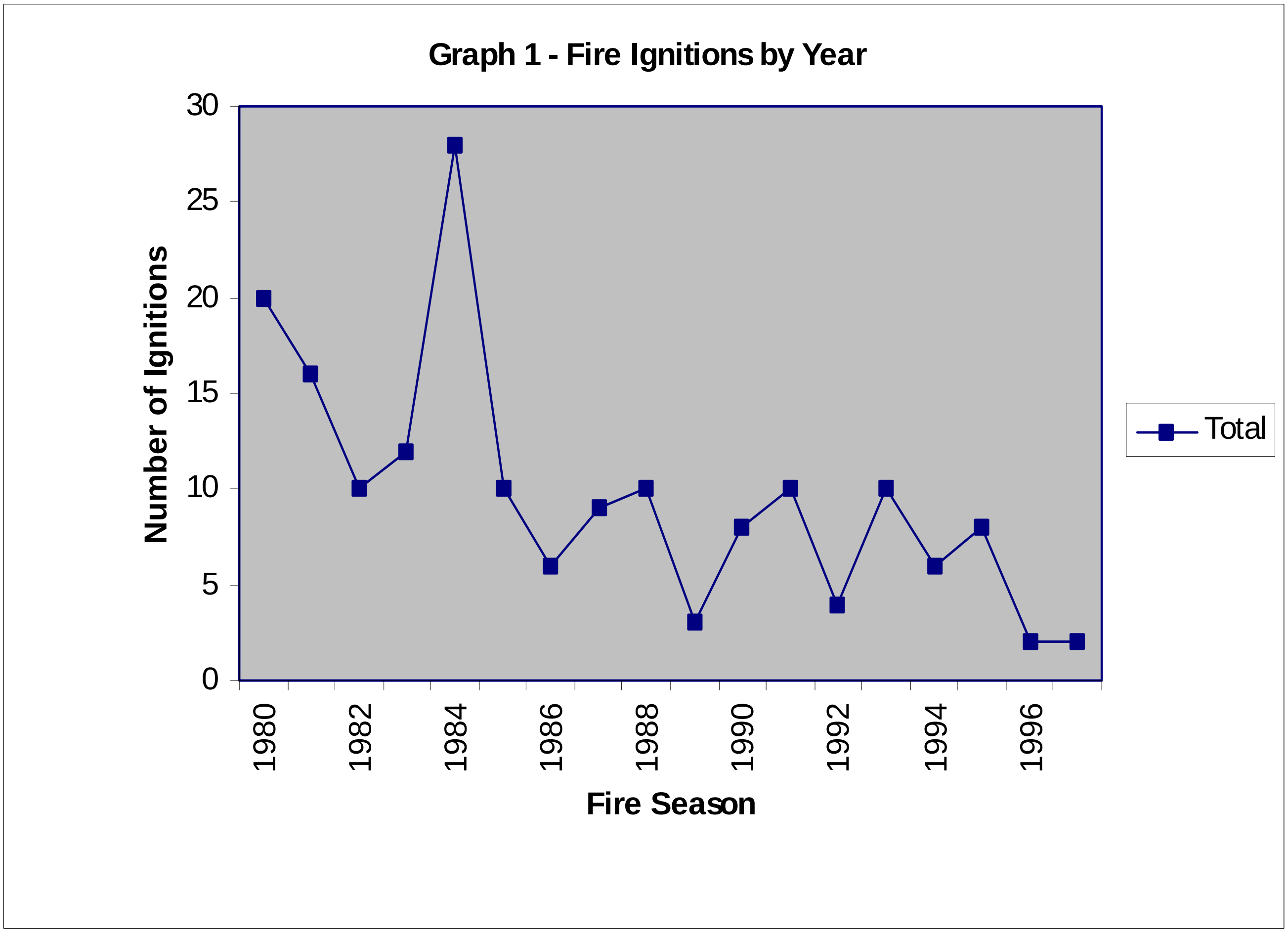


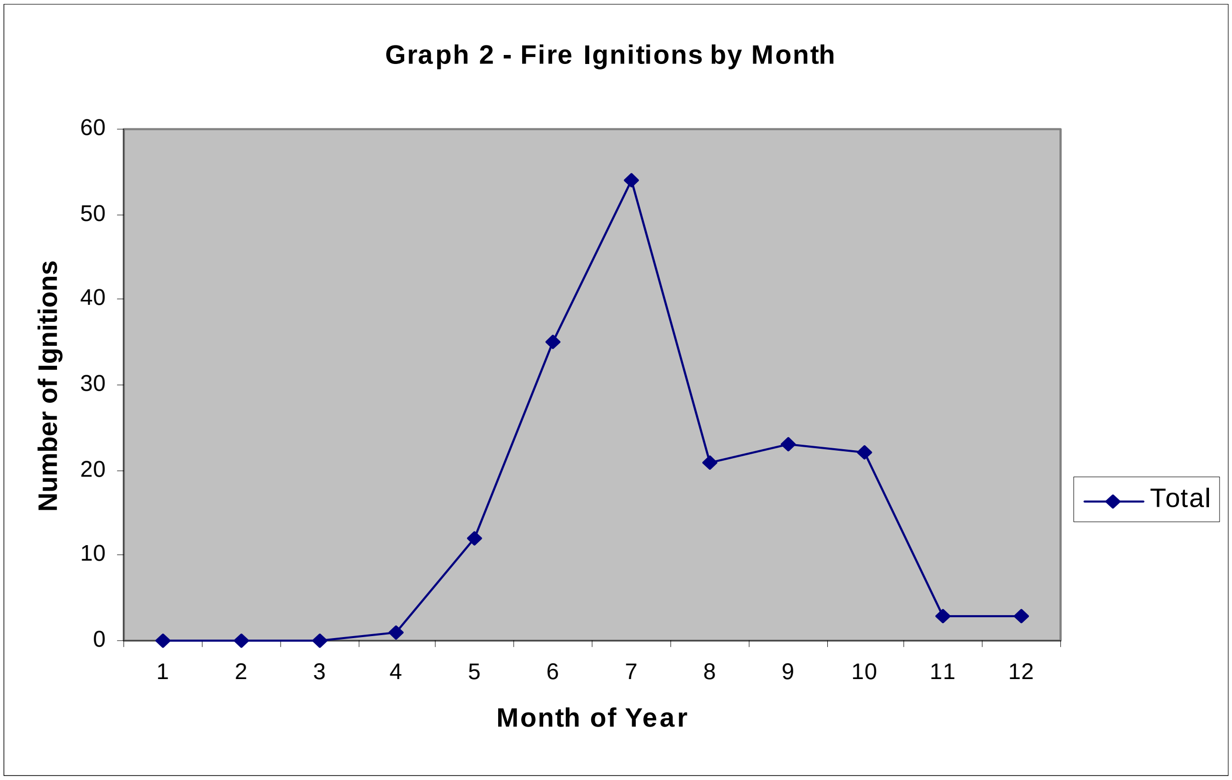
Figure 3

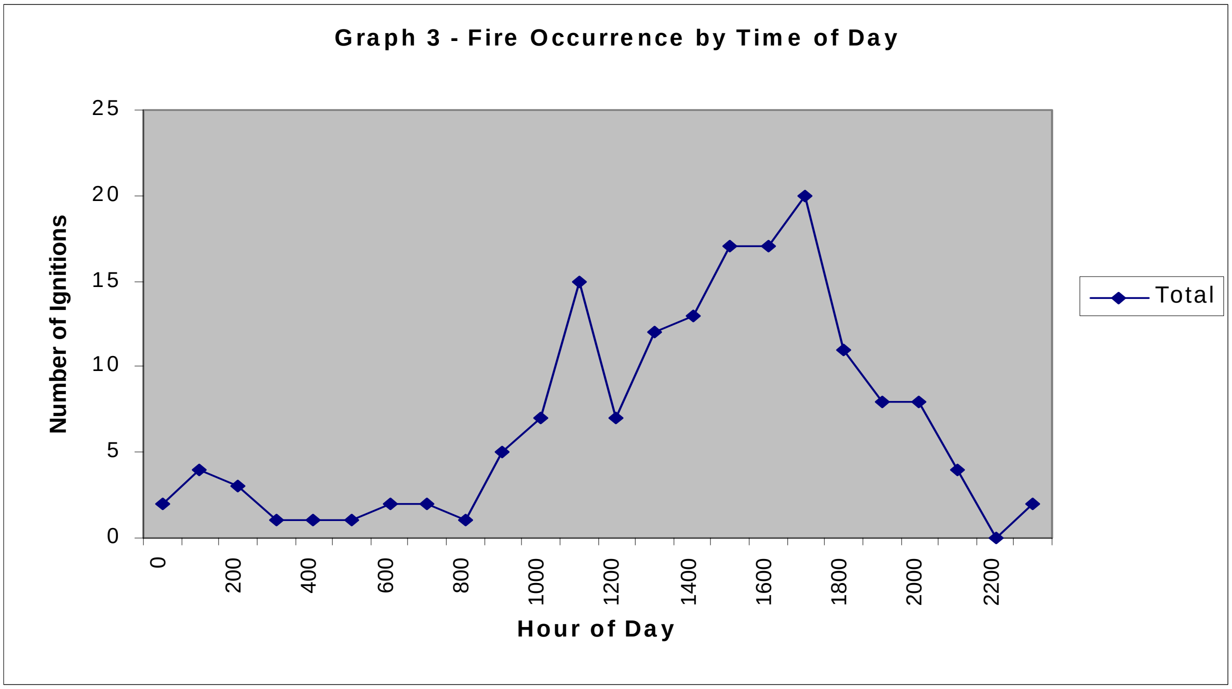
Fuel Hazard - Late Season (FMU 5)
Vegetation data classified by fuel hazard during Late Season (September - October)

Fire Risk

Fire reports for the past 20 years were compiled to characterize how, when, and where fires on the watersheds tend to occur. The causative agents, locations, days of the week and times of the day were charted and graphed to understand options for implementing fire hazard mitigation activities and deploying fire suppression resources (Graphs 1,2,3).




Graph 2 - Fire Ignitions by Month
Number of Ignitions
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
Month of Year
Total


Graph 3 - Fire Occurrence by Time of Day
Number of Ignitions
25
20
15
10
5
0
0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
Hour of Day
Total

Assessment of Potential Fire Behavior

By performing overlay analysis of fuel hazard (vegetation), slope and aspect, fire behavior can be modeled during different seasons. As previously described under Weather, three weather patterns were considered for modeling: *Early Fire Season Weather, Normal Fire Season Weather* and *Late Fire Season Weather*. A comparison of fuel hazard, slope and aspect under both *Normal Fire Season Weather* and *Late Fire Season Weather* conditions in a single management area clearly shows the change that occurs in the San Francisco East Bay Area when cool, moisture laden, on-shore breezes are replaced by hot, dry off-shore winds (Figure 4). The results of this particular analysis are critical for determining the location, method and extent of fire hazard mitigation activities and the strategic options for suppressing an active fire. Among these options is that of letting a fire "burn-out" in certain areas. The presence of nearby features that would stop a fire, such as rock outcrops or large expanses of lawn, give fire managers the opportunity to let a fire burn itself out, but only where other values-at-risk are not threatened and where the time required for "mop-up" would be reduced. This is a strategic action intended to achieve containment in the short term and should not be confused with a "let-burn" policy.

Values Threatened

Development of the FMP required identification and prioritization of those social and environmental "values" that are being protected. This value identification was a key step in developing the FMP and reflects the EBMUD Mission Statement, agency core values and management priorities. The values, in priority order, determined for the EBMUD FMP are:

- WATER QUALITY - The effects of wildland fire on water quality are well described and include increased turbidity and sedimentation, increased concentration of nutrients in surface runoff and increased watercourse temperatures (USFWS 1999a). These effects are dependent on the size of the fire; the amount and extent of vegetation cover loss, soil type, topography and proximity to the reservoir or major stream. A GIS coverage was developed from recent soil surveys and topographic data to identify areas of "High" and "Extremely High" erosion potential (Figure 5).

  Combining these data with vegetation data according to specific criteria enabled the delineation of water quality vulnerability zones (Table 1). The water quality vulnerability zones were subsequently used to identify constraints on fire hazard mitigation and fire suppression activities.

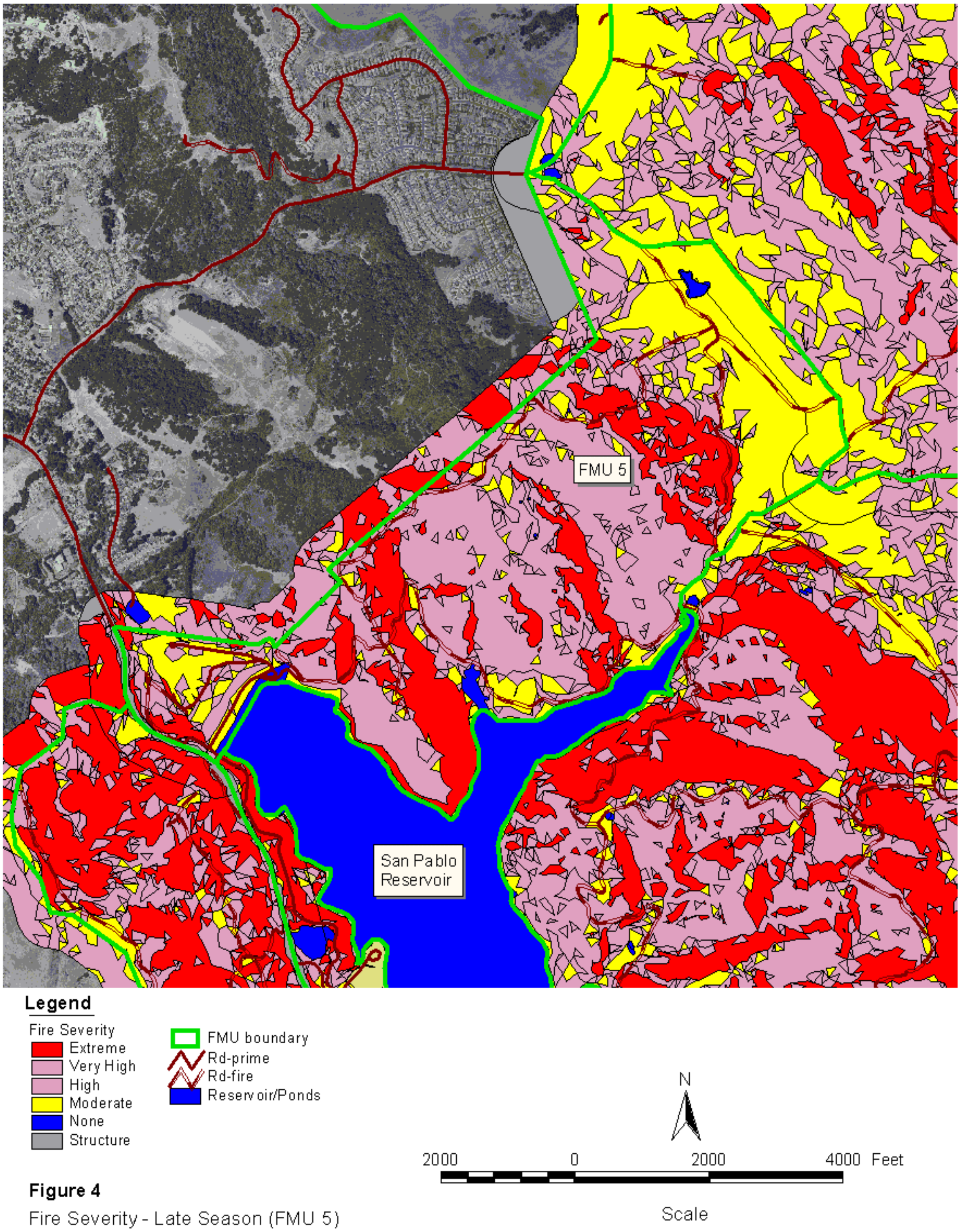


Figure 4

Fire Severity - Late Season (FMU 5)
Modeled from fuel hazard, slope and aspect
during Late Season (September - October).

Table 1			
Preliminary Criteria for Defining Water Quality Vulnerability Zones For Grazing and Fire Management			
Microorganisms			
GIS Parameter	**High**	**Medium**	**Low**
Soils	clay	loam	sand and bigger
Vegetation	forested areas	woodland, scrub, chaparral	grassland
Slope	>30%	15 to 20%	<15%
Proximity to Water	<300 feet	None	>300 feet
Particulates			
Soils	clay, clay loam, silty clay loam	loam, sandy loam, gravelly loam, silty loam	sand/gravel, loamy sand, rocks, outcroppings
Vegetation	grassland	woodland, scrub, chaparral	forested areas
Slope	>30%	15 to 20%	<15%
Proximity to water	<300 feet	None	>300 feet

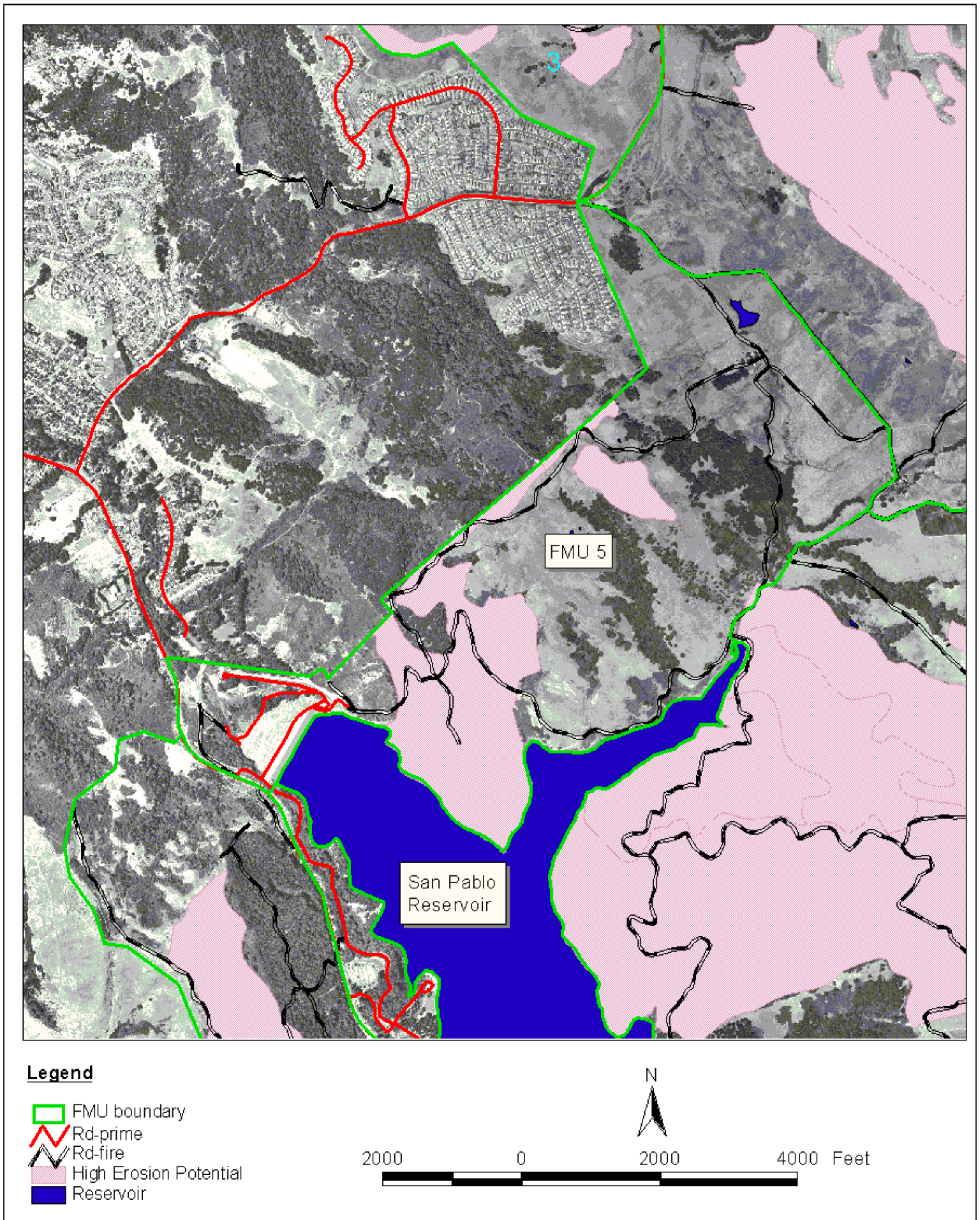


Figure 5

Areas of high potential soil erosion.

- BIODIVERSITY - The effects of wildland fire on biodiversity are complex and depend on the subtle ecological relationships of flora and fauna and how fire may influence those relationships through effects on food, cover, water and space (USFWS 1999b). Data describing vegetation communities, occurrence of common, rare, threatened and endangered species, sensitive habitats including riparian areas, ponds and springs, were obtained using established methodologies (Stebbins 1996). These data were used to identify constraints on fire hazard mitigation and fire suppression activities. They were also used to identify sensitive habitats and riparian/shoreline sensitivity zones (Figure 6).

- LIFE AND PROPERTY - Threats to human life and property and protection of public safety were identified by mapping historical ignition patterns, location of residential developments and facilities, vegetation type, topography and barriers to the spread of fire. This allowed staff planners to establish the relative exposure to fire of the developed portions of the watershed.

- PHYSICAL AND CULTURAL RESOURCES - Physical and cultural resources previously inventoried, were included as a GIS coverage that established additional constraints on planning and implementing mitigation and suppression activities. Due to their protected legal status under the Native American Graves Protection and Repatriation Act (NAGPRA), cultural resources associated with previous Native Americans historical sites were shown as exclusion zones without attribution or reference.

- GENERAL WATERSHED USES - Existing uses of the watersheds such as Christmas tree and oat hay farms, corrals, sports fields or staging areas for recreational trails were mapped and combined with other land use data to support decisions on fire hazard mitigation and fire suppression activities.

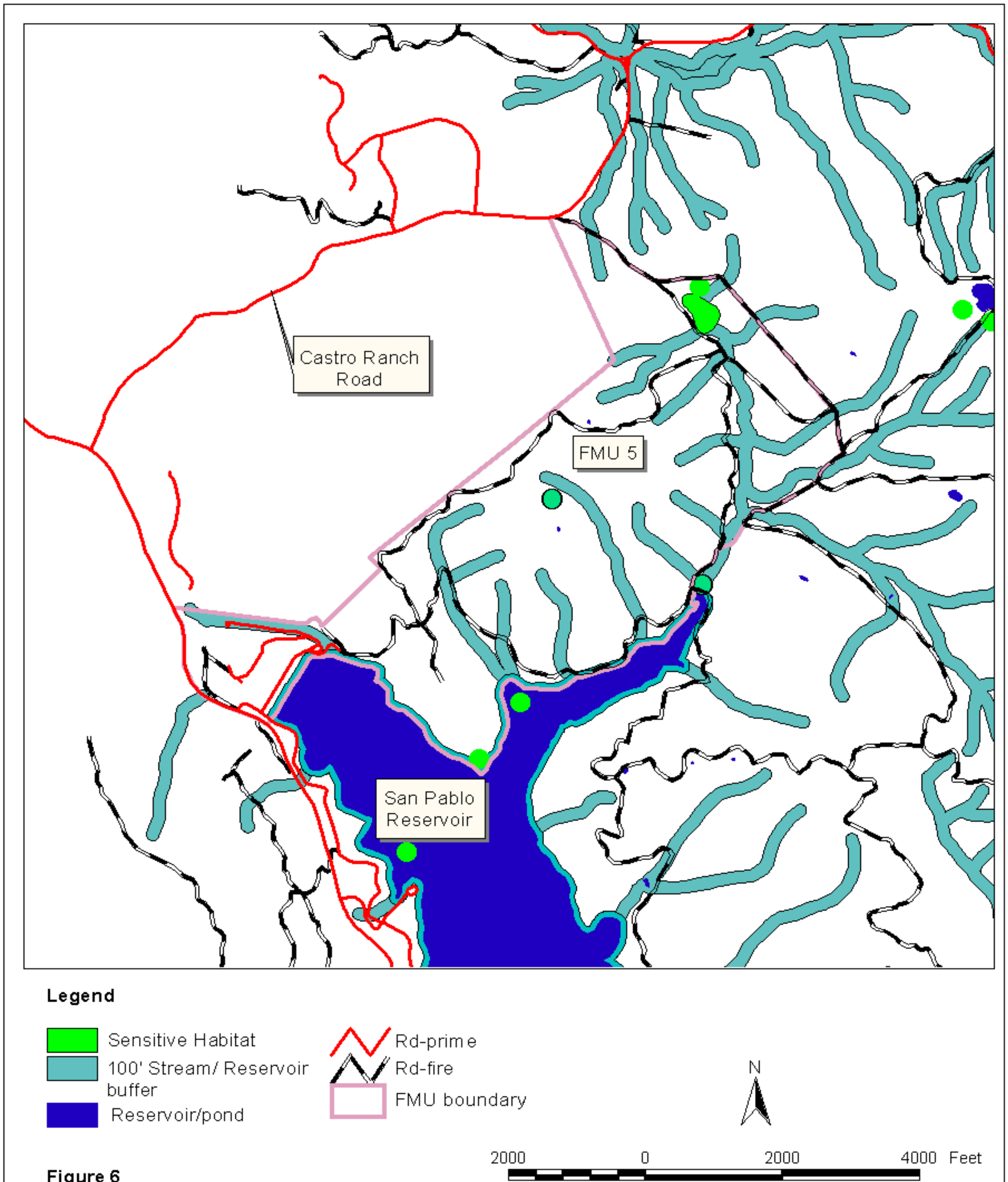


Figure 6

Sensitive Habitats & Riparian Protection (Threatened and Endangered Species)

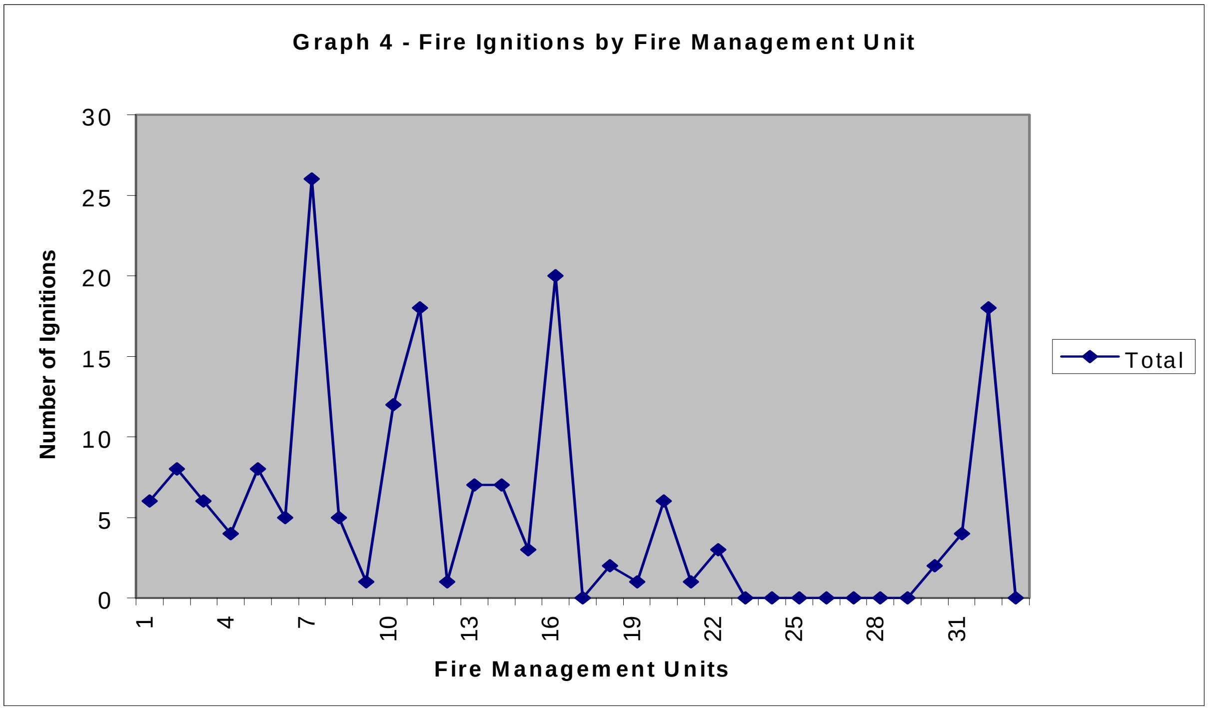
STRATEGIC PLANNING

Fire planning for the FMP utilized strategic, fire-resistant features of the landscape to support fire containment. A variety of vegetation management methods were then used to link these fire resistant features to enhance capabilities in limiting fire size.

Fire Management Units

To provide a manageable context for planning and implementation of both fire hazard mitigation and suppression activities, the watersheds were subdivided in to 33 compartments referred to as Fire Management Units or FMU's (Figures 7, 8). Each FMU is a homogeneous wildland fire planning zone with similar vegetation, defensible, natural or man-made boundaries, topographic features, expected fire behavior and values-at-risk. It was particularly important to understand relative occurrence of fires among the FMU's to appropriately allocate fire hazard mitigation efforts (Graph 4).

All planning assumed containment of wildland fire within the FMU of origin to minimize both environmental impacts and suppression and rehabilitation costs. The following criteria were used to define FMU boundaries: (1) Basin or sub-basin boundary, (2) Significant topographic features (i.e. ridge tops, drainage bottoms), (3) Natural or man-made wildland fire, (4) barriers (i.e. reservoirs, dams, greenbelts, riparian vegetation), (5) Strategically located roads and other drivable ridge tops, (6) Existing fuel breaks, (7) Changes in slope aspect, (8) Major changes in vegetation type (corresponding to fuel model), (9) Values-at-risk (i.e. water quality, biodiversity, land use).



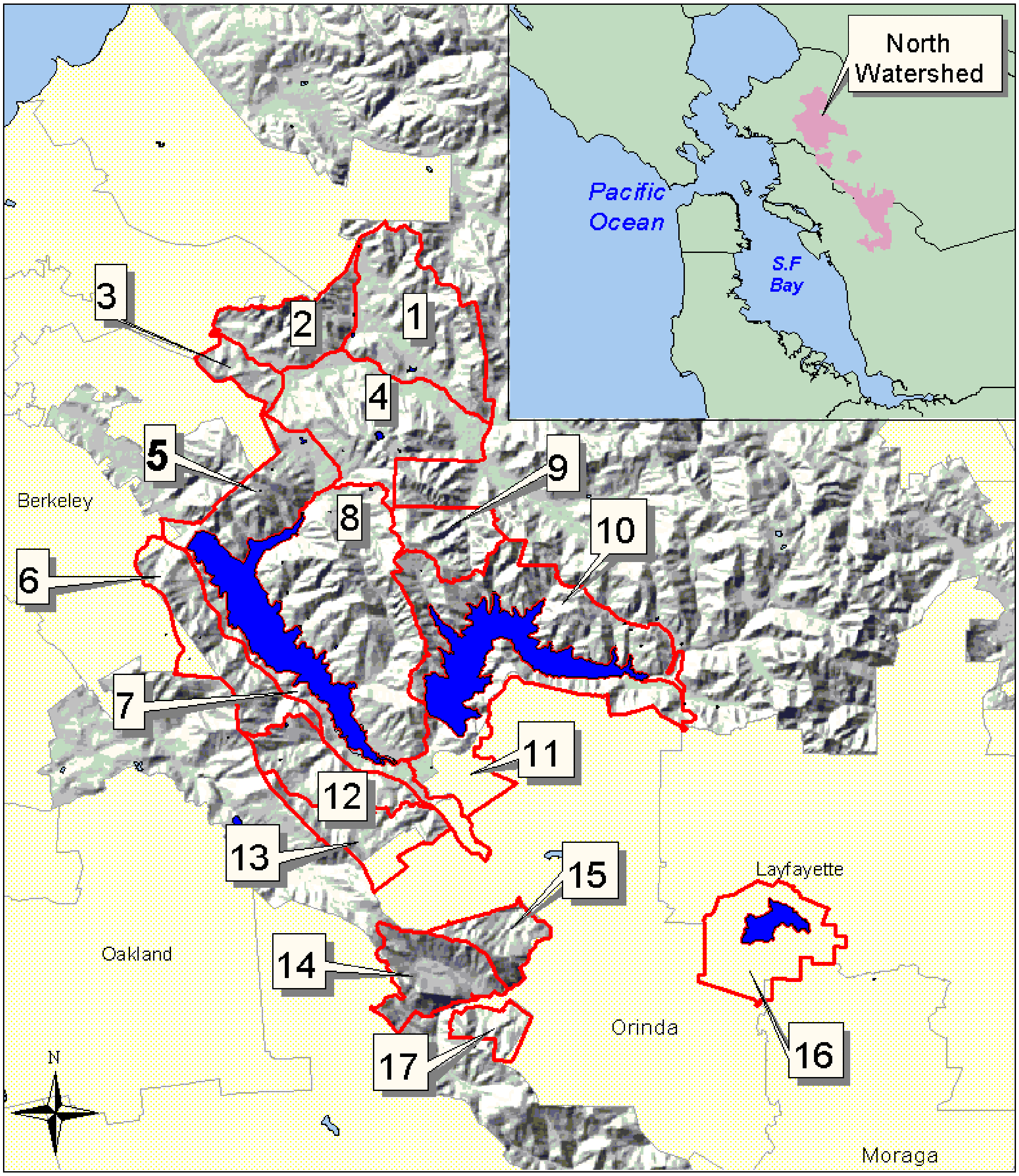


Figure 7

Location map showing East Bay Municipal Utility District North Watershed, Fire Management Units (FMU). FMU boundaries (red) shown on shaded relief map of East Bay. Adjacent urban areas are shown in yellow (stipple).

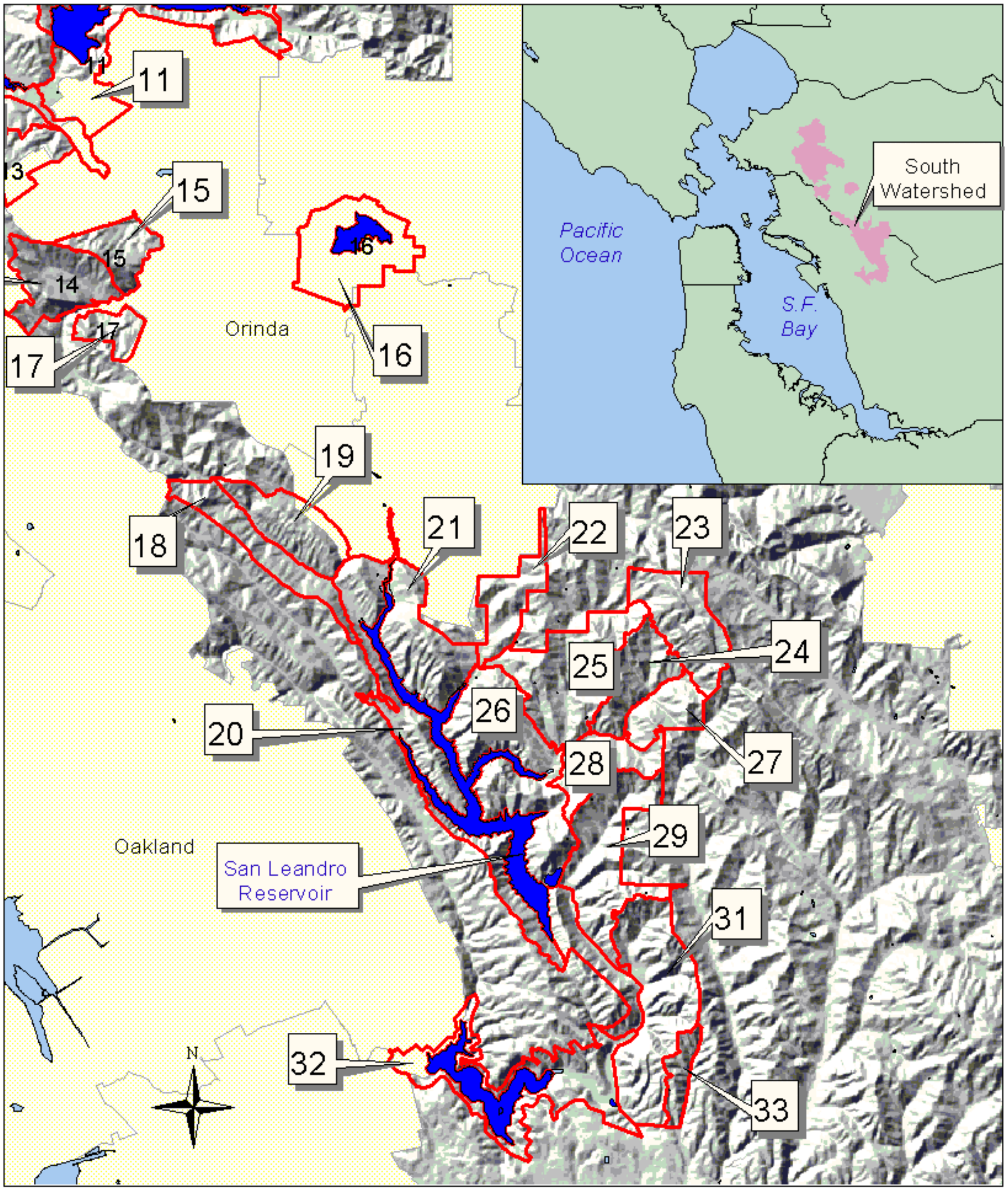


Figure 8

Location map showing East Bay Municipal Utility District South Watershed, Fire Management Units (FMU). FMU boundaries (red) shown on shaded relief map of East Bay. Adjacent urban areas are shown in yellow (stipple).

Strategic Fuel Modification Network

A strategic approach was used to minimize natural resources impacts from fire suppression and hazard mitigation activities. In areas containing values-at-risk and requiring the maximum level of fire protection, vegetation treatments were linked with natural wildfire barriers (i.e. reservoirs, greenbelts, etc.) to create a "strategic fuel modification network". This is a critical step in developing a wildland fire protection strategy and it requires an excellent working knowledge of the area. By linking these fire resistant landscape features, enhanced fire protection is achieved with minimal impacts to watershed soils, vegetation or the reservoirs, from suppression related activities.

Integrated Vegetation Management

A number of vegetation management methods are available to control vegetation and establish linkages between natural barriers. The EBMUD Fire and Fuels Management Program utilizes cattle, horse, and goat grazing, horse logging, disking, prescribed fire, mowing and brush raking. The method selected depends upon proximity to reservoirs, riparian areas and sensitive habitats, vegetation type, treatment area size, schedule, soils stability, season and cost. In an average year, these methods are used in selected areas. The treated areas are mapped and incorporated into the GIS database (Figure 9).

A Global Positioning System (GPS) receiver is used in the field to accurately record data, such as the dimensions of hazard mitigation projects. The data is directly downloaded and incorporated into the GIS. Overlay analysis is used to (1) identify areas where treatment is needed and (2) help the manager design the appropriate abatement program based on existing site and environmental conditions. Planning for both fire suppression and mitigation is supported by the same GIS coverages.

IMPLEMENTATION

The Fire Management Planning process has two key products: the GIS database and the Fire Atlas.

GIS Database

Most data sets that populate the GIS have already been described. They are intended for individual use or in overlay analysis to perform multi-disciplinary project planning. It is essential that the databases be maintained so that new information such as species locations, regulatory requirements, fire hazard mitigation projects or new residential developments is up to date. The GIS database thereby becomes an "organizational memory" and helps assure consistent application of management direction and policy. The data can also be transferred to a laptop computer for use by staff in the field. This application of computer technology is particularly useful on larger fires where more time is available to develop suppression strategies and tactics.

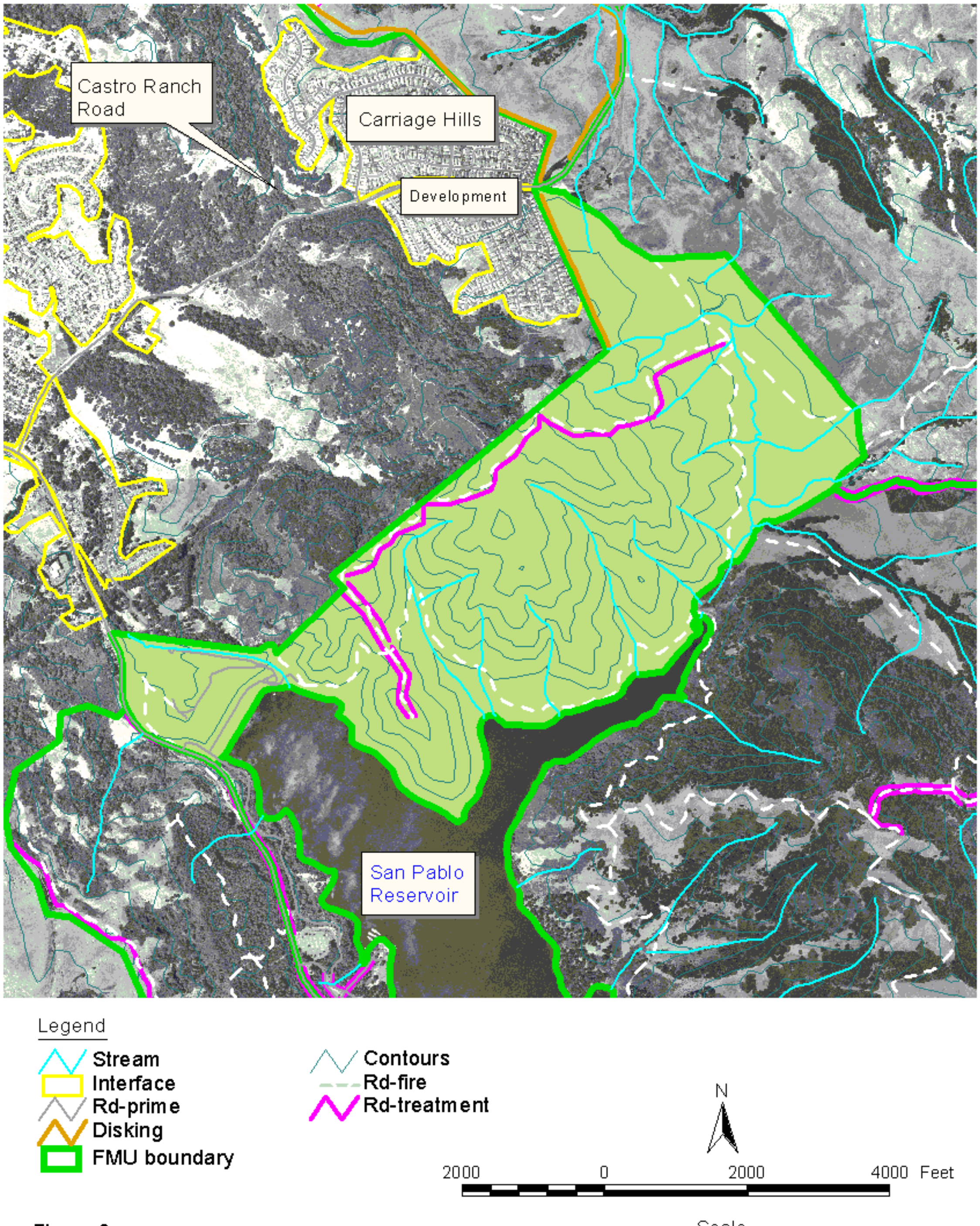
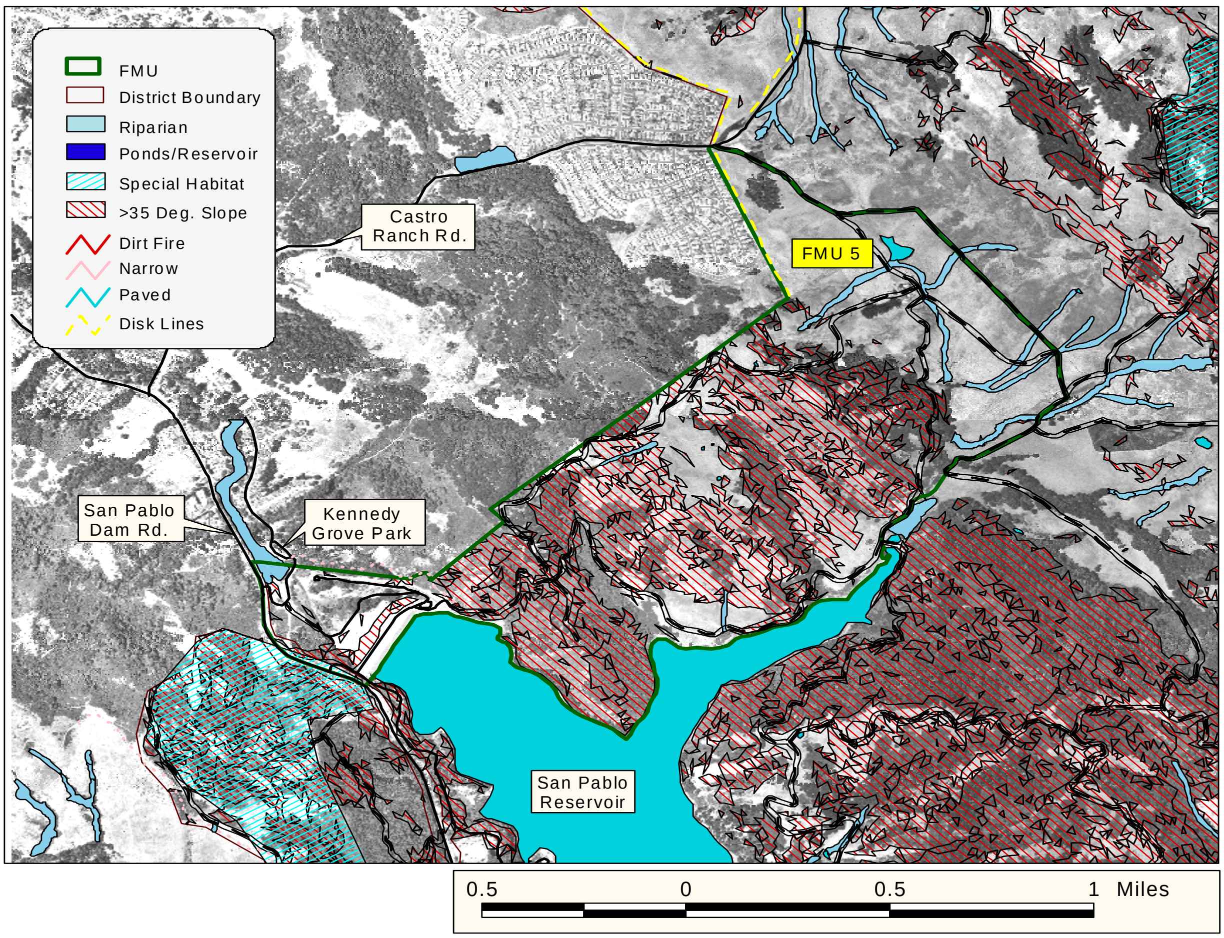


Figure 9

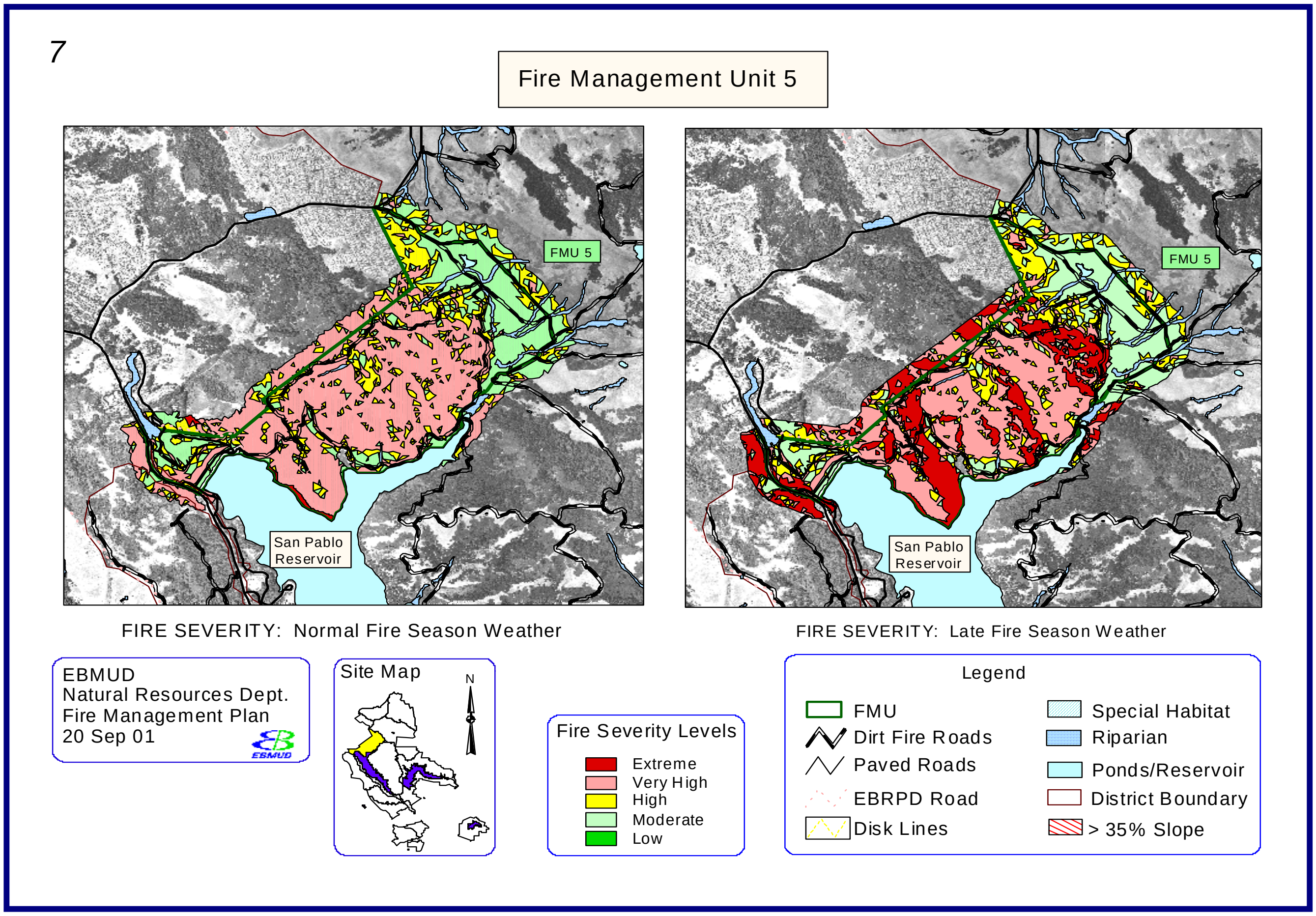
Example of fire abatement methods in Fire Management Unit 5.
Note proximity to urban interface zone (in yellow)

Fire Atlas

The Fire Atlas synthesizes the GIS overlay analyses that identified the opportunities and constraints for fire suppression and hazard mitigation activities. It contains 3 maps for each of the 33 FMU's. The first of the three maps, referred to as the Fire Atlas Locator Map (Figure 10 below), depicts the following; (1) Vulnerability zones for water quality, including riparian areas and reservoir shores, (2) Vulnerability zones for biodiversity, including endangered species and sensitive habitats, (3) Fire Hazard Mitigation measures, (4) Areas of high fire danger, (5) Water sources, (6) Fire Roads, (7) FMU boundaries.



The second and third maps, which appear reduced on a single page, compare fire severity during Normal Fire Season Weather and Late Fire Season Weather (Figure 11, below).



The Fire Atlas serves two main functions. First, EBMUD watershed field personnel use it for project planning and reference during normal work activities and in responding to fires. Second, it is shared with all of the local fire agencies to support pre-suppression and on-scene planning. Each fire agency is provided with a copy for their review (for pre-suppression planning) and subsequent use during actual wildland fire events. This approach helps EBMUD inform fire agencies about areas that may be of particular concern due to water quality or biological vulnerability before a fire happens. It also makes the same information available during a fire so fire personnel can take these constraints into account when making informed decisions about the use of bulldozers to construct fire line or aerial tankers to apply fire retardant.

MONITORING

Watershed areas are monitored before and after planned fire hazard mitigation projects and after the suppression of (unplanned) wildland fires. Monitoring is the key to adaptive management of natural resources and enables program changes to be implemented in response to measured results.

Pre-Project Monitoring

Prior to implementing land management activities that are "reasonably anticipated to have an impact on sensitive resources" (EBMUD 1996), the site will be monitored to identify sensitive water, biological or cultural resources. Staff biologists will examine the impact of the proposed project on rare, threatened or endangered species and on sensitive habitats. If necessary, a contract archaeologist will review the project site to determine if there is evidence of previous Native American habitation. Staff will review erosion potential and appropriate erosion control measures will be implemented. This level of review is systematically conducted before starting work on prescribed fires, fuel breaks, annual grazing plans, including high intensity grazing with goats, and disk lines. The results of the resource analyses will be used to adjust the project parameters to mitigate potentially deleterious impacts.

Post-Project Monitoring and Adaptive Management

Fire hazard mitigation projects are monitored upon completion and, generally, two or more seasons beyond that to record impacts such as changes in plant species composition and percent cover, animal species diversity, geomorphologic changes to drainages, soil erosion and sediment deposition. These data are then used to adjust the season and intensity and methods for a given activity or to focus rehabilitation efforts after a wildland fire.

Data from ongoing water quality monitoring in the reservoirs is also used to understand the impact of program changes over long periods of time and to make adjustments to the program in response to the data.

CONCLUSION

By developing a GIS-based Fire Management Plan, EBMUD has created a dynamic analytical tool that integrates wildfire management, resource management sensitivities, and watershed management objectives to achieve protection of water quality and biodiversity. GIS technology provides a mechanism for long-term acquisition and storage of important resource information and it enables consistent application of that information for resource management. Subsequent monitoring provides valuable feedback and supports adaptive management to maximize resource protection. This same approach, using much of the same data, can also be used to plan and implement other watershed management programs such as livestock grazing, forestry and recreation.

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VEGETATION MANAGEMENT AND THE ALAMEDA WHIPSNAKE: PLANNING AND IMPLEMENTING A FUELS MODIFICATION PROJECT IN CRITICAL HABITAT

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ABSTRACT

Threatened and endangered species add complexity and costs to the treatment of fuels. In the case of the Mallory Ridge Project it is the Alameda whipsnake *Masticophis lateralis euryxanthus*. Mallory Ridge is the only fire-defensible ridge in Los Vaqueros Watershed separating the reservoir from homes along Morgan Territory Road nearly 1,500 feet above the reservoir. State and local fire agency personnel were consulted in 1998 by watershed staff to develop a strategy to mitigate the increased fire risks of public recreation and to treat the key ridge and adjacent area to aid suppression of a wildfire ignition in this area. The strategy includes construction of a fuel break along the spine of the narrow ridge followed in five successive years by prescribed burning below the ridge.

This project also includes pre-treatment survey protocols established by the USFWS for monitoring for the snake before, during, and after fuel break construction and the burning of piles. Surveys were conducted in the spring and early fall 2001 in advance of treating the first unit in winter 2002. Preliminary surveys indicate that the Alameda whipsnake thrives within and adjacent to the project area as does its base food prey, the western fence lizard (*Sceloporus occidentalis)* Past studies and recent monitoring of low intensity grassland burning on another project indicate that the fence lizard was adept at moving away from active fire activity and re-occupied burn areas immediately after burning was completed. Based on this, it is expected that prescribed burns can be conducted and will result in only incidental "take" of the Alameda whipsnake while improving its habitat. The results of the current vegetation treatment activities and associated studies will be used to guide the resource, fire, and other agencies in the development of management practices for vegetation management treatments, including prescribed burn plans, to be applied on other projects that contain critical habitat of the Alameda whipsnake.

KEY WORDS: vegetation treatment, Alameda whipsnake, western fence lizard, water quality, Los Vaqueros Watershed, Mallory Ridge

INTRODUCTION

The protection and management of Los Vaqueros Watershed is guided by a management plan that integrates the multiple purposes for which it was created. The purpose of the Los

Vaqueros Resource Management Plan (Brady-LSA 1999) is to protect and manage the natural, cultural, and recreational resources of the watershed with an emphasis on protection of the quality of the drinking water stored in the Los Vaqueros Reservoir developed by the Contra Costa Water District in the 1990's. An uncontrolled and catastrophic wildfire would significantly compromise these purposes. The Big Valley Fire of 1967 consumed a major portion of the north side of Mallory Ridge. The fire occurred between July 22 and July 24 and burned 1,775 acres. It was driven by winds reported at up to 30 miles per hour. The fire was contained on the third day by 300 firefighters assisted by 8 air tankers. It was started by equipment welding. No homes or other structures were lost, but significant damage was done to the steep slopes of the watershed directly above the area now occupied by the Los Vaqueros Reservoir.

A fire management plan is included in the Resource Management Plan. The primary objectives of the plan are the protection of public safety, property values, water quality, resource values, and the investments made by the District in the development of the Los Vaqueros Project. The project cost $450 million to develop, including over $100 million for watershed land acquisition. Environmental mitigation costs associated with the project exceed $5 million and include 470 acres of oak replacement plantations, 60 acres of developed wetlands, and protections for 90 ponds and 25 miles of riparian corridors. The District spends over $500,000 annually to monitor the growth and success of these mitigation areas. A catastrophic fire causing damage within these areas would be a significant set-back for the project's environmental mitigation program. In addition to the adverse effects on the drinking water supply, such a fire would adversely affect the habitats of the various protected species, both plant and animal, which are the subject of the project's environmental mitigation program. The myriad of fire protection activities conducted, including the development and maintenance of fuel breaks and on-site fire preparedness and suppression, also protect the cultural resources that occur within the watershed by directing wildfires away from highly sensitive areas and containing them in areas of low sensitivity to minimize the damage or loss of culturally significant artifacts.

DISCUSSION

Considering the constraints and opportunities stated above, the objectives of the Los Vaqueros Fire Management Plan are to provide wildfire protection through multiple lines of defense and a variety of strategically-placed treatments that are easily implemented and cost effective. Most of the features of the plan have been fully implemented. What remains to be completed is the Mallory Ridge Project.

Recalling the Big Valley Fire of 1967 on this ridge and its strategic location, a vegetation management plan that includes a variety of treatments was developed in consultation with State and local fire and resource agencies based on fire, vegetation, and biological considerations. The location for the project was considered strategic for both air and ground operations in the event of an unplanned incident. There is easy air access to the reservoir for helicopter water drops and easy road access to both the top and bottom of the ridge for deployment of ground resources. Development of a continuous control line was planned from the bottom of the ridge to natural openings at the top of the ridge.

The vegetation within the project is now more than 30 years old and is well beyond the point of needing rejuvenation through prescribed burning to increase the vigor of the vegetation and its ability to resist against an intense unplanned wildfire. Prescribed burning as a treatment is easily accomplished and relatively cost effective to treat and maintain. Five burn units are planned for treatment in each of the years between 2001-2004. The first unit to be burned is the uppermost, followed by burning the next unit down the ridge in each subsequent year.

This project also considers the presence of the Alameda whipsnake since the project takes place within critical habitat of the snake. The snake was listed as "threatened" by the State in 1971 and by the Federal government in 1997, and its critical habitat was designated in October, 2000. The area designated encompasses 406,598 acres situated in the 4 central state counties of Alameda (205,083), Contra Costa (166,570), Santa Clara (20,170) and San Joaquin (14,774). The criteria for its habitat designation were the distribution of units throughout its range that provide a variety of suitable vegetation types in large areas that are connected to other similar areas. Consequently, the Mallory Ridge Project is specifically designed to rejuvenate the habitat of the Alameda whipsnake. It also is providing a research site for the collection of data that can be used to determine the effects of prescribed burning for the development of best management practices for future burn units on this project and those planned by other agencies within critical habitat areas.

The design includes limitations on the kind and size of treatment areas and season of treatment to avoid "take" and minimize "incidental take" yet still meets the fire, vegetation management, and habitat improvement objectives. This is accomplished by minimizing areas treated by hand and taking advantage of immediate natural openings to achieve a continuous fuel break that is at least 150 feet wide, re-piling brush during the burning operation, and conducting prescribed burns during the hibernation period of the snake.

Concurrent with the project planning activities, the monitoring and research project was initiated in late 2000. The objectives of the research are to determine the level of "take", assess the effect on the habitat, and provide recommendations for future burns, both on this project and others, to be designed to improve Alameda whipsnake habitat. Researcher Karen Swaim assisted with determining treatment areas and has established baseline population data for the first burn unit and a control area outside of the project area.

Given the above, treatment methods were initiated in late 2000 and are planned for completion by winter 2004-2005. The project area extends for more than 2 miles along this sharp ridge that rises from an elevation of 500 to over 2,000 feet. Disked fire lines in grassland areas are in place and are maintained annually. Hand constructed fire lines in un-roaded chaparral areas have been completed by cutting, piling, and then re-piling brush during the burning operation once the brush had cured and weather allows burning. The use of mechanized equipment in the chaparral area was precluded as a treatment method due to both the presence of the Alameda whipsnake and the need to avoid erosion and prevent sediment from entering the reservoir directly below the project. One immediate observation of the initial activity was the improved visibility of lizards, including the western fence lizard which is the base food prey of the Alameda whipsnake.

Meanwhile, the research effort has been in progress. In spring 2001, over 60 trap lines were established to capture, mark, and release snakes and lizards within burn unit one and the control area. Between mid April and mid June, 55 snakes were captured and recaptured; some as many as 5 times. Additional snakes were captured in the late summer period of mid August to mid September. During both periods, when air temperatures at Mallory Ridge exceeded 90 degrees, trapping was suspended until temperatures receded to avoid having snakes inside a trap during the more extreme temperature periods.

FINDINGS

The initial findings were positive. It is clear that there is a very vigorous population of Alameda whipsnakes within and adjacent to the project area. Consequently, it is expected that prescribed burning to meet the project objectives of improving fire protection and snake habitat can be implemented with a minimum level of take which would be considered incidental. This also means that strong statistical correlations can be made between the pre-burn baseline data and post-treatment data. A side benefit from the research related to the western fence lizards is that many have also been captured and marked so that existing literature about their ability to survive prescribed burns will be better established.

The expectation of positive results stems from the fact that clearing by hand and burning methods increase the range of visibility of the Alameda whipsnake, expose rocks outcrops on which their base food prey lizards tend to occupy, and generally improve the habitat of the snake and the lizard. Given the tendency of the lizard to immediately re-occupy a burn unit, it is highly likely that both will re-colonize a burn unit.

The vegetation management aspects of this project have been more complex than normal. The added step of re-stacking piles immediately before burning requires more effort but brings the advantage of creating more numerous and smaller piles placed closer together that reduces the initial level of burning effort. The seasonal window to burn piles and conduct prescribed burns is more restrictive than ordinary prescription burn windows but by significantly overlapping the hibernation season of the Alameda whipsnake it ensures the snake is protected in sub-surface retreats during the burn. Despite the added complexity of the process, the additional steps of actual treatment are manageable.

The overall costs of the entire project will be cost-effective compared to the losses that could occur without the project. However, the initial costs associated with the project and related research activities have been greater than most projects. The initial hand treatment areas (17 acres) have been accomplished utilizing East Bay Conservation Corps crews at a cost of $40,000 ($2,300 per acre). Due to the excessive distance from an inmate camp, no crews were readily available to perform the necessary hand line construction that would have reduced the cost to about $400 per acre. The burning of piles has been by District staff. The vegetation management plan for prescribed burning and the first burn unit plan cost approximately $10,000. The cost of the actual burning of unit one (12 acres) is expected to range from $6,000 to $10,000. It will be accomplished through a Vegetation Management Plan with the California Department of Forestry and Fire Protection. The costs of treatment through to the completion of burn unit one will range from $1,400 to $1600 per acre.

The above costs compare favorably to typical costs for various methods of vegetation treatment that range from as high as $3,500 per acre for hand labor to as low as $200 per acre for prescribed burning (Rice, 1996). Future burn units will not incur the same level of cost as the costly hand line construction, vegetation management plan, and initial burn plan that have been completed. The subsequent burns will require very little preparation and can be accomplished with significantly lower costs ranging from $400 to $600 per acre, bringing the overall project cost to $1,250 per acre.

The monitoring and research costs cannot be separated as most of the work done so far would be necessary regardless of the intent to provide guidelines for prescribed burns elsewhere in Alameda whipsnake critical habitat. To date, approximately $30,000 has been expended to develop the baseline data needed to determine the effects of future burning of the units. The costs to monitor the post-treatment future burn units will be substantially less than the cost of the development of the baseline data. The estimated cost of the biological aspects of the completed project is $65,000 or another $1200 per acre.

CONCLUSIONS

Planning and implementing a vegetation management program within the critical habitat of the Alameda whipsnake is manageable but more costly than in non-critical habitat areas. In the case of the Mallory Ridge, habitat and water quality protection constraints prohibit the use of mechanized methods of treatment for the majority of the project. Consequently, the construction of initial control lines by hand without the availability of inmate crews and the biological monitoring have significantly increased the cost by $1,900 and $1,200 per acre respectively. However, the ability to then use prescribed burning will substantially decrease the overall project treatment costs. Limiting the burn units to the upper slopes of the ridge immediately adjacent to hand lines and natural openings further reduces the cost of each successive burn unit. The cost of the initial baseline biological research and monitoring was also significant. Subsequent burn unit monitoring will be much less but will provide a solid database for drawing conclusions about the effect of prescribed burning on the Alameda whipsnake, effects on its habitat, and development of best management practices for this and other projects.

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CAN FUELS MANAGEMENT AND LISTED SPECIES RECOVERY BE COMPATIBLE GOALS?

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There is a perception that two of the listed species in the Bay Area (Alameda whipsnake, pallid manzanita) are affecting the ability of management entities to address fuels management issues.

The USFWS, one of the resource agencies that protects listed species, believes that certain fuels management actions may actually be beneficial to the recovery of the Alameda whipsnake and the pallid manzanita, both of which have evolved in a fire adapted vegetation community. However, advocating fuels management in the absence of real data could put these threatened species at risk of becoming endangered. Therefore, we are promoting a cooperative effort that will monitor the short and long-term effects of fuels management actions on these two species.

Our presentation will discuss the reasons that these two species are listed as threatened, the statutory requirements of conducting fuels management actions within listed species habitats, the cooperative efforts that are underway to insure that fuels management actions will not further endanger these two species, and finally which fuels management actions we anticipate may actually aid in their recovery.

FIRE MANAGEMENT OF CALIFORNIA SHRUBLANDS

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ABSTRACT

Fire management of California shrublands has been influenced by policies designed for coniferous forests, however, in contrast to Western forests, fire suppression has not effectively excluded fire from shrublands and in most cases catastrophic wildfires are not the result of unnatural fuel accumulation. In addition, one of the primary drivers of large catastrophic fires is the coincidence of ignitions with extreme weather. As a result, there are limitations to the potential effectiveness of fuel management strategies. Due to the nature of fuel distribution in these crown-fire ecosystems, prescription weather conditions preclude burning at rotation intervals sufficient to reliably affect the control of fires ignited under severe weather conditions. Fire management strategies that attempt to create landscape scale age mosaics through prescription burning are not a cost effective method of controlling catastrophic wildfires. Pre-fire fuels management will likely have greater success focusing on intensive management along strategic buffer zones and moving away from measuring effectiveness strictly in terms of total area treated.

Continued urban sprawl into wildlands naturally subjected to high intensity crown fires is a major contributor to increased fire suppression costs and increased loss of property and lives. Fire management will need to play an increasingly active role affecting the planning process through (1) critical analysis of causal factors driving fire regimes and (2) better publicizing the limitations of fire hazard reduction. Fire management may need to consider designing strategies tailored to different regions as studies in central and southern coastal California indicate there are marked regional differences in fire regime. Presently far less is known about shrubland fire regimes from the Sierra Nevada and north coastal regions.

Keywords: Buffer zones, chaparral, coastal sage scrub, ecosystem management, fire history, fire management, prescription burning.

INTRODUCTION

California shrublands are one of the most fire hazardous landscapes in North America because of dense contiguous fuels, summer drought, autumn foëhn winds, and an extensive urban/wildland interface. In contrast to much of the U.S., where, since the middle of the 20th century, fire suppression has produced dramatic reductions in area burned (Figure 1),

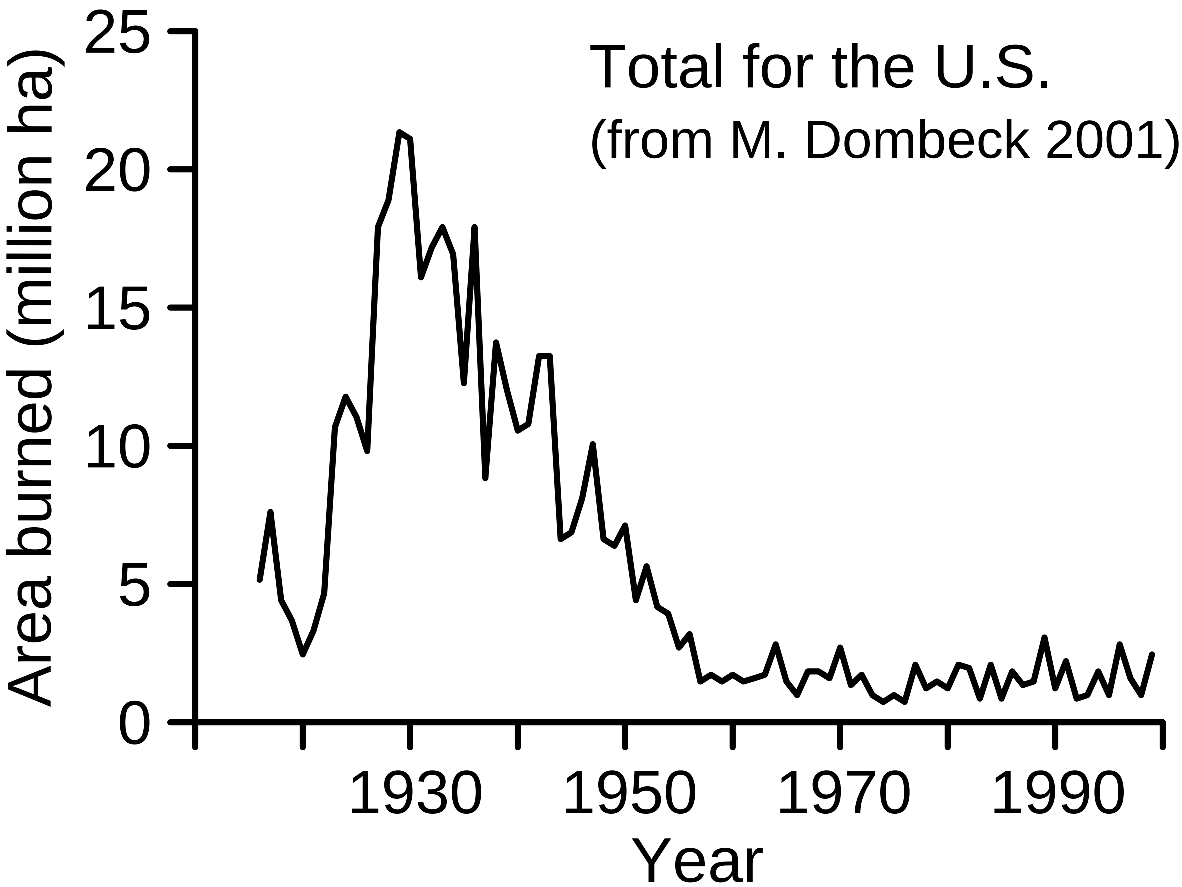

Figure 1. Total area burned in the U.S. during the 20th century (redrawn from Dombeck 2001).

California shrublands have continued to burn seemingly unabated (Figure 2). Indeed, since at least the middle of the 20th century, property losses from wildfires have increased every decade, despite concomitant increases in fire suppression expenditures, and in recent years there have been several wildland fires that have exceeded $1 billion in losses each (FRAP 1999).

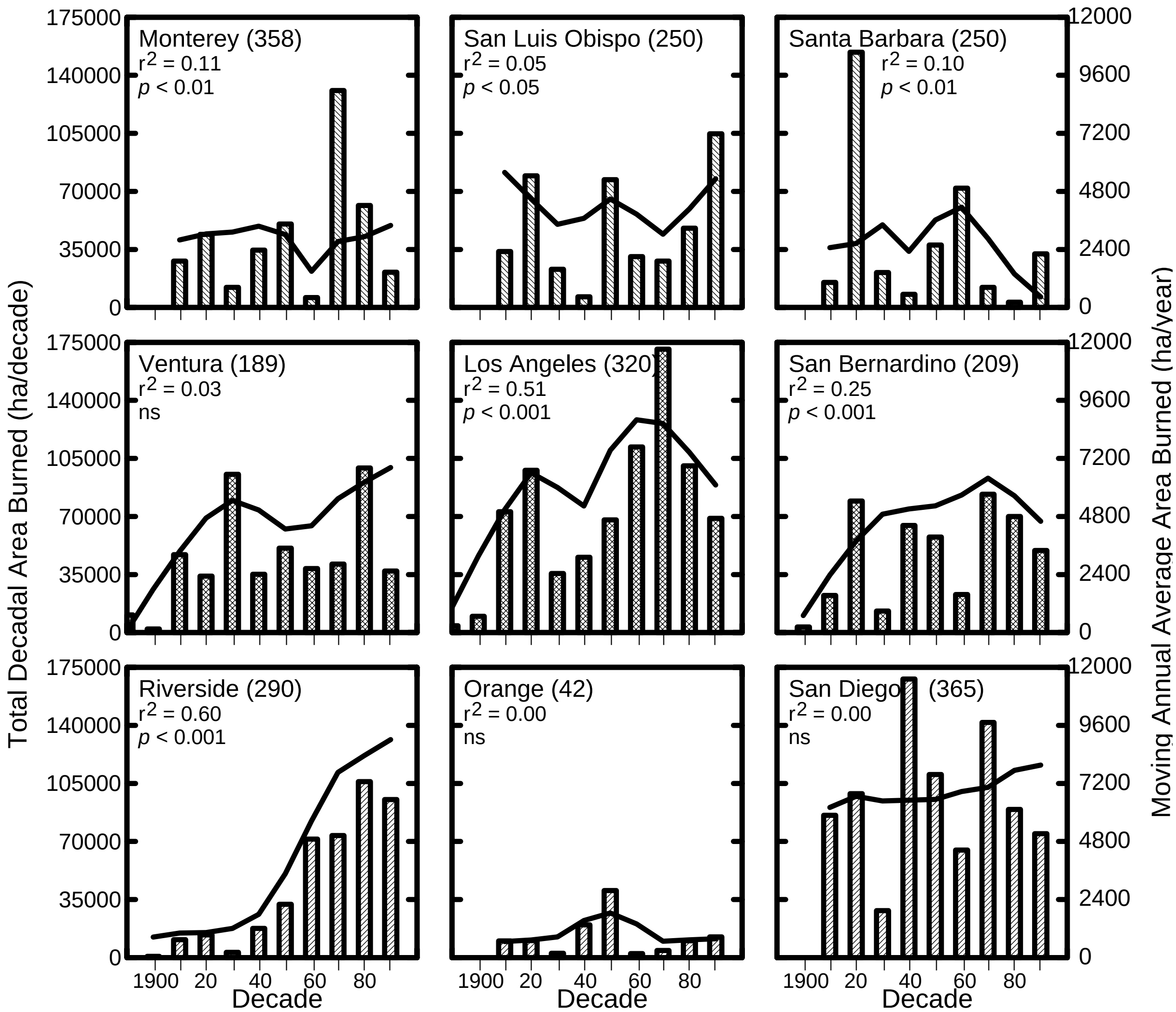

Figure 2. Area burned per decade and 10-year running annual average during the 20th century for 9 counties in central and southern California.[1]

Many have assumed that this fire hazard is unnatural and has developed because of fuel accumulation, arising from a century of fire exclusion (Dodge 1972, Bonnicksen and Lee 1979, Minnich 1983, Pyne 1995). This reasoning is a logical extension of the well-documented fire hazard in some western coniferous forests resulting from a century of fire exclusion (Agee 1993). Reduction of fire hazard in coniferous forests requires the reintroduction of fire through prescription burning and other fire management policies (e.g., Parsons and DeBenedetti 1979). Likewise, for California shrublands it has been proposed that there is an urgent need for massive prescribed burning, in order to reintroduce fire (Minnich and Dezzani 1991). Further, it has been suggested that creating landscape age mosaics through rotational burning can prevent large catastrophic wildfires (Countryman 1974, Minnich and Cho 1997, Minnich and Franco-Vizcano 1999). This fuel age hypothesis (Box 1) is reflected in fire management plans on shrubland dominated national forests in California (Conard and Weise 1998).

Ho:	Fire occurrence is constrained by the rate of fuel accumulation
Predictions:	Large catastrophic fires are a modern artifact due to fire suppression activities
	Large fires are dependent on old age stands of vegetation
	Landscape age mosaics created by prescription burning can prevent large destructive fires
Ha:	Fire occurrence is constrained by the juxtaposition of ignitions, adequate fuels, and weather
Predictions:	Large catastrophic fires are at best only weakly dependent on fuel age
	Coincidence of ignitions and severe weather are (and probably always have been) a primary determinant of fire size
	Age mosaics are not a reliable barrier to catastrophic fires

Box 1. Hypotheses on the primary drivers of fire in shrubland ecosystems.

The initial support for the fuel age hypothesis in chaparral shrublands was from modeling studies (Figure 3), which predicted that as stand age increases due to fire suppression, fire size increases. These models were interpreted to mean that prescription burning of small patches would create a landscape age mosaic capable of acting as a barrier to the spread of large

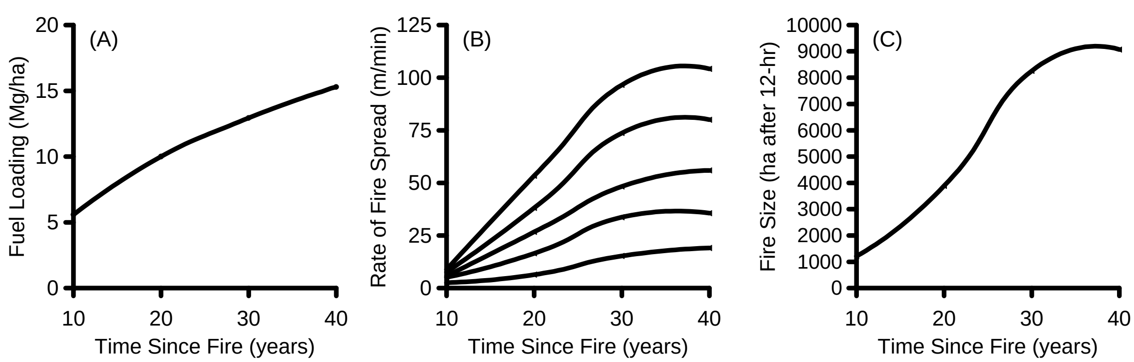

Figure 3. Modeling studies by Philpot (1974a, 1974b) with (A) assumed successional changes in fuel loads, (B) predicted rate of fire spread at increasing windspeeds from 10 to 50 kph, and (C) predicted fire size after 12 hours burning under sustained 50 kph wind speed.[2]

catastrophic wildfires. The primary support for this fuel age model has been a comparison of burning patterns north and south of the U.S. border (Minnich 1983, 1989, 1995, 1998, Minnich and Cho 1997). These studies reported a coarse grain pattern of large fires north of the border and a fine grain pattern of smaller fires south of the border. Although the conclusion that differences exist has been challenged (Strauss et al. 1989, Keeley and Fotheringham 2001a, 2001b), the primary problem is how to interpret burning patterns north and south of the border.

Minnich (1983, 1989, 1995, 1998) has assumed that the pattern of burning north of the border is the result of highly effective fire suppression activities, which have excluded fire and allowed an unnatural aging of chaparral. This assumption has largely gone unchallenged because countless fire history studies in western U.S. forests have shown fire suppression policy commonly results in fire exclusion. However, fire history studies of California shrublands have found that fire suppression has not excluded fire and as much or more area burns now than prior to vigorous fire suppression (Moritz 1997, 1999, Conard and Weise 1998, Keeley and others 1999, Weise et al. in press). These studies call into question the basic assumption behind the border comparison studies and make it doubtful that any differences in burning patterns north and south of the border can be held up as an illustration of the consequences of a fire suppression policy.

Likewise, two conclusions from the border studies are doubtful. One is that large destructive crown fires are a modern phenomenon, unknown on the California landscape prior to active fire suppression (Minnich 1989, 1995, 1998, Minnich and Dezzani 1991, Minnich and Cho 1997). Contradicting this conclusion is the fact that there has been no dramatic increase in large fires this past century (e.g., Figures 4A-B), and by the countless reports of large crown fires

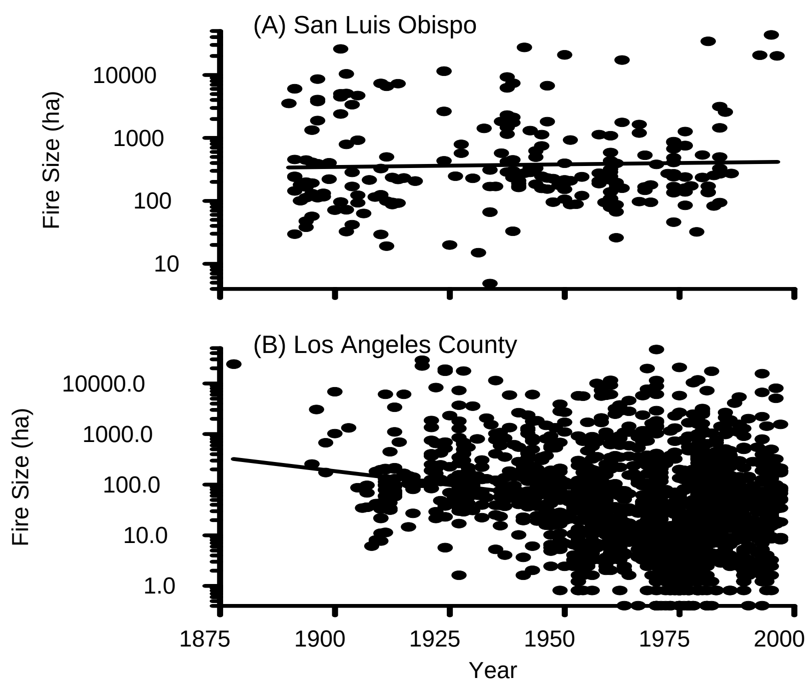

Figure 4. Fire size distribution during the 20th century in (A) the central coast and (B) southern California.[3]

in California shrublands during the 19th century (Kinney 1900, Barrett 1935, Brown and Show 1944, Brown 1945, Greenlee and Moldenke 1982, Greenlee and Langenheim 1990, Keeley et al.1999).

Another conclusion drawn from the border comparison studies is that shrubland fire regimes are constrained by the rate of fuel accumulation and are largely immune to external forcing functions such as severe fire weather (Minnich and Dezzani 1991, Minnich 1998, Minnich and Cho 1997). This is contradicted by studies north of the U.S. border that have shown fire hazard is either independent of age (Moritz 1999) or only weakly dependent up to 20 years (Peng and Schoenberg in press). Other evidence that fire behavior is not a deterministic function of fuel age is the fact that large catastrophic fires will readily burn through young stands and do not require old vegetation (Figure 5). For example one of the largest wildfires in California history was the 1970 Laguna Fire that burned over 10,000 ha of young age (5-20 years) classes (Dunn 1989).

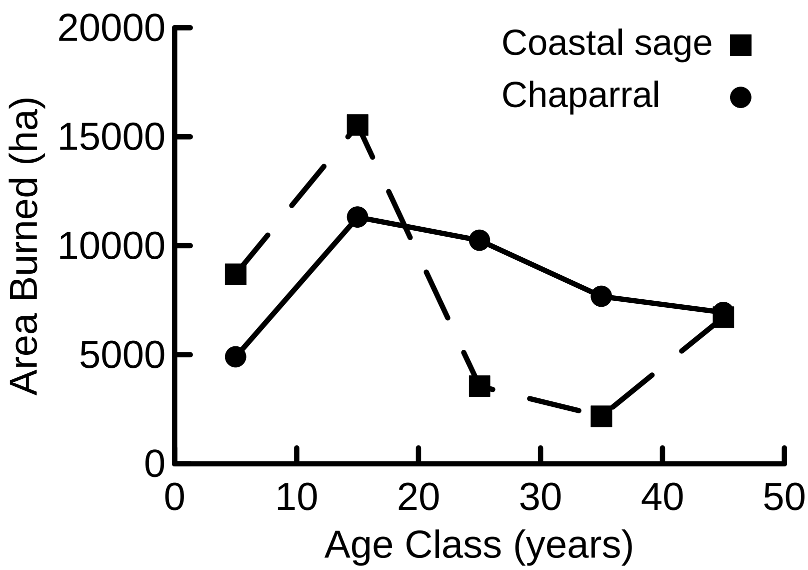

Figure 5. Age classes of chaparral and coastal sage scrub stands burned by all fires over 5,000 ha from 1967 - 1996 in the Santa Monica Mountains. [4]

Another example is the destructive 5,900 ha Romero Fire, half of which burned through 7 year age class fuels from an earlier fire (Gomes et al. 1993). In general, fuel age is of minimal value, either as a barrier to fire spread or for providing access for fire suppression forces, under weather conditions responsible for the most destructive wildfires. Almost without exception, the largest wildfires on shrubland dominated landscapes occur during severe fire weather conditions that include high temperatures, coupled with low humidity and high winds (Coffin 1959; Pirsko 1960; Schroeder et al. 1964; Weide 1968; Countryman et al. 1969; Phillips 1971; Countryman 1974; Dunn and Piierto 1987; Gomes et al. 1993; Davis and Michaelson 1995; Minnich and Cho 1997). These conditions are predictable events every autumn and are due to synoptic weather conditions that influence much of coastal California (Figure 6).

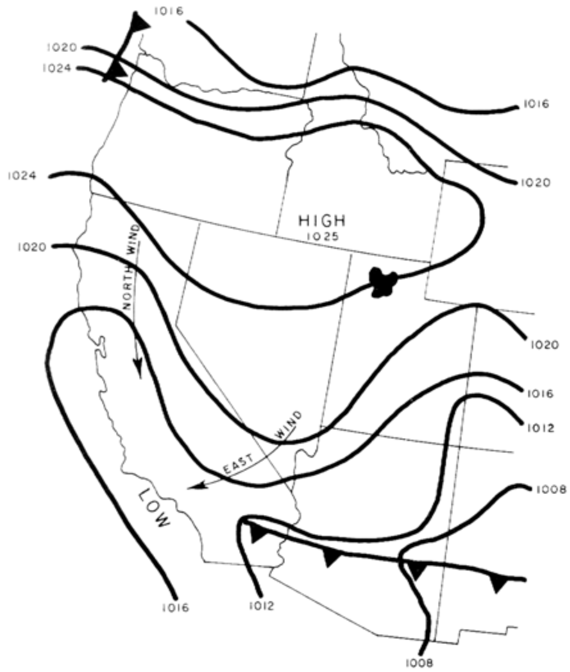

Figure 6. Surface weather map during the Great Basin high pressure airmass that generates foëhn winds in central and southern California (from Phillips 1971).

These findings strongly support fire management strategies that emphasize fire prevention and vigorous fire suppression, and raise questions about prescription burning programs that intensively treat landscapes with the goal of creating age mosaics.

PRESCRIPTION BURNING

Prescription burning may be justified as a means of enhancing natural resources as well as a means of reducing fire hazard. For example national parks consider resource benefits a primary goal of burning, whereas fire hazard reduction is typically the primary objective for the California Division of Forestry. Of particular importance is the reality that prescriptions reducing fire hazard may not always enhance resource values and sometimes may detract (Johnson and Miyanishi 1995).

Humans have long accounted for the majority of fires on shrubland landscapes in the coastal ranges and fire frequency has increased as populations have grown (Figure 7). Today fire rotation intervals throughout much of the region are far shorter than one might expect under natural conditions (Keeley et al. 1999, Keeley and Fotheringham 2001a). While lightning has long been a source of natural fires on these landscapes, it has been far less common and predictable then for many other parts of the Western U.S., for example for every 1,000 ha (2,470 ac) in Santa Clara County there is a lightning ignited fire only once every 200 years, and the pattern is similar up and down the coastal ranges (Keeley, 1982). There is little reason to expect ecosystem health in this region is suffering from a lack of fires, particularly because even the most fire-dependent shrublands are extraordinarily resilient to long fire-free periods (Keeley 1992). Therefore, by and large, there would seem to be little justification for using prescription burning for restoring the "health" of shrubland ecosystems. Of course, there are undoubtedly pockets of vegetation throughout this highly fragmented landscape that may stand as exceptions

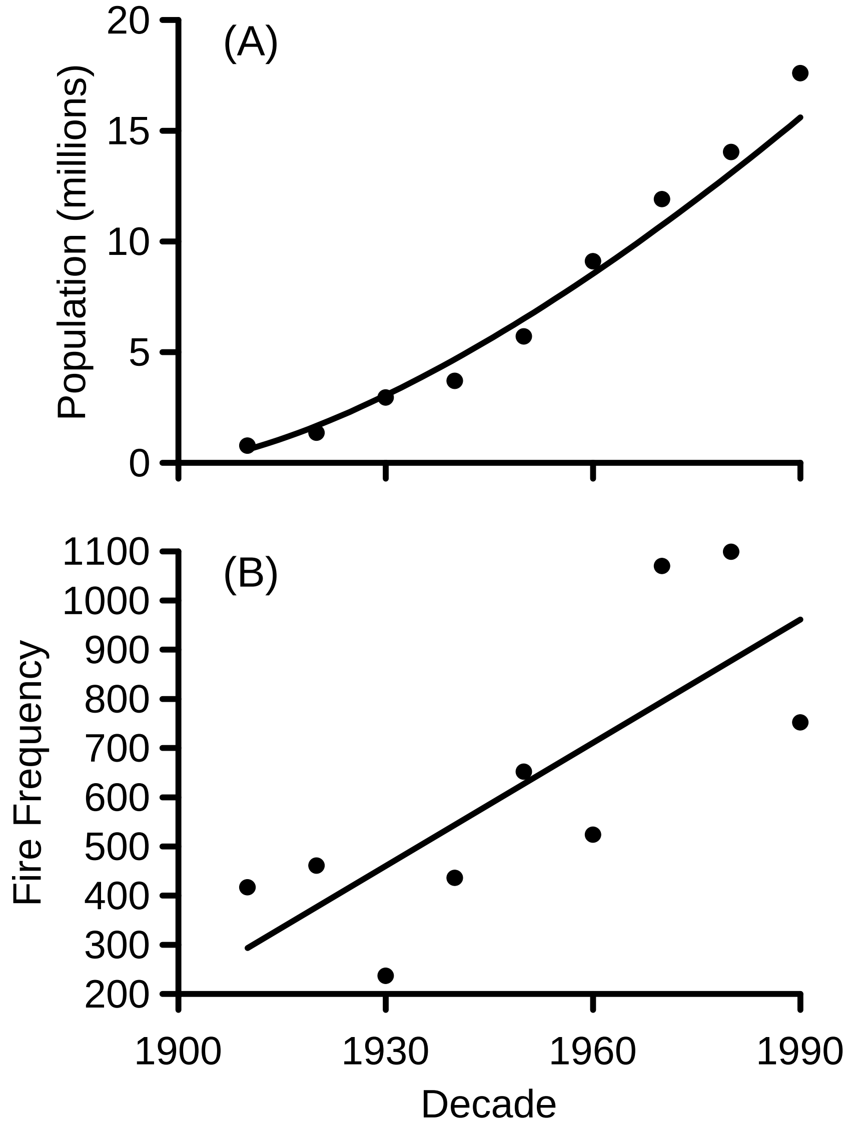

Figure 7. Twentieth century patterns of (A) population growth and (B) fire frequency from the central and southern California (includes all counties shown in Figure 2). Population data from the U.S. Department of Commerce, http://www.census.gov/populations/cencounts/ca190090.txt. Fire data source indicated in Figure 2 legend.

to this generalization. Other resource benefits from prescription burning include invasive plant control, but the primary invasive problems largely involve herbaceous species, which are favored by increased disturbance frequency (Keeley in press).

Most would agree that the primary justification for prescription burning in California shrublands is fire hazard reduction, and this is commonly accomplished by reducing fuels with prescription burning on a rotational basis. However, serious examination of prescription burning limitations and its consequent impact on constraining catastrophic wildfires is needed.

In selecting the rotational interval three factors are considered:

(1) Ability of trained personnel to contain the fire within pre-determined boundaries,
(2) Capacity of the vegetation to ignite and spread fire, and
(3) Effectiveness at reducing fire hazard.

Balancing these factors has been done quite successfully in coniferous forests where prescription burning is increasingly used as a means of reducing understory vegetation and other surface fuels. However, problems arise when applying prescription burning to crown-fire ecosystems such as California chaparral (Countryman 1974, Leisz and Wilson 1980). Often the limitations imposed by meeting the first two of these factors limits the effectiveness of prescription burning programs. In short, prescription burning can only be done safely under weather conditions that require mature chaparral, 20 years of age or more (Green 1981), but stands this age and younger will not form effective barriers to fire spread under severe weather conditions (Figure 6). Landscapes managed by such rotational burning may contribute to easier containment of fires burning under moderate weather conditions (e.g., prescription burn weather), but are of limited help under severe weather conditions (e.g., the annual autumn foëhn winds). However, it is these latter fires that become truly catastrophic and are responsible for the greatest losses of property and lives.

These considerations should not be interpreted to mean that prescription burning has no place in fire management of shrubland ecosystems, but only to emphasize the limitations to its effectiveness. Landscape scale rotational burning is unlikely to ever be a viable management strategy, both because it is ineffective against the most dangerous fires, and because it is neither economically feasible nor possible within the temporal window of burning opportunity constrained by air quality restrictions (Conard and Weise 1998). Although of minimal value in stopping fires under severe conditions, prescription burning may aid fire suppression under other conditions. The primary advantage to rotational burning is not because young age classes by themselves block the spread of fires but rather because they provide fire suppression forces with access to fires. Therefore, it would seem that strategic location of prescription burns is more critical than the sheer acreage burned. Therefore widespread prescription burning to create landscape age mosaics has less potential for success than the strategic placement of prescription burns that focus on well known fire corridors. This strategy also poses the least risk of unnaturally high fire frequency to shrubland resources, many of which are already threatened by unnaturally high fire return intervals (Keeley 2000).

CONCLUSIONS

California shrublands are just one of a number of vegetation types that typically burn in stand-replacing crown fire regimes largely driven by severe fire weather rather than by fuel accumulation (Bessie and Johnson 1995, Agee 1997). The costs associated with brushland fires in California have been steadily increasing for decades (Bonnicksen and Lee 1979, Kinney 1984, FRAP 1999). Bonnicksen (1980) pointed out that there was no relationship between fire control expenditures and area burned in California shrublands and claimed that this clearly indicated that the fire-exclusion policy was in error because it was responsible for the steady accumulation of older and older fuels. But, this conclusion rests on the assumption that the policy of fire suppression has actually worked to exclude fire, whereas in reality fire suppression has not effected fire exclusion in this region. Rather than increased expenditures being the result of an increasingly worse fuel situation, it would appear that increased expenditures are tied to increasing numbers of fires, which are tied to population growth (Figure 7). Increasing losses of property and lives is the result of continuing expansion of urban development into the high fire hazard wildland environment, placing more and more people at risk.

These facts point to the need for continued fire prevention to reduce the likelihood of ignitions during the annually-predictable severe fire weather known as Santa Ana, Mono, Northeastern, or Diablo winds (Schroeder and others 1964). In addition, it is apparent that current fire suppression activities are barely staying ahead of the increasing human ignitions on this landscape (Keeley 2001). It seems logical that constraining the rapidly expanding urban/wildland interface is critical to keeping fire hazard from getting worse on this landscape. Despite the likelihood that large wildfires will remain a feature of our landscape, there are management strategies that could limit its impact on the loss of property and lives. Most obviously would be different land planning that manages for limited human use in high-risk areas. Fire researchers and managers have an obligation to educate land planners and politicians to the causal factors driving catastrophic fires and the limitations to fire hazard reduction (Sapsis 2001). This is particularly important in light of trends towards increasing rural population growth (Bradshaw 1987).

NOTES

1. Fire data from the Statewide Fire History Data Base, California Department of Forestry, Fire and Resource Assessment Program (FRAP), Sacramento, CA, which includes historical fire records from the U.S. Forest Service national forests, California Division of Forestry ranger units and other protected areas, plus city and county records; minimum fire size recorded varied between 16 to 40 ha, dependent upon the agency). Shrubland area in 1000s of hectares shown in parentheses following the county name (from Callaham 1985).

2. From these models it was concluded that as chaparral stands increase in age due to fire exclusion, there is a resultant increase in fuels, fire spread rate, and fire size. Following suggestions by Countryman (1974), these models were interpreted to support a fire

management policy that relied heavily upon prescription burning to produce a landscape comprising a mosaic of age classes.

3. Data from source indicated in Figure 3 legend

4. (data from the U.S. National Park Service, Santa Monica Mountains National Recreation Area, Thousand Oaks, CA). Greater burning of young age classes of coastal sage scrub is likely due to more flammable fuels, longer fire season and the concentration of this vegetation adjacent to urban centers which are major sources of ignition.

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UTILITY EFFORTS TO PREVENT THE NEXT CONFLAGRATION

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ABSTRACT

The PG&E approach to vegetation management around power lines is the most sophisticated in the country, and it operates the largest vegetation management program in the world, with over 1200 workers and contractors dedicated to preventing power line/vegetation contacts. Utilizing an extensive tree inventory containing 5 million trees, based on an annual patrol of every line mile every year, the 120,000 mile system of distribution and transmission lines are patrolled and cleared, averaging two million trimmed trees per year. The integrity of the electricity grid is constantly upheld under CPUC mandates which dictate a minimum of 18 inches between vegetation and high voltage lines. In addition, during the fire season, PG&E works with CDF to ensure that the four foot rule minimum distance is upheld in wildland fire areas. In addition, over 115,000 poles with potential fire-producing elements are cleared around and made safe in case of fuse or system failure.

The transmission system, key to upholding the western grid, is an area of major effort. The threat of summer windstorms during the fire season are a major concern, and help to determine the right of way clearances that are needed in order to sustain the system integrity. Problems presented by limited operating periods which are mandated on federal lands due to endangered species concerns complicate the desire to maintain the system on a strict twelve month return cycle.

Conscious of past problems with wildfire, the CPUC has mandated several programs which are fundamental to improving the urban forests in which PG&E operates. Removal projects focus on complete removal of fast growing species from under the lines, such as eucalyptus and Monterey pine. These areas are then the focus for the 'right tree, right place' approach that epitomizes PG&E's efforts to reduce tree height and flammability under the power lines.

Key words: power lines; vegetation management; utility

INTRODUCTION

I approach this topic as a resource manager - not as a power person. I continue to feel that as a resource manager my work is on the periphery of a power giant that is dedicated to keeping your lights on. As such, the thoughts I present here are my own, and do not represent the outlook of the changing bankrupt company that employs me.

In order to appreciate the challenges in keeping the system going, we need to understand a few power principles for an overhead electrical system.

Power lines are completely unforgiving, since electricity always seeks ground, whether traveling through the lines to do your bidding or traveling through a tree (or a person's body). The high voltage power lines need to be treated as overhead ribbons of explosive fire - that are, however, absolutely essential to modern life.

As citizens, we are bound and interdependent by our needs for energy. All of us demand continuous power, and a host of power companies including those in generation, transmission, and distribution companies to name a few would like to profit through providing your power needs.

LET'S REVIEW WHAT WE ARE LOOKING AT:

Generation, whether by hydro, coal, nuclear, wind, biomass -- is where the system starts. The electrons generated travel through transmission lines - mostly on steel towers, at say 60 to 500 kV to substations where the voltage is stepped down to high voltage – also called primary voltage - say 4-21 kV. This travels down your street on wooden poles that say 'high voltage' (often on a cross arm), thence to the barrel-like transformer where the power is stepped down again, normally to 220 volts, also called secondary voltage. This voltage then enters your home on a 'service drop'. Questions about this system should be directed to those who understand it and not to a tree guy like me.

Why not put all these power lines underground, which always sounds like a scenic and sensible alternative? Further investigation shows: (1) extreme costs - never less than $200/foot, and often many times higher; (2) longer outage times since the problem is more difficult to locate and to isolate; (3) higher maintenance costs and greater human danger, since working in an underground vault with live electrons is a good way to not come out again; and, for (4) vegetation management -- let's remember that trees have roots in addition to crowns and can compromise utility systems wherever the two interact. When I served on the Napa City Tree Commission, the major reason for accepting homeowner tree removal applications was the entangling of tree roots into the underground utilities.

Because the electrical system is so unforgiving, and fire, damage and death can be an instant result from ignoring these facts, our safety is looked after by state and federal regulators who rescue us from ignorance by regulation of overhead power lines.

Tree contact - whether from a falling branch, or whole tree failure, or just a strand of bark - is the highest single known cause of most outages in many power systems. A significant cause of wildfires and acreage burned each year, most fire agencies are well aware of the regulations that I describe here.

State of California Public Resource Codes dictate actions to be taken by utilities in fire areas and fire seasons and these provisions are also often adopted in county plans. PRC 4293 demands a minimum 4' distance during fire season between high voltage lines and vegetation. Rule 35 of the CA Public Utilities Commission (CPUC) dictates an 18" minimum distance between vegetation and primary voltage lines at all times - even during storms, when wind may whip branches to and fro. Also, PRC 4292 dictates a 10' clearance to bare ground around poles with potentially explosive consequences in event of a short-circuit. The Federal Energy Regulatory Commission (FERC), regulates transmission lines and mandates even greater distances between vegetation and lines but has similar desires - to keep the juice running where it should. In many areas you may also see an overlay of city or county restrictions which normally attempt to modify - particularly reduce - what has been set forth in State and federal law.

There is another provision in PRC 4293 having to do with hazard trees that is irrespective of distance from the lines. Any tree that presents the possibility of falling into the lines due to death, decadence, or rot is to have the hazardous portion removed. This means that, say a dying redwood that is 201' tall and is 200' from the primary conductors should be examined for its hazardous characteristics, and the hazard removed if it exists.

These rules and laws are enforced by CDF and other Fire Services, and are inspected by CPUC and FERC, but the ultimate regulator of the electrical system is done naturally, often during windstorms, for nature invariably finds problems that the agencies and utilities might miss. These non-compliant infractions become apparent to us through outages and fires.

We can see the cost of not doing it perfectly. Aside from fines for not complying with agency regulations, the tens of millions of dollars and loss of resources that came from such events as the Trawner Fire and the Cavedale Fire are well-known to the fire services, the utilities, and to the people who became homeless in these incidents. The cost of the avocado picker's arms who reached too far and touched the power lines is another tragic expense that inadequate line clearance must bear.

WHAT MAKES POWER LINE CLEARANCE A RESOURCE MANAGEMENT PROBLEM?

PG&E is required to maintain distances between power lines and vegetation on over 90,000 miles of distribution line and about 14,000 miles of transmission lines. We can convert these lineal corridors into acres by calculating that the width of the area of concern to be the distance between the cross arms (8'), plus the common ROW distance (10' either side). The calculation of the area of this very narrow very long forest yields 300,000 (actual 306,000) acres under distribution lines, and over a half million acres when including the greater clearance distances required for transmission corridors.

It is important to remember that almost none of this vast land base is owned by the utility, and that the management for electrical purposes takes place under a wide variety of easements and rights of ways. By the way, the figures I just mention leave out the area from which a hazard tree might come, which probably increases the land area of management concern by more than three times.

The owners of these lands are persons, businesses, cities, counties, Cal Trans, forest industries, agencies and many other entities, most of whom would rather use their land for other purposes, and may disagree with both the objective and the form of vegetation management used for energy movement.

I want to look at this vegetation management situation as a resource manager, because the lack of flexibility in electrical systems that engineers hope to control is no match for a biological system that is infinite in its variety and often unpredictable in its changes. The ability for us to avoid being victims of nature's whims, means that the electrical systems have to be weather-proof and tree-proof, and they are not.

The march of time and biology continues to compromise the overhead electrical systems. Trees grow. In fact, trees grow, change and die -- they are not part of a green architecture. The time since the building of the lines, when there may have been a cleared field, has seen many changes, some of which are biological, such as tree planting and growth. Others are cultural and sociological, such as housing developments, endangered species restrictions, or viewshed ordinances.

CHALLENGES & CHANGES

So, too, the utility response has changed. Ten years has seen the PG&E system evolve from rather loosely defined tree coordinators run locally by divisions on an as-needed response to outages into the 2001 forward-looking decentralized department that attempts to predict and to manage the resources that disturb the juice running through the thousands of miles of lines. The Vegetation Management Department employs nearly fifty people and through contracts employs perhaps 1300 others. It is structured to provide vegetation management support to the geographic divisions of the company, but its people report to central San Francisco offices as a free-standing department.

The challenge of appropriate resource management is to attempt to grow its way into a less costly and more efficient enterprise – without igniting fires. Resource management aspects that have changed in a decade include:

- Goals
- Inventory
- Operations by committed personnel
- Communication of plans and practices within and without
- Determination

Goals

Goals of the enterprise include a desired shape of the future forest – whose canopy forms an open VEE with the vertex at least ten feet below the lines – with the sides of the green Vee gradually increasing in height so that a failed tree that falls toward the lines will not reach them. It means that the trees need to grow shorter and to have an overall lower height at maturity than is able to reach the lines. With many line heights at about 35', this makes a maximum of a 25' tall tree desirable under the lines, with only gradually increasing height as the tree is planted or grows away from the lines.

There is a kicker in that it is not just electrons mixed with biology, but also weather - wind in particular - which has less affect on the lines themselves than on the vegetation around the lines. I remember watching a eucalyptus branch, perhaps thirty feet from the lines at rest, blow in a gale to tickle the lines, threatening grounding-out of the power system.

Inventory

In order to know what vegetation needs management, an inventory is required. The inventory that began in 1995 is impressive, since any tree tall enough to reach the lines that is within the 28' ROW is recorded in a hand-held computer and in a permanent database with the species, diameter, height, history, including, by date and time, who did both the pre-inspection and the tree manipulation work. It has comments that might detail the health of the trees or even which property has a difficult dog or owner.

The operational changes that have taken place in a decade now include a pre-inspector who follows the lines and examines the condition of the trees and the encroachment into the area of the lines. These people make a prescription for what is to happen to each tree. To make their determinations, they must take into account such things as line sag as is seen on a hot summer day; maximum wind speed, and also evaluation of the condition of the crown, bark, bole, and growth rate of each tree.

This pre-inspector must prescribe the actions to follow to keep the vegetation out of the lines, convey this to the property owner, and communicate the details to the tree crew, who ideally follow several weeks later. The tree crew then does the work, hopefully as prescribed, often also making contact with the property owner.

Operations

The entire system is scheduled for patrol each year. Thus every mile of line and every tree is assessed every year. It takes over 250 pre-inspectors to do this job on a distribution and transmission system this large, with another 500-600 tree crews operating every day, sometimes in overtime, to get the task done. This has required about two million trees to be trimmed each year on the five million trees in the inventory system. This is the largest tree trimming operation in the world.

Communication

To accomplish the goal of reducing the height of the forest means that the utility must understand the silviculture of the forest. To shrink the ultimate height on a half million acres of land is a daunting task that counters biological reality. Part of the answer lies in the use of directional pruning, atechnique advocated by Alex Shigo, in which trees are pruned so as to redirect future growth on the pruned tree in directions away from the power lines. Called natural target pruning or directional or Vee trimming, it is an operational answer to a biological problem. It is the policy and basis for the utility's pruning program. Most of the answers for shaping the future forest, however, lie in communication with the owners of the trees.

I am afraid that most people do not think of the ultimate size and height of the tree that they plant. For instance, as a young forester, I returned from forestry camp with a seedling in hand and proceeded to plant it immediately next to my father's garage. Rather than curb the enthusiasm of his son, Dad let it grow until it had seriously distorted the foundation of the structure. For a tree that cost a quarter, I had done hundreds of dollars in damage by not thinking things through. This same lack of concern about consequences of growth is repeated in thousands of locations when trees are planted underneath power lines.

Also, the utilities have programs for the removal of fast growing trees and their replacement with shorter-growing species. Thus the utility arborists mantra is right tree, right place, so that a forest grows that does not need pruning, but that grows naturally smaller under the lines. To aid in this goal, PG&E has developed educational programs, one of which is called **Safe Tree**, to educate about power line dangers and to promote right tree right place.

Determination

Other changes during the past decade include the utility looking past the ROW into the surroundings and determining what hazard trees exist - at whatever distance - that may compromise the electrical system through a top breaking out or a dead tree uprooting. These are often the hardest to find, and cause many current problems, with perhaps 60% of this year's utility fires coming from these types of biological sources. The number of stakeholders living in the hinterlands has increased dramatically in the last decade, so that whenever the utility goes beyond the power line right of way, the potential for collision of utility goals and those of the trees' owners is greater and more numerous.

One thing that has not changed is the dedication of thousands of utility workers to keeping your lights on. I know of heroic efforts by individuals who have put themselves at risk to make the system whole after storm or fire. I recall watching one tree worker pelted with driving rain, tied into one tree while hanging from another, with a chainsaw in one hand while attempting to reach the tree that was leaning on the de-energized power lines. Another example is the rebuilding in five days of 40 tower structures on a major transmission line after a fire still stands as a tribute to the efforts of people who know the importance of power in our lives.

DISCONNECTS

To reiterate, the focus of both the biological and the sociological approaches are to alter the future forest shape to the open Vee. The attention to this goal has greatly reduced outages due to tree contact in the last decade and has increased reliability, but the goal itself remains unfulfilled, for utilities often must deal with the wrong tree in the wrong place in neglected and un-managed landscapes. Further, there are numerous reasons why the utility goals will be neither well-accepted nor fulfilled. These I call the *disconnects* between vegetation management and *power policies*. The disconnects are what threaten short-circuit of continuous power. A few of them are:

1. Differences in opinions about the shape of the future forest. Attempting to hide the sight of power lines is a major cause of electrical problems, outages, fires, and higher costs. Some tree owners and others seem to think that the power line can operate in a hole through the vegetation – where the line is surrounded by trees and branches -- instead of in an open vee. They could be right until the first wind or a normal branch break, and then they usually have more outages and cost the utility more to operate. In the extreme, these people with a different vision of future forest shape become 'refusals' who refuse to participate in the utility efforts to clear the lines and may require intensive time and resource investment that often has the utility calling on the fire service or even police for assistance in restraining those who stand in the way of gaining legally mandated clearances. These differences in opinions have contributed to the starts of at least several fires in 2001, as well as in 2000, and probably before..

   A corollary 'disconnect' is the desire to have fast growing tall trees hide the lines – eucalyptus, acacia, Monterey pine and others - which even when trimmed tend to grow very quickly back into the lines. In order to maintain an outage-free environment around the lines, these species may need to have 10-15' of vegetation cut each year, or even pruning twice a year. Tall growing trees with excurrent growth form growing directly under the lines must be topped, although killing them is a far better answer in terms of their biology, tree aesthetics, and power reliability.

2. Inability to appreciate time constraints: Since trees grow, and the utility attempts to operate on an annual schedule, anything which delays planned operations can have a deleterious effect on clearing the lines. Any delay may cause the vegetation contact that we fear. Such worthwhile efforts as the Migratory Bird Act and the Endangered Species Act, whose interpreters feel that these dictate a limited operating periods to avoid critters that might possibly live near the lines are short-sighted in their application, for they put tree trimming crews into an operating window that puts off schedules pruning and dictates that tree crews operate at the hottest and windiest periods of the year. This gambling of biological possibilities with operational goals will see green ecosystems flush with wildlife turned into black ones without. We had one fire which started while the federal agency who managed the forest reviewed the utility fire plan.

3. There is a biological disconnect, since every cut on a tree is a wound which can bring in insects and diseases, and can lower the vigor of the tree. In order to reduce wounding, sound

arboricultural practice recommends minimizing the number of cuts while maximizing the time between making wounds. This biological response is the basis for directional pruning, and calls for larger deeper Vee cuts in trees, but done much less frequently. The cry of some people for making tiny cuts, which reduce the clearances obtained, obviates that cutting be done more frequently, creating conflict with both biology and the utility, in the name of aesthetics.

4. Beauty versus safety and reliability is another disconnect. Can we allow one person's aesthetic sensibility to override public safety? I recall one customer who thought that her dead trees in the Vision Burn needed to be left alone. Well, a storm took down one tree she was concerned with, broke a power pole, and plunged 39 of her neighbors into the dark and cold for over six hours. She didn't know it until I called, because she was comfortably in Connecticut at the time. There are many others who play roulette with safety and reliability that affects all those living nearby.

5. Rates that don't reflect the difficulty in maintaining power to a site. It is bothersome to me that those who live deep in the forest, where extensive pruning is required each year, do not have that cost applied to their energy bills, but allow others to pay for their view and their solitude, and whose annual cost to trim may exceed what can be charged for the energy sold.

6. I think that we can solve some of these problems with a recognition that we can take *a natural step* toward improving our juxtaposition of what we need from the landscape with what we can do. We all want and need that which is economical, environmentally friendly, and provides the greatest certainly of continuous power. Wouldn't it make sense to combine what we know with what we do?

We can grow what requires little maintenance and increases chances of system reliability through proper tree choice and placement. There is a need to take a natural step in growing forest shapes that align with power demands and realizing that 'small is beautiful' within the area of the power lines. In some places the right tree is the short tree, and that Christmas trees operations, bonsai, rice, grapes and nursery operations are all reasonable choices from a standpoint of low-maintenance and high reliability.

An example of a desirable natural step is to solve two problems at once for a common positive result. For instance, the bay area is finding that sudden oak death is killing trees at an alarming rate, raising fuel loadings and endangering houses, roads, and power lines. At the same time power costs have risen and availability decreased. A natural step would be to combine these two concerns and to develop biomass power plants to create electricity which could reduce fire hazard while making us more self reliant. An expansion of this could see us managing our resources by using people and resources to promote fire safe landscapes that pay their way, rather than continuing to put fire fighters in harms way to take care of fuel problems that continue to be ignored.

One approach the utility and its new customers can foster in reducing ugliness is to realize that nature rarely travels in straight lines, and to have new power lines placed in gentle curves on the landscape. The shortest distance is often also the cheapest, but to have vegetation involved in our landscape is both necessary and desirable.

Finally, while changes in the last decade have been expensive and increased reliability, no amount of money will stop all vegetation-caused electrical fires - it is unfortunately too large a system that has a blithering array of biologic and climatologic possibilities.

SHEEP GRAZING AS A FUEL MANAGEMENT TOOL FOR THE URBAN/WILDLAND INTERFACE

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An evaluation of sheep grazing as a fuel management tool for the urban/wildland interface was conducted near Carson City, Nevada in 1999 and 2000. During May of 1999, 350 dry ewes grazed a 2.5 mile long and 150–200 foot wide fuelbreak at various grazing intensities. Sheep distribution and grazing intensity were controlled using electric fence and a herder. Depending upon grazing intensity and vegetation type, sheep reduced standing fine fuel load in amounts ranging from 765 lbs./acre to 2622 lbs./acre during the first growing season after treatment. Two growing seasons after treatment, standing fine fuel load within the fuelbreak was approximately half the amount of the adjacent ungrazed area. The reduction in standing fine fuel load was attributed to a combination of grazing and trampling by sheep. Based on survey results, homeowners living adjacent to the project indicated a preference for sheep grazing over other fuel treatment methods and overwhelming support for continued use of sheep for wildfire threat reduction projects in their neighborhoods. The results of this project suggest that sheep grazing was effective in substantially reducing fine fuel load for at least two growing seasons at the project site and that it was a preferred fuel treatment method by homeowners.

A WILDFIRE FUELS RECYCLING PROGRAM FOR HOMEOWNERS

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A major obstacle that deters homeowners from reducing the amount of flammable vegetation from around their houses is the inconvenient and costly disposal of unwanted plant material. In 1998 Cooperative Extension, in collaboration with two fire departments, the local refuse company, and a commercial compost operation, initiated a program to address this issue. Entitled "Compost Your Combustibles", the program facilitates the disposal of flammable vegetation from high hazard neighborhoods and recycles it into compost. Specific program objectives are to: 1) teach property owners vegetation management techniques to reduce the wildfire threat, 2) provide free disposal of flammable vegetation at convenient locations, and 3) recycle the plant material by mixing it with dairy manure and converting it into compost. Since its inception, the program has involved hundreds of homeowners and processed an estimated 1400 tons of potential wildfire fuel. This represents 1400 tons of solid waste that was not taken to the landfill or burned. Local fire departments also attribute a 60% reduction in burn permit requests to the program. The project sponsors believe that Compost Your Combustibles plays an important role in encouraging some homeowners to implement defensible space practices.

INTEGRATED RESOURCE MANAGEMENT OF UTILITY RIGHT OF WAYS WITHIN URBAN AND WILDLAND INTERFACES

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INTRODUCTION

In order to supply safe, reliable electric power utilities must manage the vegetation, including those plants that are tall enough at maturity to reach the conductors, but also vegetation that poses a fire hazard or interferes with access to the facility. The goal of a utilities vegetation management program is to keep electric transmission facilities safe and to prevent interruptions caused by vegetation while maintaining a harmonious relationship with varied land uses and the environment.

Utilities are required by law to manage vegetation within transmission rights-of-way (ROW). Utility ROWs in California range from 40 to 200 feet wide and represent 5 to 25 acres per liner mile. The maintenance is required by the following agencies Federal Energy Regulatory Commission (FERC) license articles 27, and 33, Public Utilities Commission General Order No. 95, Public Resource Code 4292 and 4293 and Utility Maintenance plans reviewed by CASIO.

The management of vegetation within Electric Transmission Rights-of-Ways as required by law provides a unique set of opportunities and challenges for utilities and many are now incorporating Integrated Resource Management (IRM). IRM involves an interdisciplinary and comprehensive approach to land and natural resource management. Utilities can maintain compliance on ROWs to provide safe, reliable power while managing for fuel breaks, wildlife, recreation, endangered and threatened species, and cultural resources.

Fire safety is a compliance requirement and a reliability issue. California Independent System Operator,(ISO) has adopted maintenance practices from California Utilities that require heavy vegetation in critical transmission corridors be removed if damage to facilities is possible from wildfires. Dense ladder fuels and canopy fuels can create flame lengths of 30 to 50 feet in severe fire weather conditions. For example, transmission lines in the Oakland Hills with dense fuels were observed arching during the 1991 Oakland hills fire.

CHARACTERISTICS OF ROWS

ROWs that are managed with low growing species of vegetation offer excellent opportunities for fuel breaks in Urban and Wildland areas. The Forest Service has been encouraging the management of low fuels in ROWs so they can start control burns in forests to reduce fire hazards without damaging facilities or cause outages. Local communities in rural areas have been including Utilities in planning fuel breaks, which incorporate ROWs. Shaded fuel breaks can be planned adjacent to ROWs to increase the acreage where fuels are reduced for fire safety in a community.

Wildlife diversity and species richness can be improved and managed by vegetation managers and biologists working together. Frequently, the adjacent lands to the ROW are managed in dense forests and the early succession vegetation can provide valuable diversity that has been missing with the elimination of fire in the forest environment. In urban and rural communities, ROWs can be the dispersal corridors of wildlife between local open space parks. Utilities are partnering with wildlife groups such as the National Wild Turkey Federation and Quail Unlimited on ROW management. Numerous long-term studies have demonstrated an increase in species density and richness (Bramble and Byrnes) on electric transmission ROWs that have been maintained by Utilities since 1953. Additionally, they documented greater use of the ROW that was maintained with herbicides by wildlife; including deer, rabbits, squirrels, turkeys, red-tailed hawks, numerous songbirds, butterflies, and amphibians.

Recreational opportunities are also considered in the management of ROWs. Within the Sierras, several cross-country ski resorts have incorporated trails along the maintained openings. During the summer, the same trails are also managed for Mountain bike trails, ATV and horseback riding. Within the urban and rural cities, bike and horse trails have incorporated the ROWs as corridors to travel between parks. There are also hunting opportunities on ranches, public lands and wildlife refuges that can be improved or maintained in cooperation with Utilities. Commercial recreational opportunities such as golf are also utilizing the large acreages managed in ROWs.

Threatened and endangered (T&E) species are frequently found within ROWs and are being managed for their unique habitat value. Biologists can work with vegetation mangers to identify the species habitat to be protected and vegetation management practices can be adapted to protect and enhance the habitat. Some past agency decisions to stop all maintenance activities without considering the successional changes have resulted in the loss of T&E species. Utilities are also managing lands adjacent to ROWs that represent mitigation for new projects. T&E species surveys are routinely completed as part of Utilities Environmental Compliance. Training for identification and protection of T&E species is conducted annually by Utilities. Limited Operating Periods, (LOP) are being used to reduce the potential for any impact by coordinating major maintenance work outside of breeding seasons.

Exotic and noxious plants located along ROWs can be managed with adjacent landowners and agencies to reduce their impact on local species and T&E species. Utilities are working with State Forests, Federal Forests and county parks to control noxious weeds on ROWs and access roads. Licensed Pest Control Advisors, foresters, and biologists can prescribe a combination of vegetation management techniques to remove undesirable vegetation while creating site conditions for plant and wildlife specie diversity.

Cultural resources are often identified within ROWs and can be protected and managed with agencies and private landowners. Cultural resources can be prehistoric, i.e. Petroglyphs, grinding rocks or historic, ie. Mining camps, railroad grades, etc. ROWs are usually surveyed by an archaeologist so cultural resources can be identified and protected. Federal and State lands have cultural resources identified and utilities frequently use Geographic Information System mapping to manage maintenance activities to preserve the cultural resources.

Utilities can manage for many resource values while managing the low growing vegetation required to maintain safe, reliable power. A professional vegetation management program can manage for all the above resources.

INTEGRATED VEGETATION MANAGEMENT

Utilities use Integrated Vegetation Management (IVM) to manage ROWs for IRM. IVM is a system of managing pest vegetation in which action thresholds are considered, then all possible control options are evaluated and finally the management tactics are selected and implemented. Vegetation management on electric transmission rights-of-way and roads includes a combination of mechanical, cultural, biological, and chemical methods that manipulate existing vegetation into relatively stable communities of low growing grasses and broad-leaf species. Control options are used to prevent or remedy unacceptable pest activity or damage. The choice of control options is based on worker/public health and safety, environmental impact, effectiveness, site characteristics, and economics. IVM programs are supported by industry organizations including the Edison Electric Institute, and Federal Agencies including the Environmental Protection Agency Pesticide Stewardship Program, and the U.S. Forest Service. The long-term goal of a utility vegetation management program is to provide safe and reliable service and incorporate IRM by converting right-of-way plant communities from predominately tall growing plant species to communities dominated by low growing plant species. This can be accomplished by selectively controlling tall growing plant species while preserving low growing grasses, herbs and woody shrubs over a period of many years. With proper management, the low growing vegetation can eventually dominate the right-of-way and retard the growth of the tall growing vegetation. This result in providing control of incompatible vegetation and reducing the need for future treatments.

Mechanical: Large mechanical equipment is either rubber-tired or track equipped. Mechanical mowing is generally used for the initial control of dense woody species or on 2 - 5 year cycles in areas where herbicides are not a viable option. Rubber-tired equipment, such as the "Hydro-ax" and the "Row King," are used to cut and chip woody species where slopes are less than 25 percent. The rubber tired machines can also be used along improved road surfaces such as asphalt or gravel. Track mounted equipment, including the Slashbuster and the Brontosaurs, is used on unpaved surfaces up to 40 percent slope. These large mechanical brush mowers can be used to cut and masticate woody plants to within 12 inches of the ground surface which reduces fuel hazard. Mechanical treatment usually results in vigorous resprouting of woody species. It is a common public misconception that mechanical/manual methods (chain saws and mowing) are safer and have less environmental impact than the use of herbicides. Often overlooked are the environmental and safety concerns associated with repeated cutting of vegetation such as: soil compaction from heavy equipment, soil erosion, damage to sensitive wetland areas, worker and environmental exposure to petroleum products (which are more toxic than many herbicides used for right-of-way maintenance), the potential for physical injury from sharp tools and equipment, the increased fire risk, and the repeated, significant alteration of potential wildlife habitat. The goal of an IVM system is to manage vegetation and to balance benefits of control, public health and safety, environmental quality, and cost.

Cutting or mowing vegetation perpetuates the growth of incompatible vegetation because of the biological response of resprouting. When a stem is cut, multiple sprouts can grow from the severed stump or the root system (so-called "root-suckering"). These sprouts are fast-growing because they are fed from a root system which is already well established. A repetitive cycle of cutting and sprouting results in an increasing density of tall growing species. The combination of mechanical methods and the selective use of herbicides is very effective in controlling resprouting tree and woody brush species that present problems for the access and maintenance of electric transmission facilities.

Manual: Chainsaws, polesaws, machetes, string trimmers, McLeods and chippers are used for manual vegetation management. Chainsaws, pole-saws, and machetes are used to remove woody species, such as oaks, conifers, and brush greater than 1 inch in diameter. The string trimmers and McLeods are used to clear grasses and smaller woody species. Manually cleared vegetation is then either lopped and scattered; piled and burned or chipped, depending on fuel hazard, soils, and access. Manual treatment usually results in vigorous resprouting of woody species.

Cultural: Mulches can be used to help control annual grass and broadleaf species. Seeding is also used to develop and maintain a desired species of vegetation. Wildlife groups such as the National Wild Turkey Federation provide seeding mixtures which contain low growing grass that utilities can use after initial mechanical techniques. The use of these seeding methods can quickly revegetate a site, reduce erosion, improve water quality and reduce herbicide use.

Biological: Cattle and goats are two biological methods that have been used to control vegetation. Goats are currently being used by several utilities to control woody plant species and to help convert the vegetation cover to grasses. Cattle leases have been used in some sites to graze predominately grass species along right-of-ways. Goats and cattle are not completely effective when used alone because of grazing preferences, but can be extremely effective when used in combination with selective herbicide applications.

There are also some very host specific insects and diseases that are available for control of certain weed species. The use of insects for the control of certain undesirable exotic species, such as yellow starthistle and puncture vine, has some potential in a long term IVM program.

Chemical (herbicides): The use of herbicides is regulated by the Federal Environmental Protection Agency (EPA), the California Environmental Protection Agency, the California Department of Pesticide Regulation (CDPR) and the local County Agricultural Commissioners.

Herbicide applications require the following:

1. annual safety and product training for each herbicide used
2. the use of safety equipment, including goggles, gloves, long pants, long sleeved shirts, shoes and socks

3. a written Pest Control Recommendation by a Licensed Pest Control Advisor (PCA)
4. monthly reporting of each use of herbicide county
5. annual inspections by the County Agricultural Commissioner

Foliar backpack applications can be selective or non-selective, depending on the type of herbicide and the application method. Foliar applications are usually most effective when made when the target vegetation is actively growing. The herbicide triclopyr can selectively control broadleaf weeds such as yellow starthistle without affecting desirable grasses. Even non-selective herbicides, such as glyphosate, can be used for selective control through the use of low volume directed back-pack applications or by timing the application so that the desired annual species have already produced seed.

Basal stem treatments are another selective contact treatment. Basal stem treatments are usually made using 5gallon backpack sprayers. Herbicides are mixed with an crop oil carrier to allow adequate bark penetration and are applied to the lower two feet of a woody plant. Basal stem applications have a longer application season and can provide good control from March through November. Applications are frequently made during the dormant season because they are easier once the plants have lost their leaves. Dormant applications have the advantage of being a low profile approach since the target species never leafs out in the spring and there is no brownout.

Cut stump treatments are used to prevent woody species from resprouting. After trees and brush are cut with a chainsaw or loppers, the stump is treated with herbicide. Most cut stump treatments can be made year round.

Injection is an application method in which capsules containing herbicide are injected into the woody cambium and the herbicide gradually translocates to the roots and stems. This is another low profile application, since the applicator carries a 6 foot lance and not a back-pack sprayer.

CONCLUSION

Utility ROWs offer many opportunities to manage for integrate resources such as wildlife, recreation, fuel breaks, cultural resources, threatened and endangered species, exotic and noxious weed in coordination with providing safe and reliable power transmission and IVM provides the techniques that resource managers can use to manage for IRM.

LOCAL HAZARD REDUCTION PROJECT SUCCESS STORY IN L.A.

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BACKGROUND

The County of Los Angeles Fire Department has conducted a Vegetation Management Program designed to reduce the impact of wildland fire since the late 1970's. In conducting this program, project locations are determined based on several factors including but not limited to historical fire frequency, downwind values at risk, property ownership, community support, topography, access and vegetation type. One of the communities susceptible to wildfire is Monte Nido, a small community of 500 residences located in the Santa Monica Mountains.

OBJECTIVE

Develop a fuels reduction project to the north and east of the community to reduce wildfire intensity and the number of firebrands that would be produced. METHODS: An evaluation of upwind (typically strong Santa Ana winds from the Northeast) property ownership revealed that there were 16 landowners. A letter of inquiry was sent to each landowner to determine if they would support a Vegetation Management project. Once project boundaries were determined, an environmental review was performed, contracts developed and Burn Plan produced. This project was then submitted to the California Department of Forestry and Fire Protection for approval.

RESULTS

The 335-acre project was completed in 1991. In 1996, at about 11:30 a.m., the Calabasas Fire started along the south side of Highway 101 and quickly spread south and west. In mid-afternoon, the fire burned into the Monte Nido Vegetation Management Project. Personnel assigned to protect the community stated that both fire intensity and the number of embers, which can start new fires, was significantly reduced. No homes were lost in this community although the fire continued to spread to the south and west stopping at the Pacific Ocean.

CONCLUSIONS

When strategically located in historic fire corridors, vegetation management projects that reduce the amount of vegetation and ratio of live to dead fuels significantly improves the likelihood that fire suppression resources will be effective.

THE URBAN-WILDLAND INTERFACE ECOSYSTEM: INTEGRATION OF FIRE AND RESOURCE MANAGEMENT

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ABSTRACT

As communities expand into open space and wildland or forested areas, the natural resources in the interface zone are subject to increased human impact. While fire safety in the urban-wildland interface is often a primary concern, interface ecosystem management also includes active management of the urban forest as well as the wildlands, often incorporating traditional natural resource management principles in the process. The role of fire within the native ecosystem must be clearly identified and incorporated into the management program. Interface ecosystem management requires management of all environmental resources in and adjacent to urban areas in coordination with developed environments within communities.

Keywords: urban-wildland interface, ecosystem management, wildland fire

INTRODUCTION

When you think of the urban-wildland interface (UWI), what is the first thing that comes to mind? Fire. Why? Not because it is a new phenomenon - wildfires have always been a part of nature. Not because of the acreage burned or intensity - large and ferocious fires have quite a history. It is because of the increased impact to people. Houses are burning more frequently than ever before - and in large numbers. People are injured and killed. As a result, the fire service and resource management agencies, more than any other government sector, have been dramatically impacted as to how they conduct business.

Sure, the terms "urban-wildland interface," "urban national forests," "urban forestry" and "urbanizing forests" may be common lexicon today, but not 20 years ago. Why? Have the trees moved? Do we have new vegetation types to consider? Not really. Again, its the people. People like to live in homes and wildlands simultaneously. The result? We need to manage people and wildlands together, not as two separate entities. The trend will not be reversed, so it is necessary to face the challenges and propose some solutions.

How do we integrate fire management and resource management in the UWI ecosystem, when it doesn't fit any of our current natural resource management practices? We must first acknowledge that management of the UWI is not the same as managing wildlands or urban development, but rather it is a distinct entity that requires unique management principles and bold new approaches.

For example, a few years ago the International Fire Code Institute developed a new fire code for the UWI. Also, firefighters are now being trained in tactics specifically for the UWI. Maybe its time for a new fuel type for computerized fire models that include burning structures at varying densities of development.

The dramatic urban wildfires of the 1990s brought this dilemma to the forefront of land use planning and resource management. In 2000, the explosive fires of the west brought the dilemma to the nation's attention. In the new millennium, we are poised to meet the challenge with real answers - and they may not be politically correct.

THE IMPACTS OF URBAN SPRAWL -- The urban development of rural and wild America.

New residents are escaping urban America. They are seeking regions that were once remote ranch and farming communities and are now a destination for retirees and others seeking refuge. There is now a mosaic of jurisdictions, disjunctive land use, and a broad interface between wildlands and urban development (Scott 1995). The edge between where people live and flammable wildlands occur, and the subsequent "buckshot urbanization" pattern is now the critical issue, not the amount of land urbanized (Sampson 1996).

Scott has identified several transitional gradients in the UWI edge: 1) urban enclaves embedded in natural landscapes (shotgun pattern of communities); 2) urban fringe sharing an edge with natural areas (narrow band of interface); 3) and natural area fragments embedded within urban land uses (shotgun pattern of natural areas) (Scott 1995). The Society of American Foresters (SAF) defines UWI as "the line, area or zone where structures and other human development meet or intermingle with undeveloped wildland or vegetative fuels" (SAF 1990).

An increase in population and new development in fire-prone areas leads to more time and effort in protecting structures, and more complicated, expensive, and dangerous fires (Report to the President 2000). Correspondingly, large unbroken areas of fuel no longer exist. The control of accumulated fuels is more difficult due to emerging land ownership patterns and attitudes of landowners. In addition, there is a misconception by elected officials, agency managers and the public, that UWI protection is solely a fire service concern (Federal Policy).

RISK OF WILDFIRE

Increased human impact

The increasing population is creating a UWI that places more humans and structures at risk and increases the occurrence of human started wildfires (Ebel 2000). This increased population is now the driving force affecting wildfire management. It also affects watershed and wildfire protection policies. Regardless, the impacts of people are the most critical problem (Walt 1988).

Hazard assessment

There is a need to identify and standardize a science-based urban-wildland interface hazard assessment system usable by all fire departments. The classification of interface areas should consider different variations in vegetation, climate and topography. However, one significant obstacle is that state and federal agencies are charged with wildland protection while local departments are primarily concerned with structural protection (CDF et.al. 2000).

Several assessment systems are currently available:

- The Insurance Services Office (ISO) FireLine program developed by the insurance industry is based on fuel types, slope and roads (access) (CDF et.al. 2000). However, the ISO rating criteria do not reflect UWI hazards at specific risk locations (Federal Policy).

- The California State Fire Plan is workable, but it is applied inconsistently. Four assessments include fuels, weather, assets at risk and level of service (CDF et.al. 2000).

- The California Bates system identifies Very High Fire Hazard Severity Zones with minimum fire safety standards, but there has been a failure of all communities to apply it (foundation for system is fuel, topography, weather and dwelling density) (CDF et.al. 2000).

- The Federal FlamMap system has been accepted by federal agencies, but structural density is not taken into account (result of federal policy); data themes include elevation, slope, aspect, surface fuel model, canopy cover, stand height, crown base height, crown bulk density (CDF et.al. 2000).

In order to strategically identify fuel treatment areas to protect values, a focus must be placed on high-risk areas (Cohesive Strategy 2000).

Role of fire in ecosystem

Fire is a fact of life in wildland ecosystems. The 1995 federal policy statement recognized the important function of fire in many ecosystems. The natural resource conditions in wildland ecosystems have been made more fire-prone due to successful fire suppression (Sampson 1996). Currently the role of fire in different ecosystems is being integrated into management practices (Report to the President 2000).

However, it is difficult to define the role of fire, particularly in the UWI. According to the Cohesive Strategy, "Some ecosystems depend on frequently recurring, low-intensity surface burns to cycle nutrients, control pathogens, and maintain healthy, resilient conditions". Also, fire-dependant ecosystems are typically located in valley-bottoms where homes and development are most concentrated.

Management for long-term health

Reintroducing fire to certain ecosystems will be beneficial ecologically, and can reduce the severity and extent of wildfire (Ebel 2000). In fact, fire should be reinstated to avoid a reoccurrence of the current predicament, especially since major fires are not socially or ecologically acceptable. However, to do so requires a long-term commitment. Wildlands and forests have too much fuel to consider a one-time or short-term approach adequate.

The reintroduction of fire should not be considered the only method, since the accumulated fuel load is too great. Mechanical and other means of treating and reducing the fuel load must also be incorporated into the management process. However, it must be recognized that protection is not the same as fire exclusion.

Consequences of Wildfire

Intense fires have drastically changed the ecosystems of many of the extensively burned areas (Report to the President 2000). There has been natural resource damage and economic impacts resulting in the need for restoration and rehabilitation. Many landscapes are susceptible to changes in vegetation composition, the water quality of streams and rivers is threatened, and wildlife populations are disrupted.

FIRE MANAGEMENT PRACTICES

Protection of urban development

In the 1960s and 1980s it was determined by federal policy that wildland fuels must be managed near structures. Since then, development in the UWI has complicated significantly the job of fighting large wildland fires. Homes are pressed up inside remote canyons and under the canopy of the forests (Murphy - LA Time 2000). Now in the 1990s and beyond, the UWI is the area where action is urgently needed (Lavin 1996).

UWI fires are now real estate fires, not wildfires, as the presence of structures complicates what is essentially a wildland fire (Walt 1988). Most structure loss occurs in the first few hours - often due to lack of vegetation management practices. The fires penetrate the first row of houses exposing more houses to be jeopardized (Scott 1995). Unfortunately, the current fire protection infrastructure is inadequate during fast moving wildfires (Federal Policy).

There has been a tactical shift in firefighting: 1) saving lives; 2) save homes and structures; 3) put out the fires. Firefighters now deploy resources around residential developments and leave the wildland fires to burn. The firefighters will only go so far, however, as indicated by a recent statement during the Montana wildfire siege, “Your house is not worth my life” (Murphy - LA Times 2000).

Protection of natural resources

Fire in the UWI currently demands the protection of scattered structures at the sacrifice of natural resources elsewhere (Federal Policy). This is complicated by a high fuel load from decades of increasingly proficient fire suppression, a policy to quickly extinguish fires and, in forested areas, reductions in logging which have resulted in forests with overstocked trees and heavy underbrush. A comprehensive approach to pre-fire natural vegetation management may be necessary, including fuel breaks, prescribed fires, fuel modification and reduction of fuel load (Scott 1995, Teresa & Pace 1994).

We must ask ourselves this question posed by Neil Sampson, "Should the resources of the fire suppression effort be dedicated to the protection of a dozen rural homesteads valued at $20 to $100 thousand apiece, while millions of dollars in resource value goes up in smoke for lack of quick action?" (Sampson 1996).

Protection of both -- Urban development and natural resources.

Of primary importance for an adequate level of protection is the maintenance of first-class resources for integrated firefighting management and preparedness (Report to the President 2000).

Secondly, it is necessary to reduce the accumulations of hazardous fuel by the elimination of brush, small diameter trees and other fuels. Mechanical, chemical, biological and manual methods of selective removal of undergrowth can significantly reduce fire risks. It is clear that fuel treatments mitigate fire severity. Also, the reintroduction of fire to wildland ecosystems must be incorporated. Removing excessive fuel through mechanical treatments and prescribed fire will help to protect communities at risk, prevent insect and disease damage, and generally improve overall ecosystem health and sustainability. The use of prescribed fire can change a crown-fire to a ground-based fire. Defensible space barriers should be established around the perimeter of structures (Report to the President 2000).

Finally, local community coordination and outreach must be incorporated into the management practices involving communities in the UWI. Changing demographics are expanding the UWI and creating new challenges for fighting wildland fires. This demands close coordination between local, State, Federal and Tribal resources.

The problem of fires in the UWI is multifaceted, as is ecosystem management. The top priority is to reduce fuels adjacent to and within communities, and to educate communities and homeowners about the inherent dangers of the ecosystem that surrounds them. They must learn to recognize fire hazards, design firewise homes and landscapes, and use wise planning, zoning, and building material choices.

URBAN-WILDLAND INTERFACE ECOSYSTEM MANAGEMENT

Effective ecosystem management in the UWI will include an analysis of physical and biological resources, water and fire management with a focus on stewardship in perpetuity (Teresa & Pace 1994). This analysis will permit the development of constrained management options for fire control, species management, recreation, viewsheds, etc. (Scott 1995).

"[In 1995] a fourth phase of Forest Service history began - the period of ecosystem management which concerns preservation of biodiversity, the needs of people, and economic and ecological constraints" (Thomas 2000). Since the concept of ecosystem management is relatively new, it will take time to evolve into practice. Ecosystem management requires an integration and understanding of fire history, fire behavior, past management actions, land use change, watershed needs, species viability and relative risk to human communities (Cohesive Strategy 2000).

Human dimensions

Neighborhoods continue to grow across a landscape that once burned regularly. However, the typical resident perceives neighboring wildlands as recreation areas. The constant reduction of wildland area concentrates recreation use to smaller areas. This leads to increased probability of wildfires, fuels and weeds, and intensifies the effect of fire when it occurs. Everyone in the community is responsible for fire protection and preparedness and must be informed as such (Scott 1995).

Management of the urban forest

Sustainable management and use of urban-wildland or urbanized forest resources must be incorporated into each community's urban forestry master plan. As stated by SAF, "urban forestry is the management of trees and forested lands in and adjacent to urban areas ...within cities and forest management in the UWI". Furthermore, "actions that improve forest management in urban areas and in communities are vital to the natural, social, and economic well-being of the nation" (SAF 1997).

Management of wildlands

The past policy of aggressive fire suppression has disrupted normal ecological cycles and changed the structure and make-up of wildlands. Trees and other vegetation susceptible to fire have become dominant, an accumulation of materials has created extreme fuel types, and wildfires now burn hotter, faster and higher (Report to the President 2000).

Reversing the effects of past policy is an evolutionary process. Resource managers warned of ecological changes after the 1988 & 1994 fires. In 1999, the GAO Federal Wildfire Activities report confirmed those warnings (Report to the President 2000).

Improving forest conditions is necessary to reduce the threat to adjacent residents (Sampson 1996). A landscape management approach is necessary that incorporates natural ecological processes to improve land management quality. Ecosystem functions must be maintained including native species, habitat preservation, natural communities and species of concern.

CHALLENGES

Management of the UWI is one of the most difficult issues for resource managers, since it is not driven by science or natural resource management, but political issues (Sampson 1996). There are many complications - zoning, fire and building codes, fire protection infrastructure, insurance rating systems, environmental concerns, political factors - as well as inconsistent and sometimes conflicting policies and procedures (Federal Policy).

Interagency

The overall objective is to facilitate interagency fire prevention and protection, and to ensure citizen recognition of hazards, risks, and the importance of their contribution towards minimizing exposure (Lavin 1996). The primary role of federal government is wildland firefighting, yet protecting people's lives is always the first priority: life, property, natural/cultural resources. This conflict presents an uncertainty about the federal agency role in the UWI and is a barrier to effective fire protection (Federal Policy).

Sampson maintains that the federal priority "to protect resources and property, based on the relative values to be protected" would indicate that if the value of the natural resources is higher than that of the UWI structures, then the natural resources should be protected first (Sampson 1996). However, in reality, the political implication of letting a private residence burn based on value relativism is currently not acceptable.

The key to addressing the UWI problem is the development of a partnership with federal, state and local governments and the private sector. Complicating this issue is that firefighter performance qualifications differ between structural and wildland fire certifications (Federal Policy). To remedy this, some agencies are now in the process of establishing certification standards for wildland interface firefighters.

In some unincorporated areas there are limited county zoning or land-use ordinances, and minimal requirements for setbacks from trees or brush clearance zones (Murphy 2000). According to the current Federal Policy, it is necessary to implement and enforce access, landscaping and construction standards in the UWI in order to provide for effective fire safety measures.

Environmental

Any management practices in the UWI must employ techniques that mitigate environmental degradation. Just as in a wildland setting, there must be a focus on critical watersheds, water quality, sensitive species habitat, and restoring ecosystem functions. It is possible to limit severe burns through the active management of forest and wildland conditions

(Ebel 2000). When reintroduction of fire is proposed, EPA issues regarding air quality and smoke management must be addressed (Federal Policy). Even in the UWI, it is possible to manage resources toward the continued functioning of natural ecosystems (Teresa & Pace 1994).

In order to protect both communities and maintain land health, entire landscapes must be considered in the context of specific ecosystems and their ecological dynamics (Cohesive Strategy 2000).

"The spate of environmental legislation of the late 1960s and 1970s has combined to produce an increasingly unwieldy and unworkable situation for public land managers" (Thomas 2000).

Financial

Increased programmatic funding has been a primary focal point, but there are other financial issues: identify and fund high-priority fuels management activities on federal lands (Federal Policy); adequately fund and improve public firefighting capacity (Sampson 1996); derive an income to offset the expenses.

SUMMARY

Integration of Fire and Resource Management in UWI Ecosystem Communities

- Acknowledge that UWI management differs from forest/wildland resource management and urban forestry
- Classify the various UWI types and define their boundaries
- Identify and standardize a science-based UWI hazard assessment system
- Develop scientifically sound defensible space fire safe zones for structures
- Educate homeowners about the inherent dangers of the ecosystem
- Implement and enforce minimum standards for land use planning, zoning, building, access and landscaping
- Strategically identify fuel treatment areas to protect values at risk
- Reduce fuels in forests and wildlands adjacent to and within communities using effective vegetation management practices
- Incorporate management of the urban(ized)-wildland resources into each community's urban forest master plan
- Assist private landowners to take preventive action

Integration of Fire and Resource Management in UWI Ecosystem Natural Resources

- Use a landscape management approach
- Maintain a current inventory of resources
- Actively manage resources toward the continued functioning of natural ecosystems with a focus on stewardship in perpetuity
- Designate high-value resources within landscape management units that may receive fire protection priority in lieu of structure protection
- Identify and fund high-priority fuels management activities

- Reduce the accumulation of hazardous fuels
- Identify sensitive species and implement habitat management plans
- Avoid ecologically sensitive areas
- Mitigate environmental degradation by establishing appropriate management experiments and protocols

Integration of Fire and Resource Management for UWI Ecosystem Fire Management

- Define the role of fire in the UWI
- Actively manage fire through reintroduction of fire to certain ecosystems and restoration of natural fire regimes
- Adequately fund and improve public firefighting capacity
- Maintain first-class resources for integrated firefighting management and preparedness
- Coordinate federal, state and local wildland, structural and UWI firefighter standards and certifications
- Develop and standardize UWI firefighting tactics
- Develop fire/fuel models that incorporate structures as fuel types

CONCLUSION

Challenge: to adjust the balance of structural vs. natural resource protection for successful fire and resource management in the UWI ecosystem.

Implications:

- there will be environmental impacts from management activities;
- protecting natural resources in lieu of homes will be challenged;
- reintroduction of fire into the UWI will burn houses; and
- some federal, state and local regulations will conflict.

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FLAGSTAFF INTERFACE TREATMENT PRESCRIPTION: RESULTS IN THE WILDLAND/URBAN INTERFACE

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ABSTRACT

Over the past five years, fire managers in the Flagstaff Wildland/Urban Interface have developed a system of socially welcomed fuel reduction treatments that have proven effective in reducing wildfire hazard, improving probability for successful initial attack, maintaining and enhancing vegetative diversity, and initiating improvement of overall forest health. The long term objective of the program is to facilitate stewardship of forested properties within the interface, regardless of ownership or jurisdiction.

The Flagstaff Interface Treatment Prescription incorporates not only forestry and fire science but also community and neighborhood input as vital components in successfully developing, implementing, and maintaining the treatments. With several thousand acres now treated, other benefits and lessons have been noted as well.

INTRODUCTION

Flagstaff, Arizona, located in north-central Arizona, is a high elevation (7,000 feet) metropolitan area surrounded by a dense ponderosa pine forest (figure 1 and 2). The annual

Figure 1. Flagstaff circa 1900 - Photo courtesy of Lowell Observatory

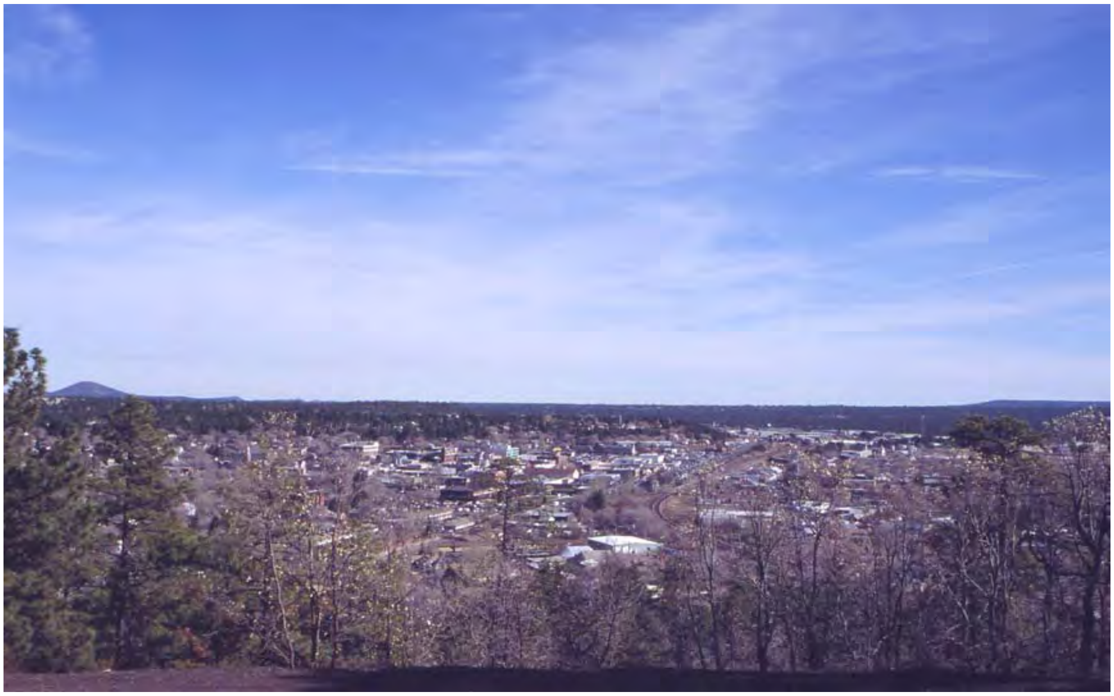

Figure 2. Flagstaff 2000- Photo by Allen Farnsworth USFS

number of wildland fire starts in and immediately adjacent to the interface area averages over 200 per year, with some years recording over 300 fires. Based upon existing hazard and values-at-risk, wildfire is the #1 fire threat to the community.

In the early 1990's, the U.S. Forest Service (USFS) began treating high-risk areas adjacent to and within the Flagstaff corporate boundary with the goal of reducing the fire threat to the southwest side of Flagstaff, including historic landmarks such as Lowell Observatory. The City of Flagstaff Fire Department (FFD) began a fuel management program after the severe 1996-wildfire season. The Ponderosa Fire Advisory Council, a consortium of fire departments and land-management agencies from the greater Flagstaff area, has also supported and recently initiated fuel reduction projects. Since the program was started, several thousand acres have been successfully treated with overwhelming public support (figure 3).

Completed fuel treatments complement the area's suppression system. With six staffed fire lookout towers that oversee the north end of the Coconino National Forest (including Flagstaff), early wildfire detection is usually possible. Once a report is received, the Coconino National Forest, which provides wildfire dispatch service to all fire agencies, can rapidly send initial attack units. An extensive road system usually enables initial attack forces to arrive on the fire scene within fifteen to thirty minutes from the time of the initial report.

Photos taken from Mars Hill looking east. Sheep Hill is seen at the far left of each photo. In the 100 years between the photos, Flagstaff grew from a rural settlement to the major metropolitan center of northern Arizona.

Figure 3. This parcel between Sinaqua High School and FFD Station 4, was broadcast burned following selective thinning. Photo by Allen Farnsworth USFS

HISTORICAL TRENDS

Prior to European settlement in the 1860's, the forest was comprised of relatively open stands of large-diameter ponderosa pine. Tree numbers averaged 30-50 per acre, with these trees arranged in small groups. While some young thickets were undoubtedly present, a savanna grass-land dominated the landscape. Fires were frequent, returning every 2-7 years, and were relatively low-intensity in nature.

By the 1880's, the forests were subjected to intense livestock grazing and timber harvesting. The removal of most of the grass, coupled with a period of relatively wet weather and the exceptional 1919 cone crop, saw many new seedlings established. For most of the 20^{th} century, a policy of active fire suppression – almost to the point of fire exclusion – was embraced and practiced.

As a result, many of the pine stands are presently overstocked with small and mid-sized second-growth trees. Basal areas commonly range from 150 to well over 200 and tree density from several hundred to a few thousand per acre. Canopy closure typically varies from 50 to 70% but often approaches 100%. An occasional juniper, pinyon pine, Douglas fir, white fir, Gambel oak, limber pine or aspen occurs among the pine stands. Insect and disease problems in these stands include dwarf mistletoe and periodic episodes of various bark beetles.

Sites are best represented by Fire Behavior Prediction System (FBPS) Fuel Model #9 - closed-canopy pine stand with needle understory. In the few open areas, the ground cover is a mix of grasses and forbs. Heavy logging slash from the early 1900's such as pitchy high stumps and cull trees contribute to the fire hazard and laddering potential.

GOALS

Generally, the goals are four-fold:

1. Reduce the wildfire hazard through a combination of thinning, brush disposal and prescribed fire.

2. Maintain and enhance vegetative species and structural diversity of the site.

3. Improve overall forest ecosystem health.

4. Engage individual property owners and the community in the effort.

The objective is to facilitate treatment of forested properties, regardless of boundary lines or jurisdictions within the area. All stands or parcels are considered valuable components of the overall ecosystem. Acres-treated is the benchmark by which we measure success.

SILVICULTURAL PRESCRIPTION

The area is a true wildland/urban interface forest, and the silvicultural prescription is fairly basic. Selective thinning, focusing on over-topped pines, is preferred. Target basal area for mistletoe-free stands is 60 to 100. If possible, "leave" trees are left in a clumped pattern rather than evenly spaced. This benefits certain wildlife species, as well as avoids a plantation appearance. Trees designated for removal are those which:

1. Create a ladder fuel effect into the overstory canopy.
2. Are suppressed or are suppressing otherwise healthy trees.
3. Exhibit reduced vigor.
4. Are damaged or deformed and contribute to fire potential.

Stands with high infestation levels of dwarf mistletoe, are thinned to reduce crowning potential during the inevitable wildfire. Small isolated pockets of mistletoe -- less than ¼ acre -- are either:

- Isolated from non-infected trees by a barrier of fifty feet to reduce further spread of the parasite, or
- Removed.

Old growth and large diameter "blackjack" pines are showcased by removing thickets of younger trees from around their base (generally within thirty feet). Oaks or other preferred species can also be highlighted by removing some or all of the encroaching pines. Other unique features, such as geologic protrusions, scenic vistas or uncommon ground vegetation, can be enhanced as well by selective removal of young pines. Under this prescription the cutting of old growth, large diameter "blackjack" pines, or standing snags is avoided unless these trees pose a threat to public safety or improvements, such as a tree leaning over a home, play area, powerline, road or hiking trail. This prescription is considered a moderate-to-heavy modification of the existing stand, involving removal of 50-75% of the existing trees, mostly of small diameter.

DESIGNATING TREES FOR REMOVAL

Simple guidelines, issued by the project manager either verbally or in writing to the crew, have worked well. Where possible, a cutter selection method is preferred. If necessary, a sample cut can be designated and reviewed by the thinning crew.

Where designating trees with paint is necessary, a cut-tree mark, as opposed to a leave-tree mark is preferred. Marking cut-trees eliminates the long term appearance of a leave-tree mark. However, one method being considered in areas scheduled for follow-up underburning involves placing only one paint mark on the leave tree as close to the ground as possible so that the scorch from the underburn will hide or eliminate the paint.

When designating trees for removal, personnel must be aware of fire behavior alignments such as prevailing wind direction, shading, slope, fuel arrangement and continuity, and potential fireline locations. Careful consideration also needs to be given to the type of fuel model conversion that may result from treatment. Converting a stand from a FBPS Fuel Model 9 to a FBPS Fuel Model 2 (open pine stand with grass understory) may be more appropriate directly adjacent to a control feature such as a road, trail or natural barrier.

CUTTING TECHNIQUES

The type of mechanized operation should be given serious consideration when cutting in the interface. A traditional harvesting operation may not be suitable in some areas, while in others it may be the preferred method. Although we use traditional timber-harvesting equipment under certain conditions, we typically utilize a "micro" harvesting approach. Trees are cut either using hand-crews with power saws or by a Bobcat shear. Wood is moved by an All-Terrain-Vehicle (ATV) with a trailer. This is not as disturbing to area residents as would be the case with larger equipment, and it allows curious people to readily approach our crews to learn about the operation which is something we encourage. In addition, smaller equipment reduces soil compaction and disturbance, minimizing the amount of soil exposed for noxious weed and other exotic plant establishment, as well as soil erosion. Stumps should be cut as low to the ground and as level as possible. This not only improves post-treatment visual quality, but facilitates wood removal and subsequent fire management needs by allowing easier access.

As much as possible of the required slash treatment should be completed daily. Leaving untreated slash – even for a few days – invites criticism from concerned residents in the area.

Lastly, restricting hours of operation in response to local conditions is another consideration. For example, if an operation is immediately adjacent to homes or a neighborhood, we typically restrict activity to those hours when most people are not home.

UTILIZATION

To the maximum extent possible, wood produced from thinning operations should be removed and utilized. Occassionally, some material may be left on-site as wildlife cover.

Figure 4. Firewood on Mars Hill was removed by the public on a designated free wood collection day. Photo by Paul Summerfelt FFD

Although current commercial markets are slim for many of the products we produce, we have had a great deal of success by designating accessible areas as free-use wood areas. Each fall, the Flagstaff Fire Department's free wood Saturdays typically draw 200+ people who will remove 100 cords of firewood in half a day. To facilitate removal, firewood must be cut into 2 to 3 foot lengths, and poles into 10 foot lengths (figure 4). Access through neighborhoods for wood removal is discussed with adjacent homeowners during the initial planning stages, not after cutting is underway. Without a market for these products, or in areas where removal is not practical, the project manager must carefully consider the size and number of the trees designated for cutting on any one site. More than one cutting cycle may be required so as to not overload the ability to treat the resulting slash in a timely manner.

SLASH TREATMENT

Slash is initially treated in one of 4 ways:

Hand Piles: This is the typical method of handling slash. Hand piles are teepee-shaped and a minimum of six feet tall and six feet wide. Pile placement needs to be carefully considered. Piles should be located in openings to avoid scorching leave trees when the piles are later burned. Likewise, placing piles on top of old stumps or logs should be avoided to reduce both the amount of smoke and the chance for "creep" when the piles are later burned. We have found that to the public, a scorched tree is worse than a cut tree and "creep" is an "escaped controlled burn."

Machine Piles: This method is sometimes feasible in more open areas. We have had the most success with the windrow piling method perfected on the Mormon Lake Ranger District. This requires directional falling into a windrow that can then be pushed into large piles by a dozer during a single pass. Because the dozer is not constantly spinning and turning, few ruts are made. The larger piles result in fewer piles per acre, speed production by an estimated 30%, and can be ignited under snowier or wetter conditions than traditional hand piles. At first, some were skeptical of this method, but once the process and results have been observed, comments have been favorable. We have also employed whole tree skidding.

Chip or Grind: Although, occasionally used this technique is comparatively expensive and chips decompose slowly in our area. If future underburning is anticipated for the site, chips may add to smoke management problems. The material can, however, be used for mulch or decorative landscaping. Hauling chips to a disposal site is expensive.

Lop-and-Scatter: The decision to utilize this method should receive careful soon after cutting, it may be effective. However, we seldom use this method. Due to the increased fire hazard, dried lopped-and-scattered slash should never be left in-place adjacent to homes.

PILE BURNING

Piles should be burned only when consumption will be greater than 90%. A test pile may need to be burned to ensure this is achievable. All pile burns should be conducted under conditions intended to reduce scorch, minimize smoke issues, and lessen potential control problems. Quality is the number one concern, not acres treated per day. This is the case regardless if the material is hand or machine piled.

Because we intend to broadcast burn most, if not all, sites we work on, we often pile some of the existing dead-and-downed material. These piles are then burned when the slash piles resulting from thinning are burned, which aids in smoke reduction during the following broadcast burn. Some material is left onsite for wildlife cover.

Hand Piles: As a standard practice, we wait for either snow cover or an extended wet weather episode. On burn day, the crew will ignite a reasonable number of piles. As they burn-down, the crew goes back through the area and consolidates each pile 2-3 times to ensure complete, and timely consumption. The work pace is governed by the intent to have all piles burned-down by nightfall.

Machine Piles: When burning this type of pile, we wait for snow. As the piles are burned, a small dozer is ideally on-hand to shape up the piles and landings. While the dozer is working, seed can be spread and worked into the ground. This results in faster site recovery, less likelihood of noxious weeds becoming established and reduced visual impact.

BROADCAST BURNING

Treating ground fuels is a critical component of our stand enhancement and fuel reduction effort. Once an area has been thinned and the slash has been treated, the site should be broadcast burned (figure 5). As our prevailing wind is from the southwest, burn blocks, where possible, are burned starting in the northeast and working toward the southwest. Fireline is usually constructed by hand or with a drag pulled by an ATV.

Figure 5. This parcel at the Brannen Homes development was broadcast burned following selective thinning, pruning, and slash disposal. . Photo by Larry McCoy USFS

As a standard practice, standing dead trees are either hand lined or otherwise excluded from the burn block. The same is true for cultural or archaeological sites or other features important to the manager that might be degraded by fire.

Once ignited, deep duff and needle accumulation at the base of the larger older trees will often smolder for days. This essentially bakes the cambium layer and death can occur 1-2 years or more after the burn. To avoid such damage, the duff and needle material is routinely raked away from high-risk trees. Usually raking to a distance of one foot from the bole is sufficient. We do the same for downed logs we wish to preserve for wildlife cover.

The preferred season for broadcast burning is normally during breaks in the summer monsoon season, during the transition from the monsoon season to drier fall weather or during the fall and early winter. While spring burning is sometimes used, it must be balanced against resource availability, training commitments, and the normally escalating fire danger indices prevailing at this time of year. However, if the planned burn is small, of short duration, and anchored to a recent burn or fuel break, spring burning can be done with reasonable safety.

Our ultimate goal is to shift more burns into the summer months to recreate the historical fire regime. This will become easier once a site has been previously burned to remove excessive accumulations of fuel.

The underburning prescription generally calls for strip-head fires along with a combination of backing fires (used at starting points and on steep slopes) with target flame lengths of 1 to 3 ft. Ignition by hand with drip torches or with ATV-mounted torches is preferred. Ignition is usually begun at mid-morning following the break-up of the night time temperature inversion and the establishment of the day time wind pattern. Every effort is made to complete ignition by early afternoon, with burn blocks generally kept small to achieve this objective. Although each burn block may have specific objectives, we generally have two overall objectives for the operation: 1) to reduce 1 and 10 hour fuels by a minimum of 60%, and 2) to keep tree mortality to less than 5% of the existing stand. Neighborhood air sheds, indicated by diurnal smoke flows, are routinely mapped so we can plan future smoke management efforts.

Intense public notification is an essential element of the program. This is achieved by posting signs in the area announcing the proposed burn, news releases, and in many cases, door to door contact throughout the nearby neighborhood(s). Any concerns receive immediate attention, either by a phone call or personal visit. If these concerns surface on the day the site is being burned, we often detail the project manager or a crewmember to visit the person while the fire is still underway. We also conduct a continuing education program through talks to civic groups, environmental organizations, and others to inform the community of the importance and benefits of the program. Our experience has shown that a previously notified neighborhood is willing to tolerate smoke for a day, but after 2-3 days, patience wears thin. A particular log, stump, or site within a burn unit may be extinguished the first night if it becomes a major concern to a nearby resident. We attempt to design our burns so they can be dispersed throughout the community so as to not constantly impact the same neighborhood(s). The Flagstaff Fire Department has offered to relocate smoke sensitive people: to-date, however, no one has taken advantage of the offer.

MAINTENANCE

Once the thinning, slash treatment, and first underburning have been completed, the treated area constitutes an effective fuelbreak for at least the next three to four years. Follow-up thinning and maintenance burns are scheduled as necessary to ensure long-term reduction of the risk of destructive fire. Typically, thinning is rescheduled every 10-15 years, while broadcast burns are on a 3-7 year cycle. Smoke management concerns are much less during such maintenance burns.

COMMUNITY INVOLVEMENT

Throughout the entire operation, the project manager must maintain contact with potentially affected residents. We routinely gather input from such persons, consider their concerns and beliefs, and where possible, incorporate their desires into the overall effort (Figure 6). We commonly go door to door to each residence that borders the proposed project to explain the project and gather first-hand comments. Follow-up visits are paid to those people who have questions or concerns. If necessary, a "case-officer" is assigned so the resident deals with the same person from the start of a project to the end.

Some might believe that people would prefer their privacy and ask for no or limited treatments next to their property line. However, we have rarely found this to be the case. In fact, most often the opposite is true: property owners want the work carried onto their land, or onto other adjacent or nearby property.

Figure 6. Project managers routinely meet with nearby residents prior to initiating treatments. Photo by Allen Farnsworth USFS

COSTS

Individual project expenses vary tremendously from site-to-site based on ownership, size, complexity, and need. It is difficult to compare one site to another, especially initial treatment vs. maintenance requirements. What should be considered is the cost of doing nothing. For our area, it is no longer a question of "if" a wildfire will occur, but "when", "where", and "how much damage" will result. We want to work with the residents before the wildfire, not during or after it. Although it takes considerable time and commitment, we believe this one-on-one community involvement is essential for the success of our program.

We have made a concerted effort to involve local businesses in our thinning efforts. Prior to 1998, no more than 10 contracts per year were issued. Since 1998, approximately 60 have been issued each year.

BENEFITS

We have experienced wildfires in several of our treated areas and have noticed the following:

- Improved access for fire fighters and apparatus.
- Increased ability to utilize barriers when locating and constructing line.
- Easier detection and suppression of spot fires.
- Decreased mop up time and effort.
- Reduced torching and mortality.
- Expanded options for a modified suppression response.
- Improved public safety

In addition, we have realized reduced trash accumulation through elimination of hiding cover necessary for transient camps and party spots. We also clean-up existing trash during operations.

RECOMMENDATIONS

Our level of expertise with the program has led to the development of the following guidelines:

1. Involve those potentially impacted or affected from the very beginning.

2. Once the project is started, commit to complete it in a timely manner.

3. Use signs, news releases, and other appropriate methods to update people on the status of the project.

4. Avoid stone-walling. When mistakes happen, immediately notify each adjacent resident, explain what happened and why, and advise them of what is being done to correct the situation. Assume full-responsibility: allow on-site personnel to make commitments to address a problem.

5. Document and follow-up special concerns or small details that may be important to a concerned individual. Personal "client" service is an absolute necessity. We must always strive to maintain the professionalism, integrity and credibility that have been established.

6. Stay focused on the ultimate objective. Reduction of fire risk requires us to produce stumps and smoke. If we are not doing that, we are not successful.

7. Success leads to success. Many landowners throughout the community have seen the ongoing and completed treatments and have implemented similar treatments on their own land.

FIRE HISTORY OF THE OAKLAND BERKELEY HILLS

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SYNOPSIS

The East Bay Hills have lost more than 3,542 homes to major wildfires. The 1991 Oakland/Berkeley fire ranks first as the state's largest home loss from wildfire and the 1923 Berkeley fire ranks fifth. Thirty-nine percent (39%) of the residences destroyed in California's' major wildfires have been lost in the East Bay Hills. The $1.7 billion Oakland/Berkeley wildfire is this nation's fifth most costly catastrophe.

The East Bay Hills are at the center of a major reverse wind funnel with Mt. Diablo and the Carquinez Straits guiding hot, dry, fall winds from the East across ridgetops and then down leeward slopes into residential areas. Diablo Winds turn everything around. They normally reach their highest speeds in the early morning, when you least expect a major fire. They can fan the flames of the smallest spark into a wildfire that can move down from the ridge in 30 minutes, expand to one square mile in one hour, and consume hundreds of residences in one hot, dry, windy, fall day. A wind driven wildfire racing down steep hillside slopes filled with residences presents an enormous fire fighting challenge for State and Local Fire Departments.

East Bay communities have made some improvements over the past 10 years in residential and neighborhood safety and fire fighting capability. However, fire prevention efforts in many of the hill neighborhoods appear to have fallen well short of optimum. Also, in spite of sincere efforts at wildland vegetation management on public lands, fuel loads remain high and the most cost-effective and environmentally acceptable ways for dealing with severe Diablo wind wildfires remains elusive.

FIRE HAZARD MITIGATION PLAN AND EIR

Following the Oakland/Berkeley fire of 1991, a seven agency Hills Emergency Forum (HEF) was formed to coordinate emergency planning and to develop a new East Bay Hills Fire Hazard Mitigation Program and Plan. The new Plan was completed and adopted in October of 1995. Following approval, each member agency was to take the required steps to independently comply with the State's environmental laws for their portion of Plan. This decision has proven to be an unfortunate mistake because full environmental review and full public discussion are key steps in the formation of public policy and the will to spend public funds, especially in the East Bay. Some agencies were able to move forward independently and some agencies have been challenged on both environmental and financial grounds thereby compromising the overall effectiveness of the Plan. The HEF has now agreed to seek the required funding to prepare a program Environmental Impact Report (EIR) that will address the Plan as a single project. The proposed (EIR) is intended to analyze how both residents and HEF member agencies can implement environmentally acceptable vegetation management practices that will reduce the risk of repeated major residential losses from wildfires.

CONVERSATIONS WITH CONFLAGRATIONS: LISTENING TO WHAT FIRES ARE TELLING US

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ABSTRACT

This paper includes some of the experiences and frustrations of a firefighter who has fought dozens of large-loss fires up and down the state from Oregon to Mexico. It is also an exploration of the dialectic between fire behavior and human behavior; how they influence and juxtapose each other in a dynamic cycle.

Though we try again and again to exert a mastery over fire, we become masters of our own destruction. Until we learn how to listen to --and live with-- fire as a partner, history will keep repeating itself and firefighters will keep chasing after the wind.

INTRODUCTION

This paper is not the result of arduous research or clinical findings. I am not an academic nor "expert;" in fact, I consider myself a perpetual student. What follows is based on over 20 years of experience and observations in fighting California wildfires, half of that time as a Fire Captain with CDF. The only verification I have to offer is experience itself. Rather than bringing a scientific mindset to the fire problem at hand, I hope to bring a humanistic perspective to it. The information I have to share is not new, but perhaps the angle of light shed upon it will be slightly different from what has been said before.

There are three major points I'd like to cover. The first is to share with you how some firefighters feel caught in a pre-fire quagmire due to the refusal to see fire as inevitable, natural or even ordinary. The second is: can fires teach us things? If so, what? If a fire could talk, what would it say? Thirdly, I would like to share with you some incident perspectives: how far have we come, and how far do we need to go?

INTOLERANCE AND EXCLUSION

Intolerance and exclusion are certainly terms that we don't like to see used when talking about fellow humans, yet these are precisely the terms used for years to describe human attitudes towards fire. Firefighters shy away from seeing fire as an emotional enemy, though we tend to use animistic terminology to describe how it behaves. We say that the fire is "dying down," or "springing to life," we say that the fire has "jumped the line" or "bumped the ridge." But we do not have an emotional relationship to fire as a soldier might towards another human enemy. Fire is neither enemy nor friend; it is a fact. It is a fact that neither firefighters nor the public has accepted quite fully. Firefighters must come to terms with society's refusal to accept fire as a natural part of our environment. We need to develop creative and innovative ways and means of dealing, not with fire as a problem, but with the public's insistence on its exclusion.

Johan Gouldsblom, in his book Fire and Civilization states: "Any attempt at wholesale suppression of natural human urges will be futile and counter-productive. We see the wisdom in this statement and yet we continuously attempt to extend human control over fire. The cost is that –like any human behavior- the more one attempts to rigidly control it, the more out of control it gets. We end up –as the Book of Ecclesiastes so aptly puts it, "chasing after the wind."

Human behavior, human nature, like fire behavior and nature itself is somewhat predictable. We can gauge the rate of our remembrance or the loss of it; we can vector our own vagarious contributions to conflagrations. We can calculate with certainty another firestorm, but not when or where. Mt. Tamalpias? The San Ramon Valley? Or the San Mateo hills across the bay, where the fire will burn in confluence with slope and wind?

I see fire behavior and human behavior are linked more closely than I've ever thought possible. We repeat our traumas like Prometheus for stealing fire without paying tribute in the form of controlled burns. We seem instead to prefer uncontrolled burns. Humans have created the fire behavior through the total suppression policy, and through an unwillingness to tolerate control burns – especially on private land. And the thermal heat of fire is nothing compared to political heat, especially the heat of an escaped control burn.

This puritanical purge of fire from the environment we now see as a mistake. The local natives, so despised by the civilized folk who first arrived, are now seen as wise custodians and partners with the environment. In our effort to control and modify the fires and fuels, we have unwittingly invited a Kali-like goddess of reconciliation to purify us of our belongings and divest us of our cities. We've unwittingly engineered the disasters; not just from intolerance of fire as integral to our environment, but from inadequate infrastructure, poorly designed and constructed buildings and from modified fuels. The cycle of repetitive loss is thus: humans create the fire behavior, the fire behavior reinforces human behavior (which manifests itself as a fear of fire) and around and 'round we go.

Floods provide an apt analogy to wildland fires. We can't stop the flood, but we can build higher houses or get out of the floodplain. Firefighters protecting homes in a firestorm is like giving us cotton balls to soak up a deluge. This is not firefighting. When we are called from our firehouses to come and defend other homes, it's already too late. The masses of engines looks impressive, but amounts to a glorified funeral procession on its way to a burial ground where chimneys sticks serve as gravestones. Yes, I've saved homes, occupied ones with people in them. But it's a defensive posture, and firefighters like myself often get our butts kicked in doing it.

I have a vision of the future, when homes in fire-prone areas are made to withstand fires. People stay where they are, the fire moves through, and life goes on. As it stands now, civilian lives are at stake during evacuation and firefighters are required to put their own lives at risk in attempts to both evacuate and save highly flammable and fully insured homes. The homes that do burn down are quickly rebuilt in the same manner, only to face another fire. Many European cities burned many times, over hundreds of years, before they started building with more fire-resistive materials. We either ignore this history or we are simply not tired of this repetitive cycle of loss yet. Either way, this is not very wise, but it does seem to be a conscious choice. We can build homes to withstand periodic fires, or keep re-building. It's our choice; the fire doesn't care.

FIRE AS A TEACHER

A good fire behavior analyst –like a good psychoanalyst- will listen to what fire is telling them. What are these conflagrations telling us? If we could ask fire what it has tried to teach us, what would fire say? They have spoken loudly and repeatedly of their history, if only we were listening.

- They have told us it is going to burn in the coastal ranges, have warned us under which conditions, have shown us repeatedly.
- They burn under a north-northeast foehn wind. They may burn with a sea breeze during the day –or not; but will burn at night.
- In minutes, the humidity can drop from over ninety percent to the twenties.
- At the same time the temperature will increase 15 to 20 degrees.
- They burn to the water. They will burn any fuel that stands in the way.
- Total suppression has been a failure; it only creates monsters. These monsters can only be appeased with small token fires or very labor-intensive fuel modification efforts.
- There are too many fuels. Oakland (oak-land) used to be just that: grass with interspersed oaks. Our current engineered environment, the non-native urban vegetation- is further compounding an already heavy fuel-loading problem and we have built homes in way.

TEN YEARS

Ten years is not long when compared to 450 million years of wildfire history. Have we learned the lessons of the past? Perhaps ten years is not long enough. Let's ask ourselves what we've done since the 1923 Berkeley fire burned almost 600 homes, or 1929 when 117 homes burned in Mill Valley. Have we changed since then? I'd like to think so. We have improved significantly in the past ten years, and we all ought to acknowledge it. We have goats. We have fire safe councils. We have weed abatement ordinances and fuel modification meetings. But is it enough?

- Fire agencies still lack the personnel to enforce public resource statutes or to adequately advise homeowners on fire-resistive vegetation.
- Wood shingle roofs abound.
- Road widths are still too narrow, and water supplies are still inadequate statewide.
- And firefighters also fall short in educating the public that fire is natural, that we need to be able to coexist with fire.

INCIDENT PERSPECTIVES

From an incident perspective, California firefighters have co-opted the exclusion of fire into our culture as well and we need to consider alternate methods to defensive firefighting. We have yet to adopt the fire management perspectives that the federal agencies have.

Perhaps we firefighters need to build into our tactical plans appropriate and reasonable fuel-reduction actions as an adjunct to our suppression efforts. The equipment, personnel and support mechanisms are already there. Perhaps we need to re-evaluate our initial attack methods and back off in favor of reducing accumulated underbrush. I call this added measure "kick burns" because we kick out the flanks to incorporate fuel reduction measures at the fire's sides. Send in crews ahead of the low-intensity fires to reduce ladder fuels and denser concentrations. The key to this philosophy is to use human-caused fires to help offset human caused fuel buildups. This may not be the answer, but it remains indicative of options that ought to be explored.

WHAT OTHER CHANGES STILL NEED TO BE MADE?

With all the laws that govern and regulate firefighters, such as hazardous materials, EMS, confined space, and the like –just to name very few- there are still no statutes requiring firefighters to be trained in any type of firefighting. Though we continue to burn and injure firefighters due to lack of training standards, even within the California fire service itself, there is still currently no system in place that ensures that State firefighters are experienced, trained and qualified for wildland firefighting (Note in 2002 new standards are being mandated, funded.).

Can we get away from defensive-only operations? Attacking flanks, even though homes are burning has increasingly become an imperative. Addressing structure defense collaterally, while focusing most intensely on the flaming flanks of the fire is a strategy under consideration and has many merits.

Can we elude the enviable chaos and confusion of a growing incident command system? There has always been a gap that develops between the growing organizational structure of incident command that often lags behind the operational needs of quickly arriving resources. There are two ways to address this gap. One is through better training and preparation of initial incident commanders, who should be able to organize and manage the Incident Command System without breakdowns or gaps all the way from initial attack up to major alarms. The other approach is to train company officers how to effectively operate within the gap, taking independent action as necessary until the command structure can provide adequate command and control oversight. Perhaps both of these solutions should be addressed in tandem.

SUMMARY

Statewide, the cycle of repetitive loss continues, not caused by aberrant fire behavior, for that is the symptom. The cause is more insidious: the repetition of human behavior that shuns the wisdom of fire. Though we try again and again to exert a mastery over fire, we become masters of our own destruction. The real question we need to ask ourselves is not how to control the fire, but rather, are we really willing to listen to what it has been trying to tell us. Can we coexist side-by-side with fire in a safe manner?

What fuels this cycle of repetitive loss is the steadfast refusal to acknowledge that we live within fire's domain; civilization, not fire, is the episodic event. Fire, 450 million years old, is the constant and we, only 10,000 years on this continent, seem to be the flash that has engulfed the hillsides. California's fire environment is part of our cultural and geographical heritage: as we shape it, we in turn are formed by it; it is part of us. We respond to it, and it responds to us. In order for this cycle to be broken, we need to learn how to live *with* fire. It is not an us-or-it attitude; we cannot banish fire from existence.

The firefighting community in California has also adopted this exclusionary attitude. The firefighting agencies as a whole form a culture that is just as -and perhaps more- resistant to change. Alternative strategies need to be explored; firefighters need to be open to new perspectives. Firefighters are still locked into a total suppression policy. The past ten years have shown progress, but in reflection, I still see we have a long ways to go. And that if wisdom is the ability to learn from past mistakes, then we are not fire-wise, not yet. A list of destructive fires in just the East Bay hills is ample evidence of how far we need to go: 1923, 1933, 1937, 1940, 1946, 1955, 1960, 1970, 1980, 1991 . . .

Until we can learn to listen to-and live with- fire as a partner, history will keep repeating itself and firefighters will keep chasing after the wind.

EVALUATING THE EFFECTIVENESS OF THE BATES BILL AND OTHER WILDLAND URBAN INTERFACE FIRE PROTECTION MEASURES FOR THE HEALDSBURG FIRE DEPARTMENT

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The Healdsburg Fire Department (HFD) provides fire protection for the City of Healdsburg, with eight paid staff, and a number of volunteers. Located 70 miles north of San Francisco, much of Healdsburg is built amongst the brush covered hills along its northern and eastern boundaries. The HFD has recognized this area as a Wildland Urban Interface (WUI) area susceptible to the threat of vegetation fires. This was validated in 1993 when a change in state law known as the Bates Bill, required the HFD to enact a series of fire safety regulations after the area was identified as a Very High Fire Hazard Severity Zone (VHFHSZ), by the California Department of Forestry & Fire Protection (CDF).

Given the limited resources of the HFD and the absence of funding provided by the legislation, it was recognized these regulations would be difficult to implement without prioritizing them. Therefore, the purpose of this research was to identify what parts of the legislation, or any other locally enacted fire safety measures or programs have proven most effective in minimizing the WUI fire problem in those areas with VHFHSZ's. Using this data, the HFD could then prioritize its efforts so as to focus on those proven aspects and enhance its prevention efforts.

Using descriptive and evaluative research methodologies, the following research questions were asked:

- Which Bates measures have been tested in wildfire situations and found to be effective?
- What other wildfire protection measures or programs have been enacted locally and if tested in wildfire situations, found to be effective?
- Which measures identified would be the most effective in mitigating the WUI threat, given the HFD's limited resources?

To perform this research, over 100 fire agencies with VHFHSZ's in the State of California were surveyed to determine the success of the Bates Bill and other WUI regulations in their jurisdictions. A series of interviews were conducted with the Assemblyman who drafted the legislation, experts in this field and individuals who had published articles on this topic. In addition, a review of available literature was performed.

The results found one Bates requirement, and five other measures that had proven effective in wildfire situations and could be implemented in the HFD given the limited staff available. They included; requiring 30' vegetation clearance around structures, implementing an annual Weed Abatement Program, developing automatic aid policies with neighboring fire agencies, implementing Public Education Programs including those utilizing Fire Safe Councils, and enacting Fire Resistive Roofing and Residential Fire Sprinkler Ordinances.

The recommendations of the research is for the HFD to implement more aggressive vegetation clearance and public education programs, initiate automatic aid agreements with neighboring agencies for WUI fires, and continue to advocate and proactively support its existing Weed Abatement program and Residential Sprinkler and Fire Resistive Roofing Ordinances. Implementing such programs would allow the HFD to demonstrate it efforts to enforce the Bates Bill, while minimizing the impact to the organization and enhancing the fire safety of the community.

RESOURCE ORDERING AND STATUS PROJECT (ROSS): A CASE STUDY IN INTERAGENCY COOPERATION

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The National Interagency Resource Ordering and Status (ROSS) project is a National Wildfire Coordinating Group (NWCG) sponsored information systems development project. This group consists of members from the Bureau of Indian Affairs, Bureau of Land Management, Fish and Wildlife Service, United States Forest Service (USFS), National Park Service, National Association of State Foresters, and the Inter-Tribal Council. Associated agencies include the Federal Emergency Management Agency, National Fire Protection Administration, U.S. Fire Administration, and the Department of Defense. The USFS is the lead agency for the project through the Aviation and Fire Management staff.

The ROSS project was initiated as a result of field need and due to serious disasters in 1994 involving loss of life and property that precipitated a series of investigations, management reviews and prescribed actions. In part, the findings cited shortcomings of fire (and other incident) dispatch systems, insufficient resource status documentation, and the inability to mobilize appropriate resources in a timely manner. The management reviews outlined numerous recommendations and directives toward improving dispatch and coordination operations, including:

The 10/94 report of the Interagency Management Review Team (IMRT) of the South Canyon Fire recommended to "evaluate the coordination/dispatch system" and to "develop a user-friendly system that allows all levels to easily input and update resource (personnel) status on a regular basis so that dispatchers at all levels can easily determine the availability of those resources."

In the 5/95 and 6/95 Federal Wildland Fire Management (FWFM) Policy and Program findings, recommendations included to "develop and utilize to the maximum extent possible the concept of closest initial attack forces," and to "use an analysis and decision-making process that considers, on an interagency basis, suppression resource commitment and availability."

In the 12/95 Federal Wildland Fire Policy Memorandum signed by former Secretary of Agriculture Dan Glickman and former Secretary of Interior Bruce Babbitt, the Federal wildland fire management agencies were directed "as a matter of high priority" to "implement the principles, policies and recommendations of the Federal Wildland Fire Management Policy and Program Report."

The ROSS project principle deliverable is a state of the art Internet based application that automates the business processes related to documenting resource status, and dispatching (documentation of incident information, resource request, assignment, travel, reassignment, release) of wildland fire fighting and other incident resources in the United States. The project's history, challenges, processes, lessons learned and deliverables serve as a model for interagency cooperation, and demonstrates the application of state of the art technology in the wildland fire dispatch community.

EVACUATION ANALYSIS AND PLANNING TOOLS INSPIRED BY THE EAST BAY HILLS FIRE

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ABSTRACT

The 1991 East Bay Hills Fire demonstrated that neighborhood characteristics like narrow roads, irregular intersections and relatively few exits can significantly impede an urgent evacuation. Unfortunately, the characteristics of this neighborhood are indicative of residential development in many fire-prone areas in the West. Furthermore, many communities are growing increasingly dense in the face of unchanging roads, leading to a gradual decline in evacuation egress. Recognition of these risks among residents is relatively low, and improving emergency planning is an ongoing challenge. This paper describes traffic simulation tools designed to assist communities in creating or improving evacuation plans. A case study is presented for a planned urban development (PUD) in a fire-prone canyon east of Salt Lake City, Utah. Results demonstrate that mean household evacuation travel times vary considerably within the neighborhood, and a planned second access road will benefit some households more than others.
Keywords: emergency preparedness, evacuation analysis, traffic simulation

INTRODUCTION

The 1991 East Bay Hills Fire demonstrated that neighborhood characteristics could significantly impede traffic flow during an evacuation. Narrow roads, irregular intersections, and relatively few exits complicated an evacuation that might have been routine in an area with wider streets and omni-directional egress. The untimely loss of Tunnel Road to the fire and the numerous parked cars further exacerbated the situation by blocking a common exit and reducing effective street capacities. While it is difficult to assign any meaningful degree of causality regarding the 25 fatalities and many injuries to the neighborhood's configuration, most would agree that accessibility in this area was exceptionally substandard. An "isochrone" is a line of equal time (similar to an isobar for barometric pressure or other isoline). It's the approximate boundary of the fire 30 minutes after its ignition (figure 1).

Figure 1. A map of the 1991 East Bay Hills fire fatalities and 30-minute fire isochrone.

In reviewing the East Bay Hills Fire, it is clear that the neighborhood at the fire origin did not have an evacuation plan. There was no simple way to notify residents. This was performed in a last minute, door-to-door fashion by heroes like Officer Grubensky who died in the fire (OES, 1992, OFD, 1992). Residents were understandably confused about whether to leave, when to leave, and which route to take. Evacuees were not aware of the available exiting routes. There were no contingency plans to address adverse events like a blocked access road. Furthermore, some evacuees safely cleared the immediate area only to return their homes a few minutes later. Although hindsight is 20-20, the events surrounding the East Bay Hills evacuation can help other communities in fire-prone areas sharpen their foresight.

There are many fire-prone communities in the West with residential configurations similar to the neighborhood surrounding the origin of the East Bay Hills Fire. In fact, it is easy to identify communities with a greater number of residences and fewer exits (Cova and Church, 1995, 1997). While not all of these areas have comparable fire hazard, many possess fire hazard sufficient to warrant earnest evacuation planning. This highlights the need for simulation tools to assist communities in developing and testing evacuation plans. These tools should help communicate the unique challenges that the residents and emergency managers might experience in clearing an area during a regional fire at the same time that they offer strategies to reduce these problems. This might include evaluating the benefit of reduced notification times, improved household evacuation plans, increased route awareness and road network improvements.

This paper describes a method for simulating neighborhood-scale evacuations at the most detailed geographic level, which is at the individual household level. The method relies on a custom evacuation-scenario generator that initializes a commercial microscopic traffic simulator. A microscopic traffic simulator, or microsimulator, simulates the movement and interaction of individual vehicles in a transportation network. The paper begins with background on the need for a method to simulate neighborhood evacuations. The next section describes the method, and the last section presents a case study in a canyon community east of Salt Lake City, Utah.

BACKGROUND

What factors make one area more difficult to evacuate quickly than another? First, it can be difficult to notify evacuees. This was certainty the case in Oakland, but in the 2000 Cerro Grande Fire, there were five available modes for notifying evacuees: TV (local and national), radio, reverse 911, mobile sirens, and door-to-door (Griffiths, 2001). This made it much easier to communicate neighborhood-specific orders to the residents of Los Alamos. Second, it can be difficult for evacuees to mobilize. They may receive clear instructions but not have adequate transportation. This is common in regions with low vehicle ownership or few drivers. Third, people may know what to do and have the means to leave, but for a variety of reasons, they may delay departure or never depart. Some may sense the need to leave but spend time videotaping possessions, loading vehicles, chasing pets, and watering down structures. Others may not perceive the risk or prefer to shelter-in-place, a viable option in certain cases. These behavioral factors (there are many others) might be consolidated into human response difficulty. Fourth, as demonstrated in the East Bay Hills Fire, the area being evacuated may have severely restricted egress leading to a condition where everyone cannot easily leave at once.

Of these four types of difficulty: notification, mobility, human response, and access, all but Mobility played a role in contributing to the outcome in Oakland. This was, and still is, an affluent area with very high vehicle ownership. Evacuation planning in fire-prone areas might focus on mitigating any one of these four areas of difficulty. For example, an advanced notification system could be installed to reduce the mean notification time or to allow area specific orders like, "Evacuees along your street should proceed immediately west on Boulevard A." Second, area residents might be educated on how evacuation orders are likely to be issued, what to do in the event of blocked roads, or how to best retrieve non-driving residents. Third, in extreme cases where it is clear that there is insufficient egress, residents might wish to evaluate options like additional roads or evacuation plans that require very high levels of community cooperation but substantially reduce aggregate evacuation times. All of these questions point to the need to develop decision support systems for communities to evaluate the numerous options.

While sophisticated tools are commonly applied to plan evacuations near chemical stockpile sites, nuclear power plants, and other technological hazards, these tools are not used in evacuation planning for fire-prone urban areas (Johnson and Ziegler, 1986;Southworth, 1992). The events in Oakland in 1991 make a strong case that they should be.

SIMULATING NEIGHBORHOOD EVACUATIONS

Simulation is a very valuable tool in evacuation planning (Southworth, 1991; Urbanik, 2000). An evacuation scenario is typically comprised of the road network, a set of traffic origin destination zones, the number evacuating from each zone, and many input parameters (i.e. passengers per vehicle and departure rate). The value of a simulation model is that it allows "What if?" questions to be posed given assumptions regarding the many factors that affect an evacuation. Common questions include:

- How long will it take to move people out of a hazardous area in a given scenario?
- What contingency plans can be developed to handle adverse events like road closures?
- How will road network improvements affect evacuation times and who will benefit?
- How might reduced notification or departure times affect evacuation times?
- How will diurnal fluctuations in population affect an evacuation?
- When is sheltering-in-place the best option?
- How many homes can a neighborhood safely support before evacuation times become unreasonable in the best of circumstances?

The method described in this paper is designed to answer these and other questions. A key goal was to avoid launching a large-scale software development campaign. For this reason, the general strategy was to develop a scenario-generator to initialize a commercial microsimulator. The microsimulator that we are currently experimenting with is Paramics$_{tm}$ from QuadStone.

Figure 2 is a conceptual diagram of the major methodological components. Text files contain parameters that define a given scenario like the mean household departure time following an evacuation order and the mean number of vehicles per household. These parameters are input into a scenario processor that handles the tasks of trip generation, departure timing, destination choice and specialized trips like those to retrieve non-driving residents. The end product of the scenario processor is an origin-destination profile that defines when each vehicle will depart from each household. For example, for a given household, one vehicle may depart 5 minutes after the initial evacuation order and another may depart 15 minutes after the order. The origin destination profile is translated into a format that can be input into a commercially available microsimulator (most accept ASCII text files). The commercial system managed the construction of the road network, the simulation and visualization of traffic, the types of vehicles, driver route choice, and driver behavioral characteristics like awareness and aggression.

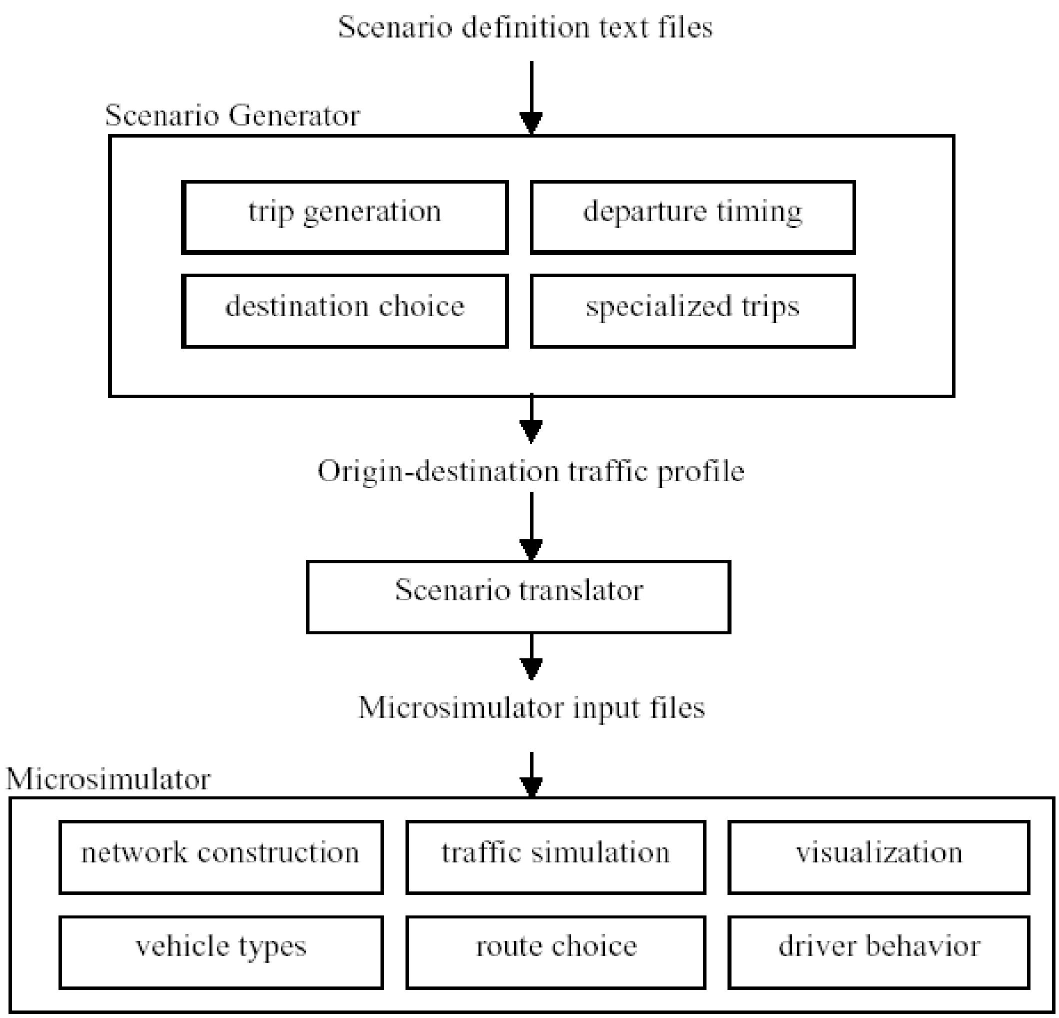

Figure 2. A conceptual diagram of the micro traffic simulation process.

CASE STUDY

Emigration Canyon is a rapidly developing area immediately east of Salt Lake City, Utah. The primary vegetation in the canyon is Gamble Oak, *Quercus gambelli* which is capable of supporting flames with a height ranging from 50 to 100 feet moving at 10 miles per hour in high winds. The main road follows the canyon floor, but our study focuses on an offshoot planned urban development (PUD) called Emigration Oaks (figure 3). Emigration Oaks has been the focus of an ongoing debate regarding the proposed construction of second access road to the

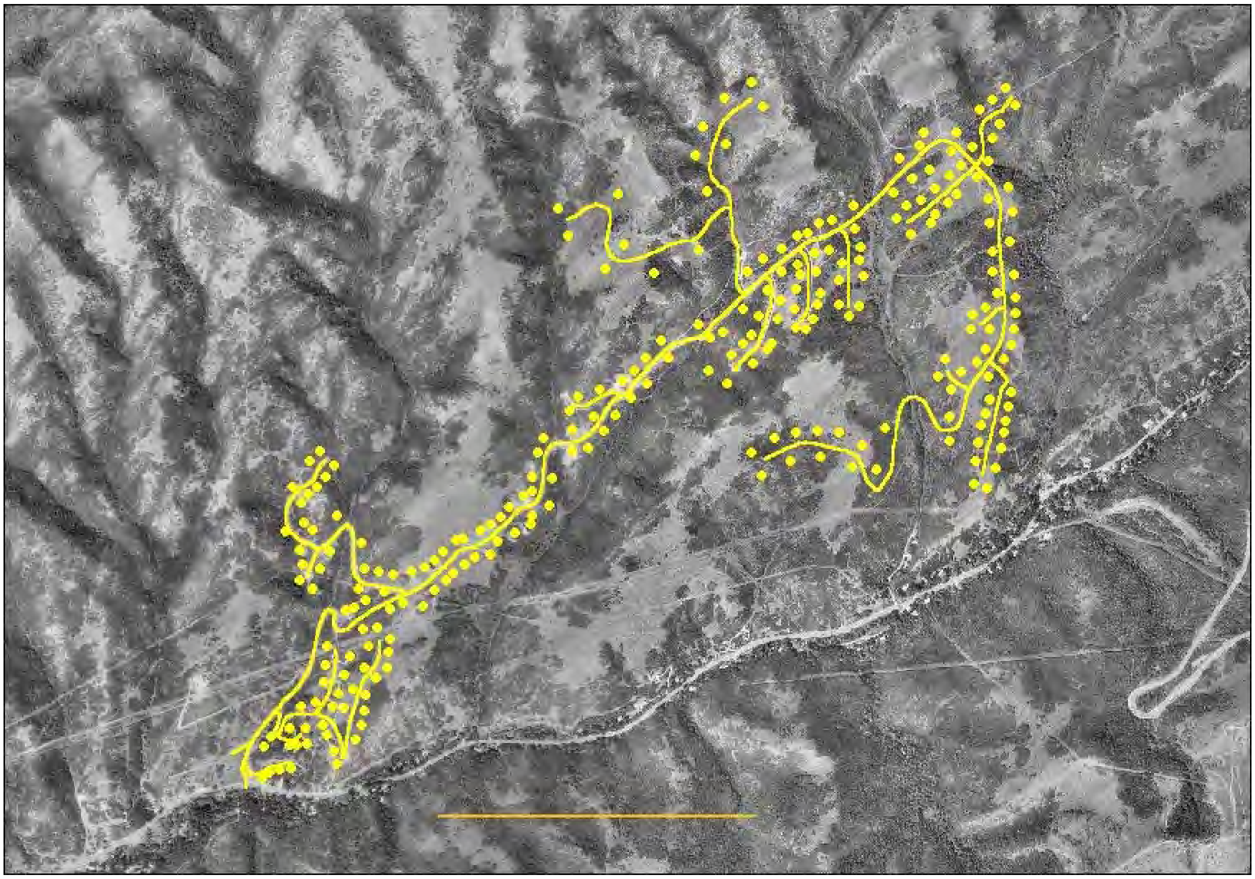

Figure 3. The Emigration Oaks neighborhood in Emigration Canyon.

community to improve emergency ingress and egress. The controversy stems from the fact that the road will have to cross someone's property as well as compromise environmental resources. Without the second access road, approximately 250 homes along a dendritic road network will rely on one exit during an evacuation (250 homes per network exit). For comparison purposes, the neighborhood at the origin of the East Bay Hills Fire had approximately 300 homes and four exiting roads (75 homes per exiting road).

Residents in Emigration Oaks have become increasingly concerned about possible evacuation problems as new homes are constructed. In addition to severely restricted access, cellular phones do not work in the canyon, and there is no installed notification system (e.g. reverse 911). This makes notifying the residents an equally challenging problem. The evacuation order during a regional fire will likely come in the form of a mobile siren combined with door-to-door notification. The community currently has no evacuation plan, but efforts are being made toward this end, of which this study is part. At this point, there are many questions that the residents and emergency managers would like to answer. For example, how long might it take to clear the neighborhood under various vehicle use and departure timing scenarios? What sort of traffic congestion might occur and where? What effect will the second access road have on alleviating potential congestion and reducing evacuation times?

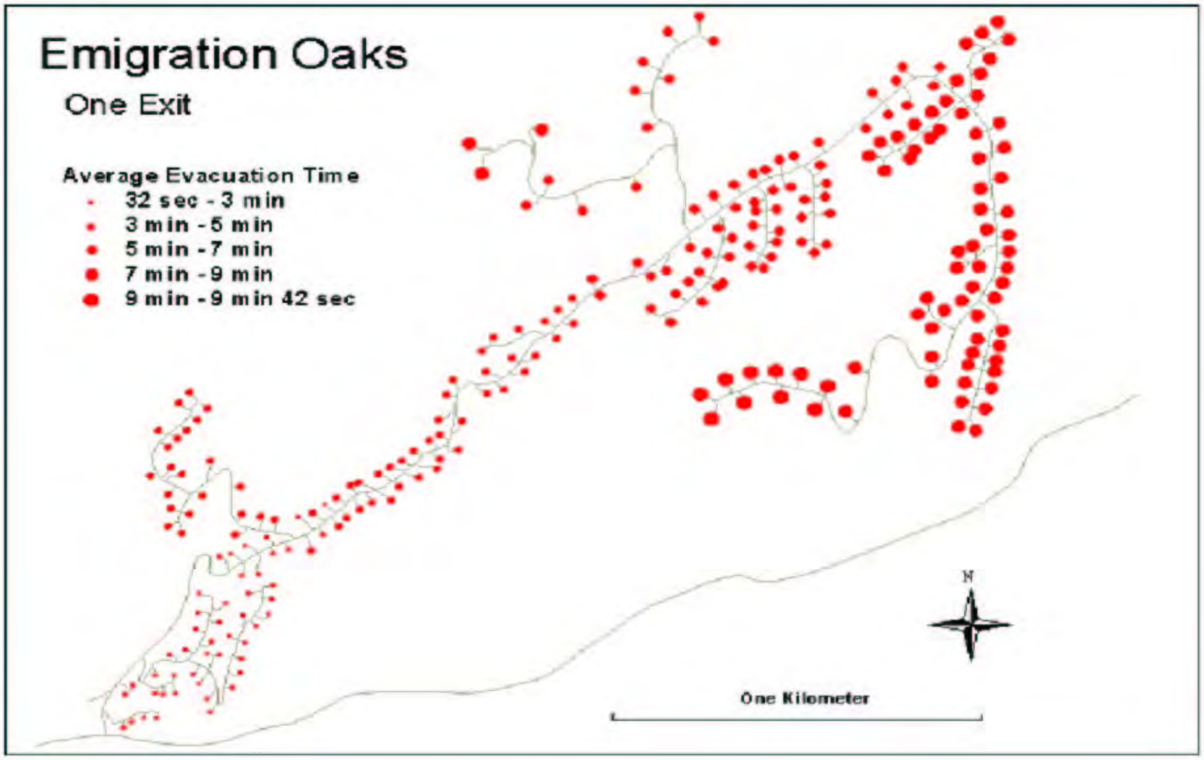

Figure 4. Mean household evacuation travel time for a given scenario.

Figure 4 depicts a map that was produced to compare mean evacuation household travel times under the assumption that the average number of vehicles originating from each household was 2 and the average departure time per vehicle following an evacuation order was 5 minutes. This can be characterized as an extremely urgent evacuation with high vehicle usage. We also assume that the number of vehicles originating from each house and the time that the vehicles depart both follow a Poisson distribution. This means that some homes will have no departing vehicles, most will have around 2, and a few will have many. Statistical simulation (Monte Carlo) was used to generate distributions for the number of vehicles per home and their departure time. Each 8 scenario was simulated until every household had at least 30 vehicle trips ($n \geq 30$). The map indicates that households in the back of the neighborhood can expect an evacuation time approximately three to eight times as long as households close to the exit. Household notification is assumed to be uniform and simultaneous, as the principle means for notifying residents in this area to evacuate is a vehicular siren. This also assumes that all residents are aware that a siren will be the means in which they will be notified to evacuate. Figure 5 depicts the standard deviation in household evacuation times within the neighborhood for the same scenario. Note that for most homes, the standard deviation in household evacuation travel times for this scenario is about 1.5 minutes.

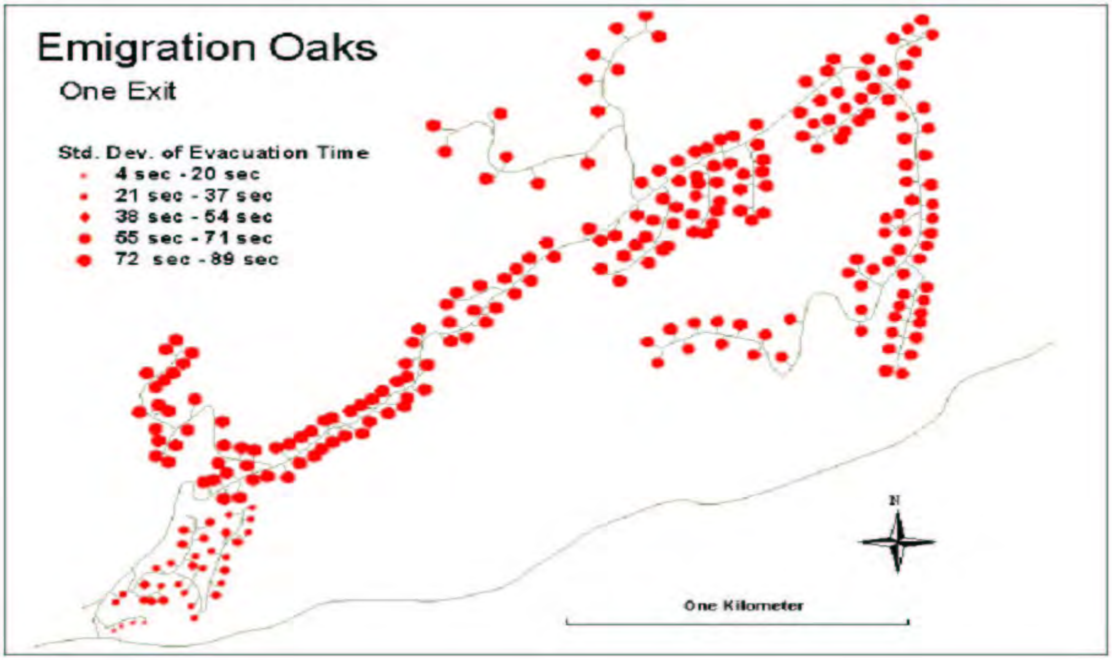

Figure 5. Standard deviation in household evacuation travel time for a given scenario.

A second access road has been proposed that will connect the end of the current road directly to the main canyon road creating a loop. Figure 6 depicts the mean household evacuation

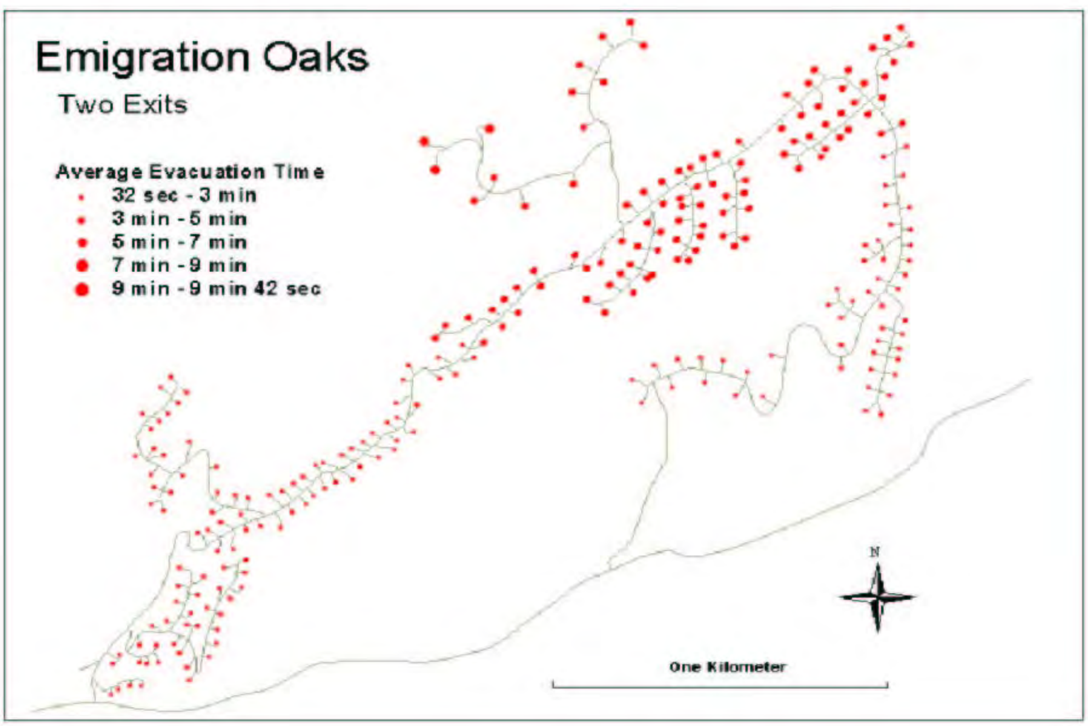

Figure 6. Mean household evacuation travel time given the second access road.

travel times for the same vehicle-use and departure-rate scenarios in figure 4. The map shows,not surprisingly, that homes in the back of the canyon will benefit substantially more in terms of reduced travel times than the homes near the original exit. After the construction of the second road, homes equidistant from each exit will have the highest mean evacuation travel times. Figure 7 shows the standard deviation in household evacuation travel time for the neighborhood

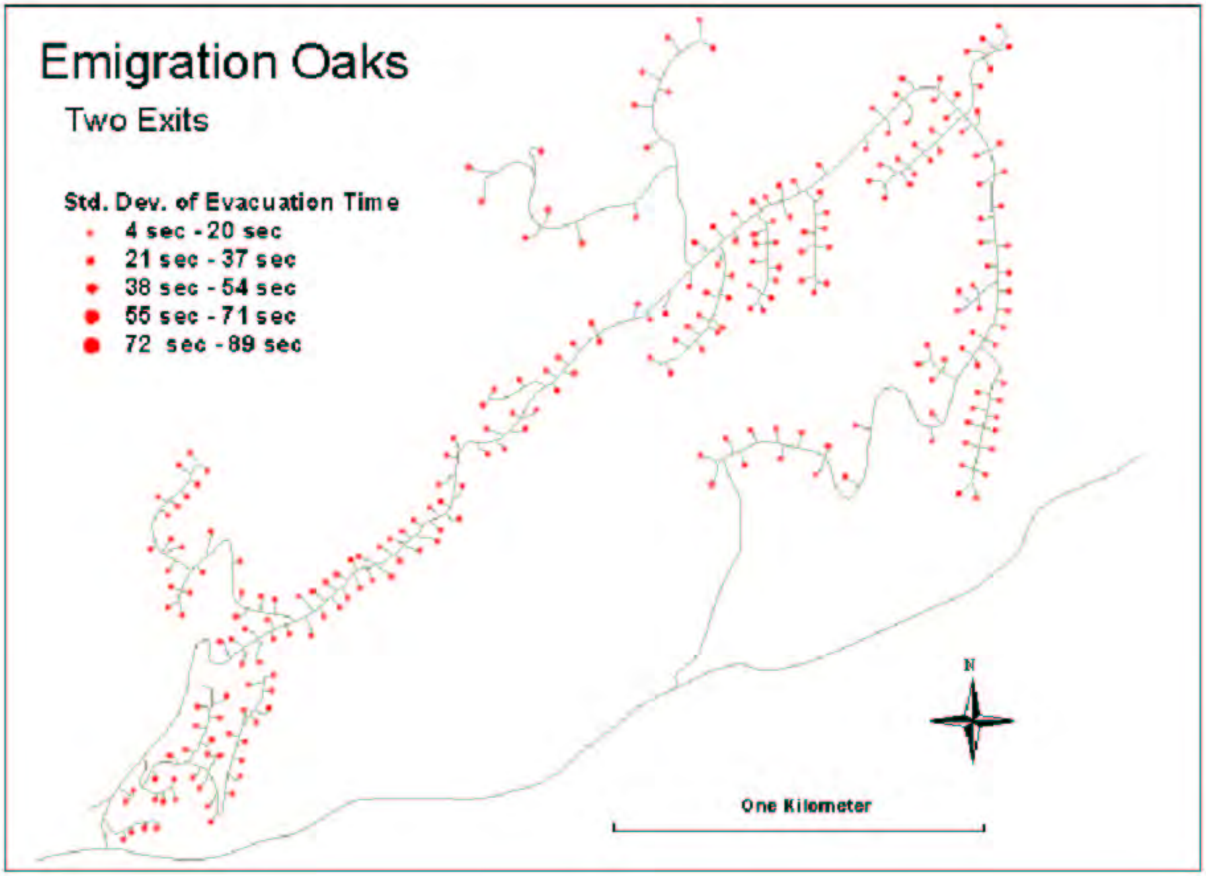

Figure 7. Standard deviation in household evacuation travel time given the second access road.

given the second access road. The standard deviation in these travel times has decreased substantially for the neighborhood given the second access road. This implies that all homes will have more consistent travel times for this scenario. This is the case because the second access road alleviates much of the traffic congestion associated with trying to get everyone out a single exit. With two exits, the average number of homes per exit will be reduced from 250 per exit to 125 per exit.

CONCLUSION

This paper outlined a method being developed to address the need for improved tools in evacuation planning at the neighborhood scale. The method was applied to a rapidly developing neighborhood in a fire-prone canyon east of Salt Lake City, Utah. Household evacuation travel time maps were generated from microsimulation experiments to depict the spatial variation in travel times within the neighborhood. The scenario was modified to test the spatial benefits of a planned second access road. The road will likely result in reduced and more consistent household evacuation travel times.

Rapid urbanization in historically fire-prone regions in the West is precipitating the need for more sophisticated approaches to emergency planning. Many of these areas were not originally designed to support the dense developments that are emerging. Awareness on the part of residents needs to be increased in regards to simple questions like how an evacuation order will be issued and what contingency plans can be put in place. The East Bay Hills Fire was a clear omen that the potential exists for urgent small-scale firestorm-driven evacuations. Twenty-five years of evacuation research can contribute to the problem of increasing the quality and quantity of evacuation planning in fire-prone areas in the West.

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THE RANCH INCIDENT VERSUS THE SISAR VEGETATION MANAGEMENT PROGRAM 1994-1999

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A fire, with Santa Ana winds in excess of 70 mph, broke out near the City of Ojai, California on December 21, 1999. Sixty-eight urban interface homes, one public school and three large private boarding schools were immediately threatened. The City of Ojai and countless agricultural assets were also at risk.

During the first few hours of the incident, it became evident that the weed abatement program and our pre-fire work which had been funded by FEMA was totally responsible for the successes in saving these assets.

The presentation goes into cost effectiveness of prescribed fire versus wildland fire. The Ranch fire consumed 4,500 acres for a cost of $1500.00 per acre. Costs for the 350 acres cut and stack project was $40.00 per acre and the cost of the 659-acre prescribed burn was $17.00 per acre including helicopter time, meals, and personnel costs.

This presentation is a true success story of the cooperation between the Ventura County Fire Department, the United States Forest Service (Los Padres National Forest), California Department of Forestry and Fire Protection, Federal Emergency Management Agency, local businesses, equestrian groups, public and private schools, Air Pollution and Control District, landowners, and local residents.

CLAREMONT CANYON - TRANSFORMING FIRE THREAT INTO A COMMUNITY ASSET

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INTRODUCTION

Claremont Canyon, with some of the largest undeveloped areas in the Oakland Hills, has the potential to be a model urban-wildland interface. Yet little has been done over the decades to implement any plans or recommendations dealing with the two predominant problems: mitigating the risk of catastrophic fire and providing better public access to this open space surrounded by the urban East Bay Area.

The Claremont Canyon watershed is about 500 acres of chapparral, forest, and grassland, lying mostly within Oakland's city limits. To the south, the Canyon is flanked by ridgeline houses rebuilt after the '91 firestorm, and, to the north, by Strawberry Canyon, partially developed by the University of California and the Department of Energy's Lawrence Berkeley National Lab. Immediately east of the head of the Canyon lies rural Contra Costa County, and west of the lower end of the Canyon spreads the city of Berkeley.

A group of nearby residents in January 2001 formed a Task Force to analyze the situation. We wanted to figure out what might be done to get resolution on the following issues: reducing the risk of wildfire and improving the limited trail system, while protecting, maintaining, and restoring the natural beauty of Claremont Canyon. The widely-acknowledged fire hazard of Claremont Canyon continues despite some efforts to manage parts of the Canyon by public and private landowners, and the often-expressed concern of City of Oakland fire personnel. But these efforts are severely limited by budget, environmental concerns, and jurisdictional constraints. In essence, all efforts to date have fallen far short of what is needed to protect our neighborhoods and the Canyon flora and fauna from future firestorms.

A newly formed nonprofit organization, the Claremont Canyon Conservancy, will attempt to be the catalyst in ensuring the implementation of ongoing canyon-wide projects. The intention of the Conservancy would be to cooperate with the primary landowners—the University of California (UC), the East Bay Regional Park District (EBRPD), the East Bay Municipal Utility District (EBMUD), and the City of Oakland— in bringing a unified perspective to dealing with the Canyon as an entire watershed and in providing incentive to initiate and maintain agreed-upon projects. The Conservancy would be a 21st century vehicle for the stewardship of a mostly undeveloped watershed surrounded by urban growth.

HISTORY- AN INVITATION TO BURN

The Claremont Canyon landscape and its uses have changed dramatically over the last century. From the 1800's through the first few decades of the 20th century, the East Bay hills were primarily grasslands with trees and brush growing only in canyon draws. Much of Gwin Canyon, a tributary on the south side of Claremont Canyon, was planted with Monterey Pines (Pinus radiata), a widely established practice in the hills to beautify the land for housing developments in the teens and twenties. That these trees were fast-growing tinder in the landscape became evident after every subsequent hill wildfire.

In 1910, Frank Haven, owner of the Claremont Hotel, planted Eucalyptus on the Claremont Canyon watershed land that provided water for the hotel grounds. Around the same time, Eucalyptus were planted in pockets throughout the Canyon. This species was thought at that time to be a valuable lumber source, but, once its defects were discovered, it was too late—it had become entrenched in the landscape. In addition to squeezing out native biodiversity, it has been found to be highly flammable. Firebrands from burning Eucalyptus in Australia have been known to spread fires 18 miles from the initial fire (Merwin, Miles, California Eucalyptus Grower). During the winter of 1972-73 many of the Eucalyptus froze and were assumed dead. Those trees on UC land were logged. Redwoods were subsequently planted throughout the upper reaches of the Canyon but were soon in competition with the fast recovering Eucalyptus. Currently, this part of the Canyon is thick with second growth Eucalyptus and an understory of mostly native bay trees. The combination of these unmaintained Eucalyptus groves with their impenetrable understory represents a worst possible case of ladder fuels that could allow a ground ignition to become a crown fire.

Up to the early 1960s, much of the south-facing side of Claremont Canyon was grazed by ever-diminishing numbers of cattle and horses. Since then – in the absence of grazing , controlled burns, or other forms of management– most all the grasslands have converted to brush and forest. These brushlands are predominantly Coyote Brush, *Baccharis pilularis*, a native shrub prone to fire, Poison Oak, and French Broom. In Claremont Canyon and much of the East Bay hills, French Broom, an aggressive exotic weed shrub, has been spreading noticeably every year since the 1980's. The uninterrupted acres of Broom and native chaparral that now cover the south-facing slopes of Claremont Canyon and most of Gwin Canyon are a high intensity fire hazard. Under Diablo-wind conditions, these continuous fuel loads combined with steep, inaccessible slopes make large fires in Claremont Canyon unfightable from the ground.

In the 20th century, fourteen major fires have passed through areas of the East Bay Hills, many driven by the late summer-fall northeasterly Diablo winds. The 1991 Oakland hills fire ranks first as California's largest home loss from wildfire and the 1923 Berkeley Fire ranks fourth. Both fires burned into Claremont Canyon. Its south-facing slope was the southern extent of the 1923 fire. Firemen at the Hemphill residence in the canyon bottom just up Claremont Ave. from Gelston Drive, lit a backfire to save the house from flames descending from the ridge. (conversation with Tappy Marron, 2001). The northern edge of the 1991 fire was on its north-facing slope, in particular Gwin Canyon. This side canyon has burned repeatedly—in 1946, 1970, and 1991.

These prescient words written four years before the 1991 fire may well apply to Claremont Canyon today:

> *In just over a century many ecosystems in the Bay Area were transformed. Exotics supplanted native vegetation and people began to take up residence in what were previously natural environments. With both fire and grazing disqualified as participants in the game of ecological balance, much of the wildland in the Oakland and Berkeley hills began what some think is a slow devolution. "Our grassland has broken down to the point where it's just weeds," claims David Amme, a botanist, native plant expert. "When you take fire and grazing out of the ecosystem, the ecosystem goes into a long sort of self-destruct, building debris and fuel. That's why I can say with no qualms at all that there will be a fire. There is no 'If there is a fire, we'll come and put it out.' There will be a fire, and it will take out everything."(East Bay Express article 8/87).*

The magnitude of future fires in Claremont Canyon will be determined by fuel loads, weather conditions, topography, and the ability of fire fighters to quell a fire early. Coordinated professional wildland fire fighting capabilities have improved in the East Bay Hills since the 1991 fire, and the addition of an Oakland Fire Station at Amito and Gravatt above the Canyon in 1998 is a notable advance. But fire fighters and equipment in steep canyons simply cannot confront fires where flame fronts move with great heat, height, and speed. Air attacks might be helpful, but if much of the Canyon is aflame and filled with smoke as in 1991, flying is dangerous, visibility severely reduced, and targets difficult to find.

HISTORY

In 1858, the transcontinental telegraph cable between the west and east coasts was strung through Claremont Canyon. Not long after, a road was built along the telegraph line. What is now Claremont Ave running from Berkeley along the canyon bottom and over into Contra Costa County, became the primary route for east-west horse and wagon travel in the central East Bay hills. In 1860 -61, the Pony Express brought news from the east coast through Orinda, up Fish Ranch Road and down Claremont Canyon on its way to San Francisco by ferry. From the late 1800's into the early 1900's, commercial development in the Canyon included a hotel and saloon rest stop.

Once the first tunnel connecting the west and east sides of the hill was built in 1903, the road reverted to a trail used for equestrian outings or for driving cattle from the east side of the hills, down Ashby Ave. to the slaughterhouses in Berkeley. In 1929, the trail was widened, paved, and reestablished as a road, this time for cars.

The University of California acquired roughly 150 acres of the upper part of the Canyon from the local water district in 1961 with no plan to develop it in any way. In the 1970's and 80's a neighborhood group, the Friends of Claremont Canyon, spurred the EBRPD's purchase of private parcels amounting to 208 acres spanning both sides of the Canyon. This land, on the verge of being developed into housing, thus became the Claremont Canyon Regional Preserve. Both UC and the EBRPD intended minimal human intrusion or interference with natural processes or habitats on their land in the Canyon— UC designated theirs an "Ecological Study Area" while EBRPD has done little to encourage hikers. A trail system for the preserve was proposed in 1973, approved and adopted by the Park Board in 1985, but the trails have not been kept up, nor was the system ever completed.

The City of Oakland's 13-acre John Garber Park is located just up the Canyon from the Claremont Hotel on the southern side. In its heyday during the 1920's, this tiny park, complete with trails and picnic areas, lay close to the mouth of a virtually wild canyon since all the automobile traffic had been diverted through the tunnel later named the Caldecott. Although it has been neglected, it has some of the largest trees in the Canyon— a mature native bay and oak forest wedged between residential streets.

SPARKING THE POTENTIAL FIRESTORM

Ignition without the presence of humans is unlikely since lightening strikes during dry weather are practically nonexistent along coastal California. Before the arrival of European settlers, the indigenous people habitually started fires in native vegetation as part of their ongoing manipulation of the environment for more food, forage, or otherwise useful materials. Both animals and plants had a good chance of surviving these low-intensity wildland fires. Although settlers may also have set fires to increase rangeland productivity, fire suppression became accepted policy in the early 1900's, contributing to the current build-up of fuel and history of accidental fires.

Making Claremont Canyon completely firesafe is probably impossible and impractical, but improving the chance of successfully extinguishing an accidental ignition is a realistic goal. What might be an uneventful ignition in less extreme circumstances, may be the beginning of a conflagration given a relative humidity below 20%, winds above 10 mph, and enough fuel. The intent of the buffer zone we propose herein is to decrease the intensity of fire, slow its spread, and give firefighters an opportunity to make a stand.

Ignitions can happen from cigarettes, fireworks, or hot exhausts of cars parked over dry roadside vegetation. Reducing the fuel loads along roads both reduces the chance of ignitions and increases the possibility of firefighters' preventing a small fire from getting out of hand. If not engulfed in flames, roadsides, especially on ridgelines, are also strategic locations for fighting fires, as well as allowing safe evacuation routes.

Ignitions may happen near or in dwellings. The same buffer zone that protects a house from burning brushlands can protect against the spread of fire to a natural environment from fire originating in buildings or yards sparked by faulty electrical systems, downed electric lines, transformer failure, power tools, oily rag combustion, barbecue sparks, and similar accidents.

Thinning out dead and dry vegetation and reducing the density of flammable brush and ladder fuels within a 250 foot perimeter of roads and structures lessens the likelihood of a minimal spark becoming a raging blaze. The buffer zone width can shrink as the local features indicate. For instance, where Claremont Creek runs within this 250 foot zone, minimal cutting is warranted. Another area where the buffer zone could shrink to less than 50 feet of the road edge is along Grizzly Peak Blvd where a rich plant community of Oracle Oak, Big Leaf Maple, Hazelnut, Oceanspray, and Huckleberry grows. The 250 feet of managed vegetation implies periodic selective thinning or mowing of Baccharis, complete removal of French Broom, spring and summer mowing of annual grasses (first to reduce their seed bank and secondly to ensure a minimal fire hazard), limbing up and removal of ladder fuel below all trees.

Ideally this work would be done by hand crews, including loggers, trained in the local ecology so that they can discriminate between desirable and undesirable vegetation. Goat grazing, though popular with the general public, wreaks havoc on any desired vegetation unless painstakingly excluded from the enclosure. Also timing is critical. For instance, periodically grazing a site infested with annual weeds in the spring and early summer may discourage their spread by seed. When to bring in the goats and for how long must be based on careful monitoring of the condition of the site. Any grazing for vegetation management needs to consider first the benefit to the flora, then to the animals. Close attention to the variability of annual conditions is another key. Though more costly, flexibility based on expert monitoring must be written into any contract specifications.

The goal is to achieve an articulated vegetation profile that would look similar to a landscape that has been "managed" by a low-intensity prescribed burn. Appropriate parts of the canyon could be gradually restored to a low density Oak Savanna. As suggested by Prof. Radke's UCB students studying the issue of the fire hazard in Claremont Canyon several years ago, this vegetation type is associated with both a low fire intensity and a low rate of density increase. Ridgelines where fires can be battled by firefighting crews and equipment would be restored to perennial grassland, while the low points in the topography, the canyons and draws, would be vegetated with trees and brush. This fuelbreak of open yet diverse vegetation represents a transition from the thick untouched native chaparral and forest to the corridors and perimeters of the Canyon that people frequent. Maintenance of this buffer zone includes active monitoring for invasive species and their immediate removal, as well as appropriate collection of garbage and trash.

The details of this canyon-wide restoration plan are to be worked out by a Technical Advisory Committee made up of expert representatives from the major landowning entities—UC, EBRPD, EBMUD, and the City of Oakland —as well as other related agencies, like CDF. A GIS study of the Canyon must be created to serve as a base for developing models of vegetation management that transform the character of some areas while leaving others untouched. These plans may incorporate a network of foot trails that will allow and encourage firsthand appreciation of the watershed. The long-term goals of fire hazard reduction and better public access can not be realized without the cooperative input of all the key players. But it is ultimately up to the concerned citizens, whose expectations have been tempered in the past by cordial but ineffective agreements, to push for action.

CONSERVANCY RECOMMENDATIONS

We share the view that large parts of Claremont Canyon should be left undisturbed for purposes of preservation, and we also take the view that large parts of the Canyon should be managed for wildfire safety and ecological restoration. It is in this spirit that we propose a major long-term program for all of Claremont Canyon in cooperation with the current major landowners. Funding, both public and private, would initiate this program and provide appropriate monitoring .

1. On the public lands (UC, EBRPD, and EBMUD), create a buffer zone of grassland, brush and trees (as described above) approximately 250 feet from road edges and from private property boundaries.

2. On the public lands, remove all Eucalyptus under 30 inches dbh (diameter at breast height), all Monterey Pines under 24 inch dbh, and all French Broom, being careful to preserve the existing native flora and diligent to reduce other exotic infestations in the area. Remove ladder fuels from remaining Pines and Eucalyptus.

3. Encourage all private landowners with property on the perimeter of Claremont Canyon Regional Preserve to mow dry grasses and other annuals low every summer, eliminate all Broom, and limb up or remove Eucalyptus and Monterey Pine.

4. In the Panoramic Hill area near Dwight Way, restore the hillside to native grassland.

5. Ensure ongoing monitoring of vegetation so that the timing of mowings, the eradication of invasive species, and the encouragement of a low density oak and grassland may be fine tuned.

6. Improve the road edges along Grizzly Peak Blvd. and Claremont Ave.: pave car turnouts, build proper drainage structures where needed, upgrade and add guard rails, provide serviced trash containers where warranted and/or provide periodic cleanup of trash, improve the safety of bicycle lanes by widening where possible and by keeping adjacent vegetation trimmed.

7. Install and maintain a trail system that connects the north and south ridgelines and the two primary properties owned by UC and EBRPD.

8. Recreate a park-like, user-friendly, neighborhood asset of John Garber Park by selective clearing of the understory, appropriate pruning of the trees, and removal of certain pest plants. Improve and add to the existing paths to include a connection with the watershed trail system.

9. Establish an educational center for natural history and ecology of the East Bay hills in the EBRPD's Gelston House.

10. Discourage encampments throughout the watershed especially during late summer and fall months.

COSTS AND RESPONSIBILITY

Cost of the initial activity recommended should fall between $2-5 million, depending on the care with which the work is done, the equipment used, and how well the work is monitored. Much of the debris created may be left within the watershed as mulch, chips, habitat piles, or short limbs piled no higher than one foot that will eventually biodegrade and recycle nutrients back into the soil. Some fallen logs can be positioned to help prevent erosion, especially by discouraging recreational offroad vehicle use (already a problem in the watershed). The initial project of tree removal should be driven by habitat improvement and native forest health, not by the financial gain from the sale of logs.

Annual maintenance costs after the initial clearing activity would vary as the specifications of the contracts change in response to vegetation conditions. As annual exotics are prevented from reseeding and as the Broom seed banks are diminished, annual costs would be reduced.

We support and encourage the owners of the public lands in Claremont Canyon to take an active stance to lessen the threat of a firestorm in the watershed. We are optimistic that they will uphold the responsibilities that accompany public ownership of land.

Private landowners adjacent to the public lands need to be aware of possible fire dangers and act in a responsible manner, too. Given the right conditions, catastrophic fires, originating either from within the Canyon or from a bordering house or yard, can affect large areas and many people.

Delays in dealing with ever-increasing fuel loads and limiting the invasion of pest plants will only increase our future problems, risks, and costs. Time is of the essence to begin initial work on the projects recommended, and to plan for their annual monitoring and maintenance. We cannot count on luck any more.

FIRESAFE COUNCIL

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FireSafe Council of Nevada County has been working in Nevada County since January 1998 to improve fire safety. Our organization consists of a Board of Directors, one staff person, and many dedicated volunteers. Our Mission is to educate the citizens and protect the natural resources from the effects of catastrophic wildland fires, while improving forest health, air and water quality.

Our many successful programs include the free residential chipping program. The newest program provides free defensible space clean-up for seniors. The FireSafe Council of Nevada County has two focuses for project work. The first is changing community attitudes and concerns about fire safety and the second is the creation for defensible space around homes and structures in Nevada County.

Our Vision is a county where we are prepared for a catastrophic fire. To have homes with defensible space, adequate access and evacuation routes identified, response plans that citizens and responders know, fuel breaks at strategic points, and communication among agencies. The outcome after a fire will be that most of us will keep our homes, we will look around and see the damage, but not the blackened devastation catastrophic fires create. Our community will still attract visitors and pride, and no one will die while escaping with their loved ones. These are important goals and concerns, that will take a cooperative effort to convert this vision into reality.

DEFENSIBLE SPACE, FIRE MITIGATION, AND THE VIEWS AND PRACTICES OF HOMEOWNERS IN THE RESIDENTIAL-WILDLAND INTERMIX

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For the past several decades, homeowners have been moving into fire prone rural and urban fringe areas expecting their homes to be protected from a wildfire yet feeling little responsibility for fire hazard mitigation around their new home. But the extent of the wildfire hazard makes this an unrealistic expectation, instead homeowners need to recognize that as part of the problem they are also an integral part of the solution.

An important component of managing the problem is the creation of defensible space around structures. While there is a plethora of brochures and manuals, dating back to the 1970's, providing instructions on creation of defensible space, the majority of homeowners continue to take little preventive action. The materials and knowledge thus are available but little implementation occurs. It appears therefore that a significant barrier to more pro-active fire management is the public and its sense of responsibility and expectations and opinions regarding fire protection and management.

Given this, one would expect that a great deal of work has been done to understand public opinions on the matter and how to influence them. Although there is much discussion amongst fire agencies of the need to educate the public, there are surprisingly few studies either about what the public actually thinks about the hazard and fire management techniques or on what incentives are most likely to encourage public involvement and support for mitigation. Much of the thinking regarding the public is merely accepted conventional wisdom. It is therefore useful to determine the current reality of homeowner beliefs and practices. Is the view that the public is a barrier to change a real, or merely a perceived, problem? What types of individuals participate in mitigation and support pro-active fire management activities? What actions have they taken and why? What factors have most influenced their taking action? What factors influence their support for various fire management tools? What types and sources of information are most influential?

To explore these questions, a case study was conducted in Incline Village, Nevada. The town is considered by many within the fire community to have a relatively effective and proactive fire management program that works closely with town residents to encourage vegetation management and use of defensible space protocol. As such, Incline Village provides a useful opportunity to examine attitudes of residents in a high fire hazard area where work has been done to encourage public involvement. Homeowners were sent a mail survey to assess their knowledge, opinions, and involvement in fire management to try to determine the reality behind both conventional wisdom and to identify characteristics of homeowners with more pro-active views towards fire management. Results indicate that with a little education the public has a much more sophisticated view of wildfire then it is generally given credit for. In addition, the better the understanding of the problem, the more likely individuals will put in defensible space and support diverse fire management practices. Educational materials and personal contact were the most influential means of disseminating fire information.

AN ASSESSMENT OF THE EFFECTS OF FIRE DISCLOSURE UNDER THE CALIFORNIA NATURAL HAZARD DISCLOSURE LAW (AB 1195)

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ABSTRACT

In 1998, California passed the Natural Hazard Disclosure Law (AB 1195), requiring home sellers to inform potential buyers of flood, wildfire and seismic hazards affecting a property. This study uses hedonic analysis and mail surveys to determine how wildfire disclosure under AB 1195 affects property values and how those effects vary with socio-economic factors and natural hazard experience. Results suggest that disclosure is capitalizing into housing values some of the costs and risks associated with hazard zone development. Without interaction effects, fire hazard disclosure under AB 1195 reduced the value of the average home by between 0 and 2.5%, depending on model used. Interaction terms indicated that disclosure affected property values most significantly in neighborhoods near where a major fire recently occurred, reducing the value of the average home by between 14 and 17%, holding all else constant, and resulting in a capitalized loss of between $46,000 and $56,000. There was also a negative relationship between fire zone disclosure and percentage of Hispanic residents. The fact that fire hazard disclosure has such a strong price effect in areas with a recent fire history may be due to insurance pricing and availability. It is possible that homeowners in fire hazard zones tend to have inadequate insurance coverage. After a major fire, many insurance companies stop underwriting insurance in these areas or steeply raise their rates. The disclosure form could have caused potential homebuyers in these areas to look further into the availability and pricing of insurance; the correction of that information asymmetry would be capitalized negatively.

INTRODUCTION

California faces some of the most severe challenges in natural hazard management in the nation. In particular California's cities are developing at an alarming rate into urban fringe areas subject to severe wildfire hazards. Recent high-value conflagrations are illustrative: the 1991 Oakland Fire, $1.9 billion in damages; the 1993 Southern California firestorms, $1 billion; the 1999 statewide firestorms, 1376 structures destroyed. Private insurers raised premiums or stopped offering fire insurance altogether in many areas of California with a recent wildfire history (Irby *et al.* 1999). Urban ratepayers in the state subsidize rural and fringe ratepayers, who pay $1.00 in fire insurance premiums for every $1.09 in costs incurred by the insurance provider (CDF 1995). As damage from natural disasters increases, the burden of government disaster assistance and hazard mitigation increases.

The California Natural Hazards Disclosure Law of 1998 (AB 1195) was an attempt to take a market-based approach towards mitigating the effects of natural hazards. It requires sellers to disclose whether their property is located in mapped wildfire, flood and seismic hazard zones. In theory, such information should enhance the efficiency of market allocations of land in hazardous areas. Better information about the presence of hazards is expected to reduce the relative price of hazard zone properties by increasing buyers' knowledge of the risks and additional expenses associated with living in them. The negative premium due to disclosure consists of the capitalized value of the added expenses, such as insurance and flood and fire proofing costs, plus an "option price" (see MacDonald *et al.*1987), or risk aversion premium that compensates for the uncertainty of potential damages and injuries in excess of insurance coverage. While one can calculate how much less the "rational" consumer will be willing to pay for a property based on added expenses, the price effect of risk aversion is far more difficult to predict because of various biases in the way that consumers translate perceived risks into financial terms (Kask and Maani 1992).

This study examined the effects of AB 1195 on property values in wildfire and flood hazard zones throughout California. Only the effects of fire zone disclosure are discussed in this paper. This project uses hedonic analysis to isolate sales price differentials in statutory flood and fire zones before and after AB 1195. In hedonic analysis, the observed price of a good, in this case housing, is regressed against a series of quantifiable attributes to deliver a schedule of marginal implicit prices. The project also explores how income, race, market segmentation and experience affect these differentials. Through a survey of homebuyers, it evaluates the extent to which AB 1195 provisions have actually been put into practice.

THE CALIFORNIA NATURAL HAZARD DISCLOSURE LAW OF 1998

AB 1195 requires sellers of properties within designated natural hazard zones to show prospective buyers a Natural Hazard Disclosure Statement prior to sale, informing them that the property is located in one or more of the following zones (Detwiler 1998):

- Very High Fire Hazard Severity Zones (VHFHSZs), designated by the California Department of Forestry (CDF) in conjunction with local governments
- Wildland fire areas, or State Responsibility Areas (SRAs), designated by CDF
- Areas of potential flooding in the event of dam failure, designated by the State Office of Emergency Services
- Special Flood Hazard Areas (SFHAs), corresponding with the 100 year flood plain, designated by the Federal Emergency Management Agency (FEMA)
- Earthquake fault zones, designated by the State Geologist; and
- Seismic hazard zones, designated by the State Geologist.

The Statement warns buyers "these hazards may limit your ability to develop the real property, to obtain insurance, or to receive assistance after a disaster." Once a local agency makes available maps showing parcels affected by the hazard zones, the seller and his or her agent are responsible for disclosing that information. The law additionally requires that homeowners in a flood zone purchase flood insurance, in accordance with the NFIP regulations, and that homeowners in both categories of fire hazard zones undertake prescribed vegetative fuel reduction within and around their property, in accordance with local fire regulations. These are critical inclusions. By informing potential buyers that living in a hazardous location requires actual expenses as well as abstract risks, the negative consequences of living there are made more concrete and tangible.

While there were hazard disclosure requirements previous to this law, most were ineffectual and not well enforced (personal communications, Peter Detwiler, Staff Director of the California Senate local government committee, 1999, 2001). AB 1195 consolidated previous state and federal hazard disclosure requirements into one Natural Hazard Disclosure (NHD) form and added requirements for several new zones. The statute placed that code section in the Civil Code. It granted a three-day rescission period during which buyers have the right to terminate a transfer after signing a contract if proper disclosure was not made. This provision gave sellers and their agents incentive to disclose early in the process rather than at the last minute, as was commonly the case when disclosure did occur in the past. Finally, in contrast to previous hazard disclosure laws, AB 1195 clearly articulated where real estate agents were liable for disclosure and where they were not. It makes clear which hazards the agent is responsible for disclosing, and it allows transfer of liability to a third party contractor conducting the hazard report. Since the third party report generally costs only $50 to $100 and frees the agent from direct and indirect liability, this change alone may drive most agents to get their clients to disclose. Mail surveys from this study indicate that a large majority of homebuyers are seeing the Natural Hazard Disclosure Form and that this form is intelligible and easy for people to understand, but it appears that disclosure is generally happening late in the buying process. If the rescission clause were better publicized, it is likely that disclosure would occur in a more timely fashion.

AB 1195 has one serious problem relating to VHFHSZ designation. While flood hazards are uniformly mapped across the country, and SRA wildland fire zones are mapped uniformly across the state, VHFHSZs, are mapped inconsistently across local jurisdictions. The 1992 Bates Bill (AB 337) required the mapping of fire hazard zones, known as VHFHSZ's, within Local Responsibility Areas (LRA), or jurisdictions where a local fire department existed. However, the bill was not designed with disclosure in mind. The bill instructed CDF to identify VHFHSZs "in cooperation with" local agencies. Local governments could exempt land within their borders from designation as VHFHSZ under the Bates Bill by declaring "functional equivalence" of local fire zoning regulations to the state model ordinance, by rejecting the CDF-recommended maps, by redrawing the maps themselves, or by refusing to comply with the Bates Bill entirely. The state submitted the maps to the locality, and then the local government had 120 days to either accept those maps or amend them; they could redraw or eliminate them if they wanted. CDF has neither the authority nor the resources to verify that a local government has "functional equivalence" in their ordinances, or that a local government's re-mapping was based on good science. According to Melissa Frago, Fire Safe Planning Coordinator for the Office of the State Fire Marshal, once a locality made such claims, CDF was unable to contest them (personal communications, 1999, 2001). California Government Code gives the local agencies the final word by stating, in section 51197.d, that "changes made by a local agency to the recommendations made by the director (of CDF) shall be final and shall not be rebuttable by the director."

Many localities have successfully exempted themselves from the zoning ordinances under the Bates Bill (e.g. vegetative clearance around structures) by rejecting the state's mapping. The question of where disclosure is needed for LRA fire zones has not yet been fully resolved. In the Civil Code created by AB 1195, disclosure is required for VHFHSZs pursuant to either Section 51178 (based on state designation) *or* Section 51179 (based on local designation). The state has yet to resolve which legally takes precedence, but due to the wording of the Civil Code section and to avoid potential liability to sellers and disclosure firms, the state recommends that properties in zones identified pursuant to both Sections 51178 and 51179 should be disclosed (Melissa Frago, personal communications, 1999 and 2001). Whether disclosure is generally occurring by the more conservative state standard when the two conflict is unknown. The state has made public its digital maps for this purpose. The common reasoning is that disclosure should be carried out if an agency with a VHFHSZ identified pursuant to Section 51178 has not designated the zone pursuant to Section 51179, but since local agencies are responsible for supplying the maps upon which hazard disclosure is made, many localities may simply provide their own map. While those responsible for disclosure (the seller, the agent, or a third party) should take the most conservative approach towards disclosure, those parties may technically be within the law if they use the maps the locality provided, even if those maps are not in accord with the state's VHFHSZ designations.

The number of local governments not in compliance with the Bates Bill highlights the magnitude of the problem. According to Irby *et al.* (1999), of 209 jurisdictions with VHFHSZs mapped by CDF, 99 did not challenge the designation (group 1), 52 claimed that they "meet or exceed" the Bates Bill minimums (group 2), and 58 "exempted" themselves (group 3), meaning they declined to participate either due to political reasons or local findings that the state mandate was not necessary for effective fire protection in their area. In the two latter cases, jurisdictions were free to reject state VHFHSZ mapping if they chose and were under no obligation to provide their own mapping. Of the 99 jurisdictions in group 1, only 54 formally "adopted" the state designated VHFHSZ. Of the 52 in group 2, and the 58 in group 3, 10 and 6 respectively adopted some kind of fire hazard zone, although in most cases not the state designated VHFHSZ. All jurisdictions in groups 2 and 3 are technically exempt from any LRA fire hazard disclosure requirements, even though many of them contain extremely flammable landscapes. Without an official VHFHSZ in the jurisdiction, most subsequent fire laws do not apply to the jurisdictions. The reasons why certain municipalities embraced these regulations while other did not are beyond the scope of this paper, but merit more research.

The overall effect of this problem is that many people who live in hazardous areas are misled into a false sense of security when purchasing a home because the NHD form claims that no known hazard exists. Moreover, disclosure could be highly inconsistent within a contested VHFHSZ. Sellers using the state maps might disclose, while sellers using local maps might not.

METHODS

This study uses hedonic analysis to isolate the price effects of disclosure under AB 1195. Economists including Rosen (1974), Quigley and Kain (1970) and Griliches (1971) developed the concept of hedonic price analysis, in which the observed price of a good is econometrically disaggregated into a schedule of implicit marginal attribute prices. Hedonic pricing is particularly suited for studying housing prices, because the value of a property is determined by many quantifiable implicit attributes, such as number of bedrooms, distance to amenities and square footage. In this study, sales price was regressed on a vector of neighborhood, locational and structural attributes, in addition to variables for flood zone and fire zone location, and transaction before or after the law. The partial derivatives of the coefficients on the interaction terms between hazard zone location and disclosure after the law represent the hedonic price of hazard disclosure under AB 1195.

A two-tier cluster sample method was used to get a representative sample of housing transactions from across the state. In the first tier, zip codes from across the state were sampled by stratifying all California zip codes by population density, median 1999 housing price and percentage of land area occupied by flood and fire zones. Zip codes with very low population densities were discarded because they lacked sufficient transactions. One of every 9 observations was sampled from each cell, yielding 63 sample zip codes located across the state. The method ensured that there would be enough samples in hazard zones (even with this oversampling of hazardous zip codes, only roughly 1 in 5 properties was located in a statutory hazard zone) and that a variety of neighborhoods would be included, across the spectrum of housing values and population density.

Once sample zip codes were chosen, individual property transaction records were obtained for the period starting 18 months before the implementation of the law to 19 months after it. Both vacant and developed parcel transactions were obtained, but the vacant parcel records were separated into a different database for separate regression (regressions on vacant land data yielded no significant results). These property points were address geocoded using GIS software. A variety of locational, demographic and market variables (Table 1) were coded for each property point. The key variables were location in FEMA SFHA flood zones, SRA fire zones and VHFHSZs. No distinction was made between properties in SRA zones and VHFHSZs. In order to determine how the effects of disclosure are affected by a neighborhood's recent experience with hazards, CDF data on California wildfires greater than 300 acres since the beginning of 1996 were obtained. The locations of the centers of those fires were geocoded. Similar data on flood locations were unobtainable.

After all variables were coded, tier two sampling began. Property records were stratified by zip code and by hazard (or no-hazard) zone. A sampling algorithm was created that oversampled strata with low populations and undersampled strata with high populations. This served to oversample hazard zone properties and properties in zip codes with relatively low numbers of observations. Each stratum was assigned a sampling weight, for use in weighted least square estimation, equal to the inverse of the sampling rate. The algorithm was designed so that the total number of hazard zone properties sampled could be set equal to a specified proportion of the total number of non-hazard zone properties sampled. After some experimentation the total number of hazard samples was set to half the number of non-hazard samples. The sample included 2,840 records in flood zones (about 62% of all flood zone records), 4,258 from fire zones (54%) and 14,478 from no-hazard zones (38%), all of which were randomly sampled from the strata and assigned weights.

Data were regressed using a semi-log functional form. Both weighted and unweighted least squares regressions were run and results were found to be robust to inclusion or exclusion of weights. Results were also tested for robustness to stratification by time of sale before or after AB 1195. Overall results were slightly sensitive to stratification, but interaction effects were robust. Three regression models were used. Model 1 included no interaction terms, except FIRE:AFTER and FLOOD:AFTER; these terms indicate the effect of hazard disclosure. Model 2 included 25 non-hazard interaction terms (chosen through backwards stepwise elimination) and eight quadratic terms applied to distance and size variables. Model 3 contained all the terms of Model 2 plus significant hazard interaction terms.

In addition to the hedonic analysis, mail surveys were sent out to 1200 households located in designated hazard zones as a means of getting a preliminary understanding of the extent of disclosure and homeowner attitudes towards it. Survey methods are not discussed here.

TABLE 1. REGRESSION VARIABLES

Variable	*Description*
PRICE	Transacted selling price of property
FLOOD	1= in the FEMA Class A Flood Zone; 0= not in that zone
FIRE	1= in either the VHFHSZ or SRA fire zones; 0= not in those zones
AFTER	1= transacted after June 1998; 0= June 1998 or before
ASSDSTCT	Appraised value of structure
BATHTOT	Number of bathrooms
BEDROOMS	Number of bedrooms
POOL	1= pool, 0=no pool
TOTALRMS	Total number of rooms
TOTALSF	Total structure square footage
LOTSQFT	Total lot square footage
NOSTORY_	Number of stories
YRSOLD	Years old
VIEW	1= view, 0= no view (only available for some counties)
FIREPL2	1= fireplace; 0=no fireplace
D2AIRPORT	Distance to nearest airport (by straight line)
D2GOLF_CC	Distance to nearest golf course or country club
D2HOS	Distance to nearest hospital
D2INDTRY	Distance to nearest municipal industrial facility, stadium or treatment plant
D2LIB	Distance to library
D2PARK	Distance to municipal park
D2SCHL	Distance to nearest school
D2SHOPCNT	Distance to nearest shopping center
NRMARINA	Within 1500 meters of a marina
D2RURFIRE	Distance to nearest CDF rural fire station
D2HAZWST	Distance to nearest hazardous waste site
D2CULTL	Distance to nearest theater, museum or cultural center
D2STAR	Distance to nearest Starbucks
NRSKI	Within 20 km of major ski area
D2OPENSP	Distance to nearest open space
MEAN_API	School Academic Performance Index (1-800)
MEAN_RANK	School state relative ranking (1-10)
POPD	1990 population density by tract
P_VAC	1990 percent vacancy by tract
POPCHG9097	Population change between 1990 and 1997 by tract, based on projections
TMEDAGE97	Projected 1997 median age by tract
PBLK	Projected 1997 percentage African American population by tract
PASIA	Projected 1997 percentage Asian-American population by tract
PHISP	Projected 1997 percentage Hispanic population by tract
POWNOC	Projected 1997 percentage owner occupied housing by tract
PUNIV	Projected 1997 percentage university educated population by tract
PUNEMP	Projected 1997 percentage unemployment by tract

PEXEC	Projected 1997 percentage of executive level workers by tract
PPROF	Projected 1997 percentage of professional workers by tract
MHHINC	Projected 1997 median household income by tract
D2CBDA	Distance to primary business district
D2CBDB	Distance to secondary business district
D2CBDC	Distance to tertiary business district
CBDIND2	Logged Central Business District Index
PRECIP	Mean precipitation per year at a given location
D2COAST	Distance to nearest coastline
D2HIWAY	Distance to nearest highway
FIRE.EXP	1= fire occurred within 10 km since 1996
Z00M2WTBD	1= within 200 meters of lake, coastline, river
PPSQFT	Median price per square foot, by zip code
SDIND1	Number of transaction by zip code over the population
SDIND3	SDIND1 / similar index at the state level
PRRATIO	Ratio of median price per zip code to median state price
MEDPRCTY	Median home price by city
PADJ	Percentage change in medprCty by quarter from first quarter price
WEIGHT	Regression weights

IMPACTS OF HAZARD DISCLOSURE ON HOUSING PRICES

Disclosure under AB1195 has lowered consumer willingness to pay and reduced property values in fire zones. The results indicate a positive premium of between 2 and 5% for fire zone location prior to AB 1195. The unstratified regressions do not indicate that the law changes that, but the time-stratified regressions do. In Model 1 for time-stratified regressions, disclosure reduces the positive premium of 5-6% down to 3% while in Model 2 it reduces a roughly 3% positive premium to between 0 and 1.8 %. The time-stratified regressions are likely better able to discern this effect because they have smaller sample sizes, are better fitting and more precise in parsing subtle effects.

The inclusion of interaction terms indicates that fire disclosure's negative effects are greatest in areas that have recently experienced a major fire nearby and neighborhoods with higher than average percentages of Hispanic residents. The most dramatic interaction result stems from a house's location within 10 km of a major fire that occurred since 1996. Prior to the law, such experience with fire has no effect on property values, while afterwards it is associated with a 14 to 17% reduction in property value. For the average priced fire zone home from the data set, at $332,000, this results in a $46,000 to $56,000 reduction in value. This strongly suggests that local experience is one of the critical factors in mediating the effectiveness of disclosure. Where home owners and potential homebuyers have some real-world event upon which to predicate their assessment of risk, disclosure can significantly change people's willingness to pay for housing. Experience with fire alone is not enough. It is the combination of local anecdotes, telltale signs (e.g. blackened brush and trees), and personal experience together with the disclosure form that alters buyer behavior. This supports Rossi *et al.*'s (1982) finding that natural hazards are conceptualized less abstractly and taken more seriously by those with some experience of disasters. The availability and/or cost of fire insurance may also be an important factor. Prior to disclosure, many potential homebuyers in these areas may not have realized that their prospective home was in a fire zone and that they would need to pay more for comprehensive fire insurance coverage. After the law, people were likely more aware that they lived in such a zone and potential buyers probably were more concerned about the availability and affordability of insurance.

Fire disclosure also has a disproportionate negative price effect for Hispanic neighborhoods. When both fire zone interactions are adjusted out, the net effect of location in the fire zone post June 1998 is actually a positive one, suggesting that fire hazard aside, these types of urban periphery properties became a very desired commodity during the housing boom that accelerated in 1998.

These results describe only the price effect of disclosure under AB 1195, not of hazard disclosure in general. While the results strongly suggest that significantly more hazard disclosure is occurring under AB 1195 than previously, there is no doubt that some hazard disclosure was occurring previously. Because of this, the results underestimate the price effect of hazard disclosure *in general*. The results simply describe the additional effect due to disclosure under AB 1195. This is an important issue in regard to flood zones, where considerable disclosure was occurring previously under the National Flood Insurance Program, but less important for fire zones, since disclosure was infrequent prior to AB 1195.

The results may significantly underestimate the magnitude of the price effect due to fire hazard disclosure in VHFHSZs. It is highly likely that the state-wide VHFHSZ map used for this study (the official map originating from CDF) greatly overestimated where disclosure actually occurred because of the uncertainty over whether local or state hazard maps should be consulted for disclosure of VHFHSZs. The map used for this study technically excludes all VHFHSZs that were rejected or amended by localities, as described above. However, it is possible that some of the VHFHSZs included on this map were subsequently rejected or amended, or that localities simply chose to ignore the designations. If many of the properties designated as being in VHFHSZs by this study were in contested zones where fire disclosure was inconsistent, then the magnitude of the capitalization would be understated.

This study reveals important relationships between the spatial distribution of racial communities and natural hazards. The interaction between fire disclosure and the Hispanic variable may be due to insurance redlining practices, which have been found to be common in black and Hispanic neighborhoods and have been the source of several major lawsuits against the insurance industry (Jones 1997, Ondrich 1998). Redlining makes it harder for members of a racial group to get the same level and quality of coverage for the same money as a member of the ethnic or racial majority. It is possible that in areas underwritten by private markets, race-based redlining is occurring, making it difficult for Hispanics in fire zones to get insurance underwritten, a factor that would be reflected in lowered property values.

POLICY IMPLICATIONS

Hazard disclosure is helping to correct information asymmetries in housing markets where hazardous land is abundant. These results indicate that better information about hazards is not only affecting consumer behavior, but that without disclosure requirements, many consumers would not be aware of the hazards affecting a property. This is not because the average homebuyer is ignorant, but because fire and flood hazards represent an imperceptible and hypothetical problem—a statistical probability that an event may happen—unlike other disclosable material facts that can be perceived, like bad plumbing or a leaky roof. While those who watch the news may be aware of fire hazard in highly vegetated areas, most potential home buyers simply do not have the experience or ecological knowledge to know if the particular ecosystem they are in is flammable, and if so, what the level of risk is. Disclosure takes these hard-to-digest abstractions and turns them into an oversimplified but intelligible dichotomous classification—hazardous or not hazardous. This knowledge is internalized in the housing price function in several ways. Consumers factor in what their additional expenses will be, in terms of insurance, floodproofing, defensible space maintenance, etc. They also assess the risk to themselves and their families and potential damage to their property over and above what would be compensated for by insurance, based on their subjective judgment and their level of risk aversion.

One of the most powerful results is that fire disclosure reduces the value of a home by up to 17% when a major wildfire had occurred in the vicinity of the home in recent years. Occurrence of a recent nearby fire had no price effect before the law. This result suggests that experience strongly mediates how potential homebuyers make that subjective assessment of risk but it also suggests that experience alone is not sufficient; it is disclosure that likely makes prospective homebuyers more aware of the area's fire history and able to factor that information into their home buying decision. The study does not answer how intense the event has to be, how proximate, and how recent for consumers to dramatically alter their behavior and assessment of risk. These merit more research.

While the law has been successful in many ways, it is perhaps more informative from a policy perspective to look at its failures. While the law has resulted in the dissemination of better information, it has done so in a somewhat arbitrary way that may unintentionally mislead many consumers. Many homebuyers might not realize that not all hazardous areas are subject to disclosure under AB 1195. A Natural Hazard Disclosure (NHD) form indicating that a house is not in a designated statutory hazard zone might mislead some consumers to believe that the property is free from all potential natural hazards, when in fact the home might be in a hazardous area that is not mapped, such as a landslide zone. This is a particular problem for local responsibility fire hazard zones.

The other failure relates to designation of local responsibility areas, or VHFHSZs. The VHFHSZs apply to some of the most heavily populated and developed parts of the state, where a major fire could be catastrophic. While FEMA has a national mapping standard for floods that does not vary across the whole country, and CDF maps SRA zones consistently throughout the state, the mapping of VHFHSZs, although in theory coordinated through the state, is under the control of various, uncoordinated local governments, each with their own agenda. Moreover, localities have an interest in understating hazards in order to draw residents and boost the tax base. The drafters of AB 1195 introduced the potential for inconsistencies and conflicts of interest when they chose to rely on the mapping designations carried out under the Bates Bill. Hence, some of the most fire prone local responsibility areas, such as the Oakland Hills, where the 1991 fire caused over $1 billion in damage (and ironically led to the passage of the Bates Bill), are not officially classified as VHFHSZ, perhaps leading many homeowners to have a false sense of security. It is recommended that the legislation be amended to clarify that disclosure should occur for all properties in VHFHSZs, as designated pursuant to the state's mapping.

Much of California's new development in Southern California, the Coast Range and the Sierra foothills is going into statutory fire hazard zones. The market effects of fire hazard disclosure could have serious ramifications for development patterns in such places. The fact that previous experience with wildfires interacts with disclosure to significantly reduce property values may be due to or compounded by the fact that after a fire, certain insurance coverage becomes more expensive or impossible to obtain, and that prior to disclosure under AB 1195, many homeowners did not realize the importance of getting fire insurance in these neighborhoods during the home buying process. While most homeowners have some homeowners insurance, according to the Insurance Information Network of California, many homeowners do not know how much coverage they have and consequently have insufficient coverage. Hearing about a recent fire, combined with seeing the disclosure form might spur new homebuyers to do more research on what coverage they need and what is available.

The effect of fires on home values and real estate markets is likely only to get worse over time. As more homes are built in these flammable environments, more structures are exposed to risk, more fire suppression and fuel buildup occurs and catastrophic vegetation and structure fires become more likely. Casualty insurance companies will be exposed to increasing levels of risk and will stop underwriting fire policies for increasing numbers of urban-wildland interface areas, further driving up the risk associated with living in these areas. Over time, it is not out of the question that this vicious cycle of fire risk could significantly alter peoples' preferences for living in fringe, urban-wildland settings and redirect development away from the current outward sprawl pattern and back in towards central cities, or to less hazardous land. If the increasing destructiveness of conflagrations makes people more aware and attuned to the hazards of wildfire, disclosure will play an extremely important role.

The effects of wildfire disclosure in recent-fire environments underscore the need for state government to enact policies that increase information of these hazards and that decrease subsidies and incentives to overdevelop these areas. However, current state policy might actually be incentivizing such development. In 1968 the state created the Fair Plan (Fair Access to Insurance Requirements Plan), which is a statutory insurance industry association, regulated through the state (Pursuant to Insurance Code Section 10091(c)), that provides basic property insurance to property owners who are unable to obtain it in the private market. It was designed to insure risks of wildfire and riot, but soon came to cover other uninsurable risks. Essentially, it forces insurance companies to pool their risk on high-risk, otherwise uninsurable properties.

In 1996 State Insurance Commissioner Chuck Quackenbush limited FAIR Plan brush fire coverage to just a few areas in Los Angeles, Santa Barbara, Ventura, San Bernardino and Orange Counties, given the increasing burden on insurance companies. However, in June of 2001, Commissioner Harry Low expanded FAIR Plan brush fire coverage to all parts of the state for properties where privately underwritten coverage was not available. Because private markets are not willing to underwrite these risks, FAIR Plan policy premiums distort the pricing of these risks and in effect subsidize continued development in hazardous wildfire zones by spreading out the risks over the population of all insurance ratepayers. Expanding the geographic coverage of the FAIR Plan increased the level of this subsidy, providing a perverse incentive to develop in some of the more hazardous, and ecologically sensitive lands in the state, furthering the cycle of fire suppression and catastrophic conflagration. This could be addressed by offering FAIR Plan coverage to existing structures throughout the state, but reinstating geographic limits on FAIR Plan for new development. Using careful planning to decide where coverage should be allowed, insurance availability could be used as a tool to direct and focus new development within defined urban-wildland fire hazard zones in which that risk could be better managed. Applying geographic limits to only new structures avoids an inequitable outcome by making coverage available to all those currently unable to get insurance through private markets.

This study shows that a market-based approach can have market effects. But can it meet policy goals as effectively as regulatory approaches? Correcting information asymmetries may not be enough to resolve problems like development in hazardous areas and mounting government disaster aid payments. Under an idealized system of "pure personal responsibility," such inefficiencies should never happen. But they do happen, both because of an inability of all consumers to achieve "pure rationality," in assessing uncertainty and risk (Kask and Maani 1992), and because government provides a safety net to all individuals. The involvement of government in natural hazard mitigation and disaster assistance is inevitable. Hence, while disclosure is critical to correcting major gaps in the information that is needed to make good decisions and protect consumers, government regulation and planning are still needed to limit and direct development in hazard zones and ultimately to reduce the burden of disaster aid (Burby 1998, Burby *et al*. 1988, Faber 1996, Holway and Burby 1993, National Review Committee 1989). As development moves increasingly into hazardous areas, the involvement of governments in all aspects of hazard mitigation must increase.

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DEFENSIBLE SPACE: FIFTEEN REASONS WHY PEOPLE DON'T DO IT

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The term defensible space refers to that area between a house and an oncoming wildfire where the vegetation has been modified to reduce the wildfire threat and allow fire fighters to safely operate. Research results clearly demonstrate that defensible space improves the probability of house survival during wildfire. Despite educational efforts by fire fighting agencies, many property owners living in high fire hazard environments have been slow to adopt defensible space practices. Based on the findings of four surveys involving property owners living in high fire hazard areas in California and Nevada, fifteen factors were identified that influence decisions to adopt defensible space practices. These factors were: lack of awareness, denial, fatalism, futility, irresponsibility, inability, lack of incentives, insurance, lack of knowledge, aesthetics, unnaturalness, disposal of slash, discomfort, illegality, and lack of ownership. If the goal is to have property owners employ defensible space practices, it is important to understand the factors that affect their decisions to take action. Once these factors are understood, resources can be strategically directed to address the real reasons for property owner failure to implement defensible space practices.

THE SCA FIRE EDUCATION CORPS: EDUCATING URBAN INTERFACE HOMEOWNERS IN IDAHO AND NEVADA.

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INTRODUCTION

The Intermountain West experiences an increased loss of homes, structures, and property due to catastrophic wildfire increases each year, and yet, more communities and homes are being developed in the wildland-urban interface. There are additional consequences as a result of this relation between community development in the interface and wildfire threat. Communities are often developed adjacent to dry, forested watersheds and other natural resource lands, which increases the potential for catastrophic fire. Property managed by the private sector contains fuel loads similar to those on public lands managed by the United States Forest Service (USFS) and the Bureau of Land Management (BLM). Homes, structures, and private lands sustain fuel loads that are no different from the existing natural fuels, such as timber and brush. The absence of a network of defensible space increases the probability of loss to many structures and also contributes fuel to fires that can adversely affect watershed geography and natural resources. An added effect of the relation between the growing wildland-urban interface and the wildfire threat is that state and federal agencies employ excessive amounts of time, money, and personnel to protect private property and the adjacent natural resources. This limits the resources that fire agencies can employ to protect existing natural resources, watersheds, and fish and wildlife habitat.

These problems are not insurmountable. Research has demonstrated that when communities and homeowners implement the concepts of FIREWISE (www.firewise.org) and defensible space, the wildfire threat to property and natural resource land is severely reduced. The challenge is how to determine the most efficient and effective methods of educating communities and homeowners about FIREWISE concepts including defensible space and how to implement an educational process with homeowner evaluations and fuels reduction projects.

As a result of increased loss of homes and structures due to wildfire in the western United States during 1999 and 2000 a National Fire Plan was adopted by Congress. This plan emphasized the need for community assistance in the wildland urban interface. The Student Conservation Association (SCA) Fire Education Corps was awarded a major grant through the Idaho Department of Lands (IDL) in Idaho and BLM in Nevada. The $325,000 project in Idaho and $140,000 project in Nevada were a direct result of the National Fire Plan monies and were a cooperative effort involving the USFS, BLM, IDL, Resource Conservation and Development Councils (RC&D), Keep Idaho Green (KIG), and local Home Depot stores. This was a new and unique strategy that paired college interns with fire prevention professionals. In Idaho and Nevada, these partners educated communities and homeowners about wildfire and how to utilize FIREWISE concepts to reduce home and structure loss. Seven person teams were trained in wildland-urban intermix property evaluations and methods with which to work with communities, and were placed in five sites in Idaho and two sites in Nevada.

BASE SITES WITH DESCRIPTIONS

Team Salmon

Salmon, Idaho was selected as the base location for Team Salmon and is centralized in the greater Salmon River valley of East-central Idaho, which is encompassed within the boundary lines of Lemhi and Custer counties. Elevation ranges from less than 3,000 feet in the river bottoms to over 10,000 feet on the Continental Divide. This range in elevation contributes to three vegetation categories. The lower elevations, 3,000 to 5,000 feet, are influenced by aspect. Bunch grass, Mountain Mahogany and sagebrush characterize vegetation on southerly slopes and along river valleys and creek channels. Ponderosa Pine is the most common timber type on the river breaks. Douglas-Fir occupies the northern aspect of slopes. Between 5,000 and 7,000 feet, the predominant vegetation types are defined by stands of Lodgepole Pine interspersed with Douglas-Fir and Ninebark. At 7,000 feet and up to tree line (~8500 ft) dense stands of Lodgepole Pine continue to dominate.

A wide range of weather and climate conditions are experienced in East-central Idaho. Contingent upon elevation, the Salmon River valley is described as semi-arid high desert or forest riparian. Summer temperatures often exceed 80° F to 90° F and winter temperature averages between 20° F and 40° F, with occasional reports of temperatures in excess of – 40° F (www.wrcc.dri.edu). Annual precipitation can average less than 10 inches on valley floors and exceed 50 inches in higher elevations. Snowfall accounts for the greatest precipitation and dominates stream flow patterns in watershed geographies. The Idaho Department of Environmental Quality (DEQ) designated the following beneficial water uses for the region's watersheds: domestic water supply, agricultural water supply, cold water biota, salmonid spawning, primary contact recreation, and secondary contact recreation. These watershed communities have recently experienced low water volume due to insufficient snow pack.

Riparian areas are generally not well developed and are primarily located within the private land sector (www.epa.gov/surf).

As a result of the 2000 wildfire season, which consumed up to 500,000 acres in the region, agency partners, including county, state, and federal, determined a need for fire-prevention and fire-education activities. Currently, in 2001, conditions exist which support the possibility for catastrophic fire events, as witnessed last year with the advent of the Clear Creek fire on the Salmon-Challis National Forest.

Team Coeur d'Alene

Coeur d'Alene, Idaho was selected as the base location for Team Coeur d'Alene and is centralized within the Northern region of Idaho, which is defined as the Idaho Panhandle. This region encompasses four counties; Kootenai, Shoshone, Benewah and Bonner. Elevations in the Idaho Panhandle range from 2,200 to 3,000 feet. The region experiences average daily summer temperatures between 60° F and 80° F and winter temperatures between 20° F and 40° F. A cool and moist climate describes the region. Precipitation is most commonly observed in fall, winter, and spring (www.wrcc.dri.edu). Concentrated levels of precipitation are recorded in winter months, including heavy rains and snow. Lodgepole Pine, Ponderosa Pine, Western White Pine, Red Cedar, Douglas-Fir, and Grand-Fir are characteristic of the predominant vegetation and timber distribution. Numerous lakes support the communal watersheds (www.epa.gov/surf).

Communities within the Idaho Panhandle support large populations of summer residents and cabin owners. Many of these residences are located adjacent to or within, federal and state lands. Due to frequent homeowner absentee status and an increasing wildfire threat, agencies, including county, state, and federal, determined a need for fire-prevention and fire-education.

Team McCall

The community of Cascade was selected as the base location for Team McCall due to a centralized location in the West Central Highlands, Idaho. McCall, Idaho is representative of the region ranging in elevation up to 5,031 feet and experiences cold and wet winters and mild summers. Average daily maximum temperature for the month of July is recorded as 81° F. The average daily minimum temperature, in January, is 13° F. Annual precipitation averages 28 inches (www.wrcc.dri.edu). Snowfall accounts for 173 inches of annual precipitation.

This region is mainly characterized by a forest riparian habitat, which is composed of dense stands of Ponderosa Pine, Douglas-Fir, Grand Fir, and Lodgepole Pine. Understory vegetation includes medium height shrubs, such as: Ninebark, Service Berry, Ocean Spray, Spireae, Chokecherry, and Mountain Ash. Invasive weeds have become prevalent and are encroaching on native habitat. The North Fork of the Payette River and Payette Lake define the communal watershed (www.epa.gov/surf).

Communities within the West Central Highlands are largely composed of summer residents and cabin owners. Residents have voiced concerns about the possible damaging effects to the watershed in the event of a large-scale fire event. According to state and federal agencies, fuel conditions on both private and federal lands are considered heavy and unnatural. As a result, there was a request for fire-education and fire-prevention activities.

Team Boise

Boise, Idaho located in Southwestern Idaho, was selected as the base location for Team Boise due to its proximity to numerous communities within the wildland urban interface. Elevations in this region range between 2,500 to 7,000 feet and the climate is described as semi-arid desert. Forest riparian conditions exist in the higher elevations. Maximum daily temperatures in excess of 95° F are recorded in peak summer months (www.wrcc.dri.edu). Total average precipitation for the Boise area is 19 inches. Common vegetation types include: Bitterbrush, Sagebrush, Bluebunch Wheat grass, and Idaho Fescue. Ponderosa Pine and Douglas-Fir are characteristic of timber stands in the higher elevations. Invasive weeds, primarily Cheatgrass, have modified fuel conditions and created a continuous and heavy fuel load throughout the region. Watershed geographies are supported by river dominated flow patterns. Communities and homeowners receive water from a mixture of city treatment facilities and personal wells (www.epa.gov/surf).

Southwestern Idaho is experiencing a constant development of communities and homes within the interface. Due to heavy fuel loads and the increasing number of homes affected by potential wildfire events, as witnessed by the eighth street fire in the Boise foothills, agency partners determined the need for fire-prevention and fire-education activities.

Team Pocatello

Pocatello, Idaho was selected as the base site for Team Pocatello due to its centralized location in Southeastern Idaho, which is delineated by three counties and the geography of the Snake River Valley. Elevation ranges between 4,500 and 6,500 feet. A semi-arid climate, including high desert topography, determines the landscape of this region. Maximum temperatures, in peak summer months, exceed 95° F. High winds and afternoon thunderstorms are characteristically observed in late spring and early summer. Average annual precipitation is listed as 12 inches. Annual snowfall accounts for an average of 30 inches in the lower elevations. Higher elevations receive up to 60 to 80 inches of snowfall (www.wrcc.dri.edu).

Cheatgrass, Sagebrush, and junipers are the common vegetation types in lower elevations. Vegetation in higher elevations shifts to include pines, firs, and select species of deciduous trees. Rivers and creeks sustain watersheds within the region. Private wells and aquifers are commonly used for personal water use and irrigation (www.epa.gov/surf).

Communities and residents are concerned about the potential for large-scale fire events and have demonstrated an interest in fire-prevention and fire-education activities. Large populations of homeowners are scattered among interface conditions and are aware of the wildfire risk. Local fire departments and fire agencies determined that many communities in the region are at risk to wildfire.

Team Elko

Elko, Nevada, located in the Northeast corner of the state, was selected as the base site for Team Elko due, primarily, to its proximity to many interface communities and a recent surge of development. Elevation ranges between less than 5,000 feet to over 11,000 feet. A semi-arid high desert describes the climate of the region. Maximum daily temperatures, in peak summer months, exceed 95° F (www.wrcc.dri.edu). Average annual precipitation is 12.5 inches. Commonly observed vegetation types include Sagebrush, Rabbitbrush, Crested Wheat, Pinyon Pine, juniper, and native bunch grasses. Invasive weeds include Cheatgrass, Thistle, Leafy Spurge, Tumbleweed, and Tall Pepperweed. Homeowners and communities in Northeastern Nevada primarily depend on groundwater wells to supply water for personal use and irrigation (www.epa.gov/surf).

Due to heavy fuel loads and an increasing number of homeowners building within the wildland urban interface, agency partners, specifically the BLM, determined a need for fire-prevention and fire-education activities.

Team Carson City

Carson City, Nevada was selected as the base location for Team Carson and is located in Northwestern Nevada along the Sierra Front. Numerous communities and subdivisions are scattered throughout this region and are located within the wildland-urban interface. The elevation of communities can range from below 4,000 feet to over 6,000 feet. This range in elevation significantly determines the climate and topography of each community.

A semi-arid desert prevails in lower elevations, where the average annual precipitation rarely exceeds 11 to 12 inches. Average July temperature is 90° F (www.wrcc.dri.edu). Afternoon thunderstorms are common and can generate high winds and intense, but brief lightning activity. Sagebrush and Bunchgrass dominate the landscape. Invasive weeds, including Cheatgrass, Tall-Whitetop, Medusahead, and Knapweed have encroached on native habitat, and have consequently altered the native fuel conditions. Residents depend on wells, which are supported by the Upper Carson watershed.

The landscape in higher elevations, above 5,000 feet, is defined as a Pinyon-Juniper zone. Grasses, Perennial Forbs, and shrubs (principally Sagebrush and Bitterbrush) define the understory vegetation. Annual precipitation averages 13 inches. July temperatures often exceed 80° F. Communities located within this region depend on private wells, which are supported by the Truckee watershed. The presence of invasive weeds is of paramount concern to local residents (www.epa.gov/surf).

A record number of wildfires were recorded in 1999 and 2001 including several large-scale fire events, which consumed over 1.6 million acres and threatened the loss of many homes and structures. As a result of repeated exposure to fire-related media, communities located along the Sierra Front became increasingly concerned about the existing wildfire threat. The BLM and local fire departments, consequently, determined the need for fire-prevention and fire-education activities.

PARTNERSHIPS

The SCA created several partnerships throughout the summer of 2001 including the USFS, BLM, IDL, Natural Resource Conservation Service (NRCS), Idaho RC&D councils, the National Interagency Fire Center (NIFC), Rural and Urban Fire Departments, Nevada Division of Forestry (NDF), Douglas County Geographic Information Systems (GIS) department, Kootenai County Disaster Services, Project Impact, KIG, Sierra Front, Fire Safe Highlands, University of Nevada Cooperative Extension, University of Idaho Cooperative Extension, The Home Depot Inc., and the South Idaho Timber Association. These partners provided SCA interns with FIREWISE (www.firewise.org) training, technical support, guidance, supplies, contact information, office space, orientation to local communities, education on localized vegetation, Global Positioning System units, Geographic Information Systems (GIS) technological assistance, and home evaluation referrals. The University of Nevada and University of Idaho Cooperative Extension offices offered specialized botany training specific to Nevada and North Idaho along with defensible space literature. Home Depot Inc. supplied model fire resistant structures at seven different locations throughout Idaho. Local Home Depot stores donated tools to assist teams with demonstration projects. The SCA was the primary coordinator when communicating with political, governmental, non-profit, private, and media contacts. These contact relations offered assistance that was essential to the design, implementation, and coordination of the Fire Education Corps Program.

GOALS

1. Create awareness and educate local communities about defensible space and wildfire dangers.
2. Conduct home evaluations and provide recommendations to wildland-urban interface homeowners regarding defensible space.
3. Develop and implement a community FIREWISE (www.firewise.org) demonstration project.
4. Assist with fire prevention projects deemed high priority by agency partners.
5. Collect GPS data and design GIS maps that will serve as useful information for agency partners.
6. Provide reports and recommendations on fire education and prevention efforts.

MATERIALS AND METHODS

Geographic Area

Geographic placement of SCA teams was determined by the interest of agency partners, centralized populations, number of communities at risk within the wildland urban interface, fire history, and climate and topography. The proximity of base sites and communities adjacent to public lands, which are managed primarily by BLM, USFS, NDF, and IDL, was accounted for. These communities have also experienced an increased urbanization in the last decade, resulting in a large zone of wildland urban interface.

Public Service Announcements

Television-based Public Service Announcements (PSA's) were sponsored by the USFS and announced the presence of The SCA Fire Education Corps. Free and comprehensive wildland urban interface evaluations were requested using a toll-free number (1-888-372-4042). The phone number was online in Idaho from the first of June through the end of September. The toll-free phone number was not available at the Nevada sites until mid-July.

Media

SCA Fire Education Corps teams contacted television, radio, and newspaper media outlets within each region. Media contacts received media kits that outlined the program (Appendix C) and consisted of a Question and Answer sheet (Q&A), press releases, team biography sheets, and talking points. Q & A sheets served as guidelines for live interviews along with talking points for the interns. Press releases were sent out for each special event, demonstration project, and team updates. Media coverage included radio PSA's (Appendix D), radio interviews, newspaper articles, television interviews, and television stories.

PUBLIC EVENTS

Teams participated in the following types of events: rodeos, community days, fairs, art shows, parades, concerts, pot luck dinners, flea markets, garage sales, fundraisers, block parties, car shows, sidewalk sales, festivals, sporting events, barbecues, holiday celebrations, farmer's markets, and fire department open houses. Display tables, including posters, home evaluation sign-up sheets, wildfire preparedness surveys, and information bags (Appendix E) were utilized at events. Information bags included a "Living with Fire" booklet, "Landscaping for Wildfire Prevention" booklet, SCA "Your Home and Wildfire" brochure, "It Could Happen To You" pamphlet, and wildflower seed packets (Appendix F), and were labeled with partner logos. Dioramas, demonstration model homes, educational videos, and SCA Fire Education Corps banners supplemented teams' efforts at some public events. USFS and BLM representatives occasionally assisted interns and showcased fire trucks, fire fighters, Smokey The Bear, magnets, key chains, Frisbees, coloring books, crayons, buttons, dry erase pads, and pencils.

PRESENTATIONS

Teams presented to fire departments, homeowners associations, civic groups, service clubs, and town meetings. These presentations were complimented by visual displays, often involving Microsoft Power Point, and were supplemented with informational materials. Home evaluation Signup sheets were available at each presentation.

Canvassing

The SCA Fire Education Corps canvassed communities in an attempt to educate homeowners about FIREWISE protocol and defensible space, and to secure home evaluations. Local fire departments and federal agencies assisted teams in locating at risk communities within the wildland urban interface. Once these communities were identified, team members employed two methods of canvassing. The first method, referred to as a literature drop (http://areaguides.com/canvassing.htm), was used to distribute FIREWISE information to as many homeowners within these communities as possible (Appendix F).

Literature drops were supplemented with direct mailing. Agency partners and local fire departments, with assistance from SCA Fire Education Corps teams, created flyers, which were mailed to homeowners in the high risk communities. The purpose of flyers was to introduce the program and encourage homeowners to take advantage of the free evaluation service.

As the program progressed, a second and more aggressive approach to canvassing was initiated. This method, door to door contact, encouraged team members to engage in conversation with homeowners. During a discussion with the homeowner the team would explain the concepts of wildland fire, defensible space, and then offer to do a free on site home evaluation, or schedule one in the future.

Evaluations

Home evaluations were acquired through canvassing and were conducted upon homeowner request. Two or more team members conducted each evaluation. One of the team members would talk with the homeowner and collect the first page questionnaire portion of the evaluation. The other team members would walk around the structure, making note of building materials, vegetation, and defensible space. To complete the evaluation, the team would escort the homeowner around the structure discussing defensible space and recommendations. Before leaving, the team would give the homeowner a copy of the evaluation, wildfire reading materials and contact information (Appendix G).

Demonstration Project

The following was the step by step action plan for the implementation of an SCA Fire Education Corps Demonstration project:

1). Determined and located, with the assistance and guidance of project partners (USFS, BLM, IDL, RC&D, and local Fire Departments), high-priority communities that were at risk to wildfire and demonstrated an active receptivity to the creation of defensible space and fuels reduction projects.

2). Initiated and attended local Fire Department and Homeowner Association meetings and presented the goals, mission, and objectives of the SCA Fire Education Corps. Utilized meetings to gauge community receptivity and desire of involved parties to assist with completion of project.

3). Canvassed pre-determined communities, repeatedly if necessary and scheduled home evaluations in the designated area.

4). Conducted as many evaluations as possible and included the GPS coordinates with homeowner's approval. Notified homeowners about the possibilities and advantages of a demonstration, or fuels reduction, project.

5). With demonstrated community approval of the project and an observed willingness of community members to participate, planning details were initiated, including an isolated time-line by which to work. Specify the exact date on which the project will conclude.

6). Determined which resources, tools, and equipment needs were necessary to complete project. Attempted to secure resources and coordinated resource implementation plans, including equipment, machinery, and labor, with assistance from local, county, and federal partners and agencies.

7). Contacted homeowners who have received a prior evaluation and were receptive to objectives of a demonstration project. With approval and willingness to contribute, time slots were scheduled for homeowners wanting assistance with the implementation of defensible space, and/or fuels reduction.

8). Created a list with all participating homeowners and tools needed to complete fuels reduction work at each property. Assigned a team leader to each participating home who was aware of home location and was confident of abilities to manage and document work completed.

9). Contacted media. Designated one individual as media specialist. It was important that this individual understand the processes and procedures of obtaining media coverage and was able to work as a liaison between the community and media.

10). Created and evaluated the schedule for resource implementation, including trucks and machinery, time and location at which to store slash and brush, labor distribution, and media representation.

11). Revised a current schedule and finalized details, including homes, truck pick-up, volunteers, transportation, risk management, lunch, camping (if necessary), media, and agency representation.

12). Implemented ground work according to schedule.

DATA COLLECTION

In order to draft reports and recommendations about the SCA Fire Education Corps a number of data collection forms and sheets were utilized. Forms included:

1). Home Evaluation Form
2). Expected Weekly Involvement Sheet
3). Completed Weekly Involvement Sheet
4). Goals Fulfillment Data Sheet
5). Team Member Notebooks

In addition to providing homeowners with FIREWISE information, Home Evaluation Forms allowed team members to collect information about communities, including elevation, latitude, longitude, number of homes in the community, and fire history.

In order to set goals for teams, team leaders utilized the Expected Weekly Involvement Sheet. Projections used for canvassing, evaluations, presentations, public events, and media relations were recorded on these forms. At the conclusion of each week, the actual activities completed were recorded on the Completed Weekly Involvement Sheet, in the same format. The Completed Weekly Involvement Sheet also provided a format for an itemized documentation of Team activities.

The Goals Fulfillment Data Sheet recorded the activities described in the Completed Weekly Involvement Sheet, but cumulatively by week (Appendix G). Team Member notebooks were the final method of data collection. Each team member recorded information regarding the efficiency of the methods they utilized in order to establish contacts, along with information about these contacts. The information collected was another source of data consulted during analysis.

ANALYSIS

Several steps were taken in analyzing the data collected by the seven SCA Fire Education Corps teams:

1. Compile Data Sheets.
2. Convert Necessary Data to a Common Denominator:
    - A). Total number of individuals educated per hour.
        - 1). 1 Home Evaluation = 2 individuals educated
        - 2). Home Canvassed = 2 individuals educated
        - 3). 1 Home Literature Drop = 2 individuals educated
        - 4). 10% of Event Attendees = # of individuals educated
    - B). Hours spent developing and fostering partnerships.
        - 1). 1 Partner Contact Established = 1 hour
    - C). Hours spent to obtain referrals.
        - 1). 1 Referral = 1 hour
3. Consider the SCA Fire Education Corps goals.
4. Determine which activities supported the program goals.

RESULTS

Geographic Areas

The geographic areas represented by the SCA Fire Education Corps were Coeur d'Alene, McCall, Boise, Pocatello and Salmon Idaho. The two additional sites were in Elko and Carson City, Nevada (Appendix B. Map 1).

Public Information

The SCA Fire Education Corps teams attended 49 events over the course of the summer. The teams distributed over 11,000 brochures, through canvassing, home evaluations, conducting presentations, public events, and while speaking with the public at Home Depot stores. Teams appeared on television a total of 19 times, including three live interviews. A total of ten informative live interviews were conducted on the radio and 36 newspaper articles appeared in local papers describing team activities (Appendix H). PSA's were run a total of 2,836 times on the radio and 438 times on television (Appendix I). Teams received 46 calls on the toll-free number that was announced on the PSA.

Canvassing

The SCA Fire Education Corps utilized two types of canvassing, literature drops for 50 percent of the time and traditional canvassing which was face-to-face contact for the remaining 50 percent of the time. Teams canvassed a total of 5,320 homes in 54 communities throughout Idaho and Nevada.

Evaluations

The SCA Fire Education Corp teams evaluated 942 homes in 31 different communities throughout Idaho and Nevada.

Demonstration Project

During the summer of 2001, six SCA Fire Education Corps sites conducted demonstration projects. Team Boise spent 55 hours on eight homes. Team Coeur d'Alene spent 62 hours on three homes. Team Elko spent 18 hours on ten homes. Team McCall spent 40 hours on seven homes. Team Pocatello spent 18 hours on one home. Team Salmon spent 124 hours on 24 homes. In total, 341 hours were spent working on 53 homes.

Graphs

SCA Fire Education Corps work was categorized into nineteen periods, each one week long. Weeks began in May 20, 2001 and concluded on September 29, 2001. Week one signified the arrival of the Team Leaders and was the beginning of the preparation period, which lasted four weeks. Team Members arrived during week five, and teams arrived at their sites at the conclusion of this week. Team Members left at the beginning of Week 15.

The allocation of time teams spent in the field is illustrated in Figure 1. The chart reveals that nearly one-third of the total time spent by teams in the field was devoted to evaluating homes. Attendance at public events, canvassing and demonstration projects also accounted for a significant portion of the total time. Less time was devoted to meetings with fire departments, homeowner associations, and partner contacts as well as presentations, literature drops, preparation and analysis.

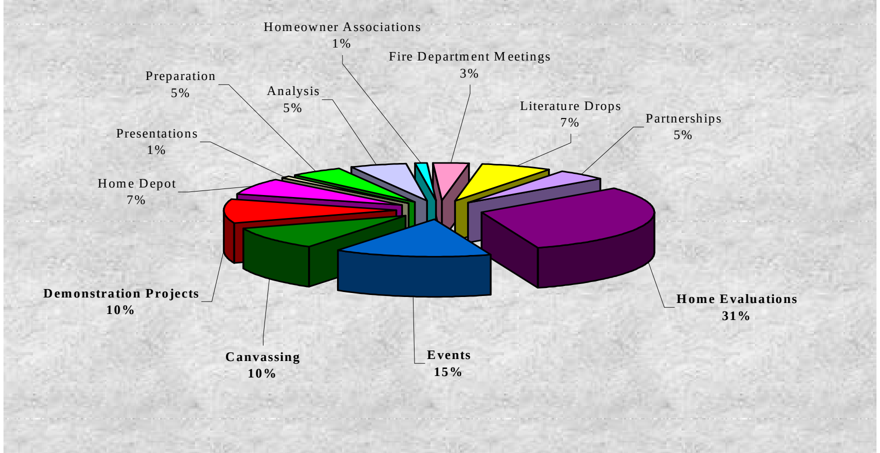
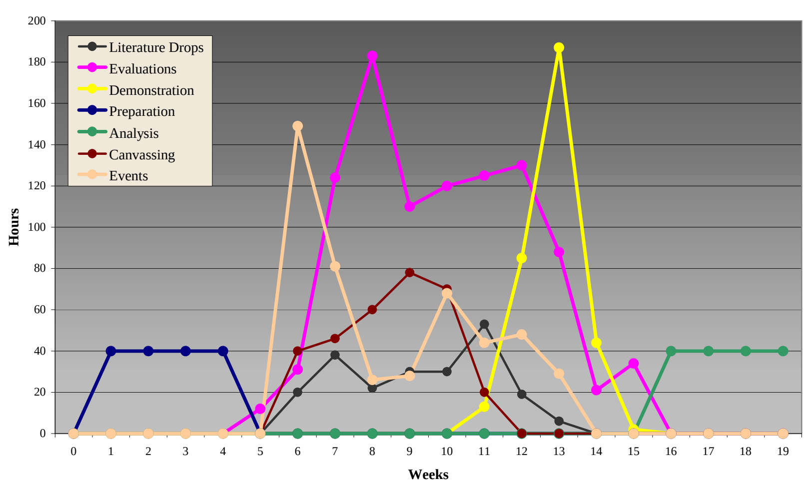


Figure 1. Allocation of Time Spent in the Field.

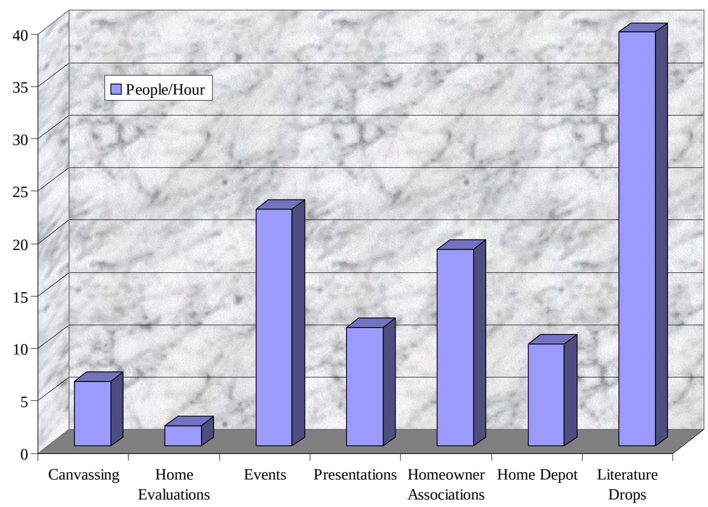
The major activities that teams were involved in on a week-to-week basis are illustrated in Figure 2. This graph illustrates the overall flow of the program, which began with preparation. This was followed by public events, canvassing, and literature drops then transitioned into home evaluations, which was followed by planning for and completing demonstration projects. This program ended with data analysis.

Figure 2. Work Accomplished per Week



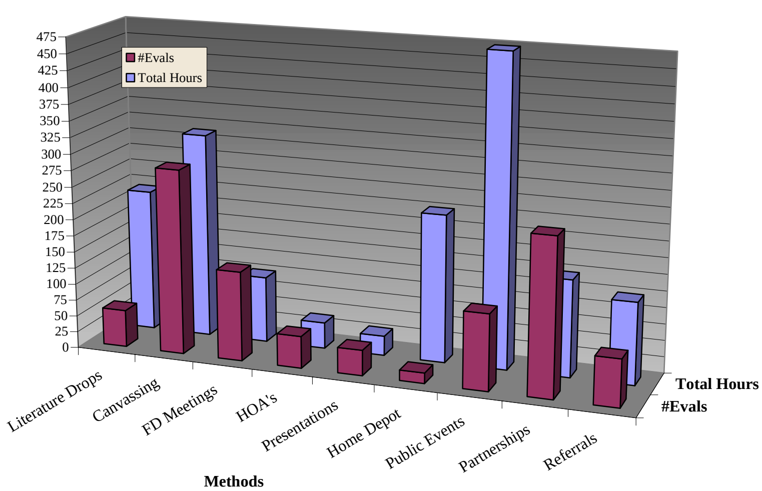
Relative efficiency of the techniques utilized by teams for educating the public is depicted in Figure 3. Literature drops overwhelmingly yielded the highest number of individuals educated per hour. Events, homeowner association meetings, and presentations ranked as more efficient techniques for educating community members. Canvassing, home evaluations and time spent at Home Depot Inc. was significantly less efficient.

Figure 3. Efficiency of Methods for Educating the Public (x/y).



A contrast between the number of hours spent doing each activity and resulting number of evaluations for each is displayed in Figure 4. The greatest portion of time was devoted to both public events and canvassing. Canvassing resulted in a much greater number of home evaluations than did public events. Significant amounts of time yielded high outputs. The least amount of time was spent focusing on partnerships, referrals, fire department meetings,

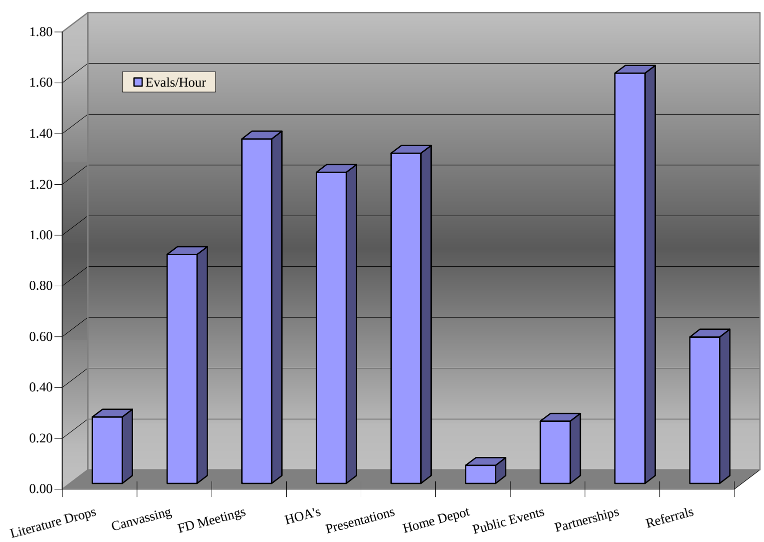
Figure 4. Methods vs. Evaluations.



homeowner association meetings, and presentations. All of these techniques displayed favorable input vs. output ratio.

Relative efficiency of each technique of acquiring home evaluations in ratio is displayed in Figure 5. Partnerships are illustrated as the most efficient technique for getting home evaluations. Fire department meetings, presentations, meetings with homeowner associations (HOA's), and canvassing were all very efficient relative to the time which was spent engaged in literature drops at Home Depot, public events and acquiring referrals.

Figure 5. Efficiency of Methods for Yielding Home Evaluations (x/y).



Eleven maps were created utilizing Microsoft Access tables and ARCView GIS 3.2 software. The maps incorporate data collected by Team Carson from the community of Virginia City Highlands located in Storey County in the state of Nevada. The GIS project entitled carsonhome.apr contains the following fields: site code, evaluation number, address, (x,y) coordinates, elevation (feet), residence type (permanent vs. vacation), adjacent land ownership, prior evaluation (yes / no), roof type, and thirty foot clearance (yes / no). The GPS coordinates for 115 homes were assigned the fields and converted into a shape file that was layered onto joined, colorless 1:24, 000 scale USGS topographic quadrangles, county maps and a map of Nevada.

CONCLUSIONS

As is illustrated in Figures 1 through 5 of Appendix A, the seven SCA Fire Education Corps teams have collectively educated over 26,000 people and evaluated 942 homes. These accomplishments coupled with the data that was collected have allowed for an analysis of the methods that were utilized. Such analysis outlines a path for continual and improved success of the SCA Fire Education Corps program.

Combined, 22% of field time was devoted to public events and literature drops. Both of these methods provided access to the greatest number of community members at a time and were excellent ways for teams to distribute FIREWISE information to individuals, thereby heightening awareness of the issue of wildfire and establishing a presence in communities. However, fieldwork data has proven that making literature drops is a more efficient way to educate the public. Thus, a portion of the time spent attending public events should be redistributed to other more efficient techniques in the future.

The input of effort devoted to staffing model homes at Home Depot stores produced very little in terms of home evaluations and educating the public. Teams spent a combined 7% of their time pursuing this activity. There is great potential in working with Home Depot, which provides an excellent arena for interacting with the community. However, a more effective method needs to be found in order to utilize them as a resource.

Homeowner Association meetings and presentations were highly productive methods of both getting home evaluations and educating the public, though little team time (2%) was invested in these activities. This was in part due to the relative difficulty of establishing contacts with private clubs, organizations and homeowner association officers. Another obstacle was the challenge of scheduling a presentation due to the infrequency of meetings held by these groups. However, because initial groundwork has been laid this year, future teams should find it easier to pursue these activities.

The most effective activities for getting home evaluations were through meetings with fire department and agency contacts. It would be beneficial to teams to invest more time developing such connections in areas where involvement with partners has not reached its full potential.

Canvassing, though time consuming and therefore relatively inefficient for educating the public, is a very effective way to acquire home evaluations. Initial weeks spent on site by teams were devoted disproportionately to public events, under the assumption that it would be an effective way to get evaluations. Data suggests that efforts during these initial weeks should be allocated more to canvassing and other efficient methods. Similarly, public events and literature drops should be utilized during times when there is a lapse in team activities, rather than during the initial weeks, which are crucial in a time-sensitive program.

Referrals are very effective for achieving home evaluations. It would be of great benefit to invest more effort in continuing the search for active community members who will assist in introducing teams to homeowners.

SCA Fire Education Corp's first goal was to create awareness and educate local communities about defensible space and wildfire danger. Teams accomplished this goal by attending public events, staffing the Home Depot demonstration homes, completing presentations to various groups, canvassing local communities, and conducting literature drops.

Results illustrate the goal of educating the public was met. Teams contacted over 26,000 people using the various methods of outreach. Each method was successful. The majority of the people educated were the direct result of efforts spent attending public events and literature drops in wildland urban interface neighborhoods. Over 8,000 people were contacted through literature drops.

SCA Fire Education Corps accomplished its second goal to conduct home evaluations and provide recommendations to wildland-urban interface homeowners regarding defensible space. Teams evaluated homes throughout Idaho and Nevada within and around the wildland urban interface. Homeowners within the wildland urban interface were given recommendations on how they could create defensible space around their property.

The SCA Fire Education Corps accomplished its third goal, which was to develop and implement a FIREWISE community demonstration project. Six demonstration, fuels mitigation, projects were accomplished with the assistance of agency partners and proved an effective method of gaining public support for mitigating wildfire risk. This was evidenced by substantial media coverage. Demonstration or fuels reduction projects were completed with the desire to assist community members with the conceptual and physical implementation of defensible space and FIREWISE. These concepts, when utilized effectively, have conclusively proved to reduce structure and property loss as a result of wildfire. Demonstration projects served to reinforce the need for communal initiative and FIREWISE responsibility. These contributed to the probability of a successful project and the potential for increased community involvement in years to follow. A desired effect of the demonstration projects was to sustain working relationships between agencies and community members, thereby creating an interdependent partnership, this can function effectively over time.

SCA Fire Education Corps accomplished its fourth goal, to assist agency partners with fire prevention projects. In Carson City, NV Team Carson created maps of Storey County and conducted evaluations on homes classified as high priority by agency partners in. This data will be used as written documentation for a grant proposal that will allow the agencies to acquire funds for fuels reduction in the area. As a second project, research was conducted on fire history in the area to assist in the making of Ed Smith's video, "Nevada Burning."

In McCall, ID agency partners from IDL needed information on homes in Yellowpine, ID in order to write a grant proposal. Team McCall conducted home evaluations in the community and provided the IDL with the information they required.

Team Coeur d'Alene assisted IDL in Bonner County, ID. The IDL received grant monies to implement a fuels mitigation project in the community of Hope Face, ID and they utilized the SCA team to evaluate homes in the area. Those homeowners will be eligible to receive funds to remove hazardous fuels.

In Elko, NV the city Fire Chief asked the team to develop a brochure for reseeding cleared or graded land. The team vegetation/botany intern conducted research on fire resistive grasses and re-vegetation and created the brochure "Recommendations for Reseeding Graded Ground" (Appendix J). The team also informed residents in the communities of Shantytown, NV and Tuscarora, NV about grant money from the Nevada Division of Forestry that was available to them. In Shantytown, NV substantial community support was generated to receive grant money. Those funds will be used to build a firebreak around town. This project is scheduled to begin in the fall of 2001. A third project consisted of the evaluation of campgrounds and parks managed by agency partners, including the state, USFS and BLM. Evaluations were conducted on structures and campsites and recommendations were given to the managers of these sites. The agencies will use the team's suggestions as a guideline to improve the defensible space in these recreational areas.

SCA Fire Education Corps accomplished its fifth goal which, was to utilize data to design GIS maps that will serve as a useful tool for agency partners. The teams collected GPS points of structures that were evaluated. The GPS units recorded the structural location and landscape data, physical addresses, and coordinates of the nearest fire stations serving each respective community. This data was compiled into Microsoft Access tables that could be joined into ARCView 3.2 software and then displayed into easy to read maps. Once the maps are created, the fire departments will have access to view these maps. These would serve useful en route to a fire to determine structural components in regards to roofing and siding material, water system capacity, utilities shut-off, hazardous materials, accessibility (streets and driveway), livestock, number of occupants, and most importantly, and whether there is defensible space. The more a firefighter is aware of before he /she enters a burning area, the better the chances are that there will be no loss of lives and less damage to the structure. Fire departments have, in the past, relied on dispatcher's notebooks for this site information that is usually outdated and inconvenient to access. Having access to location information en route to an emergency will allow the fire departments to do a better job protecting the citizens and to be safer while doing their job. Rural fire departments that the teams worked with were very appreciative of the efforts put forth by the teams to equip them with one more tool.

SCA Fire Education Corps accomplished its sixth goal which, was to provide reports and recommendations on fire education and prevention efforts. The goal of "providing reports and recommendations on fire education and prevention efforts" was done throughout the program. Sites completed progress reports each week stating the data collected for each activity. Teams shared all information and materials with fire departments, BLM, USFS, RC&Ds, and all other interested partners. Following the program, a document was completed for each site summarizing the totals of the data collected and stating recommendations for future projects.

RECOMMENDATIONS

SCA Fire Education Corps goals were developed and adapted as the 2001 summer season progressed. This pilot project utilized several methods, materials, and assistance from partnerships to educate and protect homes. The SCA Fire Education Corps recorded recommendations and improvements that could benefit future community outreach programs as well as the SCA Fire Education Corps in 2002.

Program Goals and Objectives

At the onset of the project each team leader and team member must fully understand the goals and objectives early in the program. FIREWISE is a relatively new program in the field of fire education and homeowners are learning that there are simple steps they can take to protect their home and property from wildfire. Throughout the program it was essential that team members understood that they were taking part in a community outreach project. Community outreach is a concept that is difficult to measure. The process requires a team to spread out in many different directions in order to contact influential community members. Attempting to reach social networks can be hit-or-miss, so each contact must be aggressively pursued. Partner referrals can be a very powerful form of networking. It was necessary for the team members to understand that the overall mission was to influence a behavioral change in people. In other words, building the capacity and ability of the communities to help themselves.

Partnerships

Another recommendation for a successful fire prevention and education program is to clearly define the relationship with partners. This program dealt with many partners that had important input to the teams' success. The range of community influence of the team can be increased with the help of partners. In the future, partners should be contacted months in advance. Information on when the team will be present, what they will be able to do, and what their primary goals are needs to be clearly defined. Partners should then be given the opportunity to make suggestions for the team and discuss significant activities they feel are high priorities.

Materials

In order for each team make optimal use of time, materials must be decided upon early in the program. If the goals and activities expected of a team were determined prior to the start of the program, the necessary materials could be more readily available. Time could be used to work on more home evaluations, demonstration projects, and/or special projects.

Early Contact

It would be significantly beneficial to a project if homeowners' groups were contacted before a team arrived at their site. The information given to the team by the groups would be helpful in acquiring home evaluations and interacting with more homeowners at risk. Once contact with these groups is made, meetings and presentations could be scheduled to render more attendees.

Adaptability

In order for the program to satisfy partner needs a team must be able to adapt to the partners changing desires. In order to do this, it may require that goals are more fluid or expectations more open to adjustment. This recommendation is most pertinent at sites where the fire agencies are in close communication with teams and work on related tasks. If the majority of the agency partners in a given community are asking for help on a special project, it would be advantageous for the team to participate.

Flexibility

Similar to the previous recommendation, emphasis should be focused on projects that are site specific. Communities vary drastically in many different demographic ways. For this reason, needs of one community may vary from others. In order for teams to have flexibility, each site should have the freedom to work on projects that may differ from other sites. To determine site specific goals, research should be conducted for all areas where the program will exist.

Canvassing

The most efficient process for educating homeowners was through face to face contact with individual homeowners. Many methods were used to educate the public, but the most useful were individual in-depth home evaluations that the teams conducted. Homeowners participating in face to face interactions can better understand the importance of the wildfire issue and learn to protect themselves and their homes.

Media

One of the most vital determinants of the success of a program will be relationship with the media outlets. Media is the fastest way to reach the consciousness of a community. A large number of residents in any community watch television, listen to radio, and read newspapers. As a recommendation, teams should become well acquainted with all media outlets early in the program to ensure coverage. The best way to do this is through a media kit prepared before the implementation of the program. Teams should deliver kits to all media outlets in the program's initial stages.

Home Evaluation Sheet

A home evaluation sheet is an important aspect to evaluate work done and data collected. The evaluation sheet should be clear, concise, and to the point. Sheets should include sections on homeowner's information, building materials, vegetation aspects, and suggestions. Homeowner's contact information should be included to assist in data gathering and in case the team needs to reestablish contact. Building materials and vegetation aspects should be included as a checklist to ensure an analysis of each vital characteristic of fire safety. In order to make the sheets relevant to homeowners, short and long-term suggestions should be included.

The 2001 SCA Fire Education Corps pilot program in Idaho and Nevada was successful. As a result of this success agency partners have recommended, that the program be expanded throughout the Western United States. The west will continue to burn. With more people choosing to live in wildland urban interface areas with an overabundance of fuels in the adjacent lands, the urban interface problem will continue to plague both private and federal sectors. Prevention is the best method to alleviate this dilemma. With proper education homeowners have the ability to protect their properties from wildfire. The 2002 SCA Fire Education Corp will be there to aid in these efforts.

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UNDERSTANDING INSURANCE:
AN IN-DEPTH LOOK AT THE DIFFERENT LEVELS OF PERSONAL INSURANCE

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INTRODUCTION

Personal Insurance can be very confusing. For many consumers it is simply another monthly bill to pay. In the event of a loss the insurance company will give the consumer money and services to help return him or her to the pre-loss situation. For other consumers the thought of delving into the insurance "monster" to figure it out is too daunting of a task. In this report we explore the movement from the history of insurance to key information an insured should know about homeowners insurance, then look at insurance companies and their duties, touch on the concept of reinsurance, and finally define the role of the Federal and State Governments in insurance.

HISTORY

One of the first insurance companies in the United States was founded in 1752 and called the "Philadelphia Contributionship for the Insurance of Houses from Loss by Fire" (Wood et al 1984). In the first year 143 polices were written with $1261.93 in collected premium. There was not one loss during that year. The Philadelphia Contributionship is the earliest example of an insurance company rating a policy based on the construction of the home, where frame homes premiums were priced three times as much as brick homes (Wood et al 1984). The difference in rating was due to the perception that brick homes would burn slower than frame homes, resulting in less damage. Insureds placed a "fire mark" on their homes given to them by the insurance company, which identified the home to the fire brigade. If the fire mark was missing, or was the mark of a different company, the home would be allowed to burn. Original insurance policies only covered the peril, or cause of loss, of fire (Wood et al 1984). Until the 1940ís there was little standardization in the verbiage of the contracts nor in the coverages offered.

TODAY

As we move from the early history of insurance to an insurance consumer today, many questions arise: "Why do I need insurance? Who should I go through? What types of coverages do I need and/or are available? Why do I have a deductible?"

For many consumers the answer to the first question, "Why do I need insurance?" is simple...it is required by their mortgage company. Mortgage companies provide the funding for the home, but do not insure it against losses. By having consumers purchase insurance, the mortgage companies can effectively spread their risk and reduce the probability that they will not be compensated for the value of the home. From a risk management standpoint, purchasing insurance is ideal for the "low frequency, high severity" scenario (Rejeda, G.E. 1998). Risk of a total loss to the home is low, but if it does occur, the severity of the loss is high. Retaining the risk is not financially feasible for most (as the cost to build/replace homes keeps going up), and the cost of insurance is relatively low in comparison. Insurance provides the means to return a person to the pre-loss condition for the home, personal property, and liability.

Now that you know why you need insurance, the next question is "Who should I go through?" Many insurance companies use television commercials or direct mailings to try and influence you to place your insurance business with them. Before being persuaded by the commercials or mailings, it is important to understand that there are different ways insurance is sold. Independent agents sell several different unrelated insurance company policies (Smith, B.D. 1984). The producer, who earns a commission by the insurance company he or she places the business with, decides which companies to recommend to a client. SAFECO Insurance is an example of a company that uses the independent agent system.

Another type of agent is an exclusive agent. This agent sells insurance for only one company, makes commission, and is considered an independent contractor of the company (Smith, B.D. 1984). For example, John Smith owns his insurance office and contracts with State Farm Insurance to only sell State Farm Insurance.

In contrast with exclusive agents are direct writers. Direct writers are salaried employees who sell insurance for one insurance company only (Smith, B.D. 1984). Direct writers are also companies who sell insurance directly to consumers. GEICO and Allstate are examples of direct writing insurance companies.

The final way insurance is sold is through a broker. Brokers represent the consumers. They are similar to independent agents except that rather than working for insurance companies, brokers work for the consumer. They review the needs of a consumer and try to find an insurance company that will meet those needs (Smith, B.D. 1984). Consumers should be familiar with the different ways insurance is sold, and decide which way would best serve their needs. Appendix A shows a list of the top ten Insurance Carriers in the State of California by Market Share.

After realizing the need for insurance, and deciding whom to purchase insurance from, the next question is "What types of coverages do I need and/or are available?" To be honest, insurance contracts are not the most stimulating reading material. However, when there is a great deal of money, property, and time that could be lost in the event of a loss, this is an important contract to read and understand. Some insurance contracts offer an extended replacement cost that could vary between 100-200% of the coverage amount for your home. This means that if your home is insured at $200,000, depending on the contract, you could actually have between $200,000 to $400,000 in coverage for the structure. It is very challenging to precisely know what the replacement cost of a home is. Remodels, upgraded features, fluctuations in the cost for materials/contractors all contribute to the actual cost to rebuild the home. Having a contract that provides you flexibility in the total coverage amount could ensure that you would not be underinsured in case of a loss. In California and other states many insurance companies used to offer guaranteed replacement cost in their contracts. This means that if a consumer provides all the pertinent information on the home, and has an adequate level of insurance (the adequate level varies among the insurance companies from 80% to 100% of the estimated replacement cost of the home), the insurance company guarantees to replace the home. The guaranteed replacement cost leaves a huge amount of unknown risk for the insurance companies (who generally do not like the unknown). Events such as the Oakland Hills fire in 1991 contributed to the end of guaranteed replacement cost in California for some insurance companies where many of the homes were not insured to value and large amounts of money were paid out to insureds without having collected comparable premiums.

There are two basic types of homeowner contracts, all-risk and named peril. A peril is the cause of a loss, such as a fire or roof leak. An all-risk contract covers all perils except those specifically excluded. A named peril contract covers only those perils named in the policy. There is a huge difference between the two. For example, suppose a child spills nail polish on the carpet in a home. Under an all-risk policy chances are likely that this particular loss would be covered (most contracts are not so specific on the exclusions). However, under a named peril contract chances are likely this would not be covered (the named perils are not as specific). Some insurance companies offer a premier policy that is an all-risk contract and a regular policy that is a named-peril contract. Discussing your coverage options with an agent will help you to understand which type of contract you will be purchasing. Be aware that you may have the option to add additional coverages onto your policy, such as adding the all-risk option onto a regular home policy for less than the cost of purchasing the premier product.

Another important piece of information in the insurance contract is under the personal property coverage. The section may be called "special limits" or "limitations on coverage". Insurance companies place limits within the contract on items such as money, jewelry, collector cards, rare coins, and silver if they are stolen. If you have jewelry valued at $10,000, for example, you may not have full coverage if the item(s) are stolen or lost. One option is to schedule the property. Scheduling property is an additional charge on the policy, however it covers a specific item for a named value on an all-risk basis. Scheduled items can vary from jewelry to golf clubs to stamps.

Deductibles are the final question to answer in the insured section. Deductibles have multiple purposes. They are an act of good faith on the consumer's part, showing that he or she accepts a portion of the risk him or herself. The deductible also acts as a deterrent for frequent claims. When the first $250 to $5,000 is coming out of the insureds' pockets, there are not as many claims submitted. The shift in thought is from a "maintenance" policy to a "significant loss" policy. It also helps spread the risk out for the insurance company so that they are not fully covering every loss.

RATING FOR RISK

After looking in-depth at the role of insurance for the insured, the next section will cover the role of an insurance company. The art of insurance is properly rating for the risk. When determining the appropriate rate for the risk, an insurance company uses underwriting principles and follows financial requirements outlined by the state. An insurance company also has duties to an insured after a loss. To conclude the section on insurance companies, we will briefly look at the different types of losses that comprise the majority of losses for insurance companies.

As mentioned above, insurance companies need to rate for risk. If they rate too low, they run the risk of becoming insolvent. If they rate too high, they face a loss of business due to competition (Bill Lyon, 2001). Using underwriting principles an insurance company can assess a risk (home) and determine if the current rates on file with the State Department of Insurance would be sufficient for the amount of risk. The goal of the underwriting principles is to reduce the uncertainty. Underwriting principles vary by company, but may include factors such as past loss experiences, protection class, clearance of brush from the home, the type of roof, and/or accessibility. It is key to note that not all insurance companies look at all or even some of the above factors. They either don't recognize any of the above as being indicators for loss and use other factors, have such a large book of business that they are willing to take on the unknown, or simply don't care.

The second part of rating for the risk is recognizing and following the financial requirements as set by the state governments. All insurance companies offering business within the state of California must file their rates and contracts with the Department of Insurance (http://www.insurance.ca.gov). Stock companies, such as SAFECO Insurance, must follow the Generally Accepted Accounting Principles, or GAAP. Since stock companies are public, the Securities Exchange Commission (SEC) is also involved in the financial management (Bill Lyon, 2001). An insurance company must show all liabilities on the balance sheet. Liabilities include reserves for claims, fixed expenses (employee salaries, rent, utilities, and commissions for agents, etc.), and unearned premium. Unearned premium, or money the company will realize if a policy stays in force for the whole year, shows as a liability on the balance sheet because it is an uncollected asset. There is a careful balance achieved between the amount showing as liabilities on the balance sheet for a stock company, and the rates filed to charge in a particular state. Non-stock companies, i.e. privately held insurance companies, are subject to state regulations for filing their rates. ISO, the Insurance Services Office, also helps insurance companies determine rates. They collect statistical information on claims from member companies that actuaries use to help determine rates for an area (Smith, B.D., 1984). Looking at past experiences can help predict future losses.

LOSSES

If an insurance company has properly rated for the risk using underwriting principles and following the financial requirements, they should be able to fulfill the duties after a loss. Insurance policies and service may seem similar until the time a person has a loss. When there is a loss the service of a company is evident. While the duties the insurance company pledges to an insured may or may not be written in the contract, the expectation of fair treatment, and quick, accurate handling of the claim, is reasonable.

The types of losses on an insurance policy vary, but can be grouped into the following classifications: fire, liability, and weather. Fire losses are pretty straightforward. These are losses caused by fire. Liability losses can include slander, libel, wrongful eviction, damage to a neighbor's property, trip and fall hazards (a raised sidewalk), and any negligent actions on the part of the insured. Weather losses can be caused by lightning, hail, and hurricanes, for example. From the primary classifications, secondary levels of losses include compensation for loss of use, living expenses, and building code upgrades.

REINSURANCE

The next level of insurance is reinsurance. Reinsurance can best be described as insurance for insurance companies. Technically, it is when "an insurer procures a 3rd person to insure him against loss or liability by reason of such original insurance" (Cornblum, B., 2000). Reinsurance is very critical to the insurance industry. It transfers a portion of the risk assumed to another insurer. Reinsurance also helps the strength of the balance sheet and to determine rates, since the insurer can remove some liabilities from the balance sheet and have more funds available to invest. Reinsurance is used to limit the liability on specific risks, stabilize loss experience, protect against catastrophes, and increase capacity (http://raanet.org).

There are two types of reinsurance, facultative and treaty. Facultative reinsurance covers a risk on an individual policy (Gastel, R. & Mooney, S., 1983). For example, if there is a 15 million-dollar new home risk, prior to allowing an agent to bind coverage or write the risk, an insurance company may contact a reinsurer to obtain facultative reinsurance for the specific risk. An agreement could be reached that the insurance company would insure the first 3 million on the home, and the rest would be insured by the reinsurer. Reinsurers collect a portion of the premium paid to the insurance company by the insured. Most insureds are unaware that insurance companies seek their own insurance to reduce the chance of catastrophic loss. The second type of reinsurance is treaty. In treaty reinsurance the reinsurers cover an entire class of policies (Gastel, R. & Mooney, S., 1983). For example, many insurance companies offer an umbrella or excess policy. These come in values from $1 million and up. In treaty reinsurance the reinsurer may cover all umbrella policies for an insurance company. The insurance company writes the policy, and the insured pays the premium to the insurance company, and receives a policy and all obligations from the insurance policy, however the reinsurer is really the entity covering the risk.

Recently reinsurance has become more prominent in the spotlight. The bombing of the World Trade Center on September 11, 2001 is an example of why reinsurance is key to the survival of insurance companies. As of September 14, 2001 the estimated damage to the World Trade Center alone is at approximately $20 billion (http://www.sfgate.com). This is being touted as the "most expensive disaster in American History", a spot previously held by 1992's Hurricane Andrew (http://www.sfgate.com). The insurance claims from the terrorist attack include life insurance, property loss, worker's compensation, and business interruption losses. Since the risk was spread out to different insurers and reinsurers, no one company is risking insolvency from it. An illustration that helps in understanding reinsurance is walking on thin ice. If you lay down and distribute your weight, or risk, you have a much greater chance of not falling into the water, or going under.

GOVERNMENT REGULATIONS

We have covered many different aspects of insurance to this point. The next aspect is the government. As mentioned earlier, by March 1st of every year insurance companies must show their liabilities to each state. The duties of the state and federal regulators will be discussed, as well as some new ideas of programs that could be implemented on the state and federal levels.

The state regulator for California is the California Department of Insurance (DOI). Some of their duties include approving contracts and rate levels. No insurance contracts or rates are valid until the DOI reviews and approves them (http://www.insurance.ca.gov). They also periodically audit insurance companies to make sure they are meeting at least the minimum financial requirements. In addition, insureds can use the DOI as a filter through which complaints about treatment, claims service, or any other issue with an insurance company can be made. The DOI follows up on all complaints and requires a response from the insurance company within two weeks of receiving the complaint. In essence, the DOI can be thought of as the consumer advocate for insureds.

The California DOI has a Conservation and Liquidation Office's purpose is to protect policyholders whose insurance companies are experiencing severe financial problems. The goal of liquidation is to use the money acquired from the sale of the company's assets to pay off the company's debts and outstanding claims (http://www.insurance.ca.gov). The California Insurance Guarantee Association meets the obligations of insolvent insurers by administering claims. Unfortunately there is no guarantee that outstanding claims will be fully paid (http://www.insurance.ca.gov).

The Federal Government steps in to assist state regulators. The NAIC, or National Association of Insurance Commissioners, is the governing Federal body for all states. It provides a forum for the development of insurance policy uniformity, as well assists states with audits (http://www.naic.org).

The Federal Emergency Management Agency (FEMA) developed Project Impact to help communities rebuild after natural disasters (http://www.fema.gov). Project Impact is also proactive. It helps to build catastrophic resistant communities with the idea that by taking an active role in identifying and mitigating hazards, the loss of property and cost of repairs after a loss will be significantly less. For every community that participates FEMA offers the latest technology and education on fire mitigation practices. This helps communities to identify and prioritize the actions they can take that will have the greatest benefits to the community (http://www.fema.gov). FEMA also offers low-interest loans for underinsured/uninsured people in the event of a catastrophe.

A new idea brewing is the development of state and federal reinsurance. In the state of California, we currently have a form of state reinsurance. State reinsurance attempts to place an annual cap on the catastrophe potential due to earthquakes (CPCU Journal, 2000). It provides a way to spread the risk of infrequent catastrophic losses over an extended period of time. This could help avoid insurer insolvency and quickly help stabilize the market after a loss. Market disruption is caused by a surge in demand for insurance following a catastrophic loss. Insurers are unable to sufficiently assess the risk, and meet the increased demand (CPCU Journal, 2000). In the case of a "worst of the worst" catastrophic loss, there is the possibility that the state reinsurance would become insolvent and unable to pay the numerous claims. In order to avoid this from happening, a federal reinsurance program could be developed. The federal reinsurance would step in as excess coverage to the state. The chain of coverage would start at an insured, then move to an insurance company, then to a reinsurer, then to the state, and finally to the federal government. With this many levels to travel through, it would be a "worst of the worst" scenario that would tap into the federal reinsurance program. This type of program would create a partnership between the insurance industry and the federal government to address the risk of catastrophies and spread the costs nationwide so one area is not devastated by a loss (CPCU Journal, 2000).

In the end, whether it is the case of a catastrophic or "normal" loss, the responsibility comes back to you, the insured, to help mitigate your own losses. It is much easier to take a proactive approach than to have to suffer the hardships of a loss. Actively following a few simple recommendations can significantly reduce the risk and severity of a loss. Follow the clearance requirements as set by your local fire department. Generally the requirement varies from between a minimum of 30 to 100 feet of clearance depending on the slope, accessibility, roof type, and fire hazard in your area. Wood shake roofs may be less expensive now, but they can cost you so much more if there is a fire. Install only Class-A roofs on your home. Another way to mitigate your own fire loss is to plant a fire safe garden. Many beautiful gardens are in fact fire safe. Irrigated planter boxes, trees with the low branches cut up at least 6 feet off the ground, and many other plants fall into the "fire safe" definition. Contact your local fire department or nursery for further details. My final recommendation is probably the easiest, do not leave candles unattended. According to the National Fire Protection Agency (NFPA), in1998 there were 12,540 fires caused by candles accounting for $176.1 million in home property damage. Of the 12,540 fires, 37% were due to unattended candles (http://www.nfpa.org). Fire safety does begin at home.

This paper has provided an in-depth look at the roles an insured, an insurance company, a reinsurer, and the government plays in insurance. Of all the material covered, the most important thing to remember is to be informed. Know what your coverages are, be aware of the different levels of insurance, and how they affect you, and help mitigate your own losses.

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Appendix A

Homeowners Companies by Market Share

1.	State Farm Insurance Company
2.	Fire Insurance Exchange
3.	Allstate Insurance Company
4.	California State Automobile Association Inter-Insurance Bureau
5.	Interinsurance Exchange of the Automobile Club
6.	SAFECO Insurance Company of America
7.	United Services Automobile Association

8.	Fireman's Fund Insurance Company
9.	Century-National Insurance Company
10.	Amco Insurance Company

*Information provided by the California Department of Insurance, http://www.insurance.ca.gov.

THE ROLE OF THE CALIFORNIA DEPARTMENT OF INSURANCE IN CATASTROPHES

Beverly Moodie
California Department of Insurance

The California Department of Insurance (CDI) is an active participant in providing assistance to consumers whenever an emergency is declared, coordinating with the Office of Emergency Services and the Federal Emergency Management Agency. The California Department of Insurance Consumer Services experts provide information at Disaster Assistance Centers regarding insurance questions or problems, explain how the claims process should work, the documentation that is needed, and how to contact the Department.

The California Department of Insurance regulates, investigates and audits insurance business to ensure that companies remain solvent and meet their obligations to insurance policyholders in accordance with the insurance laws and regulations of the State of California.

The CDI responds to thousands of consumer requests for assistance each month. Acting on these requests, the department protects consumers by investigating and prosecuting companies and licensees accused of insurance code violations, including fraud.

CDI's Consumer Services Division consists of the Consumer Communications Bureau, the Claim Services Bureau, the Rating and Underwriting Services Bureau, and the Market Conduct and Field Rating and Underwriting Bureaus.

Representatives of the CDI were available in Oakland within 24 hours after the fire began, to assist distressed families with their insurance needs. Department officials counseled more than 2,000 individuals at claims assistance centers, while another 1,500 received information from the CDI toll-free Hotline.

Following the 1991 East Bay Fire, the California Department of Insurance:

- Met with residents affected by the fire and set expectations for claims handling.
- Provided surveys indicating how much the average homeowner lost in the fire, the degree to which victims were adequately insured or underinsured, the number of complaints filed with the Department, and the level of satisfaction in the handling of claims.
- Targeted insurance companies for special investigations.
- Supported legislation requiring insurers to offer and clearly explain the meaning of " guaranteed replacement coverage".
- Monitored the claims resolution processes.
- Set deadline for claims settlement.
- Assessed fines to insurers.
- Set new regulations for claims settlement.

- Participated in several task forces including the Hazard Mitigation Report for the East Bay Fire in the Oakland-Berkeley Hills.
- Added Consumer Information regarding Emergency Information and Catastrophe Preparedness on the CDI website at www.insurance.ca.gov
- Continues to assist consumers daily with their insurance problems or questions, treating each situation as if it were catastrophic, because to each consumer, it probably is.

RESULTS OF REGIONAL WORKSHOP ON COMMUNITY BASED FIRE MANAGEMENT IN SOUTH EAST ASIA

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ABSTRACT

In December 2000, Project FireFight South East Asia and the Regional Community Forestry Training Center (RECOFTC) organized a regional workshop on community-based fire management (CBFiM). The main focus of the December workshop was to present, analyze and document the experiences in CBFiM from South East Asia. A key lesson learned emerging from this workshop was that successful CBFiM strategies needed to be shared with government agencies to combat the persistent paradigm that suppression and enforcement are the only effective ways to manage fire.

A number of issues were discussed and explored during this workshop; one of which was the importance of land/resource tenure security and incentives for successful CBFiM. These incentives need to focus on an investment in people and organizational structure rather than those which focus on equipment or enforcement through legal constructs. There were concerns over the different levels of community involvement (from a laborer to decision-maker) and the current shortcomings of recent efforts. It was clear that community participation in the context of CBFiM is more than just giving tools to communities and showing them how to use them. Community participation is not just labor supporting fire prevention and suppression but managing fire in terms of their own needs. Hence, CBFiM should be a component of land use planning and/or natural resource management. This means that it cannot take an independent identity but should be seen as an integral piece of an overall community capacity building process.

BACKGROUND

Recent large-scale fires throughout the world have demonstrated the high social, economic and ecological costs of uncontrolled fires. Major fires and their negative impacts have received unprecedented coverage in the international media, prompting an outcry from national and international agencies for improvement in controlling forest fires.

Unfortunately, government responses to forest fires have tended to focus on suppression and costly technological solutions to fight fires. Contrary to alleviating forest fire problems, these solutions have often increased the scale and magnitude of forest fires. Furthermore, they have largely ignored the human dimensions of fire and the positive social and ecological benefits of smaller prescribed and managed fires.

As the number of forest fires has increased, conventional suppression measures have increasingly come under question. Thus, many agencies have started to explore more proactive approaches in combating fires, including more effective prevention activities. The search for improved approaches has led to calls for revisiting traditional forest fire management regimes that emphasize prescribed burning and prevention. Many of these systems and approaches are seen to be more effective in tempering uncontrolled burns, more beneficial to local ecosystems and more cost efficient in the long term.

In December 2000, Project FireFight South East Asia and the Regional Community Forestry Training Center (RECOFTC) organized a regional workshop on community-based fire management (CBFiM). A key lesson learned emerging from this workshop was that successful CBFiM strategies needed to be shared with government agencies (primarily forest and fire control agencies) to combat the persistent paradigm that suppression and enforcement are the only effective ways to manage fire. An international conference is now being organized with this lesson in mind.

What is Community Based Fire Management in South East Asia?
Fire management by complex societies will itself be complex as an expression of;

- changing forest policy,
- the lack of stakeholder participation in the formulation of these policies, and
- stakeholder exclusion from use and/or decisions about use of fire as a land management tool that can dynamically change the resource(s).

In Asia, community-based fire management is a reflection of the complicated relationship between the people, the land they live on and their land tenure rights (or lack thereof). Therefore, fire management in Asia demands community involvement in decision-making processes, in institutional arrangements, in distinctive practices, and in the development of specialized personnel.

WORKSHOP STRUCTURE

Using a two-pronged combination of presentations and small group working sessions, participation was encouraged from all participants and organizers. As the final evaluation by participants demonstrated, the flow and program of the workshop was greatly appreciated. Everyone felt comfortable with contributing intellectually to the discourse. Eighteen presentations of twenty minutes each, including the opening session, were made covering a broad range of regional, national and community level perspectives. Panel discussions were used at the end of each presentation session so that questions could be asked of all speakers in a more comfortable dialogue than one-on-one questions.

The following are some examples of the types of outputs from these working groups, demonstrating the CBFiM trends, challenges and opportunities:

- Community based fire management currently has little or no influence on policy due to its lack of documentation and awareness raising of its merits. More documentation is needed to give CBFiM approaches credibility and rigor.
- Collaborative approaches are required. Enforcement is not going to be able to solve the fire management issues of the region.
- CBFiM must be in context of community development. There is the need to recognize that setting up a project or providing a focus can change or effect the community. Strengthening community capacity is important but it must be in balance with the community's resources and the requirements for other objectives (e.g. subsistence).

In total, six small group working sessions of seven to ten people facilitated the brainstorming of various themes including country level inventories and an articulation of where CBFiM has been to date and where it needs to go. These working sessions were designed to better understand the fundamental principles of CBFiM, its ideal situation and optimal roles for each stakeholder. Under this best case scenario, participants identified security of tenure, sense of ownership and responsibility, sustainable resources, and community capacity development as critical ingredients. They then took a reality check to articulate where CBFiM is actually seen on the ground. The final set of working sessions were designed to articulate the needs, strategies, initiatives and activities necessary to promote CBFiM by four groups; research, government, development projects and non-government organizations. Similarly to the previous working session on critical ingredients, this needs assessment was designed to provide insights to the organizers and their associated partners with a snap shot of what is needed to support CBFiM. This snapshot is complimentary to the individual presentations that represented a broad range of regional, national and community level perspectives.

The eighteen presentations were based on case studies, national level reviews, or personal insights on community based fire management. They are also summarized in a summary report to relay the context that they added to the discourse. This report is available from either of the two organizers. Another document from this workshop will be devoted purely to the papers that were given in the presentation sessions. The agenda and process and structure of the workshop demonstrates this two-pronged combination, and is depicted in Figure 1 below.

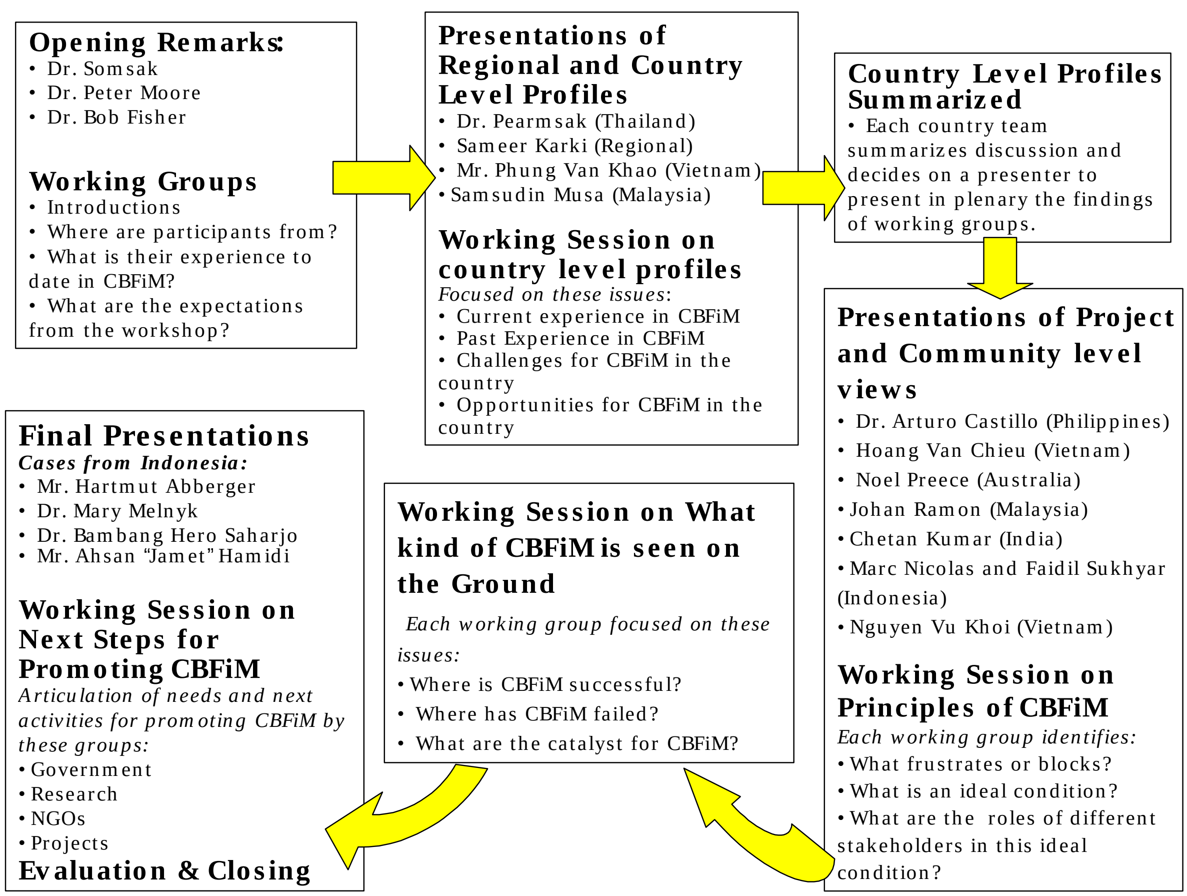

Figure 1: Workshop Structure

WORKSHOP SUMMARY

The main focus of the meeting was to present, analyze and document the experiences in community based fire management (CBFiM). Over the course of three days, thirty-six people from 11 Asian countries provided insight and ideas of the critical elements that will form the basis for the development of frameworks and platforms that support CBFiM in its planning, implementation and documentation. This group represented a diverse range of organizations, disciplines and sectors from government (10), development projects (7), academic institutions (6), international organizations (5) to non-government organizations (NGOs - 4). Some of these organizations have a direct say in the way policy formulation is developed, while others are directly affected by how fire management policy is implemented on the ground.

The objectives of this workshop were to:

- Provide a forum to review existing community based fire management approaches and assess the different avenues for community involvement in fire management;
- Gain knowledge from various countries where prefire management and community based approaches might be more effective than traditional suppression practices; and
- Synthesize the existing lessons learned into a workshop document that will further promote community-based approaches in the region.

This workshop provided insights into what kinds of community based fire management are being practiced in the region, the challenges and opportunities for CBFiM, the necessary catalysts for it to reach the ground, and the appropriate next steps for promoting CBFiM on national and regional scales. A number of issues were discussed and explored during the workshop. One major issue addressed was the importance of land/resource tenure security and incentives for successful CBFiM. The consensus was that these incentives needed to focus on an investment in people and organizational structure rather than those which focus on equipment or enforcement through legal constructs. Another profound insight was that CBFiM could not function independently from other processes, as there are important linkages between CBFiM and land-use planning, local resource management, and overall community development processes. Yet another insight was on the importance of the underlying socio-economic causes of fires. The focus around the region is primarily on the symptoms (i.e. haze) and not on the true causes. Lastly, there are concerns over the different levels of community involvement (from a laborer to decision-maker) and the current shortcomings of recent efforts. It was clear that community participation in the context of CBFiM is more than just giving backpack sprayers and McLoed tools to communities and showing them how to use them. There is a prevalent need for further enhancement, revision and documentation is on the different levels of participation and their respective levels of success. Community participation is not just labor supporting fire prevention and suppression but managing fire in terms of their own needs. If CBFiM is to be measured for its success, then it must be measured by its appropriateness for meeting the communities' needs and management objectives and not the objectives of a project or a government program for minimizing the effects of fire on a landscape. Issues of scale, both spatial and temporal, need to be understood in order to fully comprehend these community needs as well as the appropriate measures to be used to value its success or failure. That is why, CBFiM must be a component of land use planning and/or natural resource management. This means that it can not take an independent identity but should be seen as an integral piece of an overall community capacity building process.

A very successful aspect of this workshop was the inventory of what is happening in each respective country. These country level profiles shared some common themes which bode well for promoting CBFiM on a regional basis. Most countries articulated that there is still very little information regarding what is happening at the community level. Much of this is due to a lack of incentives for documenting these processes. In addition, most countries presently lack clear systems for land tenure and access. As a result, many of the fires across the region have occurred due to land use conflicts. Community forestry and CBFiM can thus be seen as a form of conflict management. Furthermore, there is a need for improved education and training but such that recognizes the technical and organizational capacity of communities in relation to managing fire, historically and culturally. Integral to this education and training is the need to evaluate the effectiveness of these community-based approaches with some sort of consistency and rigor. The development of a common framework for analysing these approaches in a credible manner was thus recommended for promoting CBFiM. Lastly, public awareness needs to be enhanced. This is necessary to raise the consciousness of fire management issues and the effectiveness of CBFiM approaches. These common themes came up numerous times though out the workshop and are integral messages to disseminate throughout the region.

NEXT STEPS

The ideas put forth during this workshop stimulated the formulation of a set of follow-up steps. While it was not the intent of this workshop to do action planning, participants helped to gather information, identify gaps in the knowledge base, and outline some potential steps for filling in those gaps.

Some of the potential steps include: the formulation of a platform/network for fire management and fire science research exchange, a writer's workshop for documenting more CBFiM cases, a review and synthesis of social, ecological and technical aspects of CBFiM, development of a common framework or methodology for analyzing CBFiM in different countries, and an international seminar to further document the experiences in the region and raise awareness of CBFiM. Much of this work will be done in conjunction with many of the partner institutions represented at this workshop and others that were not present for various reasons.

The organizers of this workshop are addressing these strategies through the organization of a larger International Conference devoted to Community Based Fire Management. The objectives of the conference are to provide an opportunity for Forestry Departments and Fire Control Agencies to be exposed to alternative approaches to forest fire management and to examine the approaches and elements for promoting these alternatives to civil society. The conference intends to identify ways to collaborate and capture the opportunities, which these alternatives offer including identifying fire research needs, forest policy reforms, legal and regulatory restructuring and appropriate strategies for socialising Community Based Fire Management. This International Conference entitled "Communities in Flames" will be held in

Balikpapan, July 25th to 28th 2001. This conference is being supported by the USFS, FAO and the EU and organized by Project FireFight South East Asia, RECOFTC, FAO, the Indonesian Ministry of Forestry and the GTZ Integrated Forest Fire Management Project.

About the Organizers

The Regional Community Forestry Training Center (RECOFTC) was established in 1987 in response to the growing awareness that community participation in forest resource management could assist in protecting forest areas as well as further rural development. The main objective of RECOFTC is to organize, provide, facilitate and otherwise support training for community forestry in the Asia-Pacific Region.

Project Firefight Southeast Asia is a global program of IUCN and WWF International working to identify stakeholders, their fire use and management practices, and ways they can work to improve fire management. It is being implemented primarily through a targeted strategy of communications and advocacy that engages local communities, NGOs and the private sector in policy dialogue.

USING GOATS FOR FIRE MITIGATION IN THE URBAN-WILDLAND INTERFACE

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INTRODUCTION

In the urban-wildland interface, alternatives to control burning for fuel management must face the scrutiny of the public; meet environmental considerations and the budget constraints of landowners. Goat grazing as a fuel reduction method has been growing in popularity since the mid 1980's. To the novice, placing a herd of 500+ animals on a site seems simplistic, a wonderful organic solution to the continual wildfire concerns. From a scientific perspective, several questions arise: what exactly they are eating; the reasons for browse preference; their long-term effects on the ecosystem; and their effects on fire frequency. For now, the unknowns do not outweigh the price of a wildland fire event that includes fire fighting, property damage and the 'collateral ecological damages.' These damages include: accelerated erosion and its effects on sediment load and habitat loss (Pittroff 2001). Applicable results from an integrated research approach from fire, range and animal science perspectives could assist the goat grazing industry.

This is not the first time domestic grazing animals have influenced fire in California. In the late 1800's to early 1900's intensive sheep grazing occurred. Sheepherders burned extensive areas to promote the growth of grass over tree species and the animals consumed quantities of live ground fuels. As a result, they removed the herbaceous layer that previously carried fires creating a discontinuity of fuels. This appears to have reduced the fire frequency in those areas (conversation with Neil Sugihara; Vankat and Major 1978). There have been many other changes around this time period, such as the decline among native peoples resulting in a disruption of traditional land-use patterns (Moratto et al. 1988) including burning; the conversion of forested areas to brush by miners (Leiberg 1902); extensive logging to support the mining and settlement efforts (Beesley 1996); and the introduction of fire suppression policies starting in 1793 under Spanish Rule (Barrett 1935). Most recently, the building of homes in the wildlands has added to the available fuel. All these components together have resulted in a different kind of fire (Skinner and Chang 1996). It is interesting to note that goats are now used to manage the present fuel regime that domestic grazing animals assisted in establishing.

Until we know more and have reasons to change how things are done, goat grazing will remain and most likely increase as part of the land manager's "tool kit". In urban areas placing goats annually on areas that contain brush and grass does reduce the ground and ladder fuels. It is measurable and observable. In order to do the job it is important to be as informed as possible.

As a fire ecologist who writes prescriptions for goat grazing in lieu of prescribed burning, or in combination with hand or chemical treatment, I have been watching the effects of goat grazing for 7 years. I have worked with more than one contractor and in particular have observed Goats R US, a locally owned company, growing from 50 animals to its present state of 4000+ animals. I wanted to learn more specifics in order to improve my management recommendations and requested an interview with Terri Oyarzun, one of the owners of Goats R Us. In this interview she offered her expertise in working with animals and a passion for what her company does. During the interview I asked questions that I felt would benefit a land manager who is considering goats as a management tool. The following is a compilation of that interview, prior conversations and some of the information that was shared during the conference's poster session.

LOGISTICS

There seems to be an aura of innocence using goats. Perhaps this is a result of the most common contact with goats-- from petting zoos. With this in mind it is important to note that while they are working, they are being cared for and "controlled" by humans. The goat contractor's goal is to keep their animals' healthy and to do the job well. I initiated the interview by asking some basic questions.

How is the operation physically setup?

When the goats first arrive to a site they are loaded off a livestock trailer into a temporary pen. This pen is fenced with flexible nylon netting that is hooked up to a battery. When the battery is turned on, contact with the fence delivers a slight shock. The goats quickly learn not to touch it. It is merely to deliver a warning to any curious off leash dogs or other animals. The size of the pen can range from the size of the herd for loading purposes up to, 5 acres.

The goats are tended to by a full time shepherd and trained dog, usually a Border Collie. The shepherd takes up camp adjacent to the pen inside a camping trailer. It is the shepherd's role to be in tune with the herd's needs. He provides the supplemental feed and water; tends to any injured animals and watches for odd behaviors that could signal a problem or illness. When the vegetation is eaten to the desired level, the herd is moved to an adjacent pen containing ungrazed vegetation. The process continues until the site is completed. The job of the dog is to herd the goats during all pen moves, to alert the shepherd if there are any intruders or when a goat needs assistance.

How many different types of goats do you use?

Our herds are composed of goats ranging from newborns to 10 years of age. The breeds we keep are Angora, Spanish, Boer, Pygmy and Alpine. The literature notes that browse impact by grazing ruminants is reported to vary widely with season, vegetation choices and type of animal (Wilson 1969). We have found that breed variation allows us to cover a wide range of vegetation.

How is the health of the goats maintained?

By administration of annual vaccines, vitamin supplementation and regular worming. Another interesting point is that we are always in the process of learning. For example, we recently were involved in a goat rescue were we accepted 200 goats from the State of Wisconsin. Soon after their arrival several of our young goats died. This was puzzling until we called the agriculture authorities in Wisconsin and asked them what diseases were prevalent in their area and the recommended medical treatment. We administered the medicine and have since had no further fatalities. In the future when we bring in goats from a distance we will first check with their local vet so we can be better prepared.

Figure 1. Angora Goats inside nylon enclosure.

How does age affect their productivity?

Older goats need more care. The moves from site to site are stressful. They need to climb a ramp and are packed into a trailer. However they still graze and can live for up to an average of 10-16 years. Many companies sell their aging herd to meat packers for human consumption or for dog food. At Goats R US, the older goats are retired to our ranch. They could still work but appear unhealthy. Just like all living things, animals age; they walk slower, they appear skinny and their coats are not as shiny. When older goats are viewed by the public, it is misinterpreted as lack of care. As a result, the landowner who hired them gets phone calls or letters of complaint. To avoid this, the older goats are left on our ranch grazing at their own pace. Other times, these older goats are taken to children's classrooms for educational visits.

PLANNING

How quickly and how large of a site can they cover? And what is the cost?

The average figure we use is: 300 goats can cover 1 acre per day. What surprises some people is that it actually costs to have goats graze on your land as opposed to us paying the land owner a grazing fee. The cost to hire the goats is based on the size of the site. The cost includes the equipment for setting up the pens, transportation, salary of the shepherd, supplemental feeding of the goats, insurance and other overhead expenses. Things that affect cost are the condition of the site, for example it will take us more time to treat a site that contains dense brush versus a grass field. The time of year can also affect the cost, during the winter months the demand is low but the goats still need to eat so we charge considerably less.

Is there an optimal time of the year to graze?

This depends on the objective of the prescription. Some land managers want a particular plant to be eaten prior to setting seed. As the growing season passes, the water content of the plants decreases as well as the nutrient content. In addition, portions of the plants that were soft and succulent earlier in the year are now tougher and may be less palatable to a herd containing older goats. Another item to note is that if the goats have been steadily eating one particular plant for a couple of months, french broom for example, they will reach a point where they will ignore it. When they get to that point we move them off the current location to a temporary site that contains different vegetation. This gives them the needed change in diet.

Other land managers have treatment milestones for the July 4th holiday and the historical fire periods. The best thing is to communicate your needs with the goat contractor early in the year so your needs can be accommodated as best as possible. Sometimes the grazing schedule is so full that we have opted to graze early in the year (April – May) and will come back later in the year (September – October) to bring down the regrowth.

Will goats eat plants that are a problem to hand crews such as poison oak? What about other plants that contain toxins?

They do eat the leaves and small branches from poison oak. Depending on the familiarity of the goat contractor with your area, they will have a good idea of what the goats will eat, what part of the plant and how fast. However, each growing season is different and the herds change their eating preferences with age. Even if you bring goats back to the same area annually, their treatment will have some variation. This is due to the weather, the state of the plants, the type of soil they are growing on and the temperament of the herd. Since there is still much research to be done on goats, our best knowledge comes from observing what they eat and how they react to it afterwards. For example, poison hemlock is a plant that is known to contain toxins. They can tolerate it if we allow them more "down time" and more frequent water breaks to assist in flushing the toxins from their system. If we don't do this and immediately move them to the next site, they can be adversely affected, possibly even die.

In your opinion does reducing the ground fuels with goat grazing do enough for fire mitigation?

We view goats as part of the fuel mitigation tool kit. They have many features that make them a good choice over other alternatives. They can work areas that are too steep for hand crews and they can clear large portions of vegetation in a short amount of time. The flashy fuel gets reduced to pellets that sit on the ground.

Fuels that are over ½ inch in diameter need to cut by a hand crew to compliment the herd's work. Brush that contains thicker fuels will be trampled as the goats attempt to reach the succulent leaves above their heads. With some tree species they will break low hanging branches for the same reasons.

If you are using goats for the first time, communication and daily field checks are critical. If they are leaving too little vegetation, ask the shepherd to move them along faster or to use smaller bunches of goats. Unfortunately, range tools such as graphic cards that show tons/acre are not enough to communicate the land manager's goals. He/she needs to go to the site and make the evaluation personally.

This past season I ran across a site that had been grazed almost down to bare mineral soil. This treatment has the local California Native Plant Society members convinced that goat grazing is bad for the environment. What's going on?

The area you are referring to is a unique site. Before I explain, let me reiterate that the goats are controlled by people. If you see something that looks out of place, ask the people in charge. The you mentioned site belongs to a public agency and is located along the wildland urban interface. In one of the homes that borders their property lives a known arsonist. The police have a record on him and have requested that the vegetation near his home be kept as low as possible. In this situation we have been grazing the site intensely and following the request of the land manager.

TRAINING

What qualifications do you have to run this type of business?

I have veterinary training, and was exposed to horses and livestock as a young child. My husband, Egon Oyarzun who is my business partner grew up in a ranching community. Our son, Zephyr is also a huge help adding new ideas and energy. Qualification to do this type of work comes from years of experience. No one can take a class to do this type of work. It's part of your life. All the shepherds that we hire come from Chile or Peru on an H2a visa. They know how to handle and care for livestock and are accustomed to working outdoors for long periods of time. This type of work is not easy, so finding qualified shepherds is a constant challenge.

At this time there is no certification process for goat contractors. We are aware of abuses that exist in this type of business. We take the best care that we can of our goats and dogs and treat our shepherds with respect, as without each of these components Goats R Us could not exist. We are truly a team.

ENVIRONMENTAL IMPACTS

How can one prevent or reduce soil erosion?

If your site has steep areas that are already eroding, we have two options. We can fence it off and graze around it, or use smaller herds of 200 or smaller animals in more sensitive areas. Also keep in mind that goats prefer to sleep on bare earth. To limit their clearing down to bare mineral soil, the shepherds can lay down hay or keep them moving more often. In this way their activity is not concentrated in one spot.

How does goat grazing affect the survivability of native plants?

Goats will generally eat anything that they can reach. Unlike sheep, they don't rip plants up from their roots. They clip them with their front teeth. This makes them a bit gentler on the existing plants. However if there are plants that you wish to protect, this must be communicated with the goat contractor prior to them arriving to the site or sensitive areas. Providing a list of scientific names doesn't suffice. Show the shepherd a sample of the plant and where it is located. Another suggestion is to use pictures as a reminder. A local plant guidebook can be a wonderful asset to reduce confusion. For example in our local area we can use the Vegetation Management Almanac for the East Bay Hills.

Some plants are especially tasty and if the herd is not well cared for they will go after plants in extreme ways. For example, we know of a contractor who does not provide regular vitamin supplements to his herds. As a result they have been seen stripping off redwood or madrone bark, girdling the trees. We do supplement on a regular basis, however just to be safe we wrap all redwood, oak and madrone trunks with plastic tarp prior to the herd's arrival. Another example is with oak trees. Goats can break off oak branches as they clip off the leaves. To prevent this from happening, low hanging branches need to be manually cut or those areas need to be fenced off. This requires planning and communication with the contractor.

Can goats spread seeds from other sites, inadvertently introducing more undesirable plants to a site?

If we know of an area that needs that type of protection, we can quarantine them for 3 days in a pen and feed them alfalfa. This clears their G.I. tract. In addition, short-haired breeds can be used because they are less likely to pickup and carry seeds on their coats.

Can goats graze on a watershed that supplies a municipal reservoir?

Yes they can. You may be thinking about cryptosporidium, a microorganism that is carried by sheep and spread by their fecal pellets. Cryptosporidium is known to cause intestinal problems for humans. Goats do not carry this microorganism so they can safely graze on lands that feed reservoirs.

What about other disease that have been receiving attention?

To date we have not heard of a single case where goats have contracted hoof and mouth disease. We believe that the best way to keep them healthy is to give them the best care available. As for sudden oak death we are not aware of any instances were goats have introduced it into a site.

LAND MANAGEMENT CONFLICTS:

Do herbicides pose a threat to goats?

This is an important topic. Herbicides are lethal to goats. A commonly used product such as Garlon 4 has a clear warning against water migration and the danger to fish. If you continue to read the label you'll come across grazing restrictions. From our experience if a goat eats vegetation that was treated within 2 weeks, they will die of poisoning. Roundup, another popular herbicide is another problem. We wait for one year prior to grazing a treated site. Recently killed vegetation is usually easy to spot, however, for added safety, if a land manager has sprayed prior to the herd's arrival, communicate this to the shepherd.

What about the use chainsaws, weedwhips and other motorized equipment near goats?

This isn't a problem. The goats are accustomed to being in an urban setting, so they are not easily startled by noise. However it is better to wait after the herd has left because after they have gone through a site, access is easier and the hand crew can clearly see where they need to work. Another item to keep in mind is that when we use motorized tools we use ear protection, so if it is too loud for our human ears, it probably is too loud for theirs as well.

PREDATORS AND ODD OCCURRENCES

How are the goats protected from predators?

Surprisingly, predatory mountain lions are not an issue. Instead, the main threats to goats come from off-leash dogs and people. Dogs that are running unsupervised sometimes charge the fence. If it is electrified then they will get a sting on the nose. This usually stops the dogs. However the goats see the dogs running towards them and panic. In their stampede they can break the nylon fence and be freed from their controlled area. If the shepherd is some distance or busy with a task, while a problem is occurring the Border Collie will quickly alert the shepherd to come help immediately.

What other problems occur?

Working in an urban setting prepares you for a variety of bizarre situations. For example, people with an agenda will wait until the shepherd is some distance from the pen, turn the electrical fences off and steal a small goat. The young babies are friendly and more approachable. Their fate is unfortunate. Oftentimes they end up as a main dish for dinner or as an unofficial school mascot. One year some Berkeley High School students stole some goats and left them on the roof of their school. Other times, animal rights activists "free" the goats. When this happens we get calls from the police that our goats are out for a stroll on the main road or dining on someone's landscaping.

Then there are those who "borrow" a few of the goats to graze their own yard while the main herd is working on an adjacent property. The problem arises when the job is completed and the herd has been trucked away before 5 a.m. When they realize that the herd has disappeared, they have no idea how to return the goats. Since they don't want to be prosecuted, they release the goats into the "wild". These goats are either killed by dogs, die of thirst or are picked up by animal control. If they arrive at animal control another challenge arises because the staff are left to guess who owns the goat. It is a matter of luck for the missing animals to be returned to their herd. If it was a young goat, (kid) that was stolen then situation becomes more complicated. The kid misses its mother and the milk she was providing. In turn the mother realizes that her baby is missing since the last move and searches the pen for days. Even if the two are reunited days later, she often rejects the kid. The kid now becomes an orphaned goat that needs to be hand-fed. These orphaned goats become special pets but it is time-consuming and unfortunate that it occurred in the first place .

Since stolen goats continue to be an issue we are working on a non-invasive way to identify our goats. We need to be creative because we find the existing methods not acceptable: collars are useless because they can get caught on their horns, branding like that used on cattle is painful and ear tags which are used on sheep can become infected and can be easily ripped off.

CONCLUSION

Thoughts from Maria Morales: The public loves them, they come to visit the goats and bring them corn husks and organic lettuce. I have even brought bunches of celery and have snapped dozens of pictures. There is no way to miss that emotional draw from this fire surrogate. Perhaps it is because as a society we have are drawn to living things. These furry creatures are seen as ambassadors of the living world and they do that job well. I have heard land managers jokingly suggest that they should establish their own herd and rent them out. It sounds like a great idea. Of course they soon realize that maintaining a herd of goats is not like adopting a litter of kittens. An important item to keep in mind is that goats are animals that have one objective—to eat. They are under control of humans. So if a grazing operation is having problems, it is the people who hold the responsibility. In my opinion, fuel reduction using goat grazing cannot replace prescribed burning. I feel that fire can be used wisely. However, reintroducing fire to the interface may be not be feasible in most areas, so goat grazing remains a more palatable choice to herbicide treatments or the blaring noise from power tools.

I occasionally hear a complaint about goats creating weed or erosion problems. This can occur if they are badly managed. As more research funds are allocated to study the impacts of goat grazing, more information will become available so land managers can make more informed decisions and improve the overall goat grazing industry.

Figure 2. Terri Oyarzun and friends

Concluding thoughts from Terri Oyarzun: I believe performance excels when people believe in their mission and enjoy their work. My family is proud of the fact that Goats R US is a team effort, and we feel very blessed and lucky to be here, sharing our lives with these wonderful animals. We welcome any questions or concerns regarding our operation.

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FIRE SAFE COUNCIL FORUM 2001

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The first statewide **Fire Safe Council Forum** was held in conjunction with the Fire Safe 2001 Wildfire Conference commemorating the 1991 East Bay Hills Fire. The Fire Safe Council Forum was designed to facilitate networking and information sharing among members of the statewide council and the more than 90 local Fire Safe Councils (FSCs) that exist throughout the state.

Following a welcome by Forum moderator Dr. David Horne of the Greater Laguna Coast Fire Safe Council, FSC Chairman Bruce Turbeville discussed the state of the statewide FSC and its role in supporting efforts of local councils. Seasoned FSC members then facilitated an informal information exchange and networking session by hosting ten informational tables addressing such topics as establishing non-profit status, hiring a coordinator/staff member, building partnerships, dealing with environmental conflicts in fire planning, publicity/media relations and conflict resolution/team building.

Director Andrea Tuttle of the California Department of Forestry & Fire Protection and Dennis Orbus of the USDA Forest Service made brief remarks to commend FSC members for their tremendous dedication to wildfire prevention. The FSC honored the Bureau of Land Management for the agency's efforts in garnering federal funding to support the wildfire prevention efforts of councils and other organizations through the 2001 Community-Based Wildfire Prevention grant program.

The afternoon session included a presentation on FireWise and a resources workshop on identifying and applying for federal, state and local funding. A television producer was present to work with local FSCs to create customized wildfire prevention PSAs for distribution to their local TV and radio stations. At the close of the Forum, many local FSCs participated in the Wildfire Conference poster session by highlighting their accomplishments at the FSC Achievement Exhibit.

The FSC Forum was extremely successful and the FSC looks forward to holding future Forums in various regions of the state.

CLOSING PLENARY SESSION COMMENTS- WHERE DO WE GO FROM HERE?

On behalf of all the conference participants we would like to acknowledge the Steering Committee, Speakers, Sponsors and others that made this conference possible. The following general thoughts and observations are worthwhile to consider when reflecting on the 2001 Fire Conference.

One of the goals of the fire conference was to expand the lines of communication between agencies and their publics. Having the participation of the local Fire Chiefs of Oakland, and Berkeley, Gerald Simon and Reg Garcia respectively, helped to set the stage for the conference. Their perspective was unique and invaluable.

Dennis Mileti's speech really helped to tie in the challenges posed by other speakers. "Don't think about fire; think about the relationship with the natural environment." Long-term commitment is necessary for future success in broadening partnerships and building sustainable communities. Agencies must incorporate their publics when undertaking projects such as watershed assessments and risk-based modeling and then provide feedback to stakeholders. Changing demographics and increasing population growth make sustainable development necessary.

Andrea Tuttle stressed that a long-term commitment requires a conclusive involvement of all stakeholders to mitigate risks over time, e.g. CDF California Fire Plan implementation. Barbara Westover's "*Housewarmings*" provided a very personal perspective that led into Don Perata's message of the importance of understanding that a single solution does not fit all. Individual communities must have the flexibility to develop policies that effectively meet their needs. When opportunities become available through various programs, such as biomass utilization, research and analysis, etc. they must be able to tailor them to their requirements. A strong scientific basis for project alternatives is important for generating and maintaining positive public response.

Lastly Bob Martin put an historical perspective on wildfire in California. Wildfire is an integral part of California's landscape. There is a strong correlation between population growth and structure loss, which is increasing dramatically. The remembrance of the 1991 Tunnel Fire is a good way to remind all of us that UWI fire will continue to be a challenge!

Modeling and Analysis: Chaired by Scott Stevens, the modeling and analysis session covered a wealth of subject matter. Some of the highlights follow:

- There is a correlation between sun spot activity and severe fires.
- Given past history the next Oakland Hills fire is forecast between 2010-2015.
- There are ongoing issues when collecting and updating remote sensing and GIS data for modeling and analysis.
- Near real-time seasonal global forecasts are improving.
- National Weather Service information transfer to the fire services needs improvement regarding forecasting of severe fire weather.

- ISO is working toward a parcel level assessment of structural fire hazards.
- In spite of the ongoing difficulty of post-mortem fire data collection there are two statistically significant mitigation activities: 50-foot clearance and fire retardant roofing
- Untreated wood shake roofs continue to be a problem!
- Fire in the UWI is more a social-political problem than a scientific one. Science can and does help, but local problem solving is pivotal.

Community Planning and Permitting: Jeff Loux led this effort, which focused on code, politics and infrastructure. Steve Quarles organized the first two hours around performance codes and testing, while Ron Montague stepped in to guide the later part of the session. The highlights were as follows:

- Prescriptive code tells you what to do and how to do it.
- Performance code tells you how a structure should react to a specific exposure.
- Testing protocols are in the formative stages of development.
- To develop code there needs to be a method to tell people what the fire scenario is, and what exposure the material should resist.
- Making simulated exposures realistic is a difficult thing to do.
- The politics of code adoption is complicated.
- A common theme is that a successful political process requires consensus, which takes time and effort.
- Water systems are not just the responsibility of public utilities, and this is also true of fire prevention and protection.
- Dramatic effects of large events require a positive approach to educate those affected to build a better future.
- Making communities less fire prone requires linkage between community values and a broad partnership of all community stakeholders.
- Community and land use planning are opportunities to engage enthusiasm of youth and community.

Fire Behavior: Session Chair, Scott Stephens explored some of the emerging possibilities:

- New statistics and physics based fire behavior models are being developed.
- The ability of new models to look at specific wind orientation, how fire affects wind and vice versa – could be incorporated into FARSITE.
- Under moderate to dry conditions Redwood litter is almost as flammable as Monterey Pine.
- Structure loss in Los Alamos occurred with a flanking ground fire, not a running crown fire.

Vegetation and Fuels Management: Carol Rice presided over this timely session. Many of the talks are germane to ongoing project issues throughout the state and nation:

- The challenges of implementing fuels reductions projects.
- New technologies for vegetation management including roller-crusher, sheep grazing, sensitive logging programs, etc.

- Concern of getting programs actually on the ground rather than fulfilling the paperwork requirements with no actual production.
- Monetary issues that are important regarding fuels reduction projects but overshadowed by water quality and endangered species issues.
- Conceptual challenges of integrating fire safety with ecosystem management.
- Research that can help to mitigate environmental issues.
- Biomass utilization panel: Costs are the biggest issue and are exacerbated by environmental protection methods.
- The fact that greenhouse gas regulation could result in the large use of biomass alternatives.

Incident Perspectives and Case Studies: David Orth directed this interesting mix of different subjects that were presented by academics and fire professionals:

- Breaking the cycle of repetitive loss is an important theme.
- Many examples of success are available for discussion by different individuals offering a variety of perspectives.
- People are trying to become better informed about why fires happen and what they can do about it, rather than complaining about the past.

Homeowner Hazards and Insurance: Melissa Fargo's session was the last and added value to the program by looking at many of the social, and ultimately the economic aspects of the UWI situation:

- There are many ways to achieve funding for: chipper programs, evacuation inspections, permitting and insurance.
- Personal contact is important for getting the fire mitigation message across.
- Natural hazard disclosure law as well as fire history and insurance availability affect property value.
- Denial is a major problem in getting people to take responsibility for fire mitigation.
- Homeowners need to be aware of the loss potential in the form of their possessions.
- The California State Department of Insurance plays an important role in catastrophic fire loss.
- Outreach and public education needs to be a hands-on experience.

Future efforts focusing on the UWI will be many and varied. There are a number of local and statewide organizations that will continue to focus on this increasingly important and costly issue for the citizens of California and the nation.

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