BERKELEY ENGINEERING
AND RESEARCH INC

Review of Safari Highlands Ranch EIR of October 2017

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Prepared for:

Endangered Habitats League
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Summary

Based on my review of the Safari Highlands Ranch project and draft EIR dated October 16, 2017, I conclude the following: The DEIR fails to satisfy requirements under CEQA in that it fails to fully disclose and reasonably propose features to mitigate significant foreseeable impacts related to wild fire risk and hazards present at the proposed site.

One need only consider the speed and manner in which the wind driven Thomas Fire near Ventura and the Tubbs Fire in Sonoma County spread to understand the erroneous nature of the fire speed and related evacuation and other projections in the DEIR.

In general, implementation of fire breaks and set backs is not an adequate solution to address wind driven fires. The most effective way to reduce risk in high wildfire hazard areas and to reduce the number of ignitions, and the best way to do that is to avoid dense development in the wildland urban interface.

While the specific modeling assumptions in the DEIR may have been accurate based on classical data and approaches, the increasing occurrence of fires like those cited above proves that currently occurring fires represent the new normal and are not "outlier" fires nor "outlier" fire conditions.

As such, the fire protection plan underpinning the DEIR findings consistently makes unrealistic assumptions and presents a misleading view of the risks and hazards to life and property safety that this project poses. These mistaken assumptions for the models run cascade into the evacuation findings and invalidate them.

The DEIR analysis includes a number of variables *ALL of which* must operate with precision in any one of several foreseeable emergencies, to conclude that fire risks would be reduced to acceptable levels. However, the Project as designed does not meet that goal and would put the lives of residents, visitors and first responders at considerable risk. There are many examples of strategic choices made poorly in the interest of over development of the site. One example - streets lined with homes developed on ridge tops and fires that travel most efficiently up slopes. This would make the hundreds of ridge top homes most vulnerable and least accessible to firefighting, due to the street arrangements on the ridge tops, and the down slope areas from which fires would attack. Other examples of unrealistic assumptions are those related to evacuation assumptions, firefighting resource and capability assumptions.

From a risk perspective there is a 100% probability that a wind driven wildfire will affect the project, particularly one originating outside of the project boundaries where conditions are not under the control of the project developer. The risk numbers and schedule of previous fires [DEIR summary Page 2.14 – 3] at the site absolutely supports this conclusion. The DEIR's use of the phrase "…wildfires may occur…" (Dudek PP 27) is disingenuous and does not reflect an understanding of what the term "at risk" means.

Specifically, Section 3 of the Fire Protection Plan's proposed project site risk analysis entirely confuses the concept of risk *and* hazard. As explained in more detail below, the term "risk" describes the likelihood of an event occurring while the term "hazard" refers to a potential impact of an explicit risk under a given scenario.
The field assessment site characteristics Sections 3.1 and 3.2 are in effect hazard assessments and not risk assessments. The historical numbers presented demonstrate absolute certainty of future fires at the project site.

In addition to the main problem of not having modeled foreseeable worst-case fires, there are significant potential fire hazard scenarios that are not addressed in the DEIR. These relate to house keeping by home-owners including policing of non-regulated consumer goods that can reasonably be expected to be present after residential occupancy of the project begins. These include lawn furniture, recreational vehicles, boats and other items that easily ignite. These fire hazards are historically important and have been documented for fire incidents in similar WUI projects. Mitigation of these hazards is dependent almost entirely upon due diligence and self-policing by homeowners and the HOA and not on the design configurations of site and structures. Details of such self-policing as well as support and resources to maintain and irrigate non-native fire resistant vegetation are not addressed in the DEIR.

Evacuation routes proposed present a substantial hazard in as much as exiting evacuees and entering first responders cannot be expected to be familiar with private roads used only in cases of extreme emergency. The DEIR assumes that residents will be familiar with evacuation routes (DEIR at 2.14-18) however there is no meaningful mechanism planned for providing the public education and drills referred to in the DEIR needed to develop such familiarity.

The DEIR also includes inconsistent conclusions acknowledging that one foreseeable finding is that scenarios exist where evacuation will not be possible (DEIR – Dudek FPP page 80) while conversely "Safari Highlands Ranch is not officially designated a shelter-in-place community" (DEIR 2.14-16) leaving open the question of what residents will do when no evacuation is possible.

The design of the site, such as clustering buildings close together at the tops of ridges -documented in section R-1 and R-2 of "SH Landscape Concept Plan" drawings - invites extreme fire behavior near such structures and increases the risk of ignition of individual homes/adjoining homes. Such siting practices are inconsistent with San Diego County guidelines and the regulations underlie them [ref http://www.sandiegocounty.gov/pds/docs/pds664.pdf and is reproduced in Appendix 1…] which set minimum standards for new buildings on slopes. Invoking alternate means to protect dozens of structures cited in the DEIR as built using substandard siting techniques below minimum coda minimums is a dubious proposition.

The DEIR also asserts that the homes will be protected from ignition by code mandated design features as well as features such as barriers which are unproven and not allowed under the WUI building code except by invoking alternate means provisions. These approaches – siting and design features – will leave residents vulnerable during a wildfire incident.

Modeling presented in the DEIR analysis includes assumptions of maximum wind speeds of 41 miles an hour. This assumption is unrealistic and provides no margin of safety to account for localized higher winds due to individual topographic features. From an engineering perspective, an additional flaw exists in the use of data based on static modeling results using FLAMMAP when transient modeling results would provide additional needed accuracy for modeling conducted.

Historically documented as well as recent fast moving fire growth such as the Lilac Fire due north close to the proposed project site illustrate the importance of considering higher wind speeds (greater than 41 MPH as used) which are becoming more common due to ongoing climate change and effects of drought conditions. Such recurrent faster moving Santa Ana winds increasing in frequency due to climate change have neither been acknowledged nor addressed in the DEIR. The recent fires at widely separated wildland locations in high hazard fire severity zones in Sonoma, Napa and Mendocino Counties, and even more recently in Ventura, Los Angeles, and San Diego Counties, are illustrative of simultaneous ignitions occurring being subjected to winds in excess of model assumptions. such as those used to model foreseeable fires at the Safari Highlands Ranch project site.

Evacuation outcomes and associated fire suppression resources available for fast-moving wildfires do not necessarily mobilize in time to be effective. This was demonstrated recently in California where mutual aid resources are becoming more limited as attested to in recent mutual aid review prepared by the San Francisco Chronicle and reproduced in the appendix. This media account considered mutual aid responses in relation to the fast moving Tubbs fire and numerous, separated fires occurring on the same night in Northern California in Fall of 2017. Appendix 2 contains this article. While the single fire station proposed for the project may be adequate to address individual structural fires and non-fire emergency response, it will have no significant impact and be essentially irrelevant in suppressing wild fires entering the project site from neighboring properties driven by downhill Santa Ana winds.

The DEIR fails to address the potential effects of climate change on the project site in its computer modeling assumptions and analysis of the availability of firefighting resources. Climate change is resulting in more severe weather in the form of extreme high winds, low humidity, high temperatures, and reduced rainfall, which will potentially contribute to substantially more severe fire seasons in the future.

Many other assumptions in the project proposal are dubious – such as the specific evacuation plans, assumptions as to human behavior, maintenance of critical fire-safety community features, etc.

Essentially, the decision to approve the project comes down to whether the City wants to assume the risk of fires impacting the safety of its citizens and the security of their assets. The proposed project would likely be exposed to catastrophic fires that result in lives lost and millions of dollars in property damage.

It is fatuous to suggest that disturbing a sizable open space parcel and adding homes and a range of non-native vegetation thru development will in some way be more fire safe than an area left undisturbed. The undeveloped parcel would be free to burn from time to time as it has frequently in the past. However, undeveloped site would recover and return to its natural state in the seasons following the on-going, recurrent wildfires.

Conversely, the developed parcel will require ongoing intense management and maintenance and still be at risk of fires each and every year with attendant hazards and ignition hazards consistent with intense development. These hazards include scenarios where catastrophic losses occur – especially as climate change evolves support greater fire risk levels and hazard.

In sum, the DEIR relies on faulty analysis to present an incomplete picture of the risks and hazards that would result from this project. In addition, the DEIR concludes that the project would result in less than significant impacts when it presents clear evidence to the contrary.

Better alternatives exist than the high development density proposed (less than ¼ acre average parcel sizes) which encourages wildfires to spread from site to site and which does not allow for individual fire fighting plans for each developed home site. Such an approach would require substantially greater separations than those proposed. Conversely, larger lot sizes for each home would enhance individual home – by - home survivability.

1. Introduction

The DEIR includes Section 2.14 "Fire Hazards." Its contents are supported primarily by the findings in the Fire Protection Plan (FPP) by Dudek, 2017. DEIR Appendix 2.14.

Other sections of the DEIR also impact resulting levels of fire safety. Amongst these are the following:

- Fire dynamics in dry, hilly and brushy areas under extreme high wind conditions and changing climate
- History of fires near and at the project site in San Diego County
- Roads
- Traffic flows
- Evacuation issues
- Site vegetation and fuel modification
- Design and construction features of buildings
- Construction scheduling
- Areal and special arrangements of structures – density of structures
- Firefighting resources
- Fire safety during construction
- Maintenance of fire safety features after project completion
- State and local codes regulating various features of the proposed project

Details addressing each of the elements above are included in the specific plan and/or other documents related to and submitted for consideration of this project.

Dangers from wildfires to life and property safety are comprised of different components: fire risk *and* fire hazard. Both of these – risk and hazard – relate to factors cited above including fire history, structures built, density of structures placed within developed areas, dynamics of foreseeable fires, impact of firefighting resources and fire hardness of built-out sites and projects and maintenance of fire safety features during and after project completion.

The objective of this report is to provide comments integrating the effects of factors such as those cited above as well as others detailed in the DEIR and/or technical literature and societal experience.

1.1 Fires at the Wild-Land Urban Interface[1]

[1] What is the Wildland Urban Interface (WUI)? – A WUI is an area within or adjacent to an "at-risk community" (see below for the definition of an "at risk community") that is identified in recommendations to the Secretary of Agriculture in a ***Community Wildfire Protection Plan***, or a WUI is **any area** for which a ***Community Wildfire Protection Plan*** is not in effect, but is within 1⁄2 mile of the boundary of an "at risk community".

While much has been written in the last 25 years about the increased risks associated with development of WUI areas, we continue to see losses of both lives and billions of dollars in property due to such development in California.[2] The 2017 fire season has been unusually impactful leading to numbers of deaths and property losses never seen before in California.

From the perspective of this review, a WUI area is an area where human-built structures and infrastructure abut or mix with naturally occurring open space. Developed open space, such as acreage used for agriculture, may also comprise portions of WUI areas. An example of these are the avocado and fruit groves near the project site . As such, a WUI area may be composed of a housing development in what was formerly open space, a school, shopping facilities or even a youth camp in such areas. The forms that such developments take and the elements they contain have substantial impact on the survivability of such communities - or their associated features - when wild fires occur.

In all cases however it must be remembered that no dwellings or structures built in a WUI area are guaranteed to survive in a foreseeable wildland urban interface fire. This caveat is included in the DEIR [Dudek, Sect 1.6 pp. G-10] as well as for example Australian Standard AS 3959.[3] The latter is the most detailed and thorough regulatory and instructional document for constructing structures in WUI zones.

> From AS 3959 - SCOPE
>
> "This Standard specifies requirements for the construction of buildings in bushfire-prone areas in order to improve their resistance to bushfire attack from burning embers, radiant heat, flame contact and combinations of the three attack forms.

"A WUI is also any area that is within 1- 1⁄2 miles of an "at risk community" **AND** has sustained steep slopes that may affect wildfire behavior, **or** has a geographic feature that aids in creating an effective fuel break, **or** is in fuel condition class 3. (An area classified as fuel condition class 3 implies that the current condition of the vegetation within the area would not be sustainable due to the absence of two or more natural fire cycles. In other words, an excess of vegetation and fuels has occurred due to the exclusion of fire which naturally reduces the level of forest fuels.)

An area adjacent to evacuation routes for an "at risk community" is another example of a WUI."

Ref: www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_053107.pdf

[2] A reference section – appendix 3 - is included which includes selected citations and text of interest.

[3] From [Australian Standard] AS 3959, 2009 – as amended 2011.

Although this Standard is designed to improve the performance of buildings when subjected to bushfire attack in designated bushfire-prone areas, there can be no guarantee that a building will survive a bushfire event on every occasion. This is substantially due to the unpredictable nature and behaviour of fire and extreme weather conditions."

From DEIR Section 11 – [Qualifiers]:

Where the project does not strictly comply with the Code, for top of slope setback, alternative materials and methods have been proposed that provide functional equivalency as the code intent. The information provided herein supports the ability of the proposed structures and FMZs to *withstand the predicted short duration, low to moderate intensity wildfire and ember shower that would be expected from wildfire burning in the vicinity of the site or within the site's landscape.* [Italics added] …….

Although the proposed development and landscaping will be significantly improved in terms of ignition resistance, it would not be constructed with sufficient fire safety features to be designated as a shelter-in-place community.

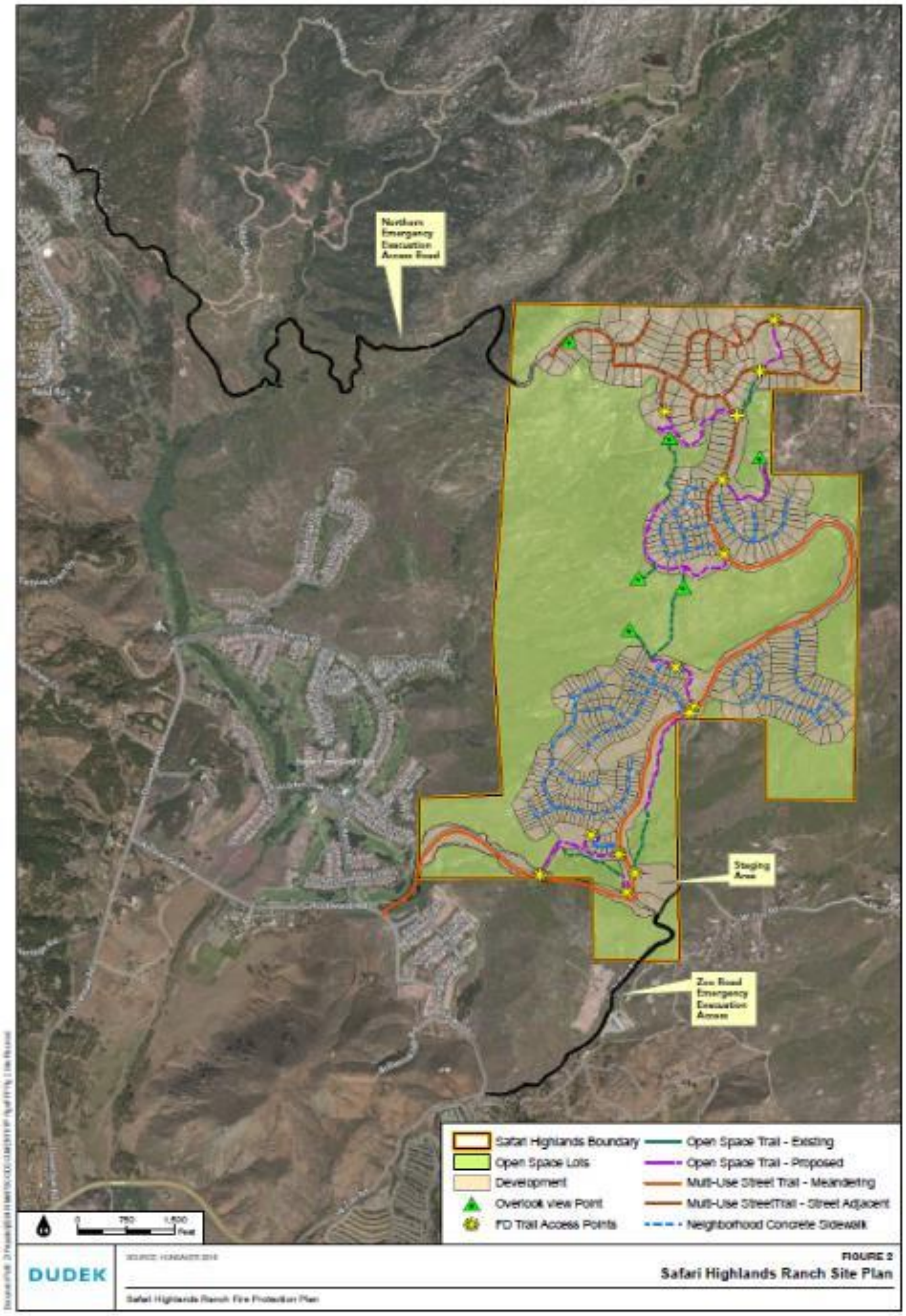
1.2 Risk and Hazard Evaluations

There is frequently confusion as to the relationship between the terms "risk" and "hazard." These are important concepts where the proposed Safari Highlands project is concerned and confusion exists in their use in the FPP.

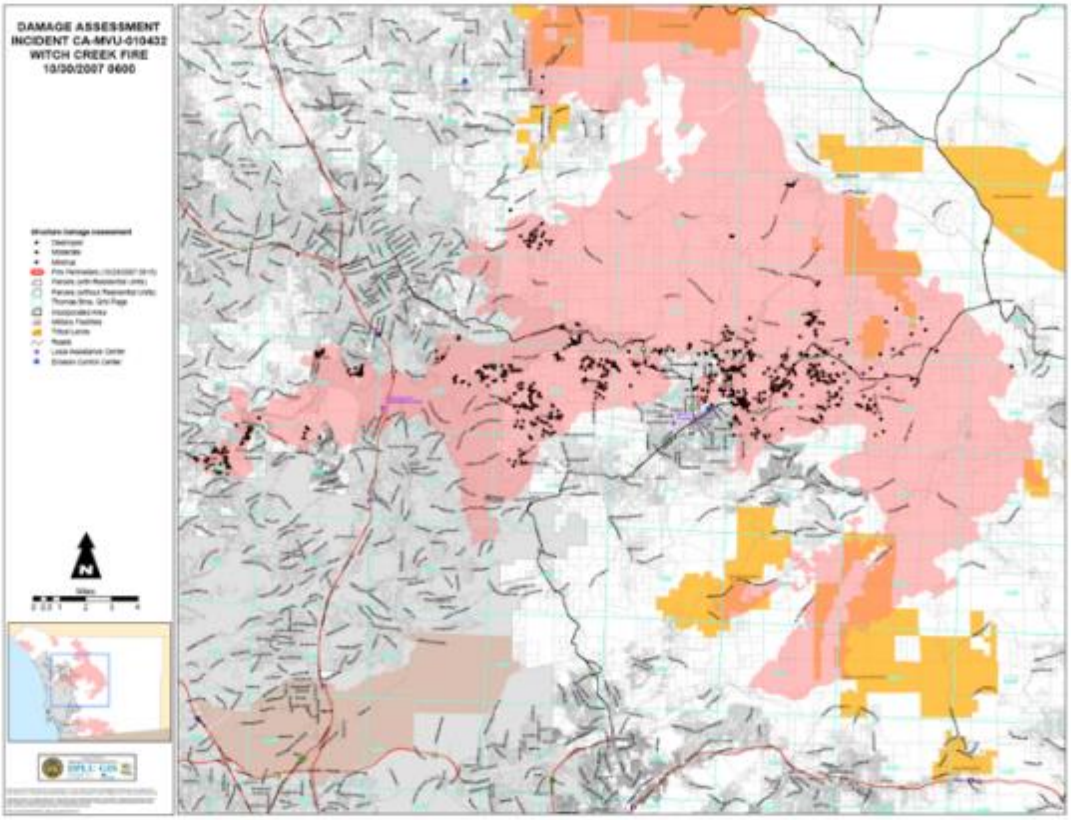
> ***Risk is the likelihood of an event*** *- such as a fire, plane crash or nuclear attack - occurring.*
>
> ***Hazard is a potential impact of an explicit risk under a given scenario***.

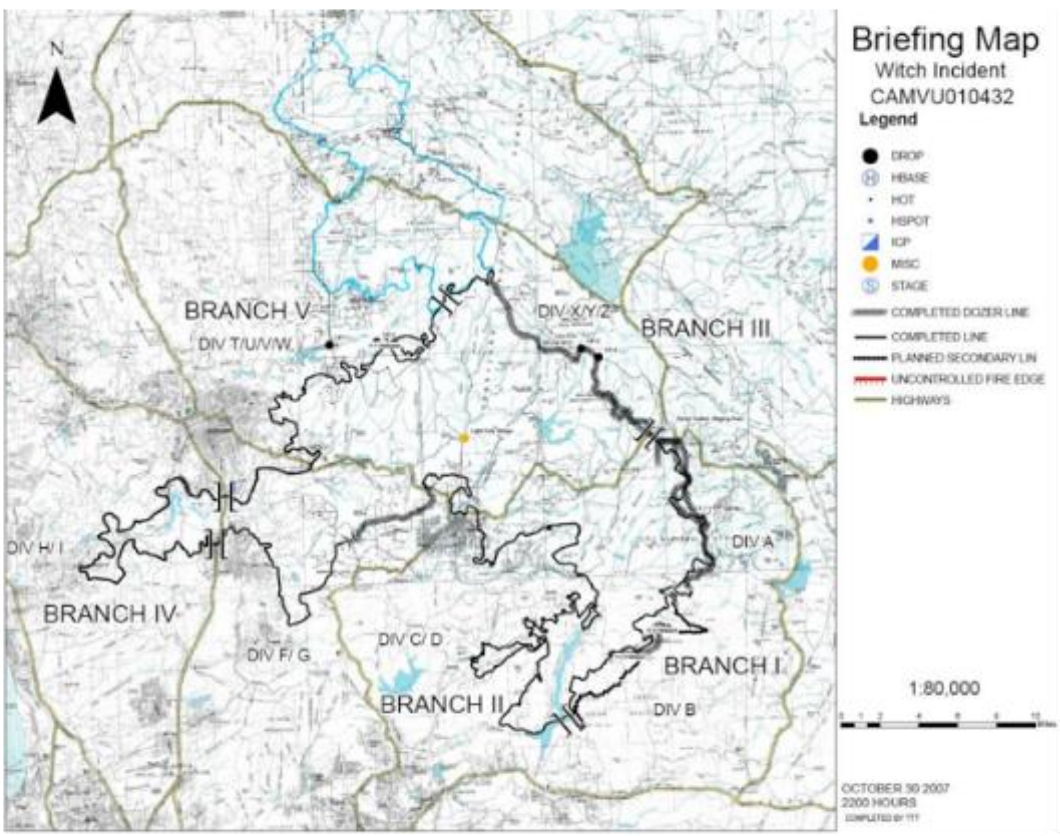
Considering the increase in frequency and intensity of fires formerly considered outliers, quantitatively the risk of future wildland involved fires at or near the project site is 100% considering the impact of foreseeable fire incidents.

Consistent with the preceding, the three images below show the project site in relation to the perimeter and damage locations from the 2007 fires in the area prepared by the California Department of Forestry.



Northern Emergency Evacuation Access Road
Staging Area
Zoo Road Emergency Evacuation Access
Safari Highlands Boundary
Open Space Lots
Development
Overlook View Point
FD Trail Access Points
Open Space Trail - Existing
Open Space Trail - Proposed
Multi-Use Street Trail - Meandering
Multi-Use Street/Trail - Street Adjacent
Neighborhood Concrete Sidewalk
0
750
1,500
Feet
DUDEK
FIGURE 2
Safari Highlands Ranch Site Plan
Safari Highlands Ranch Fire Protection Plan


DAMAGE ASSESSMENT
INCIDENT CA-MVU-010432
WITCH CREEK FIRE
10/30/2007 0600


Briefing Map
Witch Incident
CAMVU010432
Legend
DROP
HBASE
HOT
HSPOT
ICP
MISC
STAGE
COMPLETED DOZER LINE
COMPLETED LINE
PLANNED SECONDARY LIN
UNCONTROLLED FIRE EDGE
HIGHWAYS
N
BRANCH V
DIV T/U/V/W
DIV X/Y/Z
BRANCH III
DIV H/I
DIV A
BRANCH IV
DIV F/G
DIV C/D
BRANCH I
BRANCH II
DIV B
1:80,000
OCTOBER 30 2007
2200 HOURS

FPP Section 5.1 "Fire History" (Dudek pp. 31) further supports the preceding statements.

> ………there have been several fires recorded since 1910 by CAL FIRE in their FRAP database (FRAP 2015) in the direct vicinity of the project site. These fires, occurring in 1910, 1911, 1912, 1913, 1914, 1919, 1927, 1938, 1943, 1945, 1946, 1949, 1950, 1951, 1952, 1955, 1956, 1962, 1965, 1967, 1970, 1972, 1974, 1975, 1978, 1979, 1980, 1981, 1984, 1985, 1987, 1988, 1989, 1991, 1993, 1995, 1997, 2003, 2004, 2007, and 2013 burned within 5 miles of the project site. The site was burned completely in the 1910s, 1950s, 1993 (Guejito Fire), and 2007 (Witch Fire) and was partially burned in the 1930s. This information excludes fires less than 10 acres. There have been multiple fires throughout North San Diego County inland less than 10 acres. Rapid and overwhelming response to these fires has resulted in their containment before they could grow to the size that would include them in CAL FIRE's database.

Addressing the impact of this 100% probability of occurrence through analysis – including worst case potential fire scenarios - and planning for these - is critical.

In all cases, execution of the proposed project will with certainty, expose current and future residents in the area to a significant risk of injury or death from incidents occurring due to wild-land fires. Serious fire hazards which such developments cannot be entirely mitigated as acknowledged in the disclaimers in the DEIR.

1.3 Development at the WUI

The listing of historical fire occurrences at the proposed area of development in the DEIR is impressive even to this fire safety professional. That history is closely related to topography, vegetation, weather and levels of development at the project site. The site is classified as a high hazard fire severity zone (HHFSZ) by the Office of the California State Fire Marshal.

Destructive recurrent wind driven fires are well documented in California with an early example being the 1923 Berkeley Hills fire. In the 1960's, as southern California more developed in undeveloped areas, housing patterns became known as the wildland urban interface (WUI), as incidents such as the Bellaire Fire near Los Angeles became familiar and occurred with consistently increasing frequency from year to year and impacting wider areas.

As development spread along the San Bernardino Mountains, WUI fires there and to the south became an annual threat to inhabitants and property owners. Factors such as deterioration of Forest management practices, impact of prolonged droughts and insect infestations enhanced the hazards that wind driven fires in these areas posed when they occurred. In less densely forested areas dominated by brush-land - often referred to as chaparral - similar fire incidents developed annually south of the Los Angeles basin into San Diego County. Examples of these increasingly destructive fires were those in 2003 and 2007 with the Witch Fire in 2007 occurring at and near the proposed development site.

Societal pressures have led to increased development further into open space fitting the WUI description in Southern California. Along with that, a range of potentially mitigating features has been created for development and construction there. The FPP for the Safari Highlands site includes many of these state of the art features required by code and good practice.

1.4 Discussion Areas

This report will comment on the areas of importance for consideration in the city's review process listed below. Some of these are global in terms of the project proposed and others are highly specific.

- Fire Risk Elements – 100% certainty of future fires at or adjoining the proposed site.

- Fire Hazard Elements –
  - Building arrangements
  - Effects of Topography - setbacks and flame lengths
  - Fire Modeling
    - Assumptions
    - Results
  - Building types and construction
  - Governing codes and Standards
  - Neighbors
  - Egress and Evacuation
    - Project configuration
    - Public Roads
    - Private Roads
    - Evacuation psychology
  - Fire Station Construction
  - Suppression Resources
  - Construction Schedule
  - Maintenance

These elements are discussed in the sections, which follow:

2. Fire Risk and Fire Hazard

The concepts of "risk" and "hazard" relating to fire safety are often confused. It is important that they be used correctly to properly evaluate whether CEQA standards are met by the DEIR.

2.1 Fire Risk

The Fire Prevention Plan (Dudek, 2017 DEIR Section 5.1) presents a remarkable summary of dates of fire occurrence in the vicinity of the project as included in previous section 1.2. Noting that as recently as 2007, major fires occurred in the project vicinity. With numerous fires historically occurring in the past, it is clear that a 100% probability exists that fires will return in the vicinity of the project.

Should the project go forward, this risk factor will be enhanced substantially by daily activities at the site and the continued vulnerability of adjoining areas. Photos of adjoining areas are shown in the accompanying photographs taken by the author after the Witch and Guejito fires in 2007.

2007 Witch & Guejito Fire Locations showing rural open space where fires began as well as clustered homes which burned due to house to house spread

2.2 Fire Hazard Elements[4]

2.2.1 Project Site – Configuration

The fire protection plan, (Dudek, 2017 DEIR Section 5.1) states the site is a located in a highly fire prone area. The impact of surrounding elevations, which range from 203 to 6135 feet above sea level, is considerable. This topography enhances both winds and thermal effects at the site as well as movements of occupants and first responders in foreseeable emergencies. Topographical effects are discussed below.

[4] Recall that fire hazard are the [potential] consequences of a given fire scenario occurring. Fire risk is an expression of the likelihood of a fire taking place.

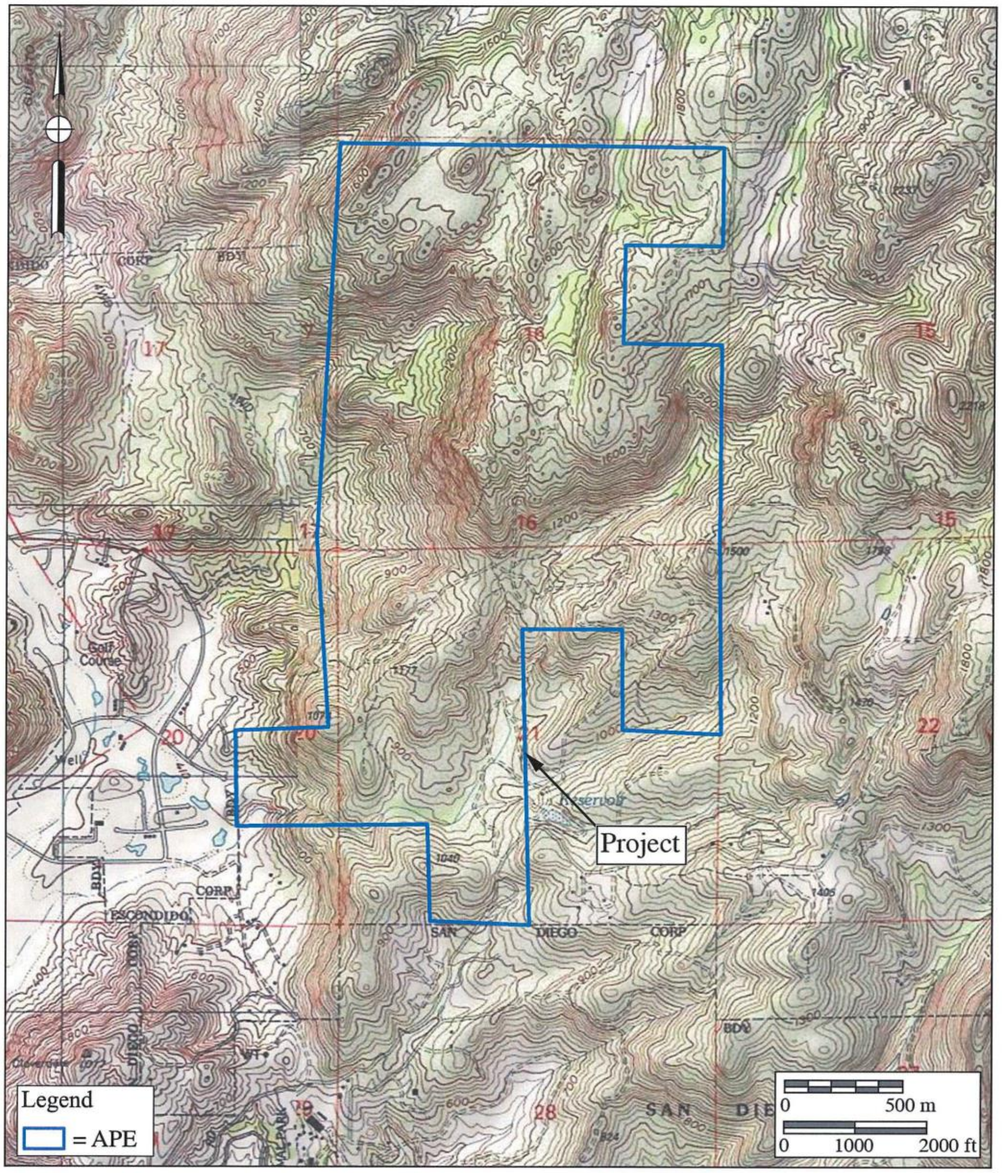


Figure 1

Project Location Map

The Safari Highlands Ranch Project

USGS *San Pasqual, Rodriguez Mountain, Escondido,* and *Valley Center* Quadrangles (7.5-minute series)

2.2.2 Project Arrangement

The overall project shape, from north to south, includes two densely developed parcels separated by steep terrain, connected by a single road. This single route - without an alternate – creates a potential egress problem should any blockage occur that would restrict emergency evacuation and ingress of first responders. Upon review of this topography one can see why the two areas are separated.

2.2.3 Evacuation Issues

In most cases, with wind driven fires such as the Lilac fire which occurred close to the Safari Highlands Ranch site in late 2017, notice is short and alarms may be given belatedly if they are given at all.

Given this over-arching fact, assurance of being able to utilize unfamiliar private roads outside project boundaries as evacuation routes presents additional life safety hazards to those which directly effect individual private residences.

In the DEIR, the circulation plan proposed uses such private, non-publicly maintained roads –external to project boundaries-for emergency evacuation. Some of these roads have tightly controlled access day to day and are behind locked gates. These roads would rarely -if ever -have been used by project residents. In a potential life or death situation this unfamiliarity would create potentially disastrous consequences

Dependence on these tortuous and unfamiliar private roads as emergency routes and ensuring their availability to evacuate the project is inconsistent with reasonable minimum safety standards. As noted in the text below from the DEIR, the project does bot and cannot guarantee maintenance and access to these routes since they are under private ownership exclusive of control by the developers.

The DEIR specifies the following regarding routes proposed for emergency evacuation:

1. Stonebridge Road:

"Stonebridge Road is currently an unpaved private access road across the Beacon Sun Avocado Ranch. This road is currently a private maintenance road that is inaccessible and unmaintained. However, with the construction of the Project, the road will be improved to Fire Department standards as noted above. A connection will be provided from Neighborhood PA E-1 to this road that will be gated. The gate will be equipped with a Knox-box or similar device that will allow the fire authorities to open the gate on demand. " (DEIR PP 65)

2. Zoo Road:

The second access road to be relied as an evacuation route is Zoo Road, described below in DEIR Appendix 2.0 at page 52.[5] Zoo Road is owned by the County and is designated as a "Z", which means it is unimproved, unmaintained, and has no public road status. Zoo employees [only] currently use the road.

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[5] The source of the description below is Page 3 of 7, in a letter from the City of Escondido Planning Division dtd. September 23, 2015

> "Emergency access is proposed along West Zoo Road, located on City-owned land; it follows the western boundary of one of the City's lessee's, Safari Park. This is not a public road: It is designated as a "Z" Road by the County of San Diego. This means it is an unimproved road that has no public road status and is not maintained by either the City or the County of San Diego. Several neighboring properties have an easement over City land to use this road. The Safari Park uses the road for employee access. No other access shall be granted. "

Dependence on unfamiliar and irregularly routed roads for evacuations which can take place in darkness and/or with smoke obscuration and reduced visibility are extremely likely to result in injuries and loss of life.

In addition, the DEIR acknowledges that in some foreseeable scenarios, evacuation will not be feasible [DEIR at 2.14-16]. Specifically, the DEIR discloses that evacuation of the Safari Highlands residents would take approximately three hours. Id. However, the DEIR inexplicably concludes that impacts related to evacuation hazards would be less than significant. The DEIR also acknowledges that the Safari Highlands Ranch is not officially designated a "shelter-in-place community." Id.

Regardless, the document concludes that because structures would be ignition-resistant, it would be safe for residents to shelter in place an await phased evacuation to avoid congestion. Id. This approach is unproven and can itself result in additional hazards. For example, as we have seen in the recent Tubbs fire in Sonoma County, injury and death can result from ambient heat and smoke inhalation well before the flames reach victims.

The DEIR fails to address evacuation impacts related to these issues.

2.2.4. Evacuation Psychology

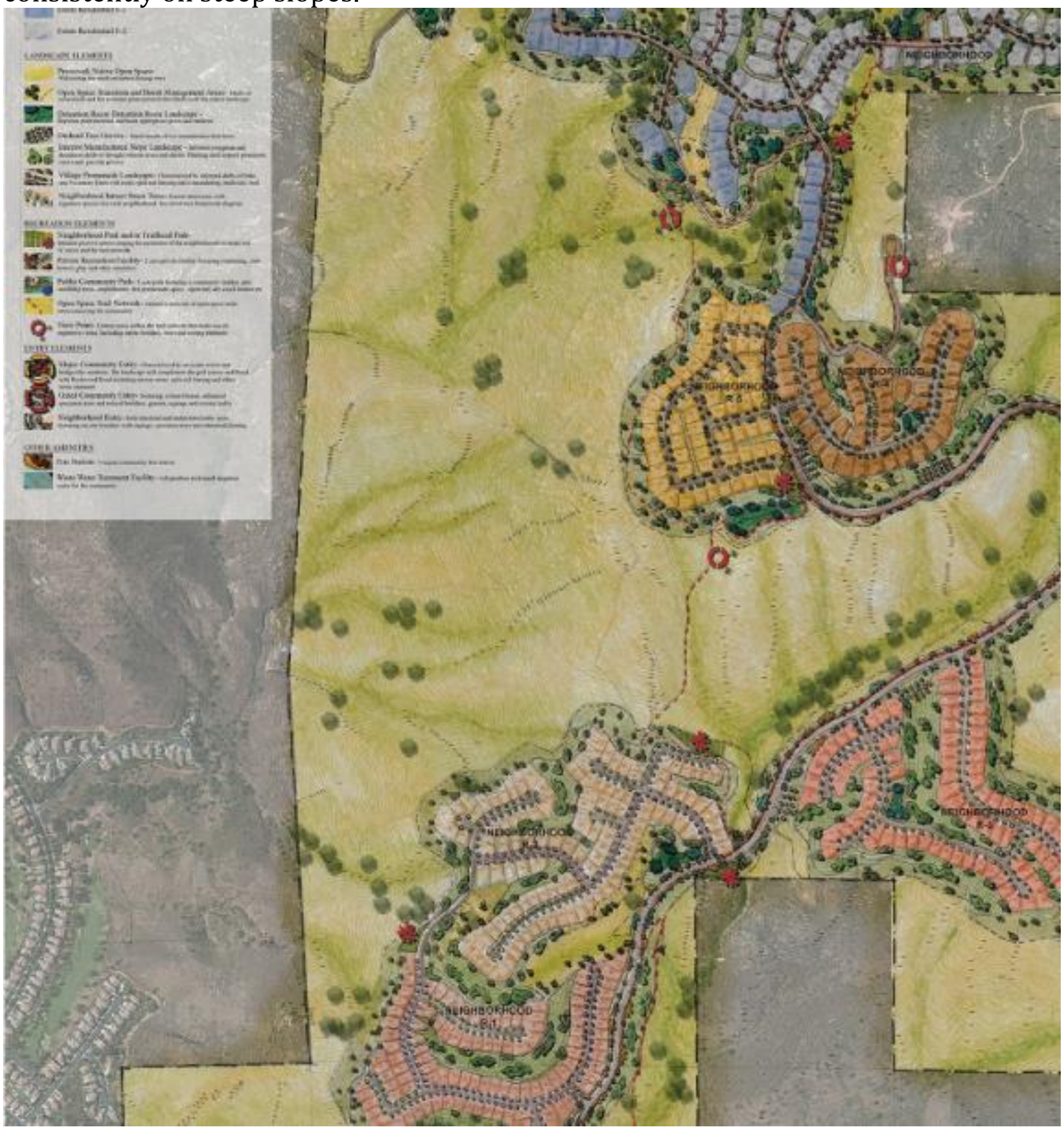
In well-known wind-driven fires (Oakland Hills Fire – Alameda County and Tubbs Fire – Sonoma County) residents died because they became lost while attempting to evacuate or because they were unfamiliar with their surroundings with smoke obscuration contributing to their disorientation. Expecting hundreds of people to evacuate on a limited number of steep routes, some of which are completely unfamiliar to them, is a risky strategy at best where a single two-car collision could lead to blockage of a critical escape route in an emergency.

The fire protection plan refers to "training" of residents for evacuations without providing details. The actual occurrence of such training would be unusual and needs to be detailed and provided for *in perpetuity* if it is to be counted on. This issue was not addressed in the DEIR.

2.3 Topography, Building Construction and Arrangements

The project area is diverse in terms of natural vegetation as well as topography.

Taking advantage of this diversity, sites for much of the housing proposed are located on ridgelines overlooking adjoining open space. As can be seen from a review of the contour lines the figure below from DEIR App 2.0, confirms this siting practice and includes topographic data illustrating siting of clusters of homes consistently on steep slopes.



As such, good practice would provide more substantial defensible space below these ridgelines than if the same clusters of homes were created on level ground. As such downslope areas below the homes sites developed, should be longer not shorter than standard requirements for defensible space.

Conversely, in the case of Safari Highlands, there are proposed building sites with as little as 15 feet of defensible space in areas where flame lengths and projected fire exposures could be quite extreme.

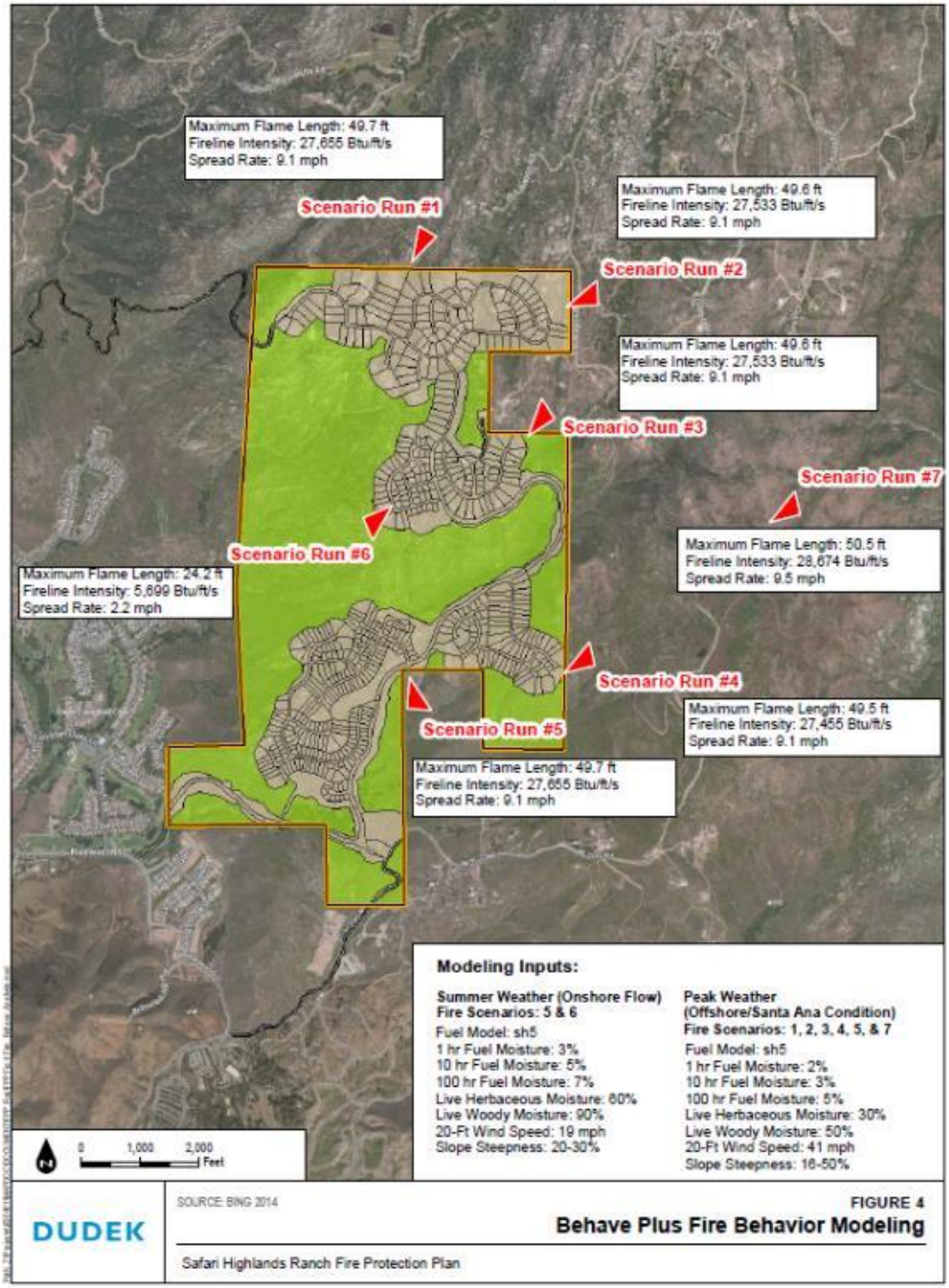


FIGURE 4
Behave Plus Fire Behavior Modeling

San Diego County has regulations for such situations (see Appendix 1 for full text.) which include the following caveats:

> "The absolute minimum setback is 30 feet. If the fire authority having jurisdiction [FAHJ], the planning authority having jurisdiction [PAHJ] and the County Fire Marshal identify the hazard in the area as "minimal" or meeting one of the other exceptions below, they may allow less than 30 feet setback."
>
> In high hazard areas, exceptions are allowed only if the parcel is too small to accommodate the structure with a 30 foot setback, or the structure is in the interior of a grouping of homes with adequate defensible space designed and maintained on the perimeter of the group."

Model code approaches to siting on ridges are presented in Appendix 1 for comparison with proposed siting practices for Safari Highlands Ranch. Siting the homes on top of ridges where fires accelerate [as they move vertically up ridges] is a bad practice inconsistent with accepted siting guidelines.

2.3.1 Building Arrangements
The project proposed building arrangements such that most homes are clustered on lots well under a quarter acre with separating widths that are under 100 feet (DEIR table I-4, Fig I-8). The proposed separations between lots are insufficient in the face of foreseeable fire and will not be effective in preventing fire spread from one affected dwelling to its neighbor under high wind conditions. The results of such fire spread from one building to another are commonly seen following windblown fire events as shown below.

2.3.2 Building design and construction features
The FPP does not provide explicit analysis of foreseeable fire impacts on individual structures/homes. The DEIR comments on the project's conformance with local amendments to the California Building Code (CBC) and California Fire Code (CFC) as is common in San Diego County. It also presents situations – as with the siting of homes on sloping terrain – where code minimums are not met unless [untried] alternate means of construction are used.

The DEIR focuses on utilizing "ember resistant construction" as the primary fire safety feature of the project design. However, it does not address many other potential construction related mitigation features that are needed to contribute to fire safety, including glazing, siding, deck designs, roofing etc.).

While the proposed building designs are intended to meet the general classification of "ignition resistant", these buildings are not "fireproof." For example, compliance with fire code provisions requiring interior sprinkler systems do not address threats from fires *outside* a building.

Likewise, maintenance and lifestyle factors, such as having combustible furnishings, other combustible personal property or firewood for the living room fireplace outside the building [that will ignite in the face of wind driven embers or direct flame impingement] create ignition hazard dangers which are not controlled by building design are the codes and standards of San Diego County. When ignitions of these items occur, resulting extended heat transfer to an ignition resistant building will still lead to fire growth and spread.

Remains of combustible gazebo

Consumer goods exposed during the 2007 fire leading to bldg. damage

Burned consumer items including those which aided ignition a of large, well separated home on a flat site in San Diego County (2007 Photos – Zicherman)

2.3.3 Set backs and flame lengths

Wild fires driven by winds spread essentially either by flying burning brands and embers lofted ahead of the fire front and leading to downwind ignition OR by direct flame impingement, such as when brush ignites and winds enhance the flames from those ignitions.

In addressing the latter direct flame impingement possibility, Pages 59 and 60 of the Dudek FPP (see Dudek Figure 4) describe 15-foot setbacks for single story and 30 foot setbacks for two-story structures. The FPP at page 38 describes potential flame lengths of 24-50 feet and at page 62 says flame lengths may occur of up to 65 feet. As noted above, 15 and 30-foot setbacks will not prove sufficient when flame lengths are twice as long.

The project includes design features including glazed barrier fences intended to drive flames up and over structures. However, these appliances cannot be relied upon to prevent structure ignition in the face of limited defensible space included in this request.

2.3.4 Fire Modeling Assumptions and Predictions discussed
The physical assumptions – i.e. topography and usual weather patterns in the fire modeling are consistent with prevailing conditions in the area. However, the analysis fails to consider worst case winds produced by Santa Anna weather conditions which have been responsible for fires in San Diego County including the 1970 Laguna fire, the Cedar fire in 2003, the Harris and Witch fires in 2007.. the Poinsetta fire in 2014 and the Lilac fire earlier in this year. Other areas in Southern California have also suffered disastrous losses due to Santa Anna wind conditions.

As, such, the FPP underlying the DEIR conclusions are based *only* on maximum wind speeds lower than can be realistically expected to occur from year to year and are not consistent with winds seen in current wildland fires – such as the recent nearby Lilac fire in San Diego County or the huge Brooks fire in Ventura County which exemplify foreseeable extreme fire behavior taking place.

From a modeling perspective, the findings are also flawed. Modeling conducted using FLAMMAP (Dudek, FPP Section 5.2) provided only static fire modeling data rather than transient data which are available using more contemporary fire modeling.[6] It is also unclear how the modeling conducted included effects of structures upon the resulting WUI mix of vegetation and structures when ignited.

The 41 MPH maximum wind speeds modeled are not high enough to reasonably reflect potential maximum wind speeds from Santa Anna winds at the project site.

The preceding factors and flawed analyses are especially relevant in light of probable effects of climate change effecting wildland urban interface habitats through higher temperatures, drought effects, high wind effects and the like currently and in the future. Careful analysis of these factors lead to disagreement with the conclusions of "Less than Significant Impact" regarding wildfire and evacuation hazards in "Summary of Wildfire Hazards" DEIR, 2.14-1

2.3.5 Neighboring Properties
The project site is acknowledged to be fire prone. With its north-south orientation and seasonal winds consistently occurring in fire season from the north east to the southwest and downhill directions, fires more probably than not will continue to occur upwind of the project. Such fires can develop in existing wildland or agricultural properties such as the avocado groves not subject to fuel modification practices which have demonstrably effected earlier fires in the area. In damage

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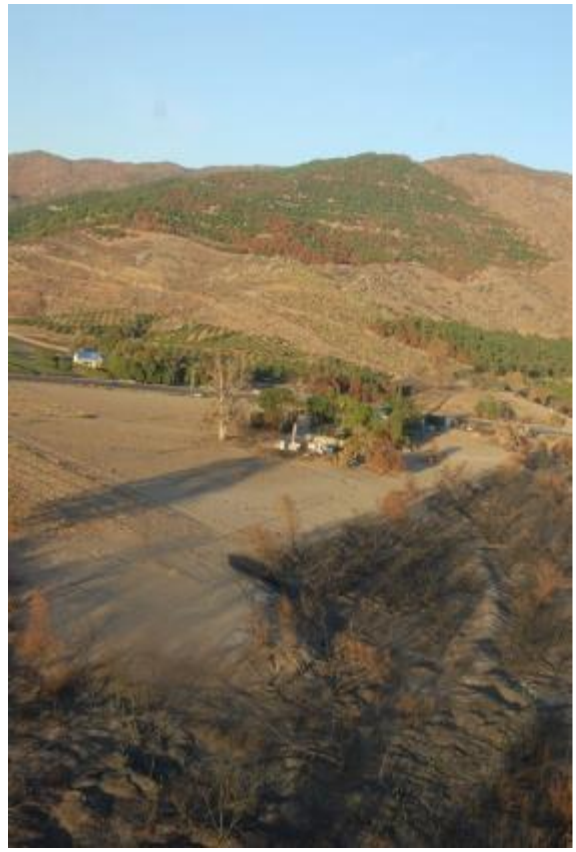
[6] See for example the review by C. Lautenberger [published in 2013] "Wildland Fire Modeling with an Eulerian Level Set Method and Automated Calibration," *Fire Safety Journal* **62**: 289-298.

survey maps from the 2007 (see preceding Section 1.2) illustrate the spread of damage in areas adjacent to the project site. No manner of fuel modification at the project site can be expected to impact these adjoining unmodified areas as illustrated in the 2007 Cal-Fire damage and fire perimeter situation maps presented earlier which include terrain that will foreseeably impact the project site.



(figures above) Agricultural areas burned in 2007 near the proposed project site illustrating spread from an agricultural area which moved into an adjoining WUI area where dozens of homes were lost.

As such it is not a matter of if - but when - the project will be threatened by burning brand showers originating outside project boundaries but effecting the 1000+ acre project site.

2.4 Maintenance

Fuel modification sections include a range of proposed features. However no "project life budget" is presented to illustrate the true cost of project operation and maintenance costs after construction has been completed for the project life. The relationship between CCR’s for the hypothetical HOA is not spelled out nor is funding for these efforts spelled out or assured.

If the project were not able to maintain these features - which are absolutely necessary for the fire safety levels proposed - fire hazard levels will go up dramatically without the mitigation features provided by healthy, fire resistant - but not necessarily drought tolerant – landscaping features to be used throughout the project.

2.5 Fire Protection, Prevention and Suppression

Enhancement of fire suppression resources at the proposed site will take the form of a new fire station. This station will provide for fire and life safety requirements for individual structure fire issues and emergency medical services. The inspections proposed to be conducted by fire service personnel are not likely to provide meaningful protection from a wind driven wild fire.

The DEIR discusses the addition of a Fire Station within the development by the City of Escondido. This would have a significant/negative affect on the city's budget. The DEIR also mentions agreements/funding contributions from Cal-Fire to help mitigate the impact on the City. However, the viability of such a scenario is not supported in the DEIR.

2.5.1 Wildland Fire Suppression

Fire suppression personnel requirements would in all cases exceed the staffing provided by the single [new] fire station. When additional suppression resources are needed, it is unlikely that they could be drawn from adjoining fire stations in Escondido as those resources would likely be dealing with other windblown fires in this diverse city and county area within the same time frame. Therefore, construction of a fire station does not assure protection in a wild land fire situation. More importantly, in such situations both the timing and availability of critical mutual aid resources to assist in a WUI fire situation are being increasingly called into question.

2.6 Construction Scheduling

Construction Scheduling - possible and probable critical elements:

A range of possibilities and probabilities presented in the DEIR can and/or will affect fire and life safety issues at the proposed project site.

First, the fire station, water tank for fire suppression, grading and surface improvements for the northern emergency access road will *not be completed* when the first project occupants move into the area. Instead, these critical fire safety infrastructure elements will not be in place until issuance of the 275th Certificate of Occupancy for the project – a period of several years potentially. During that period when as many as 275 homes are occupied little if any mitigation to address the associated fire hazards will have taken place. [7]

In addition, it is plausible that the developer could build the first one or two phases of the development and then cease developing the site. in that case there will be no mitigation at all from the proposed fire station. Likewise, fuel modification features

[7] "Upon issuance of the 275th Certificate of Occupancy for the project, the Fire Station, the potable water tank (approximately 743,000 gallons), and grading and surface improvements for the northern emergency access road will have been completed."
(https://www.escondido.org/Data/Sites/1/media/PDFs/Planning/SafariRanch/eir/101317/EIR/10ProjectDescription.pdf), Page 1.0-11

aren't an integral part of the project should it be partially completed.

These are realistic possibilities which could be mitigated with bonding or surety related features being applied to ensure complete project execution and/or execution of all fire safety features.

2.7 Prevailing Codes

There is confusion in the DEIR about prevailing codes in that the DEIR should provide an application – scope document stating what codes (and the version of that code) the proposal is based upon.

References are made variably between the Public Resources Code (PRC), the CBC, CFC, and local amendments. There is some overlap in these codes in that the CBC and CFC are subject to amendments by local (county or city) entities as part of the adoption process. These can add requirements which more stringent that the state code based on prevailing local conditions such as high risk of wind driven wildfire.

Also, the plan refers to the development being annexed by the City of Escondido and thus would convert to an LRA (Local Responsibility Area). As such, it would no longer be a SRA (State Responsibility Area), and the Public Resources Code would no longer apply. However, since Cal Fire's Fire Resource and Assessment program [FRAP] designated the area of the development as VHFHZ, the provisions of Chapter 7A of the CBC would apply whether it is SRA or LRA.

2.8 Firewise Community

The FPP calls for development-wide and individual home vegetation management plans and annual inspections. Consistent with this and after all development work is certified as complete it is recommended that a mandatory requirement be applied thru project CCR's that the development achieve and maintain status as an NFPA [National Fire Protection Association] "Firewise Community".

3. Conclusions

The proposed Safari Highlands project is a large development in a highly fire prone area. It is an absolute necessity that the DEIR include project features assuring that minimum levels of life safety will exist and safety of property will be reasonably addressed.

The DEIR fails to fully disclose the extent and severity of the project's contribution to increased fire hazard impacts to residents of the project site and to residents in the surrounding area.

The DEIR's thresholds of significance for wild land fire issues for the CEQA review is based on the following:

> Will the project ….. "expose people or structures to a significant risk of loss, injury, or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands" ?

The finding in the project summary for "Wildfire Hazards" of "less than significant" is incorrect for the following reasons:

- People and structures will be at risk from seasonal wild land fires generated on or off the project site. This is consistent with the history of fires presented by the proposers as well as disclaimers concerning survivability of structures and lack of compliance with shelter in place concepts.
- Siting of closely grouped structures on Ridge Tops subject to long flame lengths during windblown fires, which also make fire-fighting access difficult, is a flawed strategy. It is also in violation of San Diego County policies
- The addition of the project with associated day-to-day activities in the area will increase fire risk as compared to the undeveloped property
- Climate change effects will exacerbate fire risk levels as well as hazards associated with climate change directly
- Emergency evacuation schemes involve private roads whose routes and features are unfamiliar to [prospective] residents - the use of which can lead to disastrous consequences. Modeling carried out in support of the DEIR indicates that evacuation may not even be feasible under certain scenarios
- Addition of the single fire station Will provide little or no benefit to the neighborhood survival in case of a windblown wild land fire, especially one initiated outside and upwind of the project boundaries.
- Features added to the site to reduce fire hazards will require extensive maintenance and ongoing capital investment the source of which is not provided in the project plans
- There are no provisions in the project plans for the community to be developed as a "fire-wise-community" per the National Fire Protection Association guidelines.

Appendices

A1. Siting reference materials for buildings in WUI sites

A1.1 SD City Location of Structure on Lot

A1.2 ICC-2012-Int'l WUI Building Code excerpts

A1.3 AS 3959 – 29009 Australian WUI Building Code excerpts

A2. SF Chronical article describing Mutual Aid operations in the Tubbs and associated fires 11/2017

A3. Reference data and selected WUI building guidance information - Abridged and/or selected items from current peer reviewed literature and research activities

A3.1 State of California Structural Fire Prevention Field Guide For Mitigation of Wildland Fires

A3.2 Brillinger & Autry, Probabilistic risk modeling at the wildland urban interface: the 2003 Cedar Fire

A3.3 General Guidelines for Creating Defensible Space, California State Board of Forestry and Fire Protection, Approved May 8, 2006

A3.4 ASTM E-05 symposium - NIST.SP.1198 – Structure Ignition in Wildland Urban Interface (WUI) Fires workshop data illustrating current research areas

A3.5 WUI Slope treatments – Defensible space web links

Appendix 1.1

Location of Structure on Lot - Setback

Fuel modification (vegetation control) is necessary for the life of the building. Fuel modification on neighboring property is not authorized by this fire code section. The fuel modification zone may not extend beyond the lot being developed. Agreements with neighbors, while desirable, cannot be depended on; ownership and cooperation can change. Therefore, it is critical that the fire code regulate the minimum distance from structure to property line.

Where adequate setback distance is possible, the structure shall be located such that 100 foot fuel modification can be obtained on the property. This setback is particularly important where fuel modification is restricted such as an Open Space Easement or a where fuel modification may not take place (e.g. riparian areas, state or federal land.)

The absolute minimum setback is 30 feet. If the fire authority having jurisdiction [FAHJ], the planning authority having jurisdiction [PAHJ] and the County Fire Marshal identify the hazard in the area as “minimal” or meeting one of the other exceptions below, they may allow less than 30 feet setback.

In high hazard areas, exceptions are allowed only if the parcel is too small to accommodate the structure with a 30 foot setback, or the structure is in the interior of a grouping of homes with adequate defensible space designed and maintained on the perimeter of the group.

[from http://www.sandiegocounty.gov/pds/docs/pds664.pdf]

Appendix 1.2

2012
IWUIC

International Wildland Urban Interface Code™

ICC
INTERNATIONAL
CODE COUNCIL®

CHAPTER 6 – FIRE PROTECTION REQUIREMENTS

SECTION 601 – GENERAL

601.1 Scope. The provisions of this chapter establish general requirements for new and existing buildings, structures and premises located within wildland-urban interface areas.

601.2 Objective. The objective of this chapter is to establish minimum requirements to mitigate the risk to life and property from wildland fire exposures, exposures from adjacent structures and to mitigate structure fires from spreading to wildland fuels.

SECTION 602 – AUTOMATIC SPRINKLER SYSTEMS

602.1 General. An approved automatic sprinkler system shall be installed in all occupancies in new buildings required to meet the requirements for Class 1 ignition-resistant construction in Chapter 5. The installation of the automatic sprinkler systems shall be in accordance with nationally recognized standards.

SECTION 603 – DEFENSIBLE SPACE

603.1 Objective. Provisions of this section are intended to modify the fuel load in areas adjacent to structures to create a defensible space

603.2 Fuel modification. Buildings or structures, constructed in compliance with the conforming defensible space category of Table 503.1, shall comply with the fuel modification distances contained in Table 603.2. For all other purposes the fuel modification distance shall not be less than 30 feet (9144 mm) or to the lot line, whichever is less. Distances specified in Table 603.2 shall be measured on a horizontal plane from the perimeter or projection of the building or structure as shown in Figure 603.2. Distances specified in Table 603.2 are allowed to be increased by the code official because of a site-specific analysis based on local conditions and the fire protection plan.

TABLE 603.2 – REQUIRED DEFENSIBLE SPACE

WILDLAND-URBAN INTERFACE AREA	FUEL MODIFICATION DISTANCE (feet)[a]
Moderate Hazard	30
High Hazard	50
Extreme Hazard	100

For SI: 1 foot = 304.8 mm.

a. Distances are allowed to be increased due to site-specific analysis based on local conditions and the fire protection plan.

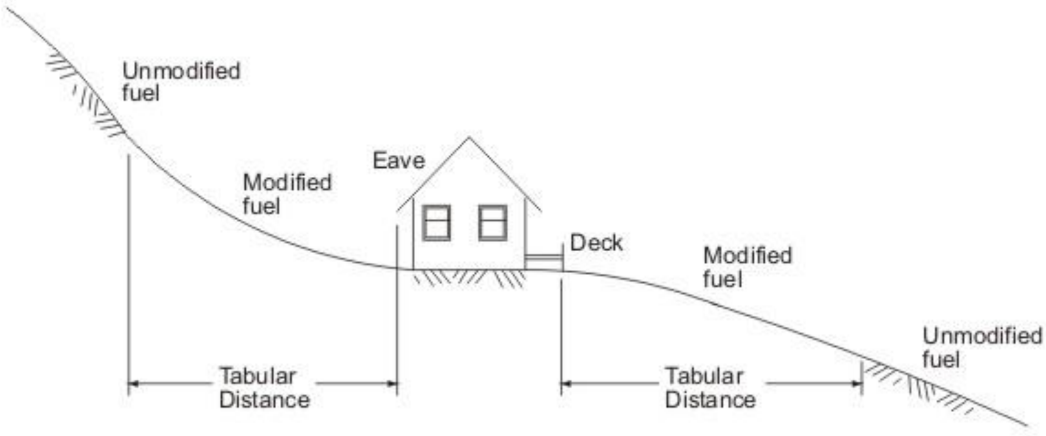


FIGURE 603.2

MEASUREMENTS OF FUEL MODIFICATION DISTANCE

603.2.1 Responsible party. Persons owning, leasing, controlling, operating or maintaining buildings or structures requiring defensible spaces are responsible for modifying or removing nonfire-resistive vegetation on the property owned, leased or controlled by said person.

603.2.2 Trees. Trees are allowed within the defensible space, provided the horizontal distance between crowns of adjacent trees and crowns of trees and structures, overhead electrical facilities or unmodified fuel is not less than 10 feet (3048 mm).

603.2.3 Groundcover. Deadwood and litter shall be regularly removed from trees. Where ornamental vegetative fuels or cultivated ground cover, such as green grass, ivy, succulents or similar plants are used as ground cover, they are allowed to be within the designated defensible space , provided they do not form a means of transmitting fire from the native growth to any structure.

SECTION 604 – MAINTENANCE OF DEFENSIBLE SPACE

604.1 General. Defensible spaces required by Section 603 shall be maintained in accordance with Section 604.

604.2 Modified area. Nonfire-resistive vegetation or growth shall be kept clear of buildings or structures, in accordance with Section 603, in such a manner as to provide a clear area for fire suppression operations.

604.3 Responsibility. Persons owning, leasing, controlling, operating or maintaining buildings or structures are responsible for maintenance of defensible spaces Maintenance of the defensible space shall include modifying or removing nonfire-resistive vegetation and keeping leaves, needles and other dead vegetative material regularly removed from roofs of buildings and structures.

604.4 Trees. Tree crowns extending to within 10 feet (3048 mm) of any structure shall be pruned to maintain a minimum horizontal clearance of 10 feet (3048 mm). Tree crowns within the defensible space shall be pruned to remove limbs located less than 6 feet (1829 mm) above the ground surface adjacent to the trees.

Appendix 1.3

AS 3959—2009
(Incorporating Amendment Nos 1, 2 and 3)

AS 3959—2009

Australian Standard®

Construction of buildings in bushfire-prone areas

STANDARDS
Australia

SECTION 2 DETERMINING THE BUSHFIRE ATTACK LEVEL (BAL)

2.1 GENERAL

The Bushfire Attack Level (BAL) shall be determined by using the—

(a) simplified procedure described in Clause 2.2 (Method 1); *or*

NOTE: See Appendix C for a flow diagram to summarize the process.

(b) detailed procedure described in Appendix B (Method 2).

BALs are based on levels of exposure defined in Table 3.1.

C2.1 *There are two methods for determining BALs:*

Method 1—a simplified procedure that involves five procedural steps to determine BALs, and is subject to limitations on the circumstances in which it can be used (see Appendix C).

Method 2—a detailed procedure using calculations to determine BALs where a more specific result is sought or where the site conditions are outside of the scope of the simplified procedure (Method 1) (see Appendix B).

BALs are used to determine which, if any, construction requirements contained in Sections 3 to 9 of this Standard are appropriate for a particular site.

2.2 SIMPLIFIED PROCEDURE (METHOD 1)

2.2.1 General

For the simplified procedure (Method 1), the following steps shall be used to determine the BAL for all circumstances except where the effective slope under the classified vegetation,
A1 calculated in accordance with Clause 2.2.5, is more than 20° downslope (see Figure 2.2).

Step	Clause	Procedure
Step 1	2.2.2	Determine the relevant FDI (see Table 2.1).
Step 2	2.2.3	Determine the classified vegetation type(s) (see Table 2.3 and Figure 2.3).
Step 3	2.2.4	Determine the distance of the site from the classified vegetation type(s) [(Point A to Point B see Figure 2.1)].
Step 4	2.2.5	Determine the effective slope(s) under the classified vegetation type(s) (see Figure 2.2).
Step 5	2.2.6	Determine the BAL from the appropriate table (see Tables 2.4.2, 2.4.3, 2.4.4 and 2.4.5, and refer to Table 2.4.1 for input values used in developing the Tables.
Step 6	2.2.7	Determine the appropriate construction requirements.

2.2.2 Step 1—Relevant Fire Danger Index (FDI)

The relevant FDI shall be determined in accordance with Table 2.1 for the identified jurisdiction or region within a jurisdiction.

TABLE 2.1

JURISDICTIONAL AND REGIONAL VALUES FOR FDI

State/region	FDI
Australian Capital Territory	100
New South Wales	
(a) Greater Hunter, Greater Sydney, Illawarra/Shoalhaven, Far South Coast and Southern Ranges fire weather districts	100
(b) NSW alpine areas	50
(c) NSW general (excluding alpine areas, Greater Hunter, Greater Sydney, Illawarra/Shoalhaven, Far South Coast and Southern Ranges fire weather districts	80
Northern Territory	40
Queensland	40
South Australia	80
Tasmania	50
Victoria	
(a) Victoria alpine areas	50
(b) Victoria general (excluding alpine areas)	100
Western Australia	80

NOTES:

1 The FDI values may be able to be refined within a jurisdiction or region where sufficient climatological data is available and in consultation with the relevant regulatory authority.

2 The FDI values were provided by the Australasian Fire and Emergency Service Authorities Council (AFAC).

3 Alpine and sub-alpine areas are defined as per the Building Code of Australia, Volume Two.

2.2.3 Step 2—Vegetation classification

2.2.3.1 *General*

Vegetation shall be classified in accordance with Table 2.3 and Figures 2.4(A) to 2.4(G). Where there is more than one vegetation type, each type shall be classified separately with the worst case scenario (predominant vegetation is not necessarily the worst case scenario) applied.

NOTE: Classification of vegetation should not be based solely on the edge of the vegetation, which may be invaded by weeds.

2.2.3.2 *Exclusions—Low threat vegetation and non-vegetated areas*

The Bushfire Attack Level shall be classified BAL—LOW where the vegetation is one or a combination of any of the following:

(a) Vegetation of any type that is more than 100 m from the site.

(b) Single areas of vegetation less than 1 ha in area and not within 100 m of other areas of vegetation being classified.

(c) Multiple areas of vegetation less than 0.25 ha in area and not within 20 m of the site, or each other.

A1 (d) Strips of vegetation less than 20 m in width (measured perpendicular to the elevation exposed to the strip of vegetation) regardless of length and not within 20 m of the site or each other, or other areas of vegetation being classified.

(e) Non-vegetated areas, including waterways, roads, footpaths, buildings and rocky outcrops.

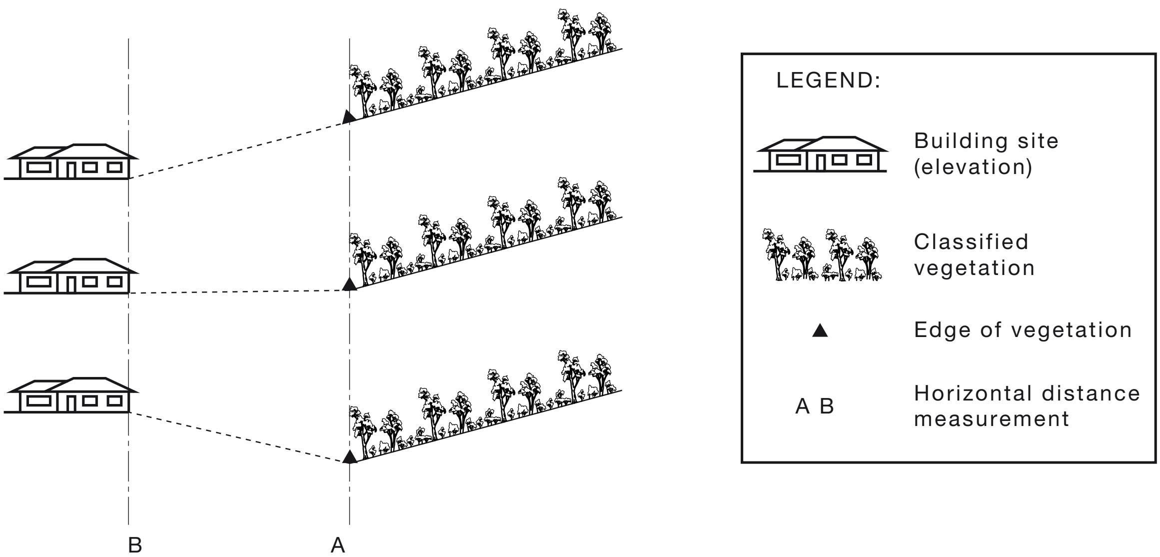
A1 A2 (f) Low threat vegetation, including grassland managed in a minimal fuel condition, maintained lawns, golf courses, maintained public reserves and parklands, vineyards, orchards, cultivated gardens, commercial nurseries, nature strips and windbreaks.

NOTE: Minimal fuel condition means there is insufficient fuel available to significantly increase the severity of the bushfire attack (recognizable as short-cropped grass for example, to a nominal height of 100 mm).

(g) '**Text deleted**'

2.2.4 Step 3—Distance of the site from classified vegetation

For each vegetation type classified in Clause 2.2.3, determine the distance of the site from the classified vegetation, measured in the horizontal plane (see Figure 2.1, Point A to Point B).



NOTES:

1 The measurement of distance A to B is measured in plan (i.e., horizontally) and is taken to the external wall of the proposed building, or for parts of the building that do not have external walls (including carports, verandas, decks, landings, steps and ramps), to the supporting posts or columns. The following parts of the building are excluded when determining the distance A to B:

(a) Eaves and roof overhangs.

(b) Rainwater and domestic fuel tanks.

(c) Chimneys, pipes, cooling or heating appliances or other services.

(d) Unroofed pergolas.

(e) Sun blinds.

(f) Landings, terraces, steps and ramps, not more than 1 m in height.

2 In the three illustrations above, the distance A to B is the same horizontal distance from the classified vegetation to the site. The area between A and B may contain vegetation not required to be classified in accordance with Clause 2.2.3.

FIGURE 2.1 DETERMINATION OF DISTANCE OF SITE FROM CLASSIFIED VEGETATION

2.2.5 Step 4—Effective slope of land under the classified vegetation

'Slope' refers to the slope under the classified vegetation in relation to the building—not the slope between the vegetation and the building.

For each vegetation type classified in Clause 2.2.3, determine the effective slope (in degrees) of the land under the classified vegetation and whether it is upslope or downslope in relation to the site (see Figure 2.2).

Effective slope of land under classified vegetation is presented in degrees, approximate slope ratios and percentages. As fires travel slower down a hill, all classified vegetation that is upslope will assume a value of 0° (i.e., flat land). Table 2.2 provides comparisons between degrees, slope ratios and percentages.

C2.5 *The slope of the land under the classified vegetation is much more important than the slope of the land between the site and the edge of the classified vegetation. The slope of the land under the classified vegetation has a direct influence on the rate of fire spread, the severity of the fire and the ultimate level of radiant heat flux.*

For Method 1 it is not important to determine the slope of the land between the site and the edge of the classified vegetation (see Figure 2.1, Point B to Point A). The further the distance the less radiant heat reaches the site.

It may be necessary to consider the slope under the classified vegetation for distances greater than 100 m in order to determine the effective slope for that vegetation classification.

Where the slope of the land under the classified vegetation is downhill from the edge of the classified vegetation nearest the site, it is considered 'downslope' regardless of the slope of the land between the site and the edge of the classified vegetation (see Figure 2.2).

Where the slope of the land under the classified vegetation is uphill from the edge of the classified vegetation nearest the site, it is considered 'upslope' regardless of the slope of the land between the site and the edge of the classified vegetation (see Figure 2.2).

Appendix 2

San Francisco Chronicle

Local

Wine Country requested hundreds of engines in firestorm's first hours. Less than half came.

By Joaquin Palomino and Kimberly Veklerov | November 16, 2017 | Updated: November 18, 2017 7:32pm

Photo: Scott Strazzante, The Chronicle

IMAGE 1 OF 16

Petaluma firefighter Kevin Larsen extinguishes hot spots at a large home that burned in the Ranch subdivision in the city of Sonoma last month.

In the early hours of the most destructive firestorm in California history, officials in Napa and Sonoma counties knew their local first responders would be overwhelmed and turned to a statewide mutual-aid system designed to swiftly bring in support crews from other regions to protect homes and save lives.

They got help, but they didn’t get what they asked for —
not nearly.

Commanders in the two counties requested 305 fire engines through the state’s mutual-aid program as the Tubbs Fire swept west from Calistoga to Santa Rosa and the Atlas Fire raced through the hills north of the city of Napa. But only 130 engines would be sent to those blazes over the first 12 hours, according to data obtained by The Chronicle under the state’s Public Records Act.

Officials in Mendocino County, where nine people were killed by another big fire, requested 15 engines from outside the county. None was sent the first day.

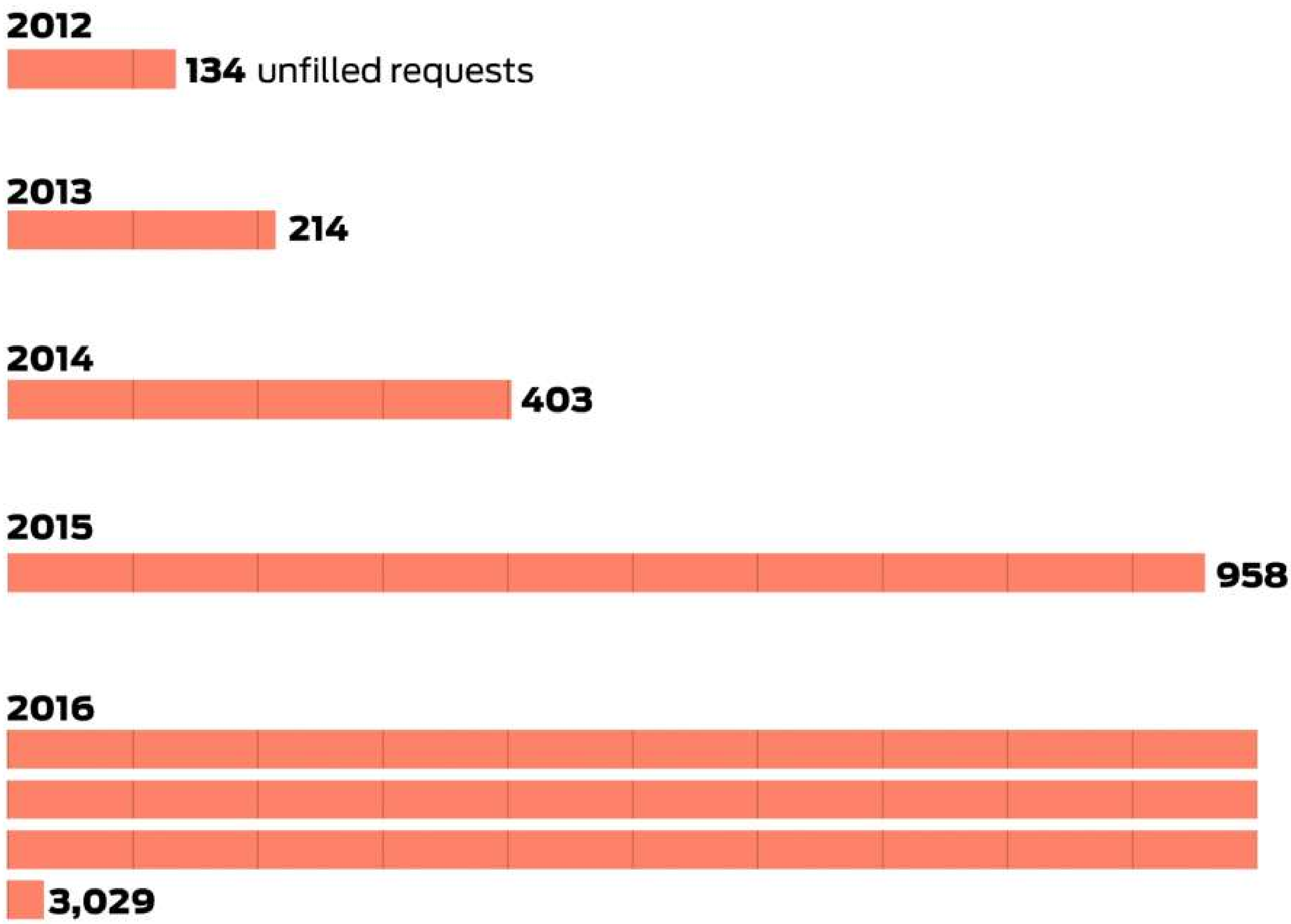
That left local firefighters largely on their own to combat a disaster in Wine Country that would ultimately demand an international effort over several weeks to control. Eventually, thousands of firefighters would converge on the area.

The records reveal a shortage of resources in the catastrophe’s most critical period, adding to questions about how prepared local and state officials were for the wind-driven fires that ignited Oct. 8 in several counties, killing 43 people and destroying 8,900 structures in the region. Emergency managers are also under scrutiny over whether they should have alerted the public to the raging fires with messages that take over cell phones.

The shortcomings reflect larger problems facing California’s mutual-aid system, run by the Office of Emergency Services, which is integral to fighting large wildfires that often do much of their damage soon after they spark. For at least the past five years, the number of unfilled requests for mutual aid during fires has grown, according to state figures.

Unfilled mutual aid requests for engines statewide

While the severity of wildfires in California has increased in recent years, it has become more difficult for the state to send assistance to local agencies in need.



Fire officials and experts attribute this increase to dwindling resources and a reluctance of local governments to share them, and say solutions won't be easy or cheap.

“I can only send what people are willing to give up out of their departments,” said California Fire and Rescue Chief Kim Zagaris, who oversees the fire mutual-aid program.

“If you’re a fire chief, it’s neighbor helping neighbor,” he said. “You do that to a point, but you still have to cover home base. Everything from 911 calls, medical emergencies, vehicle accidents, fires, HazMat, you name it, the fire department handles it. And those calls are still coming in each and every day.”

Emergency managers are concerned about strains on the system at a time when California wildfires are growing more intense and dangerous because of warmer weather, drier conditions and increased development in what is known as the wildland-urban interface.

Officials such as Sonoma County Supervisor Lynda Hopkins said the experience should prompt the state to examine how quickly mutual aid can be deployed — in particular, when multiple large fires break out at the same time. More help earlier on, she said, likely would have saved lives, homes and money.

“It’s like a chessboard,” Hopkins said, “where you are trying to move the pieces where you can, and there just aren’t enough.”

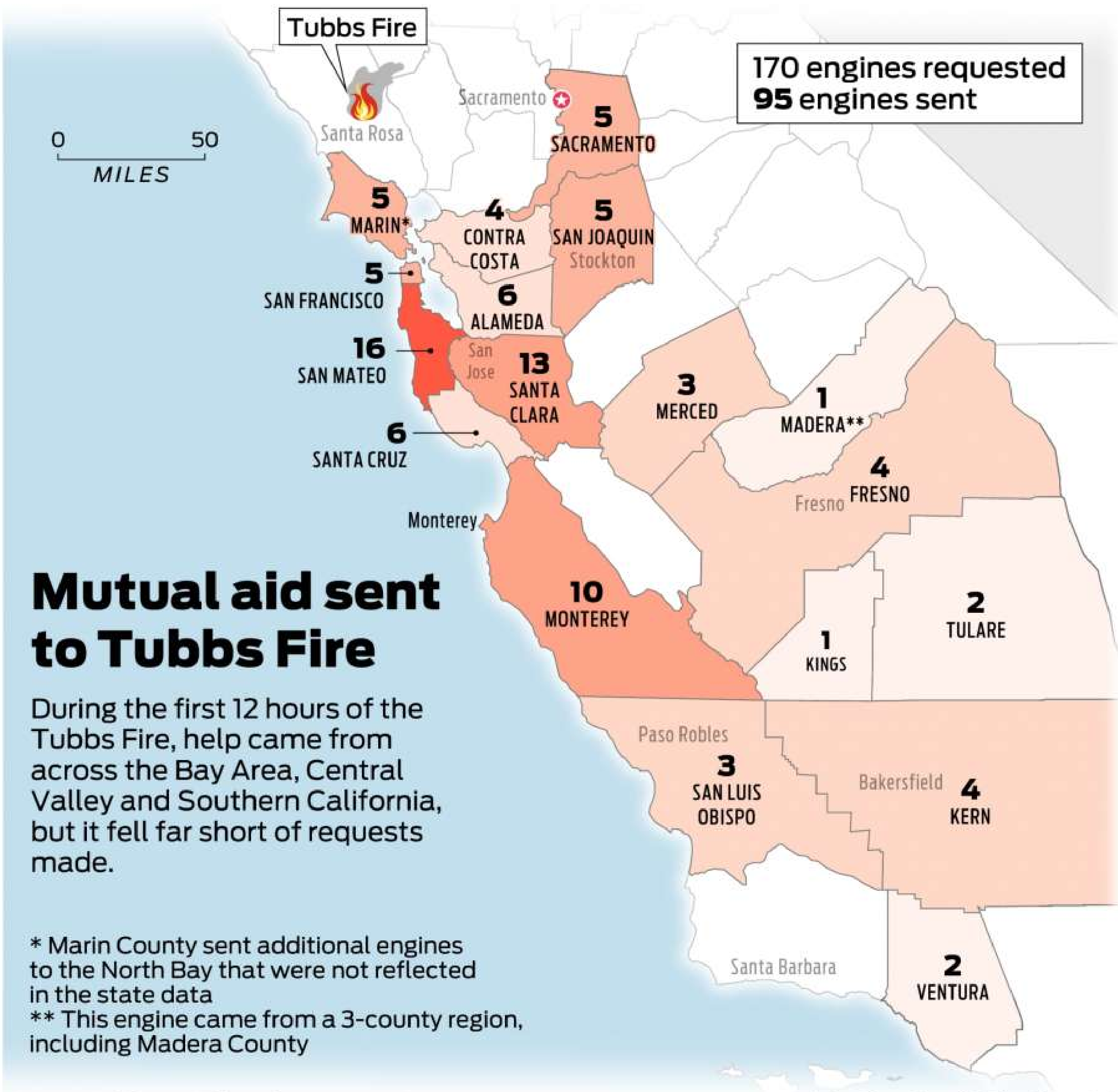
A deluge of 911 calls began Oct. 8 around 7 p.m., when a vegetation fire broke out in the middle of Santa Rosa amid a windstorm that at times carried the force of a hurricane. By 10 p.m. — after bigger blazes had ignited but before most Wine Country residents knew the region was in trouble — the hours-long struggle to get help began.

Facing a wall of flames on Atlas Peak, east of the Napa Valley’s famed Silverado Trail, Napa County Fire Chief Barry Biermann requested 50 fire engines from other jurisdictions. After descending the hill, blazing his sirens and shouting evacuation orders over his P.A. system, the chief said he called for an additional 50 engines.

The state records provided to The Chronicle show that by 5 a.m. the following day, Napa County officials had asked for a total of 135 engines from outside agencies to help fight the Atlas Fire. Only 35 were deployed in response.

The Sonoma County duty officer the night of Oct. 8, Chief Dan George of the Gold Ridge Fire Protection District near Sebastopol, said he requested 125 fire engines from around the region between 10:30 and 11 p.m. to help with the Tubbs Fire.

By early the next morning, records show that emergency managers had asked for a total of 170 mutual-aid engines for that fire. Ninety-five were sent.



Source: California Office of Emergency Services

John Blanchard / The Chronicle

Some engines were sent independently from the Office of Emergency Services mutual-aid system or through Cal Fire. And in Marin County, officials decided to send every available engine shortly after the fires ignited, which was not reflected in the state data, said Fire Safe Marin Coordinator Todd Lando.

Fire departments in San Francisco, Marin, San Mateo, Contra Costa, Alameda, Monterey, Santa Clara and Santa Cruz counties were among the first to answer the call for help, sending 65 engines to the Tubbs Fire. The remaining 30 engines came from as far away as San Luis Obispo, Kern, Tulare and Fresno counties.

The state records do not make clear exactly when engines arrived in Sonoma or Napa counties.

“I don’t remember (the region) ever being that inundated, basically having the initial request overwhelm what we had in mutual aid,” said Chief David Rocha of the Alameda County Fire Department, which handles mutual-aid requests for 16 coastal counties from Monterey to the Oregon border.

During the first days of the firestorm, many departments in the northern reaches of the state and the Sierra were dealing with their own emergencies and couldn’t help the North Bay.

Fifty-five engines were sent to help combat fires in Butte, Nevada, Yuba and Placer counties, while the Canyon 2 Fire in Orange County would later pull 64 engines from Southern California, according to officials at the Office of Emergency Services.

In one case, 10 engines driving from San Diego County to the Tubbs Fire had to be turned around to fight blazes breaking out closer to home.

“A very dynamic situation was in front of us,” said Zagaris, the state fire and rescue chief. “I think, no matter what, we’d have liked to put more engines on the ground, faster.”

Berkeley firefighter Mike Shuken was one of those who responded. He and his team began driving to the North Bay around 5 a.m. on Oct. 9. They rendezvoused in San Rafael with four engines from the San Francisco Fire Department and steered north on Highway 101 for Santa Rosa. They expected to help put out a grass fire or take over at depleted local stations.

Before they could see the destruction, they smelled acrid smoke from burning structures. San Francisco fire Capt. Pablo Siguenza, the leader of the team, navigated the firefighters to a Kmart parking lot designated as a staging area for incoming crews. But flames had already engulfed the building, and no one was there to meet them.

Photo: Leah Millis, The Chronicle

Eugene, Ore., firefighters Cameron McConnell (left), Skylar Lillingston and John Peterson work on the blaze last month near Sugarloaf Ridge State Park in the Sonoma County community of Kenwood.

By chance, Siguenza said, the team ran into a Santa Rosa crew whose members told them what radio channel local firefighters were using. The San Francisco and Berkeley engines then went looking for homes that could still be saved. When they rolled into the Coffey Park neighborhood west of the freeway, Shuken said, they found a "field on fire."

"There should have been hundreds of homes there. It was a little hard to get our heads around that," he said. "We were just going to go until we could find something we could put water on."

Siguenza said, "In my mind, I'm looking for the fire's edge. Is there a safe place to engage?"

Shuken doesn't remember seeing many other fire trucks when his crew got to town. Even by the early afternoon, he said, "there were still free-burning structures because there still weren't enough engines."

California's mutual-aid system has a prime objective: Move resources quickly into a disaster zone once local responders are taxed. Proximity is key, and calls for help

WINE COUNTRY FIRES

Some who lost homes file suits against PG&E

first go to nearby counties within a region, then firefighting agencies across California.

Every morning, fire departments report how many resources they can spare to assist other agencies, if called upon. In addition, when an emergency strikes, fire chiefs or duty officers in need will often directly call their peers in other departments, seeing what extra crews and engines they can scrounge together.

While California's system is considered the best in the country, fire officials say it is beset by challenges that are inherent to disaster management in the state, including long travel times between distant locations and difficulty filling in for firefighters from agencies that send resources.

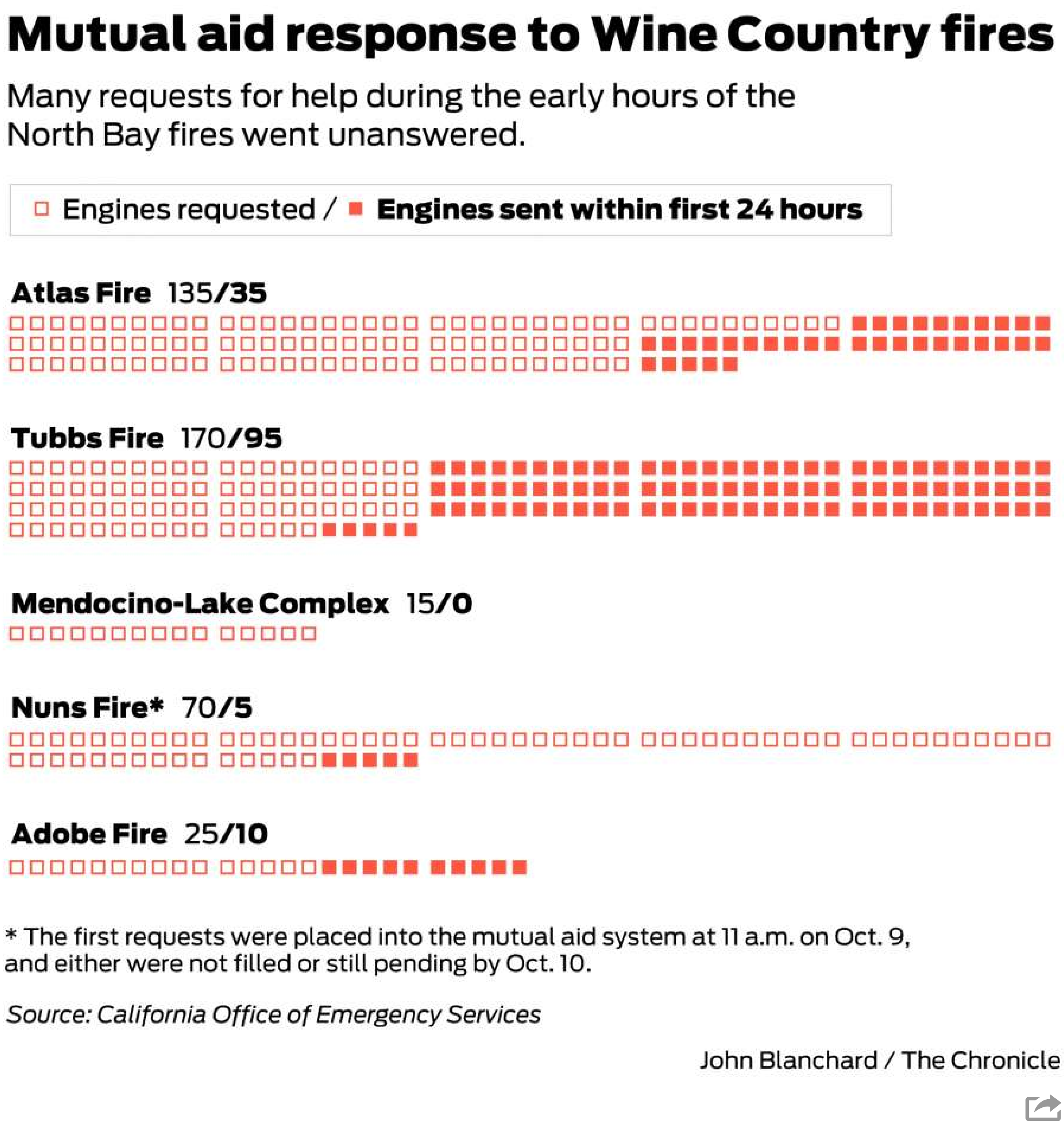
Wine Country fire victims struggle to find stability

Disputed alert system gets upgrade after Wine Country fires

A shrinking number of crews and engines because of budget cuts, paired with the greater severity of wildfires, has magnified resource gaps across the state, Zagaris said. The volume of routine calls in local jurisdictions has increased, he said, making officials in those places hesitant to help others in need.

San Francisco Fire Chief Joanne Hayes-White was criticized for sending just one engine to help Lake County authorities with 2015's Valley Fire, which killed four people and destroyed 1,955 structures. At the time, Hayes-White said the department couldn't spare any more resources, because it had six trucks at a major fire in the Sierra foothills and others were being repaired.

Last month, her department sent 12 engines to the North Bay fires. Through a spokesman, the chief declined to be interviewed.



In 2007, Zagaris said, the Office of Emergency Services could move as many as 1,150 local engines. During the peak of the October fires, roughly half that number were deployed.

Many requests for help have gone unanswered in recent years. Although officials at the Office of Emergency Services did not provide the total number of calls for aid, they said only 134 requests for fire engines or water tenders went unfilled during the 2012 fire season. That number has climbed ever since, hitting 3,029 last year.

“We are struggling,” Zagaris said. “I have fire chiefs that want to send resources, but they’ve got elected officials that don’t want them to.”

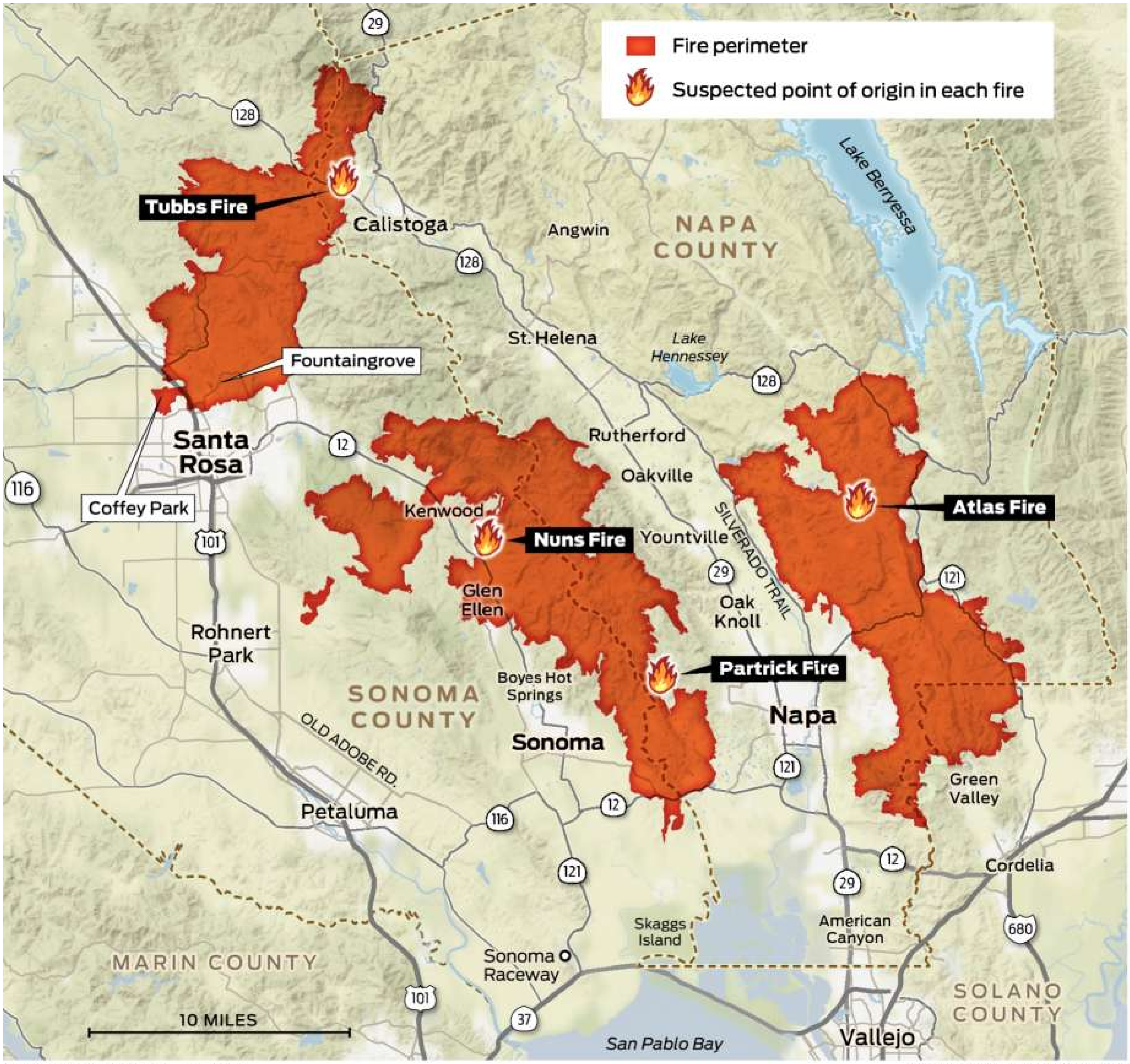
Photo: Gabrielle Lurie, The Chronicle

Dr. Stephanie Huang stands at the site of her home, which was destroyed in the Tubbs Fire in the Fountaingrove neighborhood of Santa Rosa last month.

In September, Gov. Jerry Brown approved legislation adding $25 million to the Office of Emergency Services’ budget to help pay local departments for additional staffing during times of high fire risk.

The system, though, still needs more funding, said Lou Paulson, president of the California Professional Firefighters, which represents thousands of firefighters in the state.

“Asking to send as many resources as you can out of your agency, with no commitment that someone is coming to fill your need, that will create a pressure on the system,” Paulson said. “As a fire manager or mayor or city council person, how do you sit in front of the public and make those explanations if you sent crews out and something happens in your community?”



Sources: Cal Fire, OpenStreetMap

Todd Trumbull / The Chronicle

The Wine Country fires moved with such speed that firefighters could do little to get in front of them. As a result, it's unclear whether a rush of outside assistance would have made a significant difference in halting the advance of flames across roads and freeways and into the hardest-hit neighborhoods.

But emergency managers said more aid could have contributed to the difficult effort of evacuating tens of thousands of residents — the primary mission during the first night of the fires.

In the first 18 hours, Sonoma County first responders were sent to more than 700 emergencies, said Aaron Abbott, executive director of the county's emergency dispatch center.

“If you stood in the middle of the dispatch center and listened,” Abbott said, “it sounded like you were an insect in the middle of a beehive.”

Emergency radio traffic in Sonoma County during the first hours of the crisis made clear the desire for support. A few minutes before midnight, a firefighter asked when more help would arrive, prompting an official to respond that resources were scarce, according to recordings reviewed by The Chronicle.

“We have five major fires burning in the unit,” said the official, who didn’t identify himself. “Difficulty getting staffing, so I’m throwing resources as I feel appropriate.”

Across Sonoma and Napa counties, dispatchers received calls about couples hiding from the fires in wine cellars, pools, a pond and a water storage tank. Guests were stuck in a hotel as flames scorched the building, downed trees and power lines blocked highways and escape routes, and worried relatives and friends called authorities to tell them of elderly residents who might be trapped.

Facing out-of-control blazes and a shortage of staff, fire officials gave their crews the same instructions throughout the night: Focus on rescuing people, evacuating neighborhoods and keeping yourself safe. The bulk of firefighting would come later.

Stephanie and Henry Huang, whose home in Santa Rosa’s upscale Fountaingrove neighborhood was destroyed by the Tubbs Fire, said they felt like they were on their own. As they fled their house with their two teenage sons early Oct. 9, neighbors’ homes were already on fire. County sheriff’s deputies helped them evacuate, but they didn’t see any fire trucks on the street.

“We left with nothing, just the clothes on our backs,” Henry Huang said. “Many lives were lost, and they’re lucky many more weren’t lost. Those are the repercussions of not having enough help.”

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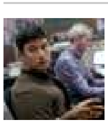
More on disaster

Giveaway: Santa Rosa neighbors help survivors. **C1**

Obituary: Marjorie Schwartz, Santa Rosa teacher. **C10**

Online: The Chronicle’s comprehensive coverage: www.sfchronicle.com/north-bay-fires



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Investigative Reporter

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East Bay Reporter

STRUCTURAL FIRE PREVENTION FIELD GUIDE

For Mitigation of Wildland Fires

CALIFORNIA DEPARTMENT of FORESTRY and FIRE PROTECTION

OFFICE OF THE STATE FIRE MARSHAL

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT

STRUCTURAL FIRE PREVENTION FIELD GUIDE

For Mitigation of Wildland Fires

April 2000

Gray Davis
Governor
State of California

Mary D. Nichols
Secretary for Resources
The Resources Agency

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Director
Department of Forestry and Fire Protection

Woody Allshouse
Acting State Fire Marshal
Department of Forestry and Fire Protection

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FOREWORD

The ***Fire Safe Guides for Residential Development in California*** have been well received and well used. However, the time has come for an update and a new title – ***Structural Fire Prevention Field Guide***. New legislation, new research data, and new technology such as geographic information systems (GIS) must all be discussed in this updated guide. Much of the experience gained has validated previous fire safe guides. In addition, CDF now has a vital "Fire Plan," and federal agencies have revised their Fire Management Policy.

The purpose of this new ***Structural Fire Prevention Field Guide*** is to facilitate implementation of state ordinances within the Urban-Wildland Interface in order to make structures safer. This Guide is intended for wide distribution to agency staff, to help homeowners, landowners, decision-makers, and local government planners learn more about factors important to land use decisions.

The Introduction of this updated Guide presents the difficulty of structure protection when accumulated fuels (due to successful fire suppression) make property damage more likely and firefighting harder. Increased numbers of structures in the wildland change firefighting strategies and often limit defensive options.

This Guide discusses the legal underpinnings of fire safe requirements, including laws and regulations covering general fire prevention and wildland fire safe regulations, recommended standards spanning entire fire and building codes, and spatial factors of lot development, infrastructure, and building construction. Guidelines for hands-on implementation of fire safe strategies through fire resistant landscaping or fuel modification are also included in this guide. A section on land use planning, particularly how fire safety can be incorporated into land use planning decisions at the general plan level, is an important portion of this guide. The section presents ways to assess hazards for land use planning decisions, with specific information on how to identify needs for increases in pre-fire management. Finally, the guide describes how to develop and implement a fire safe plan for large areas (i.e. less than a county, larger than a subdivision).

The appendices provide a useful bibliography, a glossary, statutes and regulations, legal opinions on fire safe issues, and fire resistant landscaping or fuel modification methods.

The California Department of Forestry and Fire Protection hopes this document will be well used to help enhance structure protection and minimize damage to California's abundant and precious natural resources. Users should feel free to put this material to good use by copying graphics, quote regulations, etc.

This document contains several hyperlinks to other documents and on-line sources of information about structural fire prevention and protection.

Appendix 3.2

ENVIRONMETRICS
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Probabilistic risk modeling at the wildland urban interface: the 2003 Cedar Fire

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SUMMARY

The October 2003 Cedar Fire in San Diego County was a tragedy involving 15 deaths, the burning of some 280 000 acres of land, the destruction of approximately 2227 homes, and costs of suppression near $30 million. It was the largest fire in California history. The data associated with the fire, however, do provide an opportunity to carry out probabilistic risk modeling of a wildland-urban interface (WUI) event. WUI's exist where humans and their development interface with wildland fuel. As home building expands from urban areas to nearby forest areas, these homes become more likely to burn.

Wildfires are an exceedingly complex phenomenon with uncertainty and unpredictability abounding, hence a statistical approach to gaining insight appears useful. In this research, spatial stochastic models are developed. These relate risk probabilities and losses measures to a variety of available explanatory quantities. There is a consideration of economic aspects and a discussion of the difficulties that arose in developing the data and of carrying out the analyses. Purposes of the work include highlighting a statistical method, developing variates associated with a destruction probability and employing the fitted risk probability to estimate future and possible losses. Copyright © 2008 John Wiley & Sons, Ltd.

KEY WORDS: damage; forest fires; houses; random process; risk; simulation; wildland urban interface (WUI)

1. INTRODUCTION

This paper presents a story of deriving a dataset for statistical analysis in a complex context and employing that dataset to develop wildfire risk probabilities. The concern is the destruction of a house and to estimate corresponding loses as a function of expanatories. In preparing the dataset, a variety of sources were involved. The specific concern was the destruction of houses by wildfires at the wildland urban interface (WUI). The WUI is "the place where humans and their development meet or intermix with wildland fuel," Federal Register (2004). Studying the fires at the WUI is important because the population of houses there is steadily growing as is the corresponding risk to lives. This research

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concerns the particular case of the 2003 San Diego County Cedar Fire. There are various difficulties involved in working with the data available for it. One of these is that the County is made up of two jurisdictions, the City and an unincorporated part. Sometimes the data are not available in the same form for both. Yet other data sources are needed. The data sources employed are listed in the Appendix.

The paper begins with general discussion of the Cedar Fire and then turns to modeling the probability of an existing house being destroyed as a function of various explanatories. Foremost among these are location and vegetation type at the house locations. There are important variates missing, for example, the meteorology during the fire. A productive approach to risk studies often comes from asking what is an appropriate insurance premium, P, to cover the occurrence of a damaging event. Formulas that have been proposed for P include

$$(1+\alpha)\mu_{\mathrm{L}},\ \mu_{\mathrm{L}}+\beta\sigma_{\mathrm{L}},\ \mu_{\mathrm{L}}+\gamma\sigma_{\mathrm{L}}^2,\ \alpha\mu_{\mathrm{L}}+\beta\sigma_{\mathrm{L}}+\gamma\sigma_{\mathrm{L}}^2$$

where L is the damage, μ_{L} and σ_{L} are its mean and standard deviation, and α, β, γ are weights chosen for the particular context. One sees that the expected loss $\mathrm{E}\{\mathrm{L}\}$, and a measure of its variability, for example, $\mathrm{var}\{\mathrm{L}\}$, are needed. These values will be estimated for the Cedar Fire in this work. However, because the work involves but one fire, annual premiums may not be developed from the available data. Some sort of estimate of the occurrence rate of fires is needed for that. For a discussion of premium formulas such as these, see Beard *et al.* (1984).

Difficulties arose for the destroyed properties because important explanatories, such as roofing material, were not available so the contributions of the work are limited. The explanatories employed here come from available Tax Assessor records, SanGIS (2006). These include: assessed value and size of a house and its parcel. A problem with the assessed values is that re-assessment occurs irregularly. What was done by officials during and after the fire was to estimate economic damage by assuming a cost of $150.00 per square foot. Large amounts of data were collected, but there may be disagreements in coordinate systems, scale and accuracy, as well as missing values.

The goals of the work include: providing visual displays for insight and understanding, looking for associations with various explanatory variables, trying to understand costs, modeling destruction of property, and to provide some discussion of private and social costs in general. One question is: can one obtain reasonable estimates of the probability of a house's destruction given the available explanatories? Another is: what can be said about the statistical variability of the total estimated loss?

2. THE CEDAR FIRE

There were various large wildfires raging near San Diego in the fall of 2003. Their burn scars may be seen in Figure 1. The fires developed in the forests and were driven by winds to move and destroy homes in their path. The Cedar Fire began in the Cleveland National Forest near San Diego. Initial ignition occurred when a lost hunter set off a signal flare. It landed at the point of fire origin indicated in Figure 3. The fire lasted from 25 October to 4 November 2003. It started in the unincorporated area of the county but reached part of the City of San Diego. There were 15 deaths, 6000 firefighters involved, approximately 2227 homes destroyed, 280 000 acres burnt over, and evacuations implemented.

Wind, particularly its strengths and directions, was much involved in the development and extinguishing of the Cedar Fire, Mutch (2007). So-called Santa Anna conditions were present part of the time. The fire moved exceedingly quickly at the beginning because of the winds and the presence of dead scrub. In the end, the fire had spread out in all directions. The estimated point of ignition and final

Figure 1. The burn areas for the Southern California fires as seen by satellite 5 November 2003. The Cedar Fire's perimeter, as sketched in Figures 2 and 3, may be seen in the figure from a picture in Clark *et al.* (2003).

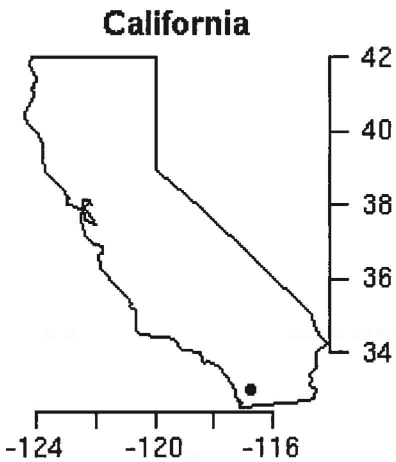

Figure 2. Map of California with the Cedar Fire point of origin indicated by the black dot.

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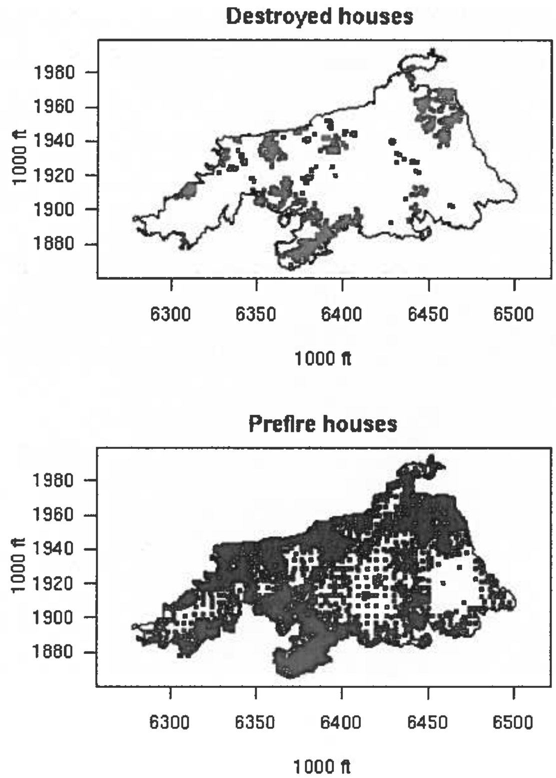

Figure 3. Top panel shows the locations of houses destroyed in red and the bottom those existing just before the fire. The black dot in the top panel is the estimated point of start of the fire.

perimeter may be seen in Figure 3. The two panels of that figure show the locations of the destroyed houses in grey/red, and of the houses existing just before the fire in black/blue. The house locations just before the fire come from the Tax Assessor records given in SanGIS (2004). The destroyed house locations come from coordinating details in an excel file provided by San Diego County with those in the Tax Assessor records. One notes clustering in both panels of the figure. The top panel also shows the estimated point of origin as a black dot. In the dataset studied, there were 2227 houses destroyed from a total of 19 560.

3. ANALYSES

3.1. Vegetation and proportions destroyed

A first analysis, provided in Figure 4, simply plots the proportion destroyed against the vegetation class in which the houses are situated. It also includes approximate 95% confidence intervals. The vegetation class comes from the SANDAG 1995 Vegetation Dataset (www.sandag.cog.ca.us). It is based on the predominant vegetation class in each of a set of polygons covering the burn area. The class names are provided in Figure 4. The horizontal dashed line in the figure is the overall proportion destroyed, 2227/19 560 = 11.39%. The figures in brackets after the named classes in the figure are the counts of the

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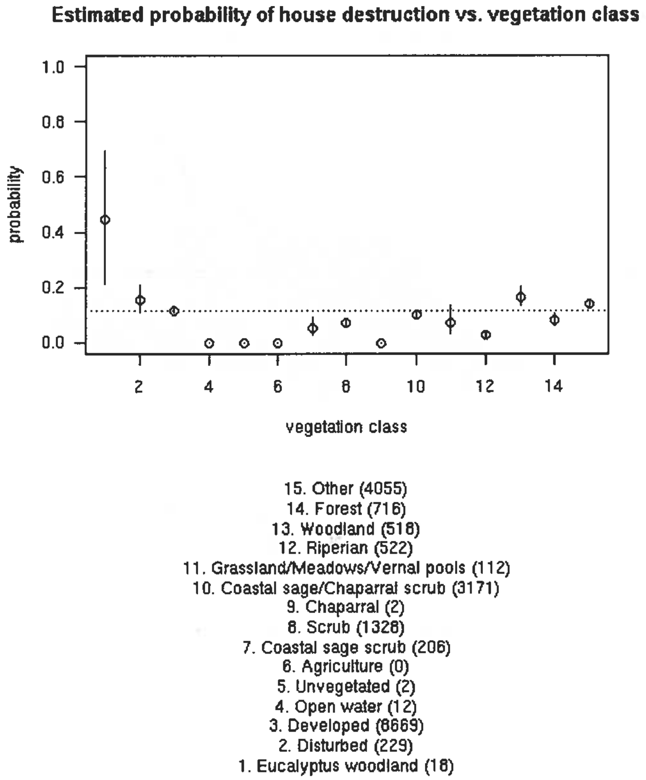

Figure 4. The top panel plots proportions destroyed with approximate 95% confidence intervals. The bottom panel lists the vegetation classes.

original houses falling in the class. One notes the claim of 12 houses in open water. This provides a warning of the errors present in the data. Incidentally, none of the open water houses were listed as destroyed in that dataset. Other classes with none destroyed are five, six, and nine. Having in mind the analyses that follow a pertinent model here is

$$\text{logit}[\text{Prob}\{\text{house destroyed}|\text{vegetation class } i\}] = \alpha_i \tag{1}$$

with i running through the vegetation classes. The proportions in the figure are then $\exp\{\hat{\alpha}\}/(1+\exp\{\hat{\alpha}\})$. Working within the same class allows the various model fits to be compared.

Continuing with this discussion, Figure 5 shows that much of the fire area was estimated as covered by coastal sage/chaparral scrub before the fire. This may be compared with the Cedar burn scar in Figure 1. It appears as if virtually all the vegetation has been burnt by the fire. This may have resulted from several years of drought in the region.

3.2. *Location and the generalized linear model*

A goal of this work is to understand the probability of destruction of a house as a function of pertinent explanatories. Vegetation has just been considered. Next is location. The vegetation classes were listed

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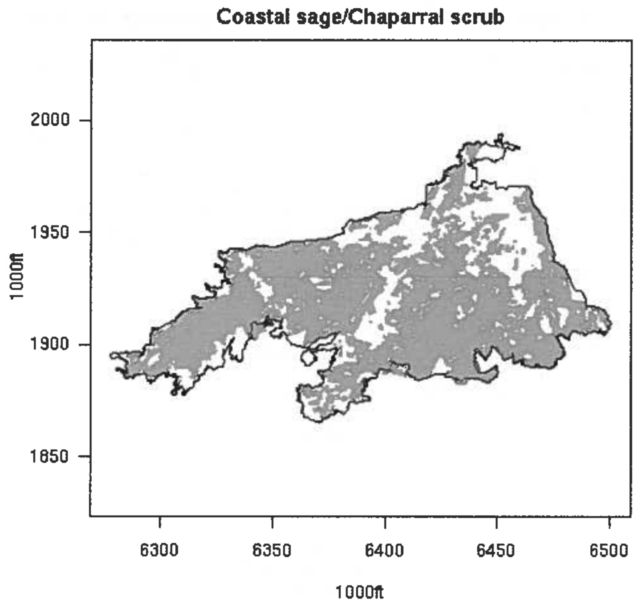

Figure 5. The region covered by coastal sage/chaparral scrub before the fire.

in Figure 4. The particular case of coastal sage/chaparral scrub is shown in Figure 5. As noted, it covers most of the fire region. In the case of location (x, y) alone, the model employed will be written,

$$\text{logit}[\text{Prob}\{\text{house destroyed}|\text{located at } (x,y)\}] = \beta(x,y) \tag{2}$$

with (x, y) location. The function β will be assumed smooth. To this end, a thinplate spline was employed, see Wahba (1990). In it, the function β is represented by

$$\beta(x,y) = \sum_{j=1}^{J} \gamma_j r_j^2 \log r_j$$

where for the nodes (x_j, y_j) the variable $r_j^2 = (x-x_j)^2 + (y-y_j)^2$. The nodes are taken on a latice. As the γ_j appear linearly, the function glm(.) of R may be employed in the analysis.

The estimated β (x, y) is displayed in Figure 6 as both an image and a contour plot.

The figure provides evidence for dependence of the probability of destruction on location. One sees a hot spot in dark green. The contour plot shows a highest level of 0.3. There are a number of destroyed houses clustered all around the boundary of the level 3 dark green region. The regions with lowest estimated chance of house destruction are shown in level 0 red. They make up about a third of the area. The smoothing has spread out the probability values.

There is always a need to assess the uncertainty of inferences and the validity of models generally. A direct way to do this is via a synthetic plot, Neyman *et al.* (1953), Brillinger (2008). In the construction of a synthetic plot, one simulates data from a fitted model and then compares these pseudo-observations to a display of the actual ones. In this present case, the fitted probabilities of Figure 6 were applied to thin out the original population of houses. This was done three independent times and Figure 7 provides the results. The upper left panel shows the actual houses destroyed. The other three panels are the

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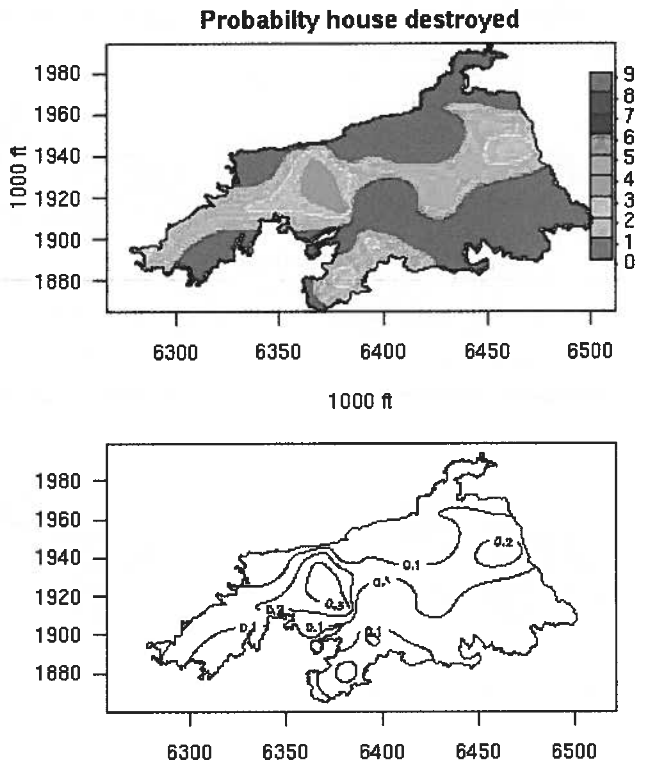

Figure 6. Estimated destruction probability as a function of location. The estimate is displayed in both perspective and contour form.

results of the independently random thinnings. The results are not unfavorable to the model. In this analysis, the only explanatory variable included in the model was location.

3.3. Other explanatories

In this section, generalized linear model analyses are carried out for the following cases of explanatories:

location and vegetation,
location and vegetation and size of parcel acreage (acres),
location and vegetation and total living area (sqft),
location and vegetation and assessor land value (\$),
location and vegetation and assessor value of improvements (\$).

The model fits all have the form

$$\text{logit}\ [\text{Prob}\{\text{house destroyed}|\text{located at}\ (x,y),\ \text{vegetation type}\ i,\ Z=z\}] = \alpha_i + \beta(x,y) + \gamma(z) \quad (3)$$

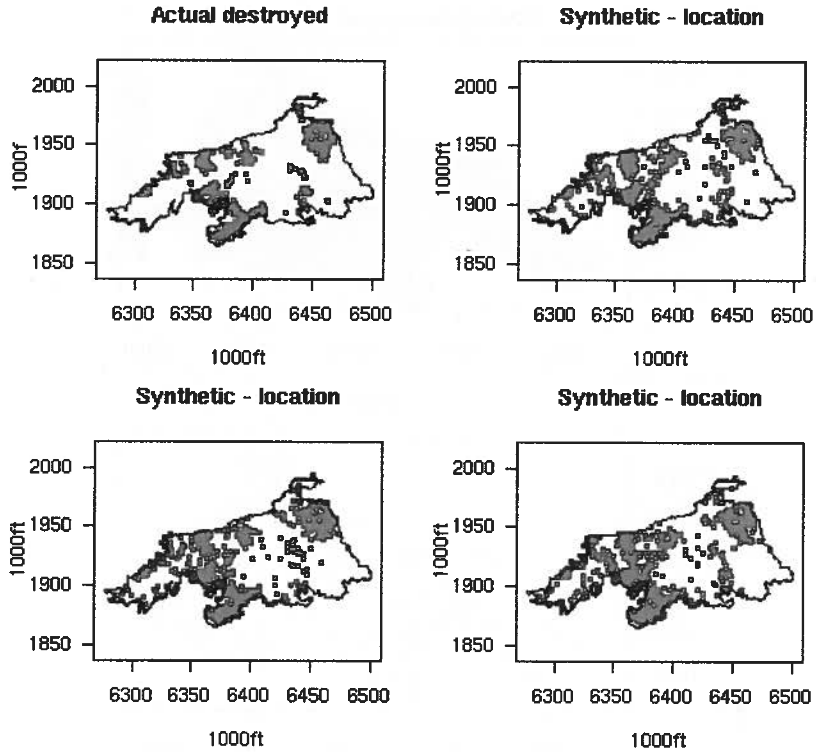

Figure 7. The locations of the original houses destroyed and three synthetic plots involving random thinnings employing the estimated probability function of Figure 6.

with i indexing vegetation type, Z a continuous and real-valued explanatory variable, and γ a smooth function. In the computations to estimate γ, Z will be taken to be a re-expression of variable values found in the assessor records. These values were taken from a SanGIS layer datasheet dated 8/18/2002, that is, about a year before the fire.

In the glm() computations, once again thinplate splines were employed in the estimation of β. In the case of the function γ, the quantity Z was taken to be the square root in the case of an area and the log10 in the case of a dollar value. The function γ was represented as a bspline. The estimates of the respective γs are given in Figure 8. The two area-based variates are given in the left column and the house-based ones in the right column. Approximately 95% marginal confidence intervals have been added in each case.

Examination of the plot of the top left panel provides evidence that the risk of destruction of a house is principally associated negatively with the increasing size of the parcel the house is located in. This is to be contrasted with the figure directly below which evidences an increase in risk with an increase in assessed value up to around \$100 000. The right column's figures do not suggest much dependence of the risk probability on the size of the house or its assessed value except in the case of the largest living areas. This last may represent a greater effort on the part of the firefighters to save such properties.

The dependence on the variables may also be studied via an analysis of the deviances obtained in the glm() fits. These are provided for the models indicated in the table below. The bracketed figures are

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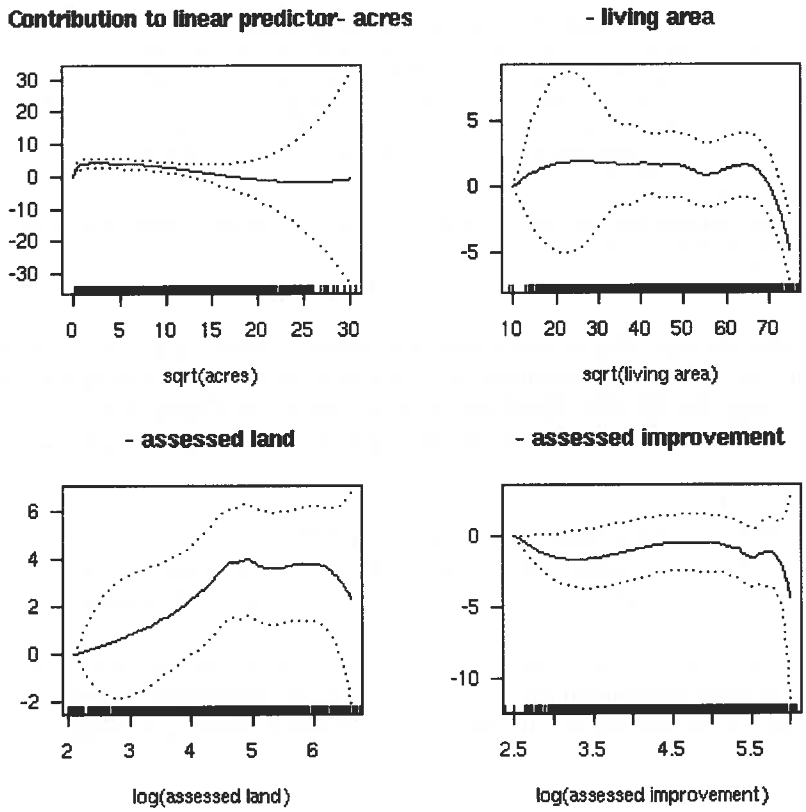

Figure 8. Estimated transforms, γ, of explanatories. The x-axis variable re-expresses the original variates by square roots and logs, respectively, in an attempt to improve the estimates.

degrees of freedom. The degrees of freedom vary because of missing values whose number changes from variate to variate.

The results for the models with explanatory vegetation, location, and both in turn are given in Table 1.

The deviance changes here are so large that it seems reasonable to include the variates vegetation and location in each of the following models and this will be done. Next the variates acres, living area, assessed land value, and assessed improvement value will be added to the model separately.

In an assessment of the remaining models, their deviance values will be considered. Working with deviances is problematic when the response is binary valued; however, we will take refuge in the

Table 1. ANODEV following model (3)

Vegetation	13 709.47 (19 546)	27 116 (19 560)
Location	12 566.96 (19 524)	27 116 (19 560)
Veg and loc	12 432.54 (19 510)	27 116 (19 560)

Second column: the final deviance.
Final column: original deviance. Bracketed numbers are degrees of freedom.

Table 2. ANODEV following model (3)

Acres	7671.4 (12 094)	7881.9 (12 104)	210.5	10	1.040e-39
Living	8102.1 (11 390)	8161.2 (11 400)	59.1	10	5.417e-09
Assessed improve	9219.9 (12 460)	9306.7 (12 470)	86.8	10	2.313e-14
Assessed land	11 515.1 (18 000)	11 985.7 (18 010)	470.6	10	8.234e-95

Second column: final deviance.
Third column: deviance with vegetation and location included. Fourth column: deviance change when indicated variable added. Fifth: degrees of freedom. Final column: χ^2 p-value.

following remarks on page 122 in McCullagh and Nelder (1989). "It is good statistical practice, however, not to rely on either D (deviance) or χ^2 (Pearson chi-squared) in these circumstances. It is much better to look for specific deviations from the model of a type that is easily understood scientifically. ... The reduction in deviance thus induced is usually well approximated by a χ^2 distribution."

The results obtained for the model (3) are shown in Table 2.

No matter which variate is added, the change in deviance is substantial. In terms of p-values, the assessed land value is the smallest. In future computations, all four of these variables will be added at the same time.

Figure 9 provides boxplots concerning the sizes of the houses in the dataset classified according to whether the house was destroyed or not. As evidenced by the interquartile ranges, the spread of the destroyed houses is somewhat larger than that of the non-destroyed houses. Also, the notches of the two

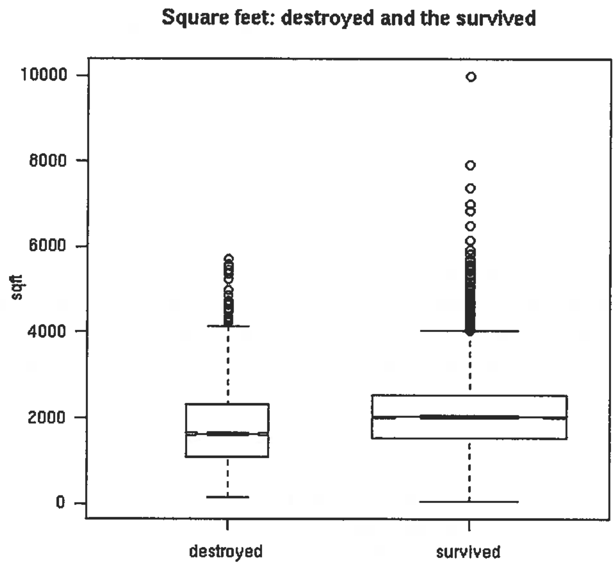

Figure 9. Squared feet destroyed and survived statistics displayed as notched box plots. The boxes' widths are proportional to the square roots of the respective number of data values.

DOI: 10.1002/env

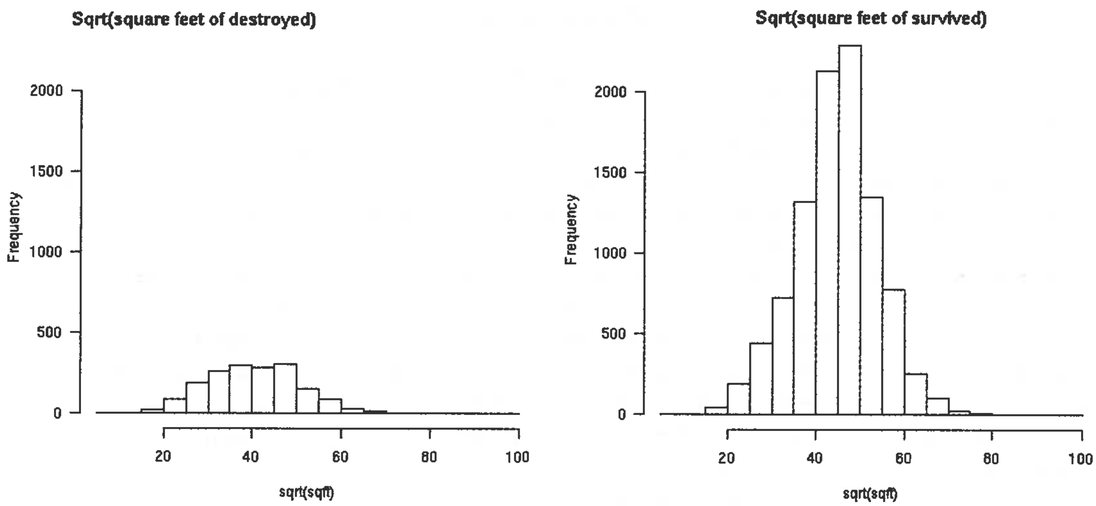

Figure 10. Histograms of the square roots of the square feet destroyed and survived.

boxes do not overlap providing evidence that the median size of the destroyed houses is smaller at the 5% level of significance.

The destroyed and survived houses may also be compared via the histograms of their square feet of living space. In preparing these, it proved more reasonable to work with the square root of the square feet. The histograms became more symmetric and took on shapes suggesting possible specific distributions for their description. The histograms appear in Figure 10.

Using the cases with available square feet in the records, there are 1757 houses destroyed and 9691 survived. The sample average and standard deviation for the destroyed houses are 1751.7 and 869.2 sqft, respectively. These are estimates of the μ_L and σ_L referred to in Section 1 as basic to the computation of premiums. One could multiply up by 150 to get 2003 dollar costs.

The fitted model may be employed to derive some interesting numbers via simulation. Suppose that one wishes to gain some appreciation of the fluctuations of the total loss, as an insurance company would. Suppose that one works with the losses in units of square feet. Considering all the houses existing before the fire, the estimated expected loss using the fitted function of Figure 4 is 3 247 666 sqft. This is obtained by summing for each house its fitted probability times its size in square feet. But now, one can generate synthetic samples and sum the sizes of those "destroyed." An insurance company would be interested in the upper percentiles of the distribution of the difference, that is, the difference between the actual loss and the expected loss. It would assist them in setting the weights α, β, γ to avoid ruin. In a run of 10 000 "fires" the 90, 95, and 99 percentiles obtained for the loss were 99 620.32, 127 095.67, and 176 793.90 sqft.

These values can be converted to 2003 costs by multiplying with $150. The assessor's assessed values were available to work with, but have not been studied because similar houses can vary widely in their assessed values depending on just when the assessments were carried out.

Similar approaches to the modeling of this section were taken in Brillinger *et al.* (2003) and Preisler *et al.* (2004). Autrey (2005) is another pertinent reference.

DOI: 10.1002/env

4. DISCUSSION

Assessing the full economic impact of wildfires on society is a very challenging task. Forests provide several non-market goods and services which are especially difficult to quantify and valuate. Wildfires tend to have many different negative effects on society ranging from immediate physical destruction to long-term health and environmental deterioration. Unfortunately, many of these effects cannot be captured by standard methods of non-market valuation, which are often based on observed prices, indirect behavior, or self-reported valuations (for a review, see, e.g., Field and Field, 2005). Consequently, many economic price-based models that assess wildfire management and economic impact typically fail to adequately account for effects on non-marketed resources such as recreation, flora and fauna, air quality, soil, water quality, or cultural heritage. Furthermore, these models require a considerable amount of information, which in many cases is unavailable. Because of these restrictions, there still exits a substantial gap in the scientific understanding of the overall social cost associated with wildfires.

In the particular case of the Cedar Fire, lack of availability of information prevented us from using standard price-based models to assess its economic effects. Alternatively, using the available information, we are able to provide a set of basic descriptive statistics and some tentative estimates of its direct economic impact. Some specific economic values were employed in the previous section, namely assessed land and assessed improvement values. As mentioned before, these calculations underestimate its overall negative effect on society, although they do provide some interesting new results.

In terms of direct economic valuation, the 2003 Cedar Fire generated over 2200 residencies destroyed alone which accounts for at least a direct estimated economic cost of $7000 million according to the information in our database. In addition to these losses, the cost of fire suppression was estimated in $32.5 million. Unfortunately, these figures do not account for the effects that the fire had on non-marketed resources and the corresponding long-run implications associated with them. Just to give an example in terms of vegetation, it is estimated a total loss of around 1/2 of the tree canopy population and 3/4 of both chaparral and shrub populations which, in turn, affected substantially the ecosystem services: retaining storm-water runoffs and removing air pollutants have an approximate estimated cost of $25 million and $1 million, respectively. These figures refer to the city of San Diego, see American Forests (2006). See also Figures 1 and 5 above, which show the near total disappearance of the green cover for the whole county.

It is important to remember that the data studied and the results have many limitations. It was noticed, for example, that some houses were classified as destroyed when they were not. There were errors in the estimated locations, both in definition and measurement. For example, there were 12 houses supposedly located in water. The limitations of deviance as a measure of fit in the case of 0-1 variables has been mentioned. There is a need to remember that these analyses are just getting at associations, for example, there may be lurking variables/proxies such as effort applied to save a building. There may be disagreements in coordinate systems, scale and accuracy, as well as missing values. Also, just one fire was studied in this research. There are other fires. There are other models. There are other known explanatories. Furthermore, there are both model and statistical uncertainties.

To properly assess the effect of the wildfire, it is important to estimate both social costs (e.g., vegetation lost or air pollution) and private costs (e.g., assets destroyed). Moreover, an appropriate analysis would account for both short-run and long-run effects. It is the case, however, that one needs really good data to proceed. This study provides but one dimension of private costs in the short run.

Figure 8 above depicted the role of different explanatory variables available to include in the model. These were plot size in acres, size of the living area in square feet, assessed land value, and assessed house improvement value. It is interesting to note that while the size of the living area and the assessed

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house improvement value do not appear to be important in explaining the likelihood of the house being destroyed, the other two explanatory variables (plot size in acres and assessed land value) exhibit a considerable nonconstant, nonlinear effect on the probability of destruction. In particular, the statistical results suggest that (i) the larger the parcel size, the lower the probability of the house being destroyed, and (ii) the greater value of the land, up to a possible threshold, the greater the likelihood of destruction. These findings may have important implications in terms of risk premia and risk profiles since, for instance, houses located in larger plots should have lower risk premia. The second finding suggests an interesting risk profile namely houses located on lands relatively inexpensive (approximately less than \$100 000) have an increasing risk profile, while houses located on more valuable geographical areas have a flatter risk profile.

5. CONCLUSION

This has been each of a blue collar statistics study, a data analysis, and statistical model building. It is a work in progress, but some things have been learned. These include that: a generalized linear model provides a unified approach, it makes sense to work with square feet to deal with changing construction costs, one can estimate basic risk probabilities and limits of losses, and one can simply involve GIS files in an analysis using the *R* statistical package.

An attempt is made to assess the economic impact of the Cedar wildfire by employing a simple, often used, measure of house value namely its square feet. This was converted into dollars via a multiplier of \$150 in the official statements and reports at the time of the fire. Using the square feet, a one-dimensional quantification of the economic effect of the Cedar Fire was obtained. Further, using the results of the statistical model we also discuss the role of some observed characteristics of the houses affected, allowed us to examine the relative importance of these characteristics.

ACKNOWLEDGEMENTS

There were many people who helped in the assembly of the dataset and direction of research for this study. They include: A. Ager (USFS), J. Batchelor (SD County), J. Benoit (USFS), L. Campbell (Tierrasanta), M. Diaz (SD Foundation), F. Fujioka (USFS), D. Gilmore (SD County), P. Godden (SanGIS), A. Gonzalez-Caban (USFS), C. Hunter (Rancho Santa Fe), R. Lovett (UCB), J. Lyon (Poway), D. Martell (U of Toronto), R. Martin (SD County), H. Preisler (USFS), M. Rose (Tierrasanta), D. Sapsis (State of California), P. Spector (UCB), M-H. Tsou (SDSU), T. Westerling (UCM), C. Westling (SD County), K. Wright (USFS). This work was supported by grants NSF DMS-0504162 and DMS-0707157.

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6. APPENDIX

The sources of the data will now be recorded.

Much of the data came from the SanGIS CD, "San Diego Firestorm 2003." That CD included the Tax Assessor Records for 8/12/2002 for the entire county, that is, before the 2003 Cedar Fire. Which in turn included the Assessor Parcel Number (APN) and the locations of the houses.

The data on the destroyed houses in the unincoprorated part of the county came from the County of San Diego office. For the houses destroyed in the City, specifically Tierrasanta, Scripps, and Poway, use was made of the web and telephoning. The destroyed houses could then be matched up with the Tax Assessor's records to obtain additional details of use in the analyses.

Appendix 3.3

General Guidelines for Creating Defensible Space

State Board of Forestry and Fire Protection (BOF)
California Department of Forestry and Fire Protection

Adopted by BOF on February 8, 2006
Approved by Office of Administrative Law on May 8th, 2006

Contents

A. Purpose of Guidelines

Effective defensible space

Recent changes to Public Resources Code (PRC) 4291 expand the defensible space clearance requirement maintained around buildings and structures from 30 feet to a distance of 100 feet. These guidelines are intended to provide property owners with examples of fuel modification measures that can be used to create an area around buildings or structures to create defensible space. A defensible space perimeter around buildings and structures provide firefighters a working environment that allows them to protect buildings and structures from encroaching wildfires as well as minimizing the chance that a structure fire will escape to the surrounding wildland. These guidelines apply to any person who owns, leases, controls, operates, or maintains a building or structure in, upon, or adjoining any mountainous area, forest-covered lands, brush-covered lands, grass-covered lands, or any land that is covered with flammable material, and located within a State Responsibility Area.

The vegetation surrounding a building or structure is fuel for a fire. Even the building or structure itself is considered fuel. Research and experience have shown that fuel reduction around a building or structure increases the probability of it surviving a wildfire. Good defensible space allows firefighters to protect and save buildings or structures safely without facing unacceptable risk to their lives. Fuel reduction through vegetation management is the key to creating good defensible space.

Terrain, climate conditions and vegetation interact to affect fire behavior and fuel reduction standards. The diversity of California's geography also influences fire behavior and fuel reduction standards as well. While fuel reduction standards will vary throughout the State, there are some common practices that guide fuel modification treatments to ensure creation of adequate defensible space:

- Properties with greater fire hazards will require more clearing. Clearing requirements will be greater for those lands with steeper terrain, larger and denser fuels, fuels that are highly volatile, and in locations subject to frequent fires.

- Creation of defensible space through vegetation management usually means reducing the amount of fuel around the building or structure, providing separation between fuels, and or reshaping retained fuels by trimming. Defensible space can be created removing dead vegetation, separating fuels, and pruning lower limbs.

- In all cases, fuel reduction means arranging the tree, shrubs and other fuels sources in a way that makes it difficult for fire to transfer from one fuel source to another. It does not mean cutting down all trees and shrubs, or creating a bare ring of earth across the property.

- A homeowner's clearing responsibility is limited to 100 feet away from his or her building or structure or to the property line, which ever is less, and limited to their land. While individual property owners are not required to clear beyond 100 feet, groups of property owners are encouraged to extend clearances beyond the 100 foot requirement in order to create community-wide defensible spaces.

- Homeowners who do fuel reduction activities that remove or dispose of vegetation are required to comply with all federal, state or local environmental protection laws and obtain permits when necessary. Environmental protection laws include, but are not limited to, threatened and endangered species, water quality, air quality, and cultural/archeological resources. For example, trees removed for fuel reduction that are used for commercial purposes require permits from the

California Department of Forestry and Fire Protection. Also, many counties and towns require tree removal permits when cutting trees over a specified size. Contact your local resource or planning agency officials to ensure compliance.

The methods used to manage fuel can be important in the safe creation of defensible space. Care should be taken with the use of equipment when creating your defensible space zone. Internal combustion engines must have an approved spark arresters and metal cutting blades (lawn mowers or weed trimmers) should be used with caution to prevent starting fires during periods of high fire danger. A metal blade striking a rock can create a spark and start a fire, a common cause of fires during summertime.

Vegetation removal can also cause soil disturbance, soil erosion, regrowth of new vegetation, and introduce non-native invasive plants. Always keep soil disturbance to a minimum, especially on steep slopes. Erosion control techniques such as minimizing use of heavy equipment, avoiding stream or gully crossings, using mobile equipment during dry conditions, and covering exposed disturbed soil areas will help reduce soil erosion and plant regrowth.

Areas near water (riparian areas), such as streams or ponds, are a particular concern for protection of water quality. To help protect water quality in riparian areas, avoid removing vegetation associated with water, avoid using heavy equipment, and do not clear vegetation to bare mineral soil.

B. Definitions

Defensible space: The area within the perimeter of a parcel where basic wildfire protection practices are implemented, providing the key point of defense from an approaching wildfire or escaping structure fire. The area is characterized by the establishment and maintenance of emergency vehicle access, emergency water reserves, street names and building identification, and fuel modification measures.

Aerial fuels: All live and dead vegetation in the forest canopy or above surface fuels, including tree branches, twigs and cones, snags, moss, and high brush. Examples include trees and large bushes.

Building or structure: Any structure used for support or shelter of any use or occupancy.

Flammable and combustible vegetation: Fuel as defined in these guidelines.

Fuel Vegetative material, live or dead, which is combustible during normal summer weather. For the purposes of these guidelines, it does not include fences, decks, woodpiles, trash, etc.

Homeowner: Any person who owns, leases, controls, operates, or maintains a building or structure in, upon, or adjoining any mountainous area, forest-covered lands, brush-covered lands, grass-covered lands, or any land that is covered with flammable material, and located within a State Responsibility Area.

Ladder Fuels: Fuels that can carry a fire vertically between or within a fuel type.

Reduced Fuel Zone: The area that extends out from 30 to 100 feet away from the building or structure (or to the property line, whichever is nearer to the building or structure).

Surface fuels: Loose surface litter on the soil surface, normally consisting of fallen leaves or needles, twigs, bark, cones, and small branches that have not yet decayed enough to lose their identity; also grasses, forbs, low and medium shrubs, tree seedlings, heavier branches and downed logs.

C. Fuel Treatment Guidelines

The following fuel treatment guidelines comply with the requirements of 14 CCR 1299 and PRC 4291. **All persons using these guidelines to comply with CCR 1299 and PRC 4291 shall implement General Guidelines 1., 2., 3., and either 4a or 4b., as described below.**

<u>General Guidelines:</u>

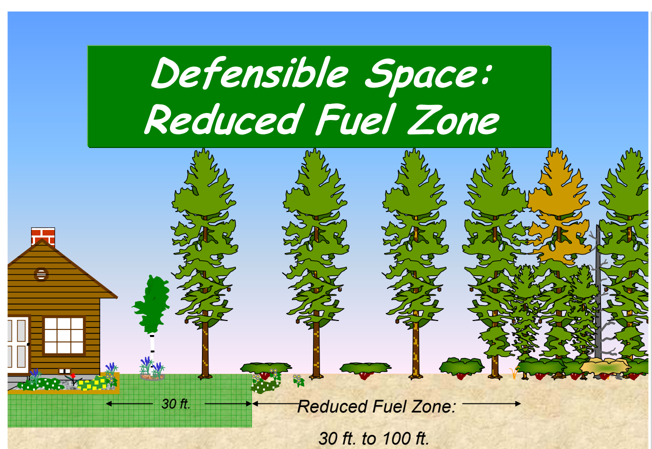
1. Maintain a firebreak by removing and clearing away all flammable vegetation and other combustible growth within 30 feet of each building or structure, with certain exceptions pursuant to PRC §4291(a). Single specimens of trees or other vegetation may be retained provided they are well-spaced, well-pruned, and create a condition that avoids spread of fire to other vegetation or to a building or structure.

2. Dead and dying woody surface fuels and aerial fuels within the Reduced Fuel Zone shall be removed. Loose surface litter, normally consisting of fallen leaves or needles, twigs, bark, cones, and small branches, shall be permitted to a depth of 3 inches. This guideline is primarily intended to eliminate trees, bushes, shrubs and surface debris that are completely dead or with substantial amounts of dead branches or leaves/needles that would readily burn.

3. Down logs or stumps anywhere within 100 feet from the building or structure, when embedded in the soil, may be retained when isolated from other vegetation. Occasional (approximately one per acre) standing dead trees (snags) that are well-space from other vegetation and which will not fall on buildings or structures or on roadways/driveways may be retained.

4. Within the Reduced Fuel Zone, one of the following fuel treatments (4a. or 4b.) shall be implemented. Properties with greater fire hazards will require greater clearing treatments. Combinations of the methods may be acceptable under §1299(c) as long as the intent of these guidelines is met.

4a. Reduced Fuel Zone: Fuel Separation



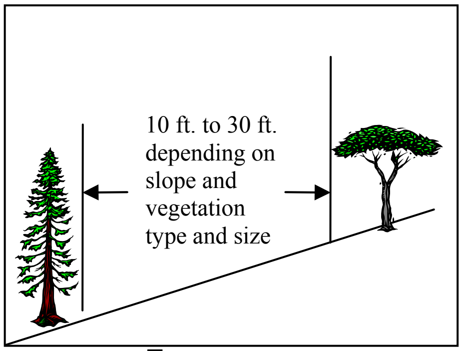
In conjunction with General Guidelines 1., 2., and 3., above, minimum clearance between fuels surrounding each building or structure will range from 4 feet to 40 feet in all directions, both horizontally and vertically.

Clearance distances between vegetation will depend on the slope, vegetation size, vegetation type (brush, grass, trees), and other fuel characteristics (fuel compaction, chemical content etc.). Properties with greater fire hazards will require greater separation between fuels. For example, properties on steep slopes having large sized vegetation will require greater spacing between individual trees and bushes (see Plant Spacing Guidelines and Case Examples below). Groups of vegetation (numerous plants growing together less than 10 feet in total foliage width) may be treated as a single plant. For example, three individual manzanita plants growing together with a total foliage width of eight feet can be "grouped" and considered as one plant and spaced according to the Plant Spacing Guidelines in this document.

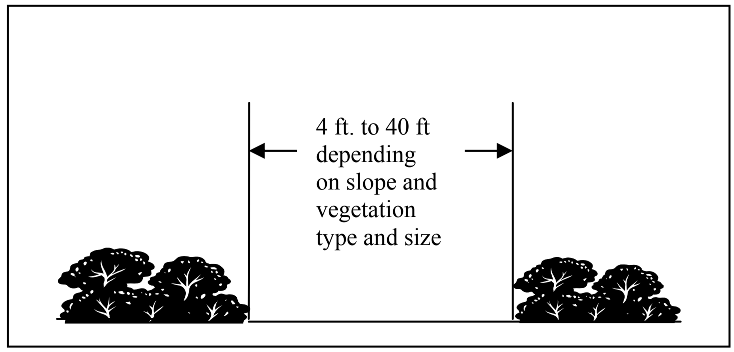
Grass generally should not exceed 4 inches in height. However, homeowners may keep grass and other forbs less than 18 inches in height above the ground when these grasses are isolated from other fuels or where necessary to stabilize the soil and prevent erosion.

Clearance requirements include:

- Horizontal clearance between aerial fuels, such as the outside edge of the tree crowns or high brush. Horizontal clearance helps stop the spread of fire from one fuel to the next.



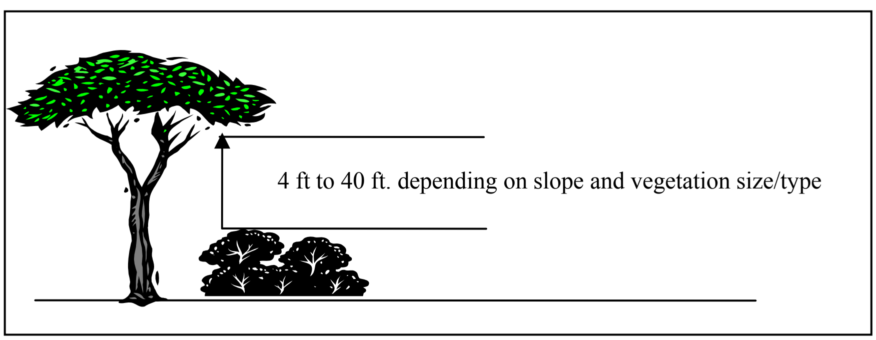
Trees



Shrubs

Horizontal clearance between aerial fuels

- Vertical clearance between lower limbs of aerial fuels and the nearest surface fuels and grass/weeds. Vertical clearance removes *ladder fuels* and helps prevent a fire from moving from the shorter fuels to the taller fuels.



Vertical clearance between aerial fuels

Effective vertical and horizontal fuel separation
<u>Photo Courtesy Plumas Fire Safe Council.</u>

Plant Spacing Guidelines Guidelines are designed to break the continuity of fuels and be used as a "rule of thumb" for achieving compliance with Regulation 14 CCR 1299.		
Trees	**Minimum horizontal space from edge of one tree canopy to the edge of the next**	
	Slope	Spacing
	0% to 20 %	10 feet
	20% to 40%	20 feet
	Greater than 40%	30 feet
Shrubs	**Minimum horizontal space between edges of shrub**	
	Slope	Spacing
	0% to 20 %	2 times the height of the shrub
	20% to 40%	4 times the height of the shrub
	Greater than 40%	6 times the height of the shrub
Vertical Space	**Minimum vertical space between top of shrub and bottom of lower tree branches:** 3 times the height of the shrub	

Adapted from: Gilmer, M. 1994. California Wildfire Landscaping

Case Example of Fuel Separation: Sierra Nevada conifer forests

Conifer forests intermixed with rural housing present a hazardous fire situation. Dense vegetation, long fire seasons, and ample ignition sources related to human access and lightning, makes this home vulnerable to wildfires. This home is located on gentle slopes (less than 20%), and is surrounded by large mature tree overstory and intermixed small to medium size brush (three to four feet in height).

Application of the guideline under 4a. would result in horizontal spacing between large tree branches of 10 feet; removal of many of the smaller trees to create vertical space between large trees and smaller trees and horizontal spacing between brush of six to eight feet (calculated by using 2 times the height of brush).

Case Example of Fuel Separation: Southern California chaparral

Mature, dense and continuous chaparral brush fields on steep slopes found in Southern California represents one of the most hazardous fuel situations in the United States. Chaparral grows in an unbroken sea of dense vegetation creating a fuel-rich path which spreads fire rapidly. Chaparral shrubs burn hot and produce tall flames. From the flames come burning embers which can ignite homes and plants. (Gilmer, 1994). All these factors results in a setting where aggressive defensible space clearing requirements are necessary.

Steep slopes (greater than 40%) and tall, old brush (greater than 7 feet tall), need significant modification. These settings require aggressive clearing to create defensible space, and would require maximum spacing. Application of the guidelines would result in 42 feet horizontal spacing (calculated as 6 times the height of the brush) between retained groups of chaparral.

Case Example of Fuel Separation: Oak Woodlands

Oak woodlands, the combination of oak trees and other hardwood tree species with a continuous grass ground cover, are found on more than 10 million acres in California. Wildfire in this setting is very common, with fire behavior dominated by rapid spread through burning grass.

Given a setting of moderate slopes (between 20% and 40%), wide spacing between trees, and continuous dense grass, treatment of the grass is the primary fuel reduction concern. Property owners using these guidelines would cut grass to a maximum 4 inches in height, remove the clippings, and consider creating 20 feet spacing between trees.

4b. Reduced Fuel Zone: Defensible Space with Continuous Tree Canopy

To achieve defensible space while retaining a stand of larger trees with a continuous tree canopy apply the following treatments:

- Generally, remove all surface fuels greater than 4 inches in height. Single specimens of trees or other vegetation may be retained provided they are well-spaced, well-pruned, and create a condition that avoids spread of fire to other vegetation or to a building or structure.

- Remove lower limbs of trees ("prune") to at least 6 feet up to 15 feet (or the lower 1/3 branches for small trees). Properties with greater fire hazards, such as steeper slopes or more severe fire danger, will require pruning heights in the upper end of this range.

Defensible Space retaining continuous trees

Photo Courtesv Plumas Fire Safe Council.

Defensible space with continuous tree canopy by clearing understory and pruning

Authority cited: Section 4102, 4291, 4125-4128.5, Public Resource Code. Reference: 4291, Public Resource Code; 14 CCR 1299 (d).

Appendix 3.4

NIST Special Publication 1198

Summary of Workshop on Structure Ignition in Wildland-Urban Interface (WUI) Fires

Sponsored by ASTM International E05 Committee

Samuel L. Manzello
Fire Research Division
Engineering Laboratory

Stephen L. Quarles
Insurance Institute for Business & Home Safety
Richburg, SC
This publication is available free of charge
from: http://dx.doi.org/10.6028/NIST.SP.1198

September 2015

U.S. Department of Commerce
Penny Pritzker, Secretary

National Institute of Standards and Technology
Willie May, Under Secretary of Commerce for Standards and Technology and Director

Table of contents

1. Introduction
1.1 Workshop Objectives

A workshop entitled *Structure Ignition in Wildland-Urban Interface (WUI) Fires* was held on June 18-19, 2015 in Anaheim, CA. The workshop was sponsored by ASTM International Committee E05, and was under the direction of Dr. Samuel L. Manzello of the Fire Research Division, part of the National Institute of Standards and Technology's (NIST) Engineering Laboratory, and Dr. Stephen L. Quarles of the Insurance Institute for Business & Home Safety (IBHS).

Wildfires that spread into communities, commonly referred to as WUI fires, are a significant problem in Australia, Europe, and the United States. WUI fire spread is extraordinarily challenging and presents an emerging problem in fire safety science. While it is accepted that WUI fires are an important societal problem, little understanding exists on how to contain and mitigate the hazard associated with such fires.

From a simple point of view, the WUI fire problem can be seen as a structure ignition problem. Some building codes and standards already exist to guide construction of new structures in areas known to be prone to WUI fires in order to reduce the risk of structural ignition. These codes and standards have been developed based on best information at the time they were developed. Often this information was anecdotal.

This workshop has formally begun the discussion: *based on current research, are these current codes and standards adequate*? Proven, scientifically based retrofitting strategies are required for homes, and other buildings, located in areas prone to such fires.

The presentations of the workshop were separated into four topic areas: post-fire studies, structure ignition/firebrand accumulation and generation studies, WUI modeling, and evaluation of mitigation strategies.

This report is organized into specific sections with appendices. Specifically, Section 1.2 is the oral presentation schedule, Section 1.3 is participant listing, and there is an appendix that contains the oral presentations delivered at the workshop (Appendix 1).

<u>Dedication</u>
This workshop was dedicated to the memory of Dr. Robert Hawthorne White, a staff scientist at the US Department of Agriculture, Forest Service, Forest Products Laboratory, for 39 years. Dr. White made significant contributions to fire safety science and ASTM in particular. A slide highlighting his career was provided at the workshop and is also found in Appendix 1.

1.2 Program of Workshop

June 18 ,2015

1:00 pm	***Introduction to Workshop*** ***Dr. Samuel L. Manzello, Co-Chair, Engineering Laboratory, NIST, USA***
	Plenary Lecture **Session Chair Dr. Stephen L. Quarles (IBHS)**
1:10 pm	***Are Existing Building and Fire Codes Providing Adequate Protection for Communities Exposed to Wildland-Urban Interface Fires - An Overview of Existing Wildland-Urban Interface Fire Codes*** ***Mr. Nelson Bryner, Engineering Laboratory, NIST, USA***
	Regular Session **Session Chair Dr. Stephen L. Quarles (IBHS)**
2:30 pm	***Review of Pathways to Fire Spread in the Wildland Urban Interface*** ***Michael J. Gollner, Raquel Hakes, Sara Caton and Kyle Kohler, Department of Fire Protection, Engineering, University of Maryland, College Park, MD, USA***
3:00 pm	**Break**
3:30 pm	***Role of Event-Based Data in Wildland-Urban Interface Fire Mitigation – Limitations of Incident-based Data*** ***Nelson Bryner and Alexander Maranghides, Fire Research Division, National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA***
4:00 pm	***EcoSmart Fire as Structure Ignition Model in WUI: Predictions and Validations*** ***Mark A. Dietenberger and Charles R. Boardman, USDA Forest Products Laboratory, Madison, WI, USA***
4:30 pm	***Firebrand Generation and Impact on Wooden Constructions in the Wildland-Urban Interface*** ***Kamila Kempna, Mohamad El Houssami, Eric Mueller, Jan C. Thomas, Rory Hadden, and Albert Simeoni, Fire Safety Engineering Department, University of Edinburgh, Edinburgh, UK***
5:00 pm	**Adjourn**

June 19, 2015

	Session Chair Dr. Samuel L. Manzello (NIST)
8:00 am	*Upgrading Heritage Buildings to Resist Exterior Fire Exposure by Sympathetic Means and a Method to Assess Aggregate Envelope Performance* *Geir Jensen, Tobias Jarnskjold, Thomas Haavi, COWI AS, Trondheim, Norway*
8:30 am	*Fire Hazard in Camping Park Areas* *Miguel Almeida, Luís Mário Ribeiro and Domingos Viegas, Center for Forest Fire Research ADAI – LAETA, Coimbra, Portugal; José Raul Azinheira, Alexandra Moutinho, João Caldas Pinto, IDMEC/CSI – LAETA, Universidade de Lisboa, Lisbon, Portugal; Jorge Barata, Kouamana Bousson and Jorge Silva, AEROG – LAETA, Universidade da Beira Interior, Covilhã, Portugal; Marta Martins, INEGI – LAETA, Instituto de Engenharia Mecânica e Gestão Industrial, Porto, Portugal; and Rita Ervilha and José Carlos Pereira, IDMEC/LASEF – LAETA, Universidade de Lisboa, Lisbon, Portugal*
9:00 am	*Firebrand Production from Building Components with Siding Treatments Applied* *Sayaka Suzuki, National Research Institute for Fire and Disaster (NRIFD), Chofu, Tokyo, Japan; and Samuel L. Manzello, National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA*
9:30 am	*Accumulation Patterns of Wind-blown Embers around Buildings* *Stephen L. Quarles and Murray J. Morrison, Insurance Institute for Business & Home Safety (IBHS), Richburg, SC USA*
10:00 am	Break
10:30am	*Fire Performance of Exterior Wood Decks in Wildland-Urban Interface* *Laura E. Hasburgh and Samuel L. Zelinka, US Forest Products Laboratory, Madison, Wisconsin USA; and Donald S. Stone, Materials Science and Engineering, University of Wisconsin, Madison, Wisconsin USA*
11:00 am	*Spot Fire Ignition of Natural Fuel Beds of Different Characteristics by Hot Aluminum Particles* *James L. Urban, Casey D. Zak and Carlos Fernandez-Pello, Department of Mechanical Engineering, University of California Berkeley, Berkeley, CA USA*

11:30 am	***Experimental Investigation on Building Component Ignition by Mulch Beds Ignited by Firebrand Showers*** ***Samuel L. Manzello, Fire Research Division, National Institute of Standards and Technology (NIST), Gaithersburg, MD, USA; Sayaka Suzuki, National Research Institute of Fire and Disaster (NRIFD), Chofu, Tokyo, Japan; and Daisaku Nii, Building Research Institute (BRI), Tsukuba, Ibaraki, Japan***	
12:00 pm	**End of Workshop**	

1.3 Participant Listing

LAST_NAME	FIRST_NAME	AFFILIATION
Alfawakhiri	Farid	American Iron & Steel Institute
Alfrey	Robert	Not Provided
Almeida	Miguel	ADAI (Portugal)
Alvares	Norman	Suite 431
Anderson	Erik	Koffel Associates
Badders	Barry	Intertek Testing Services, NA, Inc.
Banks	Eric	BASF Corporation
Barajas	Miguel	Not Provided
Beaton	Michael	Intertek Testing Services NA, Inc.
Bokkes	Southern	Riverside County Fire
Bovard	Timothy	Pittsburgh Corning Corporation
Bragg	Tammy	Not Provided
Brewer	Sarah	Unifrax I LLC
Brooks	Robert	Rob Brooks & Associates
Bueche	David	Hoover Treated Wood Products
Bundy	Matthew	NIST
Cerda	Oscar	Not Provided
Chulahwat	Akshat	Colorado State University (CSU)
Craft	Steven	CHM Fire Consultants Ltd
Dean	Aaron	Orange County
Delos Reyes	Kathleen	Los Angeles County Fire Department
Dietenberger	Mark	USDA Forest Products Laboratory
Fernandez-Pello	Carlos	University of California Berkley
Fletcher	Karen	Riverside County Fire
Frater	George	Canadian Steel Construction Council
Gales	John	Carleton University
Gann	Richard	NIST
Gebhart	Richard	Owens Corning
Gollner	Michael	University of Maryland
Hadden	Rory	University of Edinburgh
Hasburgh	Laura	USDA Forest Products Laboratory
Hasegawa	Harry	Firequest
Hathorn	Stan	Royal Mouldings
Hendricks	William	Safer Building Solutions

Hirschler	Marcelo	GBH International
Janssens	Marc	Southwest Research Institute
Jarnskjold	Nils M Tobias	NTNU
Jensen	Geir	Securo As
Johnston	David	Vinyl Siding Institute
Jourdain	Charles	California Redwood Association
Jumper	Alan	LP Building Products
Kane	Daniel	Not Provided
Kearns	Lyn	Not Provided
Keating	Jay	IKO Industries
Keltner	Ned	Fires Inc
Ladwig	Richard	PABCO Building Products, LLC
Manzello	Samuel	NIST
Mathes	Dennis	Lomanco, Inc
Merrick	Paul	Louisiana-Pacific Corporation
Morel	Sid	Not Provided
Murrell	Janet	Warrington Fire Research
Oaks	Don	Not Provided
Onodera	Gina	CertainTeed
Palumbo	Christopher	HPVA Laboratories
Patashnik	Oren	Not Provided
Pazera	Marcin	Not Provided
Pepper	Freddie	Riverside County Fire
Phillips	Aaron	Tamko Building Products Inc
Pickett	Brent	Western Fire Center Inc.
Quarles	Stephen	Insurance Institute for Business & Home Safety
Samuels	Matthew	USG Corp
Scoville	Christopher	Trex Company Inc.
Shinkoda	Pamela	CGC Inc.
Shipp	Paul	USG Corporation
Simontacchi	John	Firefree Coatings, Inc
Sloan	Dwayne	Underwriters Laboratories Inc
Stacy	Howard	Priest & Associates Consulting LLC
Stansberry	Herbert	Intertek
Suzuki	Sayaka	NRIFD (Japan)
Swanson	Rex	Louisiana-Pacific Corp
Traw	Jon	Traw Associates Consulting
Trevino	Javier	Priest Associates Consulting, LLC
Urban	James	University of California Berkeley
Van Zeeland	Ineke	Canadian Wood Council

Vargas	Melissa	LA County Fire Department
Wangel	Robert	Koppers Peformance Chemicals
Wessel	Robert	Gypsum Association
Woychak	Ronald	Firewise 2000, Inc.
Yang	Jiann	NIST
Yeh	Borjen	Apa-The Engineered Wood Assn
Zhou	Aixi	UNC Charlotte
Zicherman	Joe	Berkeley Engineering and Research

Appendix 3.5

Authors note:

On line sources of WUI Slope treatments and Defensible space are listed with links below:

The table and figure are from 2015 International Wildland-Urban Interface Code, Chapter 6 page 25. The link to ICC IWUIC is https://codes.iccsafe.org/public/document/toc/556/ . You can view the code for free or purchase a copy from the same website.

The Australian Bushfire Code, Construction of Buildings in Bushfire-Prone Areas, AS 3959, includes several additional figures with different slope configurations and multiple tables on separation distances. The Bushfire code website is http://www.as3959.com.au/

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CURRICULUM VITAE

JOSEPH B. ZICHERMAN, Ph.D.[1]

Summary:

Dr. Zicherman is a scientist specializing in fire dynamics, the fire performance of materials and systems and selected problem areas relating to polymers, paper and wood.

The emphasis in his work has been on the performance of complex systems such as buildings and their environments, and rail transportation vehicles and combustible furnishings and components. His work interests include causes and the growth and spread of fires as well as the performance of materials and sub-systems and systems as part of such projects. Fire related codes and standards are also an area of his specialization.

His clients include research organizations, government agencies, manufacturing companies and trade associations. Another significant focus of Dr. Zicherman's work includes investigative work related to retrospective analysis of fire related phenomena.

Academic Background:

Ph.D. - University of California, Berkeley, CA (1978)

Major: Wood Science and Technology

Minor: Polymeric Materials/Fire Performance of Materials

MS. - North Carolina State University, (1970)

Major: Wood and Paper Science

Minors: Polymeric Materials/Experimental Statistics

1 Update May 13, 2015

Berkeley Engineering And Research Inc. 808 Gilman Street, Berkeley, CA 94710 Tel 510-549-3300 Fax 510-962-8230

BS. - SUNY College of Forestry (1967)

Major: Wood Products Engineering

Professional Experience:

May 2015 – present: Senior Fire Science Consultant – Berkeley Engineering and Research

1977 – 2015 Founder and Senior Fire Science Consultant - Fire Cause Analysis.

Areas of Dr. Zicherman's expertise include fire science and fire investigation, polymers and paper technology (including aging, coatings and adhesives) with an emphasis on polymer based building products, construction technology and rail passenger vehicle fire performance and Wildland/urban interface fire problems.

January, 1981-March 1981; January, 1983- June, 1986: University of California, Berkeley. College of Natural Resources, Forest Products Laboratory. Lecturer (1/81-3/81 and 1/83-3/83) in Wood Physics. Invited position teaching the graduate course in Wood Physics. Also, Associate Research Wood Technologist dealing with building products technology and the fire performance of wood.

1979-1982: Assistant Research Engineer; U.C. Berkeley, College of Engineering, Civil Engineering Dept., Fire Test Facility. Research position involving fire performance evaluation and research in products and building technology.

1973-1978: Assistant Specialist for coatings and adhesives technology U.C. Berkeley -Forest Products Laboratory. Basic and applied research in whole and composite wood products and polymers.

1970-1973: Chemist and Section Head-D. P. Joyce Coatings and Resins Research Center, Glidden Coatings and Resins Group, Division SCM Corp., Strongsville, Ohio. Assignments dealt with manufactured housing, coatings systems including radiation cured and 100% solids finishing systems for a variety of substrates. Section head of the powder coatings group with responsibility for both basic and developmental research in that area. Designed and supervised pilot manufacturing operations and specifications for production facility. Interfaced with equipment and raw materials suppliers as well as customers and licensees. Traveled in Europe doing technology assessment in polymers, coatings and plastics areas.

1967-1970: Research Assistant-North Carolina State University: Conducted research under Forest Service Grant award for activities related to wood coatings and ash content.

Significant Activities:

Recipient - with co-authors - of Journal of Failure Analysis and Prevention 2011 "Best Paper Award" for paper entitled Failure Analysis and Prevention of Fires and Explosions with Plastic Gasoline Containers (Volume 11, Page 455-465)

Conducted System-wide Fire Safety Assessment update for the SCRRA Metrolink System. Consistent with 49.CFR238, FCA systematically reviewed fire safety requirements and associated performance of the Southern California Commuter Railroad for the period 2001 to 2011.

Project Manager – 2009-2011 – Project: Predicting Fire, Heat and Smoke Release Rates of Railcars for the SFMTA Central Subway Project – Client AECOM for San Francisco MTA

Developed "Southern California Wildland Urban Interface Data Set" under contract to the US Department of Commerce NIST Building and Fire Research Lab under Grant No. 60ANB7D6151.

Created Fire Management Plans and Vegetation Management Plans for projects in Southern California Wildland and Wildland Urban Interface Areas for the Long Beach School District (Student Camp in the San Gabriel Mountains) and the Chandler School in Pasadena.

Addressing passenger Rail fire safety issues including conducting Fire Safety Analyses of both powered and un-powered rail passenger vehicles. Vehicle fire safety analyses, as well as analyses of maintenance and operating buildings for fire safety. including Recent work includes peer reviews of a new self powered LRV design for Austin, Texas as well as analyses of the anticipated fire performance of a transit station design in East Los Angeles requested by regulators.

Principal Investigator for the office of the California State Fire Marshal conducting an evaluation of proposed technologies to mitigate urban/wildland interface fire problems. This project resulted in two reports and a presentation to GAO panel at National Academy of Sciences, Washington D.C., in August 2004 on Urban/Wildlife Fire problems. The reports resulting from these activities are available at the following:

- Technical Rpt: http://osfm.fire.ca.gov/pdf/regulations/UWIRpt1-ALL091004.pdf
- Cost Benefit Study: http://osfm.fire.ca.gov/pdf/regulations/UWIC-BRpt091004.pdf
-

Consultant to the State of Rhode Island District Attorney task group charged with the investigation of the fire incident at "The Station" nightclub in Warwick RI. Provided testimony to the Statewide Grand Jury investigating the incident - 2005.

Co-Author: "Origin and Cause of Fire," 2008. In **Scientific Evidence in California Criminal Cases,** Ch 12, pp. 505 - 590, Published by the California Bar Association – Continuing Education for the Bar (CEB), Oakland, Ca.

Co-author: text section on Post Fire Analysis ["Failure Analysis and Analytical Tools"] in the "Users Manual for NFPA 921 published jointly by the NFPA and the IAAI - 2003 & 2007 editions

Member - Participant – NFPA Research Foundation Phase I and II programs on Sub-lethal Exposure to Fire Smoke. Program addressed ISO initiatives related to "Fire Threat to People and the Environment"

Co-author in HUD funded project "Fire Performance of Archaic Building Materials." Developed a rating system implemented in all of the model US building codes, by Federal agencies and included in various NFPA codes to assess the anticipated fire performance of existing building materials in the field – originally completed 1982; Managed revision and updating program – 1999 under contract to the National Institute of Building Sciences [NIBS], Washington, D.C.

Editor and Contributing Author – Council on Tall Buildings in Urban Habitats (Lehigh University) High Rise Fire Safety Monograph - 1992

Fire-safety contributor to preparation of "Building Safety Assessment Guidebook" and "Building Safety Enhancement Guidebook" by the Council on Tall Buildings in Urban Habitat of Lehigh University. The workbook format of these documents was developed to assist high rise building owners and managers in assessing fire safety levels at their properties following the 9/11 World Trade Center incident - 2001-2002. Presented to the National AIA Meeting, San Diego, Cal – Nov. 2003

Participation in the FRA funded program "Experimental application of fire hazard analysis for US Passenger Train Systems" as Peer Review Committee member and consultant to the Center for Fire Research, NIST – 1996-2000

Consultant to the Volpe Center, US-DOT, Cambridge, Mass. on matters related to fire safety of rail passenger vehicles for the Federal Railway Administration.

Participation in investigations/forensic evaluations of high rise fires including those at the MGM Grand Hotel - Las Vegas, The First Interstate Bank Building fire - Los Angeles, The Cathedral Hill Hotel Fire - San Francisco, the Dupont Plaza Hotel Fire - San Juan Puerto Rico, the One Meridian Plaza fire, Philadelphia.

Activities related to wild land/ urban interface fire problems including acting as a consultant to the City of Oakland conducting post fire assessments following the Oakland

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Hills conflagration. Significant work in this technical area has also included co-authorship of a report for the East Bay Regional Park District on wild land/urban interface fire mitigation and work on other wild land fires in Southern California and the Rocky mountains.

Development projects related to exterior durable fire retardants for wood and wild land substrates.

Initial development with the 3M Corporation Technical Ceramics Group of AUTO CAD capable Product selection software systems for use in fire protection features design and specification for construction.

Participation in investigations/forensic evaluations of major industrial facility fires including those at the Stapleton Airport fuel facility - Denver, CO, Mountain Cold Storage - Tacoma, WA., Brewster Heights packing facility, Brewster WA., Dole Foods Facility, Yuma, AZ., Japanese National Telescope Facility, Mauna Kea, HI., Safeway Facility, Richmond, CA., major smoke detector malfunction case, Davenport, IA; KFX Synfuel facility – Gillette Wy., Rombauer Winery Fire, Calisotga, Ca., Tri-City Foods Fire, Washington .

Participation in maritime and aircraft related fires including the DTB - 40 fire Honolulu and the Ricky Nelson Plane Crash., discharge by oxygen cylinders in transit-Continental Airlines/Federal Express

Design Consultant addressing insulation system configuration and materials utilized at the Keck Observatory, Mauna Kea, HI. Client: joint UC Berkeley/Cal Tech design team.

Principal investigator [1995 through 2009] - Post Earthquake Fire Investigation Program - Sponsor – FEMA as grantor to the Natural Hazards Research Center, University of Colorado, Boulder, CO.

Chairman of ASTM E.5 Subcommittee E.5.17 [1996 thru 2002] addressing fire test standard development for transportation applications. During tenure was responsible for the successful development of a state of the art Fire Hazard Assessment Methodology for Rail Transportation Vehicles [ASTM E-2061–03] as part of ASTM Committee work approved by ASTM E.05 Main Committee in December 1999.

Task group chairman charged with evaluation of the enlargement of scope of the vehicles section of the NFPA 130 [rail passenger and fixed Guideway vehicle] Standard to encompass intercity and commuter rail vehicles in conjunction with the American Public Transit Association and the Federal Railway Administration.

Authorship of guides and manuals reviewed by the model code agencies developed to detail safe means to install plastic pipe, tube and conduit in fire rated construction for trade associations and corporate clients in industry.

Continuing member of International Code Council as well as member and participant in BCMC and ICBO East Bay Chapter working groups that developed the initial building code language governing the installation of plastic pipe tube and conduit in the 1980's.

Dispute resolution contribution related to combustibility issue to the Los Angeles Metro Blue Line Light Rail Project vehicles. Also work on "Combustible Contents" Issues related to the LAMTA Green Line – 1996-1999.

Development of techniques for the application of Rate of Heat Release technology for rail passenger projects in San Juan, PR and Los Angeles, Ca. and Emeryville, CA.

Development of techniques for the application of Rate of Heat Release technology for building applications including atrium applications consistent with requirements of the Uniform Fire Code including the Chiron Headquarters in Emeryville, Ca.

Consultant to US Consumer Products Safety Commission for subjects relating to Omega O-ring sprinkler design issues – 2001.

Principal Investigator – US DOT-FRA mandated Fire Hazard Assessments prepared for commuter rail systems in Chicago, Los Angeles and San Francisco – 2001.

Principal Investigator – US DOT-FRA mandated Fire Hazard Assessments prepared for builders of rail passenger vehicles including commuter cars and engines for push-pull applications – 2001-2003

Project Manager – Conducted Performance Based Hazard Assessment [on a Pro-Bono basis] for the University of California NCAA Champion Intercollegiate Rowing Program to address concerns associated with construction of a new boat house in a remote area – 2002 [*Go Cal Bears!!!!!!*].

Service To Professional Societies-Technical Community/Memberships:

University of California (Berkeley), Forest Products Laboratory –Technical Advisory Board; member from 1999-2004, Chairman 2000-2001.

United States Consumer Products Safety Commission – SGE (special government employee) dealing on voluntary basis with problems involving fire safety and consumer products at the request of the CPSC technical staff 1992 thru 1996 focusing on furniture related flammability issues. Consultant to CPSC on recall issues regarding problems with o-ring based sprinkler systems 2000-2001.

Editor & Co-Chairman of Committee 8A--Fire; Council on Tall Buildings and Urban Habitat, Lehigh University, Bethlehem, PA – thru 1992

Society of Fire Protection Engineers (SFPE) - Member

Underwriter's Labs – Member - Standards Technical Panel. Fire Tests of Pneumatic Tubing and Plastic Sprinkler Pipe for Flame and Smoke Characteristics, STP 1820

American Society for Testing Materials (ASTM)

Committee E-05-Fire Test Standards – Member at large – Executive Committee;

Member Subcommittees and associated task groups as listed below:

5.22 Surface Burning
5.11-Fire Retention
5.22.02 Mounting Methods for the Steiner Tunnel Test
5.14 External Fire Experiments
5.15 Furnishings and Contents
5.17 Transportation (Former Chairperson thru 2002)
5.44/5.33 Fire Safety Equipment
5.41 International Standards for Fire Ignition and Growth
5.42 Fire Containment
5.43 Fire Threat to people and the Environment
5.91 Planning and review

Committee E-06-Performance of Buildings.

Member Subcommittees and associated task groups as listed below:

6.21 Sprayed on Fire Protective Materials (.01 TG)
6.77 High Rise External Evacuation Devices

Committee ASTM-F15 Consumer Products.

Member Subcommittees and associated task groups as listed below:

F15.10 Studies for Flammable Liquid Containers

Committee ASTM-F8-Sports Equipment and Facilities

American Academy of Forensic Sciences – Member through 2000

American Public Transit Association – Passenger Rail Equipment Safety Standards (APTA-PRESS) System Safety Committee participant.

American Society of Heating, Refrigerating and Air-Conditioning Engineers, (ASHRAE) - Associate Member, since 2004-2008.

Journal of the International Association of Arson Investigators - Editorial Board Member, reviewer, contributor

National Fire Protection Association - General Member

Member of NFPA- 130 Committee on Rail Rapid Transit Fire Safety Issues

Task Group Member - NFPA Fire Test Committee - degrees of combustibility.

Member – Research Advisory Council on Post Fire Analysis of the National Fire Protection Association Research Foundation 2000-2002.

National Institute of Building Sciences (former member)

Consultative Council Member

Insulation Task Force

Common Building Code Format Committee

National Institute of Standards and Technology (NIST) - Center For Fire Research/Building

and Fire Research Laboratory -

Member of Peer Review Committee Study Group related to Fire Safety

Regulations of Passenger Trains - FRA sponsored group (1995-1996)

International Code Council (ICC) – Professional Member

International Conference of Building Officials (ICBO) – Professional Member and

Member -Fire and Life Safety and Fire Risk Assessment

Committees Advisory Panels (1982-1991)

Building Officials & Code Administrators Int'l Inc. (BOCA)- Member

Southern Building Code Congress International (SBCCI)- Member

Board for the Coordination of the Model Codes (BCMC)

Member-Task Group on Non-Combustibility and Degrees of Combustibility (and associated groups)-current-Task Group and Thru Penetrations and Fire Stopping - 1982-86

International Association of Plumbing & Mechanical Officials (IAPMO) - Member

Society of Plastics Engineers (SPE) – Member (1980-2000)

Forest Products Society - Trustee, Northern California Section - 1982-1986 and 1998-2002; member through 2002.

Society For Wood Science and Technology – Member through 2002.

Sigma Xi – Scientific Honorary – 1978-2000

East Bay Regional Park District - Member - Fire Prevention Committee

International Association of Arson Investigators - Member

California Conference of Arson Investigators – Member

<u>Grant And Publication Reviewer:</u>

United States Dept. of Agriculture Competitive Grants Program - grant reviewer

Journal of Fire & Materials - reviewer

Fire Technology - reviewer

NFPA Fire Journal – reviewer

Journal of the International Association of Arson Investigators - Editorial board member and reviewer

Forest Products Journal - reviewer

Journal of Coatings Technology - reviewer

Wood and Fiber Science - reviewer

USDA Forest Products Laboratory, University of Wisconsin - grant reviewer

Chemical Engineering Magazine - reviewer

Publications, Reports:

Failure Analysis and Prevention of Fires and Explosions with Plastic Gasoline Containers, 2011. Journal of Failure Analysis and Prevention: Volume 11, Issue 5 (2011), Page 455-465. Co-authors - Glen Stevick, David Rondinone, and Allan Sagle.

“Portable Plastic Gasoline Container Explosions and Their Prevention” **Society of Forensic Engineers and Scientists,** 2010, with Glen Stevick, David Rondinone, and Allan Sagle. <http://www.forensic-society.org/whitepapers.html>

“SFPE Classic Review Papers(s): Fire performance under Full-scale Test Conditions – A State Transition Model and Coupling Deterministic and Stochastic Modeling to Unwanted Fire.” by Robert Brady Williamson, 2009. J. Fire Protection Engineering.

“Development of a UWI Data Set and Its Uses.” 2009, with Ben S. Autry. Proceedings: Fire and Materials Conference, PP. 181, San Francisco, Calif.

Final Report: Southern California Urban/Wildland Interface Dataset (SCUWI): Scoping and Resolution Study. 2008, Ben S. Autry, co-author. Prepared for the NIST Building and Fire Research Lab; Funding - Cooperative Agreement 60ANB7D6151

“Origin and Cause of Fire,” 2008. In **Scientific Evidence in California Criminal Cases,** Ch 12, pp. 505 - 590, Published by the California Bar Association – Continuing Education for the Bar (CEB), Oakland, Ca.

“Clark County and RJA – Say it isn’t so!” 2008. Letter to the Editor, NFPA Journal, Vol. 102, No. 4., pp 8. July/August.

“Forensic Evaluation of Textile Flammability.” 2009, with M.M. Hirschler and P.Y. Umino. Fire and Materials, 33:345-264.

“Is Pyrolysis Dead?” 2006, with Peter Lynch., Fire & Arson Investigator. Vol. 56, No. 3.

“Is there a time bomb in the sofa?” 2005. Co- author Robin Foster. Trial: Journal of the Association of Trial Lawyers of America. Vol. 41, No. 12.

“Fire at the Urban Wildland Interface: Performance of California Homes.” September 04. California Department of Forestry and Fire Protection.

"Fire at the Urban Wildland Interface; Cost Benefit Evaluation." September 2004. California Department of Forestry and Fire Protection.

"Plastic Pipe and Fire Safety", 2004. Fire Protection Engineering, Spring Vol. 22. Society of Fire Protection Engineers, Washington, D.C.

"Unconventional Emergency Evacuation Measures and Procedures" 2003. NFPA Journal, November/December.

"Plastic Pipe and Fire Safety", 2003. PM Engineers, October 2003. Troy, MI.

"Fire Performance of Foam Plastic Building Insulations", 2003, Journal of Architectural Engineering, September 2003.

"Fire Performance of Electrical Insulating Materials Used in Fluorescent Lighting Fixtures", 2003. Journal of the Int'l Assoc of Arson Investigators. Vol. 53 No 3. (Also published in CCAI's "The Fire-Arson Investigator Newsletter", August 2004.

"Tall Building Fire Safety–Post 9/11", 2003. CTBUA Review, Jan-March 2003, Council on Tall Buildings in an Urban Habitat.

"Polymer Products in Rail and Bus Applications" 2003. In Proceedings - Fire & Materials 2003, PP 259. San Francisco, CA.

"*Building Safety Assessment Guidebook*" and "*Building Safety Enhancement Guidebook,*" [contributor], 2002. Post 9/11 workbooks developed by the Council on Tall Buildings in Urban Habitat, CTBUH, Lehigh University, Lehigh, Pa.

Technical Note: The Fire Performance of Electrical Insulating Materials Used in Fluorescent Lighting Fixtures. Fire and Materials, 25, 209-213, 2001.

Assistance Needed on Sprinkler Project [relating to Central Sprinkler Company glass bulb sprinkler head performance], 2001. Letter to the Editor – Fire and Arson Investigator, 51(4) pp 6-7. With F. Hsu. (Note: Same letter appeared in the July 2001 issue of "Fire-Arson Investigator", published by the California Conference of Arson Investigators).

Paper: Permanence, 2001.(in) Encyclopedia of Materials: Science and Technology, F.C. Beal Editor, PP 6678-6682, Elsevier Press, London, England. With R.A. Kundrot

Contributions to Final Environmental Impact Report for CPVC Pipe Use in Potable Water Piping in Residential Buildings, 1998. California Department of Housing and Community Development, State Clearinghouse Number: 970820040. See Section 5. "Hazards in Fire", pp. 69. [see also State of California Expanded use of Plastic Pipe EIR – Appendix I of HCD-227

Recommendations for Revising the Fire Safety Performance Requirements in Federal Railway Administration Notice of Proposed Rulemaking (NPRM) for Passenger Equipment, September 23, 1997. Prepared for the Volpe National Transportation systems Center, USDOT, 9.98.

Application of Heat Release Technology to the Design of Rail Rapid Transit Vehicles, June, 1998. In Proceedings – Fire Risk and Hazard Assessment Research Application Symposium, National Fire Protection Research Foundation, SF, Cal.

"Finish Ratings of Gypsum Wallboards", 1998. Fire Technology, V. 34, No.4 (pp356).

Guest Editorial, 1997. Jour Int'l Association of Arson Investigators. V. 48, No. 2 (pp 6).

Letter to the Editor, Re: Combustion Toxicity data Interpretation, Fire & Materials, Vol. 16. (1993).

"Fire Safety of PVC Raceways and The Model Building Codes", Carlon Electrical Products, Cleveland, Ohio, First Edition, 1992, second edition, 1993.

"Fire Performance of Fire-Retardant Wood Fiberboard Ceiling Tile", 1992 - Fire & Materials, Vol 16 (Co-authored by D. Allard, Ph.D.)

"PC-based Product-selection Systems to Enhance Fire Safety in Construction", Fire and Materials, Vol. 16, 53-60, 1992.

"Is PVC Piping Firesafe?", Building Standards. September-October, 1992. PP. 12-17.

Editor, "Fire Safety in Tall Buildings", 1992. McGraw-Hill, Inc, NYC, NY.

Forum - Issues in Science and Technology, Volume VIII Number 2, Winter 1991-92. "National programs in science and technology".

"Enhancement of Fire Safety in Buildings: Microcomputer Systems for Selecting and Specifying Products". in proc. of Sixteenth International Conference on Fire Safety, Millbrae, CA, January 17, 1991. By Joseph Zicherman, David Frey and Lon Katz, IFT; Richard Licht, Kristen Jensen and Tony Schommer, 3M Company.

"Plastic Pipe in Fire Resistive Construction", The Plastic Pipe and Fittings Association, Glen Ellen, Illinois, first edition, 1985, second edition, 1991.

"Performance of Plastic Plumbing and Electrical Products in Fire Resistive Assemblies", 1992. In Fire Hazard and Fire Risk Assessment, ASTM STP 1150, PP 66-83. Presented at the ASTM Symposium on Fire Hazard and Fire Risk Assessment. San Antonio, TX, December 3, 1990.

"Fire Initiation Propensities of City of Sacramento Compost Materials Used in

Landfill Operations". Prepared for City of Sacramento Department of Public Works Solid Waste Division. December 3, 1990.

"Is PVC Piping Firesafe?", 1990. NFPA Fire Journal, Nov/Dec, 1990 (Vol 84, No. 6).

"Engineering Report on Fire Resistive Floor-ceiling Assemblies with Carlon Tubing and Conduit", 4/90. Submitted to the National Evaluation Service of CABO on behalf of Carlon, Cleveland, Ohio.

"Fire and Wood" - 1989; in: Concise Encyclopedia of Wood & Wood - Based Materials, Editor - Arno P. Schniewind, Pergamon Press, New York.

"Compartment Tests of Polyurethane Foam Seating Assemblies", December 1989-Fire and Arson Investigator (Vol 40, #2) (Co-Authored by D. Allard, Ph.D.)

"When to Call the Scientific Expert". The Function of Experts in Fire/Failure Related Cases-Newsletter of Trial Techniques Committee, Tort and Insurance Practice Section, American Bar Association - Winter, 1988.

Book review: "Plywood & Adhesive Technology" by Terry Seller, Jr. - 1987. Wood and Fiber Science, Jan. 1988 (Vol. 20, No.1).

"Fire Performance of Plastic Pipe, Tube and Conduit" - In Proceedings: Fire Retardant Chemicals Association Fall Conference, "Fire Safety Progress in Regulations, Technology and New Products." October 18-21, 1987, Monterey, CA.

"Compartment Tests of Polyurethane Foam Seating Assemblies", May 1988 - Fire Technology. (Vol. 24, No. 2) (Co-authored by D. Allard, Ph.D.)

"Wood and Fire", 1986; in: ENCYCLOPEDIA OF MATERIALS SCIENCE AND ENGINEERING, M.G. Bever, editor-in-chief, Pergamon Press, New York, (Pages 5377-5382).

"Are Less Sensitive Detectors Available?", 1986. Fire Journal, (8,5 [11]) - Letter To The Editor.

PLASTIC PIPE IN FIRE RESISTIVE CONSTRUCTION, 1st Edition, 1985. Installation manual prepared for the Plastic Pipe and Fittings Association, Glen Ellyn, IL. (2nd edition 1990.)

UNIFORM CODE FOR BUILDING CONSERVATION, 1985. Guideline U.C.B.C. -2 - Fire Ratings of Archaic Building materials, ICBO, Whittier, CA.

CODE FOR EXISTING BUILDINGS, 1984 (1st Ed'n). BOCA Int'l, Country Club Hills, Ill. (Includes "A Guideline for Assessing the Fire Performance of Archaic Building Materials" cited above.)

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Presentations:

"Investigating Fires Aboard Passenger and Freight Trains and Railroad Rights of Way." 4/2011, with Dennis Field. Presentation to Wildland Fire Litigation Conference, San Diego, California.

"Development of a UWI Data Set and Its Uses." 2009, with Ben S. Autry. Presentation to the Fire and Materials Conference, San Francisco, Calif."Forensic Evaluation of Fabric

Flammability." 2006, with M.M. Hirschler and P.Y. Umino. Presentation to the 17th Annual Conference on Fire Retardants, Stamford, Connecticut, 3/06.

Presentation to GAO panel at National Academy of Sciences, Washington D.C., in August 2004 on Urban/Wildlife Fire problems.

Presentation to the Technical Compliance Unit of New York City's Department of Buildings, June 24, 2004 on Plastic Pipe, Fire Safety and the International Building Code.

Experimental study of materials exposed to electrical resistance heating as a potential cause of fire, January 2001. Fire and Materials 2001 Conference, San Francisco. With Kevin Brown and Frank Hsu.

Update on Codes, Standards and Regulations Affecting Fire Performance of Passenger Rail Vehicles, May, 2000. Rail Transportation Section Meeting, NPFA Annual Session, Denver, CO.

Use of Heat Release Information in the Design and Regulation of Rail Passenger Vehicles, December, 1999. ASTM E.05 Research Review, New Orleans, La.

Plastic Pipe in Fire Resistive Construction, Sept 1999. Continuing Education presentation to the International Code Consortium membership meeting St. Louis Mo.

Fire Risk Assessment for Rail Passenger Vehicles, Oct 1999. APTA-Press (American Public Transit Assoc.–Passenger Rail Equipment Standards) Meeting, Wilmington, DE.

Application of Heat Release Technology to the Design of Rail Rapid Transit Vehicles, June, 1997. Fire Risk and Hazard Assessment Research Application Symposium, National Fire Protection Research Foundation, SF, Cal.

"Research on the Use of Polymer Foam Insulation in Construction". Soc. of Fire Protection Engineers (SFPE) Northern CA-NV Section meeting, Berkeley, CA 10/17/97.

"Shipboard Fire! A discussion of Fire Cause and Origin in the Maritime Context with Case Studies". International Association of Defense Counsel (IADC) meeting, Pebble Beach, CA 2/97 (with D. Perkins, CFI).

"Fire Safety Issues Associated with Spray Polyurethane Foam". Society of Plastics Industries - Spray Polyurethane Foam Division meeting, Anaheim, CA 2/97.

"Rail Rapid Transit Vehicle Fire Safety Design Issues". Society of Fire Protection Engineers, N. Calif. Chapter meeting, Berkeley, CA 9/95.

"Jack London's Wolf House Fire". American Academy of Forensic Sciences, Nashville, Tenn, 2/96, with Robert N. Anderson, Ph.D. et al.

"Fire Performance of High Rise Building" presented to the Arizona Structural Engineers Assoc. (ASEA), Phoenix, AZ 1/96.

Guest Instructor: Fire Science Fundamentals and Fire Investigation, Arizona Conference of Arson Investigator's Seminar, Phoenix, AZ 7/95.

"Assessing the Fire Performance of Rail Passenger Vehicles-A Changing Technology". Presented at the NFPA & Rail Transportation Systems Mtg, Denver, CO, May, 1995.

"Fire Performance of Rail Transit Passenger Vehicles". Presented at the Annual NFPA & Rail Transportation Systems Meeting, San Francisco, CA - May, 1994.

"Performance of Structural Systems and Building Sub-Systems to Threats Posed by Fire and Smoke". Presented to the Structural Engineers Association of Oregon, 11/94

Guest Instructor: Teaching Fire Science Fundamentals with State Fire Marshal Personnel. Arson 2A Fire Course, Napa, CA. Nov. 1994.

Two day seminar presented to the Santa Clara County Arson Task Force on January 4 & 5, 1993. Topic: "Advanced Concepts in Fire Investigation".

Wood Building Research Center of the University of California Forest Products Laboratory, Emeryville, CA; Invited speaker-Topic: "Fire Performance of Wood". May 4, 1992.

Guest Instructor: Advanced Fire Science Analysis Seminar, [IAAI] - Boise, Idaho; August 14, 1992. International Association of Arson Investigators, Inc. Topic: "Recreating the Fire Scene Through Modeling & Animation".

"Enhancement of Fire Safety in Buildings: Microcomputer Systems for Selecting and Specifying Products". Presented at the Sixteenth International Conference on Fire Safety, Millbrae, CA, 1/17/91. By Joseph Zicherman, David Frey and Lou Katz, IFT; Richard Licht, Kristen Jensen and Tony Schommer, 3M Company.

"Cost Benefit Studies of PVC Pipe Tube and Conduit" Presented at the CSI-Construction Specifics Institute - Annual Meeting, San Diego, CA July, 1990

"Fire Performance of Plastic Pipe, Tube & Conduit" - presented to the Fire Retardant Chemicals Association - Fall Technical Conference, 10/18/87 - Monterey, CA.

"Fire Performance of Contemporary Building Products and Furnishings", East Bay Arson Round Table - CCAI, Berkeley, CA, 10/15/87.

"Fire Performance of Electric Raceways"-Testimony presented to Seattle Electrical Code Adoption Hearing, concerning adoption of the 1987 National Electrical Code, Seattle, WA. 12/87.

"Performance of Plastic Plumbing and Electrical Products in Fire Resistive Assemblies". Prepared for presentation at the ASTM Symposium on Fire Hazard and Fire Risk Assessment. San Antonio, TX, 12/3/90.

"Combining of Modeling, Computer Graphics and Timeline/Witness Data for Consultants": ASTM Committee E.5 Forensic Seminar, San Francisco, CA, 6/90.

"Forensic Fire Investigations"-presented to the East Bay Chapter of ICBO-6/89, Danville, CA.

"Value and Utilization of Experts in Subrogation" - presented to Lawyers Subrogation Seminar hosted by Bolling, Walter & Gawthrop - 6/89 - Sacramento, CA.

"Condominium Construction Defects" - presented to the Mount Diablo Property Association monthly meeting - 3/89.

"What Every Structural Engineer Needs to Know About Fire Protection" - Presented to Structural Engineers Association of N. California (SEAONC), 11/88,San Francisco CA.

"Fire Performance of Plastic Pipe, Tube & Conduit" - presented to the Fire Retardant Chemicals Association - Fall Technical Conference, 10/18/87 - Monterey, CA.

"Fire Performance of Contemporary Building Products and Furnishings", East Bay Arson Round Table - CCAI, Berkeley, CA, 10/15/87.

Comments on plumbing revisions prepared for the Chicago Building Code. Testimony delivered to the Building Code Revision Panel, Chicago, IL. 9/86.

"Fire Hazards of Non-metallic Electric Raceway". Testimony presented to the Sacramento Toxic Hazards Commission, 12/86.

"Fire Performance of Plastic Pipe - An Update", presented to the Arizona State Chapter Meeting of ICBO, Phoenix, AZ, 5/18/85.

Research Society Meeting in St. Louis, MO, June 1984. (Presented by B.W. Gammon, co-authors - A.P. Schniewind and R. White).

"Materials Properties & Fire Investigation" presented to the Fire Investigation Section, Santa Clara Fire Chiefs Association on 10/6/83.

"Use of Fire Performance and Fire Test Data in Fire Investigation", presented to the San Mateo County Fire Investigation Unit, Millbrae, CA, 5/26/85.

"Plastic Pipe & Fire Safety; The Model Building Codes, Fire Test Work & a Historical Perspective". Presented to the ANSI - A-40 Committee, Boston, MA, 10/85.

"Modeling Load-Bearing Stud Wall Fire Endurance" presented to the Fire Protection Research Society Meeting in St. Louis, MO, June-1984. (Presented by B.W. Gammon, co-authors - A.P. Schniewind and R. White).

Moderator - Panel on Manufactured Housing Technology, 6/82. Meeting, Northern California Section - Forest Products Research Society, San Mateo, CA.

Expert Witness - California Legislature Assembly Committee on Governmental Organization, 2/11/81. Testimony on effects of contemporary building materials and contents on high-rise fire safety.

"Research Efforts in Housing Rehabilitation" Forest Product Research Society, Northern California Section Meeting - Fresno, CA 10/80.

"Full Scale Fire Tests of BART Vehicle Materials". Presentation to the N. California section of Society of Fire Protection Engineers,1/80(with R.B. Williamson & F. Fisher).

Expert Witness - California State Commission for Housing and Community Development, 10/20/80. Testimony related to fire performance of plastic pipe for residential and commercial structures.

"Fire Related Problems with Contemporary Residential Building Materials" at the California Fire Chiefs Assoc. of Fire Prev. Officers Mtg. 2/23/79.

"Influence of Construction Materials on the BART Fire of January, 1979" presented to the Santa Clara County Chapter of the ASCE, Spring 1979.

"Wood/Char Microstructure in Treated and Untreated Wood." National Meeting Forest Products Research Society, 7/79.

"Fire Performance of Contemporary Plastic Materials". Presentation to the Products Liability Committee of the San Francisco Bar Association, 9/79.

"Fire Protection Problems Associated with Cellulose Insulation Products", 1978. Society of Fire Protection Eng. - Fire Protection Engineering Seminar, Anaheim, California, 5/78.

"Fire Performance of Wood" at ASTM D-7 Committee Meeting on Wood Products, Richmond, California, 10/77 (with R. B. Williamson).

"Instrumental Approaches to Powder Coatings Characterization" at the American Chemical Society National Meeting, Chicago, Illinois, 8/73.

"Powder Coatings for the Container Industry" at the National Metal Decorators Association Convention, Miami Beach, Florida, 10/73.

"Design of Resin Systems for Powder Coatings" at the SME Powder Coatings Conference, Cincinnati, Ohio 3/72.

"Polymer Resins for Powder Coating" at the University of Southern Mississippi Polymer Conference Series, Biloxi, Mississippi, 7/72.

"Painting Southern Pine" presented at the Conference on Southern Pine Utilization Alexandria, Louisiana, 11/6